European Union Network
for the Implementation
and Enforcement of Environmental Law

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USE OF SELF-MONITORING AND REPORTING OF AIR EMISSIONS ON COMPLIANCE ASSURANCE

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Introduction to IMPEL

The European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL) is an international non-profit association of the environmental authorities of the European Union (EU) Member States, and of other European authorities, namely from acceding and candidate countries of the EU and European Economic Area (EEA). The association is registered in Belgium and its legal seat is in Brussels, Belgium.

IMPEL was set up in 1992 as an informal Network of European regulators and authorities concerned with the implementation and enforcement of environmental law. The Network's objective is to create the necessary impetus in the European Community to make progress on ensuring a more effective application of environmental legislation. The core of the IMPEL activities concerns awareness raising, capacity building and exchange of information and experiences on implementation, enforcement and international enforcement collaboration as well as promoting and supporting the practicability and enforceability of European environmental legislation.

During the previous years IMPEL has developed into a considerable, widely known organisation, being mentioned in a number of EU legislative and policy documents, e.g. the 8th Environment Action Programme that guide European environmental policy until 2030, the EU Action Plan: "Towards a Zero Pollution for Air, Water and Soil" on Flagship 5 and the Recommendation on Minimum Criteria for Environmental Inspections.

The expertise and experience of the participants within IMPEL make the network uniquely qualified to work on both technical and regulatory aspects of EU environmental legislation.

Information on the IMPEL Network is also available through its website at: www.impel.eu

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Project Manager/Authors: Ana Garcia (IGAMAOT, Portugal), Romano Ruggeri (ARPA Sardegna, Italy), Mário Grácio (IGAMAOT, Portugal) Credits to Experts that responded to the project questionnaire from: Croatia, Finland, Germany, Ireland, Italy, Lithuania, Portugal, Romania, Serbia, Slovakia, Slovenia, The Netherlands and United Kingdom (England)	**Report adopted at IMPEL General Assembly Meeting**: Adopted by written procedure on 20/03/2025 **Total number of pages: 46** Report: 40 Annex: 6

Executive Summary

This project aims to produce a support document on the use of duty-holders self-monitoring and reporting of air emissions on compliance assurance focused on its reliability and use on compliance assessment by a designated competent authority, including baseline practices from different countries on duty-holders self-monitoring and reporting of air emissions in stacks, measured continuously and periodically to be used by environmental permit authorities, as well as competent authorities for compliance assessment of self-monitoring and reporting, concerning specifically air emissions but also as input for other emissions or impacts, on water, waste or even biodiversity.

It also aims to support the strengthen of legal dispositions in EU and national legislation on self-monitoring and reporting and compliance assessment by a designated competent authority.

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USE OF DUTY-HOLDERS SELF-MONITORING AND REPORTING OF AIR EMISSIONS ON COMPLIANCE ASSURANCE

1. INTRODUCTION

Many European Union (EU) environmental directives and regulations have mandatory obligations for monitoring, namely of pollutants emissions, resources consumption or waste management, but also of other environmental impacts, under specific regulations.

Several pieces of these EU legislation imply, more or less explicitly, that the operator from each installation (duty-holder) should be responsible for monitoring, and for that purpose can subcontract an accredited third party. Usually, it is not specified how to ensure its reliability and assessment by public authorities, or how it could (should) be used on compliance assurance, leaving this prerogative to each Member State, that must define specific dispositions when transposing it to national law.

Concerning the Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010, the Industrial Emissions Directive (IED), as amended by Directive 2024/1785, monitoring is considered an important element in preventing and reducing pollution and ensuring a high level of protection of the environment taken as a whole.

The document from the European Commission Joint Research Centre (JRC) Reference Report, concerning air and water emissions from Industrial Emissions Directive (IED)[1] (JRC, 2018), with the aim to help competent authorities to define monitoring requirements in the permits of IED installations, on air and water emissions, mentions that the objectives of monitoring are many and diverse and "*Operators and competent authorities should have a clear understanding of the objectives of monitoring before monitoring begins. The objectives and the monitoring system should also be clear for any third party involved, including contractors, e.g. accredited testing laboratories, and other possible users of the monitoring data (e.g. land-use planners, public interest groups and central government)*"[2].

Monitoring, in the legislative context of control of environmental aspects from IED installations, although can be used for other purposes, is intended to be an element of compliance assessment according to article 14[3]. In the 2024 version of IED, in dispositions of Article 70, monitoring is carried out in accordance with the uniform conditions [defined by European Commission after exchange of information between Member States, the sectors concerned, non-governmental organisations], and

[1] Thomas Brinkmann, Ralf Both, Bianca Maria Scalet, Serge Roudier, Luis Delgado Sancho; *JRC Reference Report on Monitoring of Emissions to Air and Water from IED Installations*; JRC, 2018, EUR 29261 EN; doi 10.2760/344197,

[2] The document states that monitoring can be applied to assess compliance with permit requirements and used to other purposes such as find the optimal balance between process yield, energy efficiency, resource input and emission levels; analyse the causes of certain types of emission behaviour (e.g. to detect reasons for variations in emissions under normal or other than normal operating conditions); predict the emission behaviour of an installation, e.g. after operational conversions, operational breakdowns or an increase in capacity; check the performance of abatement systems or determine the relative contribution of different sources to the overall emissions; provide measurements for safety checks; report emissions for specific inventories (e.g. local, national and international, such as the E-PRTR); provide data for assessing environmental impacts (e.g. for input to models, pollutant load maps, assessment of complaints); or set or levy environmental charges and/or taxes.

[3] See article 14: Article 14, Permit conditions, that requires Operators to provide to environmental authorities' information on the basis of results of emission monitoring data that enables the competent authority to verify compliance with the permit conditions; and comparison with the emission levels associated with the best available techniques.

shall be recorded, processed and presented in such a way as to enable the competent authority to assess compliance with the operating conditions, emission limit values and environmental performance[4].

Monitoring can be periodic, defined as the determination of a measurand at specified time intervals, or continuous, usually required when the flow of pollutants is above a certain limit, and implies the measurement and/or collection of large amounts of samples and data, many times requiring the use of specific equipment, laboratory methods, complex procedures and methodologies, specialized experts and technicians and accredited entities or certified standards, intensive human resources expertise and high costs actions.

Subsequent reporting should allow the assessment of compliance with the law, regulation or permits, by a designated competent authority and, whenever applicable, timely correction of non-conformities (or infringements) and prevention of its reoccurrence.

In a universe of thousands of regulated entities (operators/duty-holders) and installations, public authorities do not have human resources to perform monitoring by themselves, even if costs are incurred by duty-holders. In this context, monitoring and subsequent reporting is usually a responsibility of the operators/duty-holders, what is often called self-monitoring and reporting.

Under the umbrella of European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL), and the Supporting Industrial Emissions Directive (IED) Implementation Project 2021-2024, runs the present project that aims to produce a support document on duty-holders self-monitoring and reporting of air emissions, focused on its reliability and use on compliance assessment by a designated competent authority.

This report includes practices from different countries on duty-holders self-monitoring and reporting of air emissions in stacks, measured continuously or periodically, and procedures adopted by environmental permit authorities, as well as competent authorities for compliance assessment, concerning specifically air emissions, but that intends to be an input also for other pollutants emissions or impacts, on water, waste or even biodiversity.

It also aims to contribute to the necessary strengthen of legal dispositions in EU and national legislation on self-monitoring and reporting and compliance assessment by a designated competent authority, as justified in chapter 2.

This report does not intend to be a technical document concerning selection of pollutant parameters, sampling, monitoring, methods, quality assurance, uncertainty, data treatment and assessment compliance of emission limit values (ELVs), or Best Available Techniques and associated emission limit values (BAT-AELs), enforcement and inspection. Concerning monitoring and specific technical issues, the mentioned document JRC 2018, provides very complete information to competent authorities and operators/duty-holders of the general aspects of the monitoring of emissions to air and water, specially from installations under the scope of the IED and was a major support for the drafting of

[4] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:02010L0075-20240804%20

this report. Another very relevant document considered was the OECD Technical Guide On Environmental Self-Monitoring, in countries of Eastern Europe, Caucasus, and Central Asia, 2007 (OECD, 2007), also with quite important inputs on the theme.

The importance of a self-monitoring and reporting was recognized by the Environmental Compliance and Governance, an Initiative from the European Commission.

The Communication on EU actions to improve environmental compliance and governance {SWD(2018) 10 final}[5] mentions that in practice, mechanisms for securing compliance involve Member States using three broad classes of intervention (collectively referred to as 'environmental compliance assurance'): 1) compliance promotion, 2) compliance monitoring, and 3) follow-up and enforcement. The respective work programme of Environmental Compliance and Governance 2020-2022 includes a set of actions directed to European Commission, Member States and Networks.

Although in 2) "compliance monitoring", the definition does not explicitly mention self-monitoring and reporting, the mentioned work programme includes a specific Action 9, on "Strategies for verification of self – monitoring and reporting", to be led by IMPEL.

Action 9 aims at exploring, supporting and further strengthening mechanisms and methods to optimise the informed use of self-monitoring data from duty-holders, as a fundamental step in assuring environmental compliance by Member State authorities, together with permitting, surveillance, inspection and enforcement. It is recognized that a credible self-monitoring scheme would decrease burdens of inspection, improve chances for a swift detection of breaches and thus help to limit environmental damages making authorities action more efficient. Timely and effective data evaluation by competent authorities, permitters and inspectors could lead to targeted action, to ensure correction, prevention and sanctioning of offences, but also revisions, suspensions, and revocations of permits.

The preset IMPEL project and report intends to contribute to Action 9. Further developments, beyond 2025, are also in place by IMPEL, namely in the new IMPEL Project 2025-2027 on Self-Monitoring in Water Permits (SMWP), for water emissions, reuse and abstraction.

IMPEL is working on self-monitoring from duty-holders since at least 1999, and previous reports published on this topic, used as major sources for the present report, include[6]:

- IMPEL report on Operator Self-Monitoring, 1999 (IMPEL, 1999)
- IMPEL report on Supporting Implementation of the Industrial Emissions Directive, Subgroup Self-Monitoring, 2016 (IMPEL 2016)
- IMPEL report Supporting Implementation of the Industrial Emissions Directive (2010/75/EU) and doing the right things (permitting), 2017 (IMPEL, 2017)

[5] From the Commission, the European Parliament, the Council, the European Economic and social Committee and the Committee of the Regions. More information available at the link: https://environment.ec.europa.eu/law-and-governance/environmental-compliance-assurance/commission-support_en

[6] Available at https://www.impel.eu/en/topics/industry-and-air/industrial-emissions/projects/supporting-ied-implementation/outputs (see Chapter on. Bibliography)

- Doing The Right Things (IED) Combined guidance, 2018 (IMPEL, 2018)

As a part of the present IMPEL project, an online Workshop on Operator self-monitoring air emissions was held on 28th September and 11th October 2021, jointly organised by *Agenzia Regionale per la Protezione dell'Ambiente della Sardegna*- ARPA Sardegna (Italy) and *Inspeção-Geral da Agricultura, do Mar, do Ambiente e do Ordenamento do Território* - IGAMAOT (Portugal). The workshop focused on Operator self-monitoring, on air emissions, continuous and non-continuous, on the reliability of self-monitoring and its reporting by operators (duty-holders).

The workshop had more than 100 participants from 25 countries and was attended by representatives from national and regional environmental Agencies, Inspectorates and Police, Ministries of Environment, Public Prosecutors and Universities. Presentations were covered by IMPEL, European Commission – DG ENV (Directorate - General for Environment) and EIPPC Bureau (European Integrated Pollution Prevention and Control Bureau), OECD (Organisation for Economic Co-operation and Development), INECE (The International Network for Environmental Compliance and Enforcement), and environment authorities experts from Austria, Chile, Croatia, Finland, Germany, Italy and Portugal[7].

The report of the IMPEL workshop, "Strategies for verification of self-monitoring and reporting of air emissions workshop" (IMPEL, 2021), was approved by IMPEL General Assembly, and available at IMPEL website, as well as all the presentations.

In the beginning of 2023, the IMPEL project team asked IMPEL experts, permitters and inspectors' response to contribute with their views through a questionnaire on self-monitoring and reporting of air emissions and assessment of compliance with the law, regulations and permit requirements. The questionnaire was organized in 7 topics (see Annex):

- Q1: Periodic measurement- Reliability of data of self-monitoring
- Q2: Continuous measurement- Reliability of data of self-monitoring
- Q3: Reporting to supervisory authorities – periodic measurement
- Q4: Reporting from operator to supervisory authorities – continuous measurement emission system (CEM)
- Q5: Uncertainty of air emissions measurements. Methodology to assess compliance with limit values
- Q6: Analysis from supervisory authorities and dealing with non-compliances
- Q7: Other than normal operating conditions

The IMPEL project team collected 31 experts' answers from 12 countries: Croatia, Finland, Germany, Ireland, Lithuania, Portugal, Romania, Serbia, Slovakia, Slovenia, The Netherlands and United Kingdom (England). The responses to this questionnaire provided a major input to the content of the present report.

[7] IMPEL REPORT- Strategies for verification of self-monitoring and reporting on air emissions workshop

2. PRACTITIONERS' NEED FOR A SELF-MONITORING AND REPORTING SCHEME

Self-monitoring and reporting, and compliance assessment by public authorities- what we call in this IMPEL report a "self-monitoring and reporting scheme"- is not considered as a specific step in most EU legislation.

Consequently, in compliance assurance monitoring[8], which aims to identify and characterise duty-holder conduct and detects and assesses any non-compliance, what represents the "diagnostic" and "surveillance" part, the focus is on inspection.

In practice, this means that the burden of proof of compliance relies on inspection authorities, rather on duty-holders and that self-monitoring and reporting and its assessment by a competent authority is not recognized as a compliance assurance step between permitting and inspection, with the same focus and importance.

If a self-monitoring and reporting scheme would be recognized in legislation with specific dispositions as permitting and inspection, as well as explicitly be included in compliance assurance monitoring, it would be a practical application to the polluter – pay principle[9]. This principle requires that polluters should bear the costs of their pollution, and not the taxpayers, including the costs of measures taken to prevent, control and remedy pollution and the costs it imposes on society, and is a key concept behind EU environmental policy[10].

A self-monitoring and reporting scheme should be the first screening to assess legal compliance in a universe of thousands of operators/duty-holders and identify early breaches and (potential) offenders/polluters that should be priority targets for inspection.

The Recommendation 2001/331/EC of the European Parliament and of the Council of 4 April 2001 providing for minimum criteria for environmental inspections in the Member States (RMCEI), states that in the preparation of the inspection, a documental analysis should include the assessment of "self-monitoring carried out by or on behalf of operators of controlled installations"[11].

[8] According to Communication on EU actions to improve environmental compliance and governance {SWD(2018) 10 final} 'environmental compliance assurance, includes: 1) compliance promotion, 2) compliance monitoring and 3) follow-up and enforcement.

[9] The Polluter Pays Principle: Inconsistent application across EU environmental policies and actions (ECA, 2020, available at https://www.eca.europa.eu/lists/ecadocuments/sr21_12/sr_polluter_pays_principle_en.pdf, recommendation for the Commission to assess the scope for strengthening the integration of the Polluter Pays Principle into environmental legislation;

[10] https://environment.ec.europa.eu/economy-and-finance/ensuring-polluters-pay_en

[11] For the purposes of this recommendation, 'environmental inspection' is an activity which entails, as appropriate […] (c) the carrying out of activities for the above purposes including […]: consideration of environmental audit reports and statements, consideration and verification of any self-monitoring carried out by or on behalf of operators of controlled installations.

In IED (2024), the only text that refers specifically to "self-monitoring" is on Article 3, on the definition of "environmental inspection": "*all actions, including site visits, monitoring of emissions and checks of internal reports and follow-up documents, verification of self-monitoring, checking of the techniques used and adequacy of the environment management of the installation, undertaken by or on behalf of the competent authority to check and promote compliance of installations with their permit conditions and, where necessary, to monitor their environmental impact*."

The definition of environmental inspection in IED does not seem consistent with the rest of the text of this Directive, where "self-monitoring" is not mentioned again. It might also favour different interpretations that could lead to a more diffuse role of permitters and inspectors on who is responsible for systematically and timely assess self-monitoring and reporting from operators/duty-holders.

It is important to realise that an inspection, in a strict sense, usually implies onsite visits to each installation. However, inspections with a site visit can only be performed periodically, many times not even once every year, due to the intensive allocation of human resources and high number of installations. This means that ensuring monitoring requirements are fulfilled by inspection authorities might not be feasible.

A random and aleatory check of self-monitoring and reporting whenever an inspection is performed (or even when a new permit is being emitted) cannot substitute a systematic and timely assessment of self-monitoring and reporting from operators/duty-holders from a designated competent authority. When this happens, self-monitoring and reporting cannot be considered a credible instrument for compliance assurance.

In this context, EU legislation in general, and IED in particular should be clear, detailed and specify that there should be a competent authority to systematically and timely assess monitoring reports of operators/duty-holders from all controlled installations, recognising self-monitoring and reporting and its assessment as an autonomous step of compliance assurance monitoring, between permitting and inspection, as illustrated in Figure above, on Regulation, including a self-monitoring and reporting scheme.

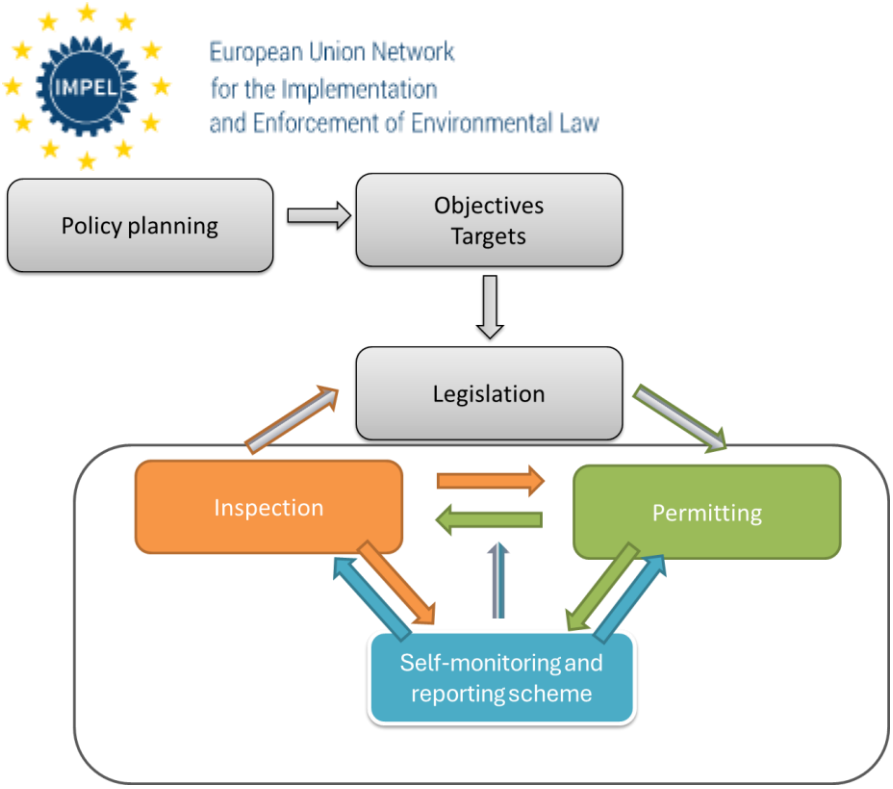

Figure: Regulation, including a self-monitoring and reporting scheme

An inspection programme, to be effective, must focus on priority sectors, areas, and installations. Risk analysis is crucial to this end and IMPEL IED Expert Team is continuously developing innovative tools to support inspectors, under IMPEL Integrated Risk Assessment Method (IRAM), that includes, amongst other criteria, operators/duty-holders performance and compliance, and should have as one of the main sources of information the assessment by competent environmental authorities of self-monitoring and reporting, implying the use of reliable and actual data.

A credible self-monitoring and reporting scheme is adherent to the principle of prevention. Preventing more to react less means an investment on tools to detect early breaches and put more focus on targeted action to ensure timely correction, prevention and sanctioning of offences.

A self-monitoring and reporting and its assessment by a competent authority involves evaluation of large amount of data, checks, validations and comparisons and, to be effective and efficient, needs the use of automatised information technology (IT), data processing that benefit from new tools such as artificial intelligence. The results will provide data on early breaches that should be investigated by inspectors, in benefit of a preventive and intelligence led action.

If this preventive action potential is not fulfilled, more infringements to the law tend to occur. Consequently, the working time from authorities is tendentially allocated to more reactive approach, meaning the reaction to situations when the damage to the environment has already occurred and will need to be repaired[12], many times irreversibly, or with long lasting adverse effects on environment or even on human health.

[12] https://www.eea.europa.eu/help/glossary/eea-glossary/prevention-principle

It is also important to recognise that investigations to find those who were responsible for such damage to the environment (and that must be legally charged), are complex, require high investment on human and material resources (paid by public funding), and many times lead to unsuccessful results.

A thorough analysis of self-monitoring and reporting by a designated competent authority and the communication of such assessment results and follow up to inspectors and permitters (and duty-holders) will not only ensure a more efficient and effective approach to compliance assurance but also minimize the risk of different interpretations of complex legal and permit requirements.

It would contribute to ensure a level playing field and create fair conditions for all market operators, and that some operators are not in financial advantage compared to others. If unreliable it will stimulate unfair competition between economic activities, due to different levels of investment, with operators that will minimize monitoring costs or even present fake results.

IMPEL practitioners identified the above as main obstacles to be addressed and reported the need for a more efficient use of authorities´ resources, technical capacity, availability of compliance environmental data, but also the need to minimize miscommunication of responsibilities between authorities (and with the regulated community) (IMPEL, 2021)[13].

A reliable self-monitoring and reporting scheme will only be possible in a context of clear and detailed dispositions in the law. This is a key factor, because if not considered credible, it can be perceived as an activity operating under a framework of conflicting interests, where duty-holders supervise themselves and are responsible for self-accusations of infringements to the law, jeopardizing the credibility of results, and consequently its use in compliance assurance.

Legislation should set clear rules, and a timely action by a designated competent authority empowered to judge compliance with limit values (e.g. pollutant emissions, extraction of natural resources or waste treatment), followed by enforcement actions directed to (potential) non-compliances, imposing corrective actions, also to prevent, minimise and mitigate any adverse impact to the environment and public health.

All legally required self-monitoring and reporting data should be brought by the authorities as evidence for prosecution or even when a case goes to court, due to legal infringements that should be sanctioned, whenever applicable.

It must also be used for revision of the permit with a focus on preventing potential non-conformities in time, by more effective means, and taking into account the costs and benefits and the principles of precaution and prevention) or, if necessary, suspension or revocation of permit, prohibiting any

[13] Results of IMPEL Implementation Challenge 2021 to environmental authorities on Industry, Noise and Air Quality, refer the major challenge to their role is clarity of permit requirements, the application of emission limit values, the biggest barriers to good levels of compliance are complex legislation. such as the IED applying to operations in this area of work, both terminology and requirements can be misunderstood and to enforcement was identified as a lack of resources for inspection and lack of trained staff, Miscommunication of responsibilities with other authorities, miscommunication or lack of positive communication with the regulated community or the public can worsen already difficult relationships and lead to non-compliance and negative outcomes and need for more availability of information and data on compliance.

operation (or part of it) which poses an unacceptable risk to the environment and/or cannot comply with a permit or other legal requirement.

For that purpose, law, regulations and permits need to detail how it works and results are used in compliance assurance (JRC, 2018)[14], and whenever necessary involve qualified third parties in this process, that together with the operator/duty-holder would be (legally) co-responsible and testify on the adequacy of procedures, methodologies, and that results are accurate, reliable, representative and comparable.

[14] The JRC Reference document from 2018, referring to monitoring of air and water emissions states that "*A clearly defined monitoring objective, an appropriate monitoring plan based on standardised methods (e.g. EN standards) and a quality assurance system, e.g. in accordance with EN ISO/IEC 17025:2017 [1, CEN 2017], help to ensure accurate, reliable, representative and comparable monitoring data.*"

3. ELEMENTS OF A SELF-MONITORING AND REPORTING SCHEME/LEGISLATION

In this IMPEL report, the main definitions are:

Self-monitoring and reporting scheme:

Self-monitoring and reporting as a responsibility from operators/duty-holders for each installation/activity/project, and assessment by a designated competent public authority, with clear and detailed dispositions specified in legislation, regulations and in more concrete and operational biding dispositions specified in the respective permit, including a plan for:

i) Self-monitoring:

Requirements directed to operators/duty-holders for systematic and periodic/continuous measurement and/or collection of samples and/or measured parameters, including in special cases indirect monitoring[15]*, using specified procedures and methods, defined on a biding plan set by the permitting authority, that must prove compliance with environmental laws, regulations and permit conditions.*

It may range from collecting samples (including of the ambient conditions in the vicinity of the facility), operational data, that represent the environmental impacts of the installations operation or activity, according to specified parameters, such as: production capacity, quantity and quality of raw materials and fuels, and emission of air, or water (e.g. concentration and/or load of a pollutant), water extraction (e.g. flow), emission of wastes (e.g. quantities and characteristics, for example in waste management, production, transportation, final destination) or protection of wildlife (e.g. observation of certain conditions of specific habitats or species, for example measuring the number and state of nests from a bird species in a certain period and location).

ii) Self-reporting:

Requirements directed to operators/duty-holders to report to a designated competent authority the results from self-monitoring, in a defined format, frequency and reporting mode, with a conclusive and fundamented assessment of compliance with the law, regulation or permits and, when applicable, with information on timely correction and prevention of any non-conformities (including legal infringements and complaints), and consequent data record keeping.

[15] For example, in air emissions Predictive Emission Monitoring Systems (PEMS), surrogate parameters, mass balances or operational parameters.

iii) Assessment of self-monitoring and reporting:

A designated competent authority timely and systematic analysis and assessment of all self-monitoring and reporting submitted, with conclusion of non-conformities, reporting of the legal infringements, as well as any anomalies and follow-up measures, including prevention, correction and sanction, when applicable.

An extract of this assessment is communicated to operators/duty-holders and includes a legal procedure, in case of a legal infringement, and/or follow-up of measures to be taken to ensure correction and prevention of non-conformities, with a deadline.

All relevant information must be timely communicated to permitters and inspectors, and when applicable, lead to other measures driven by the designated competent authority, to ensure enforcement, sanction, and prosecution and, when necessary, revision, suspension or revocation of permits, to protect the environment and public health at an early stage and preventing (further) damages from occurring.

The construction of a periodic self-monitoring and reporting scheme must rely on a Regulatory Framework with relevant laws, regulations, on permitting, inspection, but also specific monitoring and reporting requirements, with binding rules and competent authority powers, with responsibilities, procedures, infringement and preventive and corrective actions as part of compliance assurance monitoring, including:

- Proportional and systematic monitoring requirements of each installation that must balance its pollution potential and operator performance with respective costs paid by the operator/duty-holder and comparison of monitoring results for each specific sector.
- Reliable and quality monitoring and reported data in a specified frequency, format and mode from operators with the objective of proving compliance with environmental laws, regulations and permit conditions, that need always to represent concrete operating conditions of the installation capacity, that must be detailed and stated in the permit;
- Monitoring and reporting requirements and feedback from assessment by the designated competent authority, directed to the operators/duty-holders, ensuring timely correction from any anomaly detected and powers to apply targeted actions, to ensure correction, prevention and sanctioning of offences, but also revisions, suspensions, and revocations of permits.
- Timely feedback of relevant information on monitoring and reporting requirements assessment from competent authority to permitters and inspectors, and operators/duty-holders, to ensure straight forward action in the scope of respective competences but without duplication of work.

- Powers of competent authority, permitters and inspectors must include to require additional self-monitoring and reporting, data and information, sample and analyse, access to data and to site for verification.

Legislation and regulations must also include:

- List of infringements (including noncompliance with permit conditions);
- Emissions exceedance infraction conditions, with clear definition of infringement and relation to abnormal and normal operation conditions[16], start up and shutdown[17], incidents and accidents[18] and repeated violations;
- Use of submitted data and records as evidence in administrative infringement cases and sanctioning of offences, corrective measures, but also revisions, suspensions, and revocations of permits;
- Ensure follow up preventive and corrective measures by competent authority;
- Responsibilities from operators and qualified third parties' involvement, that can be (legally) co-responsible and testify on the adequacy of procedures, methodologies, and that results are accurate, reliable, representative and comparable and be also responsible for data reporting and submission.

[16] abnormal operation": any technically unavoidable stoppages, disturbances, or failures of the plant, abatement techniques or the measurement devices (malfunctions and repairs).
[17] Start-up:"is any period, where the plant has been non-operational, for instance until fuel has been fed to the plant in a sufficient quantity to initiate steady-state conditions as described in the application or as agreed in writing with the permit authority.
"shut down" is any period where the plant is being returned to a non-operational state as described in the application or as agreed in writing with the permit authority.
[18] Incidents and accidents must be clearly defined.

4. SELF-MONITORING AND REPORTING PLAN

The self-monitoring and reporting plan should be integrated in each permit and be easily revised and changed by the competent authority, whenever necessary.

The operator might have a responsibility to develop a draft self-monitoring and reporting plan according to legislation and regulations and already include a proposal for such a plan in the permit application. This could encourage involvement of facility managers in the development and implementation of self-monitoring plans. Nevertheless, the permit specifications are always a responsibility and decision from the permitting authority.

The self-monitoring plan should contain at least the following detailed description of information/data (JRC, 2018; IMPEL 2017; IMPEL 2016):

- Identification of emission sources: Identify all sources of air emissions within activities and operations;
- Emission inventory and sources: Comprehensive inventory of the types and quantities of pollutants emitted by each source, including data on emission factors, and associated process parameters, fuel and raw material parameters, and other relevant variables and monitoring collection points for each emission and parameter and relevant onsite equipment (monitoring, process and or/abatement), when applicable (including air quality measurements/sensors);
- Operation performance conditions of the installation or activity during each parameter monitoring (considering capacity and characteristics of raw materials and fuels) during each emission monitoring and continuous and discontinuous processes such as batch or loading processes and abatement or treatment equipment;
- Selection of sampling and monitoring methods: Select appropriate monitoring methods for each emission source based on regulatory requirements and the characteristics of the pollutants being emitted, and requirements to ensure quality, such as accreditation and certification for each emission monitoring, as well as period of sampling/measurement. This could include manual stack sampling, ambient air monitoring, or other methods as necessary and collection points for each emission monitoring, that might include air quality measurements/sensors;
- Monitoring schedule: Establish a schedule for conducting monitoring activities based on regulatory requirements, operational factors, and the specific characteristics of each emission source. This may involve continuous monitoring, periodic sampling, or a combination of both;
- Data collection and analysis: procedures for collecting, recording, and analysing monitoring data, including of original data (and time for keeping this data), treatment of measured data, data generation, aggregation and verification. This may include establishing data

management systems, quality assurance/quality control protocols, and data treatment and validation procedures to ensure the accuracy and reliability of the data collection and treatment, and retaining monitoring records for a specified period of time;

- Reference to how to access and use the original (raw) data for verification purposes;
- Limits and accepted uncertainty, for each emission monitoring for the concentration and mass flow for each pollutant/polluting substances released into the environment, as well as other parameters, including operational and surrogate (quantitative, qualitative or indicative) or Predictive Emission Monitoring Systems (PEMS) and clear definition of the situations when it is considered a non-compliance with the law (including if considered an incident and accident or other than normal conditions);
- Reporting and recordkeeping: procedures for reporting monitoring results to regulatory agencies with a specified frequency, format, mode for submission, and deadline.;
- Specific deadlines and dispositions to report exceedance of limits, even if classified as an incident/accident, and to report to the authority measures to prevent, correct and limit damage, to limit the environmental consequences, as well as new monitoring and reporting to show compliance;
- Calibration and Maintenance: program for calibrating and maintaining monitoring, equipment to ensure accuracy and reliability of measurements, but also relevant process, instrumentation and abatement equipment, frequency and parameters and time for keeping records. This may involve regular calibration checks, routine maintenance activities, and documentation of equipment performance;
- Clear responsibilities from operator and qualified third parties involvement, their (legally) co-responsibility on the adequacy of procedures, methodologies, and that monitoring results are accurate, reliable, and represent the operation parameters of the installation and also on reporting /data submission:

It could also include:

- Training and Personnel Responsibilities: Provide training to personnel responsible for conducting monitoring activities to ensure they understand their roles and responsibilities. This may include training on monitoring procedures, equipment operation, safety protocols, and regulatory compliance requirements;
- Audit and Performance Evaluation: Conduct periodic audits and performance evaluations of the continuous monitoring system to verify compliance with regulatory requirements and identify opportunities for improvement. This may involve internal audits, third-party assessments, performance evaluations against established performance criteria and management of complaints.
- Continuous Improvement: Implement procedures for reviewing and updating the self-monitoring plan on a regular basis to reflect changes in operations, regulatory requirements, or best practices on air emissions monitoring and control.

In a continuous measurement emission system (CEM) plan, with an Automated Measuring System (AMS), it should also be considered:

- Monitoring equipment on key emission sources to continuously measure pollutants in real-time;
- Data acquisition and Management: Implement systems to collect, record, and manage data from CEM/AMS and other monitoring equipment. This may involve establishing data acquisition systems, data logging procedures, and secure storage for monitoring data;
- Data validation and quality assurance: Develop procedures to validate the accuracy and reliability of monitoring data. This may include conducting regular calibration checks, performance audits, and data validation tests to ensure that monitoring equipment is functioning properly and producing accurate measurements;
- Alarm systems and event notification: Implement alarm systems to alert personnel in the event of exceedances or anomalies in emissions data. Establish procedures for responding to alarms, investigating the cause of deviations, and implementing corrective actions as necessary.

The self-monitoring report should contain at least the following detailed description of information/data (JRC, 2018; IMPEL 2017; IMPEL 2016):

- General information, such as the operator's name, the address of the installation, the name and the address of the testing laboratory
- Sources and pollutants and respective sampling/measurement sites, points and sections;
- Dates and times of the measurements;
- Operation performance conditions of the installation during each parameter monitoring (considering capacity and characteristics of raw materials and fuels) during each emission monitoring and continuous and discontinuous processes such as batch or loading processes and abatement or treatment equipment;
- Sampling and monitoring methods, number of individual measurements and the timing and duration of the individual measurements;
- Measurands (i.e. pollutants and reference quantities);
- Measured data, data generation, aggregation, conversion to specific standard conditions, uncertainty, including all calculations, and final results;
- Identification of any deviations from the monitoring plan, including any disturbance or lack of conditions to perform a sampling according to the accredited methods (for instance number and position of sample intakes in stacks);
- Compliance assessment, including exceedance of emission limits;
- Analysis of causes for exceedance (considering specific continuous monitoring conditions applicable to abnormal and normal operation conditions, incidents and accidents, and for continuous monitoring systems its breakdown and maintenance) and when applicable

preventive and corrective measures and new monitoring and reporting to show compliance in a specific deadline.

- Responsible entities/persons for the report.

The measurement report must have detailed information, in a transparent and traceable, and allow to trace, amongst others, the operating conditions the storage and handling of every sample, methodologies, the results back through the calculations from all raw and other input data.

It is also a common practice that between periodic measurements the operators are obliged to record emission relevant parameters to assure that abatement techniques or critical equipment are well functioning. For instance, for smaller filter bags, operators should be obliged to show periodic maintenance and performance tests of equipment for the treatment of emissions to air, more than periodic measurements that will be done in a time interval that might be too long to ensure its proper functioning. For small combustion plants, periodic tests to ensure good combustion and data on the quality of fuels used will be very important.

In a CEM plan, with an AMS, it should also be considered start-ups and shutdowns as well as maintenance and repairs of measuring equipment, and how respective measurement results are considered in the conformity assessment.

Under certain conditions, measurement results/reports are made publicly available, namely according to IED Article 24(3)(b).

Some authorities also request a submission and archive of all complaints received of an environmental nature related to the operation of the activity during that period, as well as the provided response.

5. SELF-MONITORING AND REPORTING RELIABILITY

In most countries periodic measurement of air emissions is subcontracted by the operator to an external accredited laboratory, a legal entity qualified on collecting samples/measurements from air emissions from stationary sources. In most countries the operator cannot perform its own periodic monitoring of air emissions, and when it is allowed there needs to be a fundament application and the need to comply with the requisite of an internal accredited laboratory and a special permission from the Ministry of Environment.

Concerning continuous measurement, it is commonly performed by the operator, and verification of its correctness is done by an external accredited laboratory, a legal entity qualified on collecting samples/measurements from air emissions from stationary sources.

The accreditation of the laboratories is usually a competence from a national body for accreditation, that ensures the use certified methods of the European Committee for Standardization (CEN), whenever they exist, or, if they do not exist, accredited for the standards of the International Organization for Standardization (ISO), or approved by the International Electronical Commission (IEC) or other international or national approved standards. The accreditation process is in accordance with the "umbrella" norm EN ISO/IEC 17025- General requirements for the competence of testing and calibration laboratories. EN ISO/IEC 17020- Conformity assessment. Requirements for the operation of various types of bodies performing inspection and EN ISO/IEC 17024- Conformity assessment. General requirements for bodies operating certification of persons.

Concerning specifically air emissions, there is a wide range of specific standards, just as few examples EN 15267 on Air quality- Assessment of air quality monitoring equipment or EN 15259 "Air quality- Measurement of stationary source emissions- Requirements for measurement sections and sites and for the measurement objective, plan and report" and EN 17255 "Stationary source emissions- Data acquisition and handling systems".

On continuous measurements, it is especially important to consider the standards EN14181 "Stationary Source Emissions - Quality Assurance of Automated Measuring Systems". EN 14181 includes a procedure (QAL2) to calibrate the AMS and determine the variability of the measured values obtained by it, so as to demonstrate the suitability of the AMS for its application, following its installation; a procedure (QAL3) to maintain and demonstrate the required quality of the measurement results during the normal operation of an AMS, by checking that the zero and span characteristics are consistent with those determined during QAL1; and a procedure for the annual surveillance tests (AST) of the AMS in order to evaluate (i) that it functions correctly and its performance remains valid and (ii) that its calibration function and variability remain as previously determined. This European Standard is designed to be used after the AMS has been certified in accordance with the series of European Standards EN 15267- QAL1- certification for automatic emission measuring instruments divided into the following work procedures: Laboratory test, Field test and Auditing the manufacturer's quality management system. The norm EN ISO 9169- "Air quality.

Definition and determination of performance characteristics of an automatic measuring system", can also be relevant.

Concerning reliability, it is key factor to ensure the representativeness of the samplings or measure *in situ*, considering operation performance conditions of the installation or activity during each sampling parameter monitoring (capacity and characteristics of raw materials and fuels). In the questionnaire most authorities emphasized that the report of these conditions and data should be guaranteed not only by the operator but also by the laboratory involved, as a third party.

When the purpose is compliance assurance, and under the scope of accreditation, laboratories should check information of operating/capacity conditions, fuel and materials used during the sampling/measurement *in situ*, and extract evidence of such data, that should be explicit in the self-monitoring report.

The aim is to check if the sample represents the conditions of operation performance conditions of the installation specified in the permit, because in practice, if the information is only provided by the operator there is a conflict of interests, and the risk of unreliable information that consequently jeopardize the reliability of all self-monitoring and reporting data. A third-party validation is necessary.

In case of periodic monitoring, operating/capacity conditions, fuel and materials used during the sampling/measurement *in situ* should be clearly specified in the permit. According to the results from the questionnaire, in several countries, this corresponds to the full (nominal) production capacity of an installation regardless of its regime, shifts, working hours or value of actual production to meet market demand, or the "worst case scenario", translated in the maximum design capacity and production volume, maximum input of raw and secondary material, as well as fuels, and the most dangerous substances as well as most pollutant fuel authorized in the project.

It is recommended never to use undetermined terms like "representative" capacity of the installation or "representative sample" because means that authorities will need to collect evidence to prove what "representative" means, a time-consuming task that could easily be contested in court.

In continuous measurement it is very important to know the original data, the data treatment methodologies and software, and ensure no data is erased (even if automatically), due to considered out of normal conditions of the operation of the installation, abatement equipment or measuring equipment. All this data must be kept in the installation for a reasonable period.

The authorities should have the possibility to contract an external accredited laboratories to collect samples or measure in situ, without previous notice to operators, to check results and such costs should be paid by the Operator if there is an infringement. The competent authority should also have the possibility to witness the periodic sampling, and some countries request a previous notice of the periodic sampling/measuring dates of at least two weeks in advance.

Slovak Republic: In the Slovak Republic, operators of large and medium sources are, among other things, obliged to monitor and demonstrate compliance with emission limits, technical requirements, operating conditions and fulfil the requirements for automated emission measurement systems and air quality monitoring.

These duties are performed by operators through authorized persons. An accredited laboratory that performs air emissions monitoring for compliance assessment must employ at least one authorized person to whom the Ministry of the Environment of the Slovak Republic, Department of Air Protection, has issued a responsible person certificate.

An authorized company/person, for carrying out authorized measurements, calibrations, tests or compliance inspections must meet at least the following requirements:

- An accreditation certificate for activities performed according to the "general" accreditation standard ISO/IEC 17025 for emissions or air quality measurements and for tests or calibrations of automated measuring systems and according to ISO/IEC 17020 for compliance inspections of automated measuring systems,
- A certificate of compliance with notification requirements issued by the Slovak National Accreditation Service (SNAS), which is the relevant national notification authority according to the Air Act,
- Employs at least one "physical" authorized person to whom the Ministry of the Environment of the Slovak Republic, Department of Air Protection, has issued a responsible person certificate.

Netherlands: The measurement (sampling and analysing) can be done only by accredited laboratories. This is set down in the general binding rules or in the permit. According to the EN 15259 which is prescribed in the general binding rules or in the permit, the laboratories have to prepare a measurement plan prior a periodic measurement and report afterwards according to the standard. In the report all irregularities concerning sampling and/or operating conditions have to be mentioned. In case of combustion activities operators are obliged to inform the competent authorities two (2) weeks before a periodic measurement or control of continuous measurement by an accredited laboratory. This gives the opportunity for competent authority (inspectors) to be present and observe the conditions of the self-monitoring. In this situation authority checks the operating conditions in the control room and the competency of the laboratories.

Serbia: Periodic measurement in situ is performed by an accredited laboratory in accordance with the requirements and recommendations of the EN 15259 standard at representative measurement points and after emission reduction devices if such a device exists. Periodic measurements are carried out in working conditions at the highest load of the stationary source of pollution. The operator provides data on used raw materials, fuel, capacity. Inspectors are occasionally present at the performance of periodic measurements, and most often when there is a citizen's complaint.

Finland: Official emission measurements are taken by an independent certified sampler and the samples are analysed in an accredited external laboratory. Using a certified sampler ensures the representativeness of the sampling. The operator's representative is also involved in the planning and implementation of the sampling.

Germany: The laboratory needs a special accreditation; the laboratory must verify the conditions during the measurement. There are external checks by supervising authorities during the measurement, such as witnessing the sampling or sometimes, in exceptional cases, contracting an external measurement.

United Kingdom: The Environment Agency regulatory staff and United Kingdom Accreditation Service (UKAS) perform scheduled and unscheduled audits and inspections of monitoring perform audits. Operator's management of monitoring is assessed using a formal audit approach called "Operator Monitoring Assessment" this assesses - Management of monitoring; Periodic monitoring and test laboratories; Continuous monitoring; Quality assurance.

Italy: The Italian network of regional Environmental Protection Agencies (SNPA) issued the Guidance "*Conditions on continuous measurement emission system supporting IED permitting process*[19]": it proposes to the competent authorities uniform and shared guidelines concerning the main specifications of the monitoring conditions to be included in the Self-Monitoring Plans, for IED installations equipped with Continuous Emission Monitoring Systems, for which compliance with the UNI EN 14181 technical standard is required or prescribed, in order to ensure a consistent and transparent approach across the national territory.

Another importance Guidance issued by SNPA is the "*Guideline to develop self-monitoring plans and reports*[20]": it clearly states that the self-monitoring is entrusted to laboratories accredited to the UNI CEI EN ISO/IEC 17025:2018 standard, which certify the performance of significant parameters and BAT AELs using recognized methods.

If the sampling activity is carried out by the Operator, the traceability of the various operational phases related to sampling and sample preservation (during transport) is ensured. Therefore, the sampling plans are always attached to the test reports (lab bulletins) or, in any case, made available to the Inspection Authority at the installation.

[19] https://www.snpambiente.it/wp-content/uploads/2022/09/LG_SNPA_Prescrizioni-Condizioni-AIA-SME.pdf

[20] https://www.snpambiente.it/pubblicazioni/linee-guida-snpa/linee-guida-per-lo-sviluppo-del-piano-di-monitoraggio-e-controllo-revisione-2022/

Case studies indirect monitoring

Concerning the use of indirect monitoring (ex: Predictive Emission Monitoring Systems (PEMS), surrogate parameters, mass balances), usually authorities reported it is not allowed, except when the correlation is good and clear and the indirect determination is also considered useful, only in rare cases. The norm PD CEN/TS 17198:2018 Stationary source emissions. Predictive Emission Monitoring Systems (PEMS). Applicability, execution and quality assurance is relevant to consider.

There is a benefit seen for instance, for smaller filter bags, when operators should be obliged to show periodic maintenance and performance tests of equipment for the treatment of emissions to air, more than periodic measurements that will be done in a time interval that might be too long to ensure its proper functioning. For small combustion plants, periodic tests to ensure good combustion and data on the quality of fuels used will be very important.

United Kingdom: A Monitoring certification scheme (MCERTS[21]) certification scheme for PEMS was under development.

Netherlands: For combustion plants the possibility of using Predictive Emission Monitoring Systems according to NVN-CEN TS 17198 is set down in the general binding rules. EN14181 also applies to PEMS. For periodic measurements there is a common application of indirect monitoring by using so-called emission relevant parameters. Dependent on how harmful the emission is, the emission relevant parameters are used as a supplement to periodic measurements. In this way there is an emission monitoring in the periods between periodic measurements.

Case studies – responsibility from accredited laboratory in periodic measurement and sealing and checks for continuous monitoring

Germany: The measuring institute shall make a statement as to whether measurements were taken at maximum emissions in periodic measurement.

In continuous measurements, measuring devices must be suitability-approved and published in the Federal Gazette. Proper installation must be certified by a notified measuring point. Measuring instruments have internal hour counters and memories; special operating states such as start-up and shutdown are also recorded.

Finland: For CEM, measured information is saved and calculations are performed in process information systems, so the operator can't change that by itself. System provides browsing history covering the usage time of the software. The continuous measurement equipment must have product conformity certificate.

[21] https://www.gov.uk/government/collections/monitoring-emissions-to-air-land-and-water-mcerts

Slovak Republic: The Decree on Monitoring establishes the following obligations in relation to the acquisition and processing of data:

- The automated emission measurement system and its technical measurement, calculation program, data, evaluation, information means, the quality control and management system, the relevant technical and operational documentation, depends on its purpose during installation and during operation must, (unless a special regulation provides otherwise or is not specified otherwise in the permit), meet the requirements according to technical standards and technical standardization information or other similar technical specifications with comparable or stricter requirements in matters of evaluation of air quality monitoring equipment and data collection and processing systems (For example, file STN EN 17255, file STN EN 15267) and,

  - be protected against unauthorized changes during data transmission and processing, including ensuring data encryption when transmitted over a public network and recording of all states and configuration changes in accordance with technical standards for collection and processing systems or other similar technical specifications with comparable ones,

  - ensure signalling, recording of fault conditions, power failure and evaluation status of compliance with emission requirements, including prevention of data loss, especially in the event of a power failure,

  - ensure the backup of all data for at least 5 years, including the function of restoring data from the backup and the possibility of exporting at least initial data from the database in a documentable, simple and machine-readable format in accordance with technical standards for data collection and processing systems,

  - meet the other established conditions for the detection, validity and processing of the results of continuous measurement of data on compliance with specified emission requirements,

  - meet the requirements for technically correct assessment of compliance with the determined emission requirement by continuous measurement,

- record the data of the data and evaluation system and process the results of continuous measurement in the scope and form of continuous measurement protocols with details in accordance with technical standards for data collection and processing systems.

6. COMPLIANCE ASSESSEMENT

The use of appropriate IT tools for submission of data and reports must be associated with a database for the storage and exchange of the operator reports and of the assessment process, which may involve the access to information from several authorities and experts (IMPEL, 2018).

A database allows easy access from the competent authority for self-monitoring and reporting but also permitters and inspectors to access historic data on self-monitoring and reporting to serve as a source of information in the event of an enforcement action, to help determine the past performance of the duty-holder, and appropriateness of past and current practices (OECD, 2007)[22]

When the assessment shows an exceedance and conclusion of non-conformities, including reporting of the legal infringements, as well as any anomalies, an extract of this assessment should be communicated to duty-holders and include a legal procedure, if there is a legal infringement, and/or follow-up of measures to be taken by duty-holders for correction and prevention, in a certain deadline, and with instructions on how to show their implementation. Other measures driven by identified competent authority (ies), on prevention, enforcement, sanction, and prosecution and, when necessary, revision, suspension or revocation of permits, to protect the environment at an early stage and preventing (further) damages from occurring.

All relevant information must be timely communicated from the designated competent authority to permitters and inspectors, to ensure straight cooperation in the scope of respective competences and no duplication of actions.

The responses of the competent authority will graduate from (OECD, 2007):

- Revision of the permit with a focus on preventing potential non-conformities in time, by more effective means, and taking into account the costs and benefits and the principles of precaution and prevention) or, if necessary, suspension or revocation of permit, prohibiting any operation (or part of it) which poses an unacceptable risk to the environment and/or cannot comply with a permit or other legal requirement or even does not have any permit;
- Enforcement actions in non-compliant situations (including both lack of quality monitoring for adequate evidence and non-compliance with limit values), where the general approach is to ensure compliance by imposing corrective actions, including a to prevent, minimise and mitigate any adverse impact to the environment, and requiring the operator to investigate and report on the reasons for the non-compliance, and in some serious cases the authority should also consider carrying out its own investigation;

- Prosecution/court action where legislation requires such action for all non-compliances or where the non-compliance is great and has a significant environmental impact and/or the process operator has a history of non-compliances and may have an impact on human health.

All legally required self-monitoring and reporting data must be brought, by the authorities as evidence, into court and shall be used as a basis for non-compliance actions and prosecution against the facility.

Serious, including criminal response, is reserved for the most serious cases. Also, in such cases enforcement response policies elaborate what is the proportionate government response to the range of possible violations and repeated offences or bigger installations or companies experiencing large (intolerable) or avoidable spills, presence of environmental damage (OECD, 2007).

Presenting a false reporting, inexcusable failure to report, tampering with a monitoring device, falsifying or failing to keep records must be treated as criminal offence.

The main consideration for the competent authority to decide on an appropriate response is the compliance zone to which a particular situation belongs. However, the authority may also take a precautionary approach, particularly when other considerations give further information on the risk of non-compliances occurring in future. These extra considerations can be quantitative or qualitative and may include (OECD, 2007):

- Severity of the non-compliance on the basis of: duration, frequency, and foreseeability; The number of limits exceeded, e.g. for different substances; The magnitude of the exceedance(s);
- The reactions of the operator to minimising and mitigating adverse impacts to the environment.
- The competence of the operator;
- The reliability of the process equipment, procedures, and management control;
- The previous compliance performance of the installation and/or operator;
- The sensitivity of the receiving environment;
- The possible risk of harm to the receiving environment and human health.
- These qualitative considerations may lead the competent authority to adjust the thresholds at which the three forms of response (i.e. acceptance, negotiation, or enforcement) may be adopted for a particular situation. For example, if the previous performance and competence of the operator are poor, the authority may start negotiating for improvements when the measured results are between the compliant and borderline zones.

In compliant situations, the authority could consider the following actions (OECD, 2007):

- Recommending continuation of the monitoring programme with the same scope or re-focusing on higher priorities;
- Recommending reductions in the frequency and/or scope of the monitoring programme;
- Switching from monitoring of direct values to surrogate parameters in order to save costs where the generally greater uncertainty of surrogates is acceptable in such compliant situations.

Responses are needed in borderline situations to reduce the probability of exceeding the limit. Best practice is for the authority to negotiate with the operator and encourage the operator to make voluntary improvements. (This approach is constrained by legal requirements in some countries.) Best practice is to consider requiring the process operator to (OECD, 2007):

- Carry out a detailed investigation of the individual process activities in order to establish why a borderline situation has arisen;
- Develop a time-tabled plan, based on the investigation, for specific actions and improvements which can be undertaken to re-establish or achieve compliance;
- Carry-out additional monitoring and reporting while the plan is being implemented, to demonstrate that progress is satisfactory.

Other uses of self-monitoring data besides checking the compliance with permit conditions and follow up enforcement actions, when there are anomalies could imply (OECD, 2007; IMPEL, 2018):

- Check of overall compliance of the installation with environmental permit conditions, and analysis of trends, namely any changes in activities, process, capacities, raw materials, fuels and abatement techniques, also and comparison with BAT and relative contribution of different sources to the overall emissions;
- Performance assessment (comparing with previous year's performance; trends analysis: increase/decrease of self-monitored data; comparing with previous year's performance; comparing performance with similar plants.);
- Measurements assessment (check qualification of the third certified lab- methods used. In case of CEMS check if calibration was performed by certified laboratory;
- Determine the parameters that should be measured because of the industrial process (input raw materials, fuel, product): check if permit covers all aspects; and
- Assess critical conditions to be focused on in the next inspection.

As already mentioned, legislation and permits should be clear of what are the mandatory parameters subject to self-control of air emissions in each stack, in function of the sector/origin/raw material/fuel, and specific conditions and deadlines when an emission limit value is exceeded, and the cases when

an infringement procedure takes place. Nevertheless, all the parameters in the law (besides the ones subject to self-control) should be applied. The correction and prevention of the causes that led to the exceedance and reporting of measures in place to the competent authority should be mandatory. Reincidence of exceedances in a certain period should be an aggravated offense.

Case studies – compliance assessment

Ireland:

Compliance is assessed through the following means:

- Site inspections, on-site assessments and audits of documentation
- Monitoring of emissions by external contractors on behalf of the EPA
- Reviews of licensee periodic air monitoring records and reports
- Reviews of licensee continuous emissions monitoring systems (CEMS) and CEMS results
- Reviews of abatement and CEMS maintenance procedures and records

Non-compliances are issued where a condition of the licence has not been met, an Emission Limit Value (ELV) has been breached, or where any other emission of significance has been deemed to have occurred.

Licensees are issued with a formal notification of non-compliance along with instructions to carry out corrective actions and investigations as appropriate by a specified date.

Depending on the severity of the breach or breaches of conditions of the licence or ELV, the EPA may escalate enforcement action by initiating compliance investigations and other actions up to and including prosecutions for offences.

Finland: Large scale operators participate in municipal united monitoring in which co-operation with the Finnish Meteorological Institution is waged.

Forms which have been filled in the electronic system are approved electronically. 6.4 Email or automated message from an electronic system (a message of approval or a request for more information). 6.5 Note of complaint and request for clarification -> monitory letter -> administrative compulsion -> request for investigation

Netherlands: The compliance is assessed after subtracting the reported measurement uncertainty, which shall be less than the maximum permitted measurement uncertainty, from the measurement result. This procedure is set down in the general binding rules or in de permit. Most of the measuring laboratories includes the compliance assessment in the report. The competent authorities assess the report and do check if the compliance is correctly assessed.

Italy: If specified in the permit, the continuous measurement emission system (CEMS) can be used as a tool for compliance monitoring (therefore used to detect non-compliances and to trigger the

sanctioning- administrative or criminal- procedures) and is not merely intended as a self-monitoring tool.

The above-mentioned Italian *"Guideline to develop self-monitoring plans and reports* indicates that the laboratory should indicate the measurement uncertainty whenever the measured value exceeds the reference limit. In defining decision rules for the compliance of results with legal limits, reference should be made SNPA Guidance "*Shared criteria of the system for estimating and interpreting measurement uncertainty and expressing the result*".

7. DATA MANAGEMENT

Data management involves the organisation of data reported by the operators and its conversion into information by authorities, for the purpose of compliance assessment. It includes transfers of data how and when data are to be transferred and to which databases.

Data management also relates to data processing – collation, analysis, and condensation of data. Processing would normally be carried out in stages, so that recent data are available in a detailed form and earlier data in a more summarised form.

Data must also be systematically archived in a secure store, so that records of past performance are readily available OECD, 2007)[23].

The designated competent authority must ensure a timely systematic analysis and assessment of all monitoring and reporting submitted by duty-holders and an immediate analysis and assessment of exceedance conclusion of non-conformities, including reporting of the legal infringements, as well as any anomalies.

Ideally, dealing with big quantity of data, there should be an IT System/electronic platform where:

- Data from each operator is stored and where accredited Laboratories and/or operators report all information.
- Automatic analysis of compliance should be possible, with pre-loaded limits that submitted information would be compared against and (potential) infringements alarms sent to authorities and to operators.
- Operators should have a mandatory requirement to immediately take action to correct the situation and make new measurements and submit it to authorities to show compliance with the law, in a specified deadline.
- All the information would be stored in the IT system.

It is not desirable that continuous monitoring raw data is sent from the operators in real time and directly to the authority. This would create a burden for the authority, that would be in practice responsible for handling, storage and reacting to potential noncompliance, instead of the operator.

Case studies – IT systems for self-reporting in periodic measurements

Croatia: The operator is obliged to submit the reports on the periodic measurements performed and the annual report on continuous measurement to the Ministry for the previous year through the Internet application of the ministry's website. When entering data, it is mandatory to attach the electronic version of the original report.

[23] OECD TECHNICAL GUIDE ON ENVIRONMENTAL SELF-MONITORING , 2007, pages 91-92

Finland: The measurers always write a report according to reporting standards (e.g. SFS-EN 17255) and it includes among others, measurers, measuring site and plane, measuring equipment, standards and accreditation information, weather conditions, measuring parameters, deviations, measuring and laboratory results and calculations, measuring uncertainty and compliance with the limit values.

Germany: A measurement report prepared about the result of the measurements and submitted within 12 weeks of the completion of the measurements. The measurement report shall contain information on the measurement planning, the result of each individual measurement, the measurement method used and the operating conditions relevant to the assessment of the individual values and the measurement results. This shall include information on fuels and feedstocks and the operating status of the facility and emission control equipment.

Ireland: All communication and submissions are made through an allocated IT system LEMA (Licensing, Enforcement & Monitoring Application). Operators report incidents (breaches of licence conditions or Emission Limit Values) through the EDEN portal, which is a licensee facing web-based application which allows licensees interact with the EPA.Not reporting an incident is a breach of the licence.

Netherlands: The accredited laboratories report the results of the performed measurements according to EN 15259, which means that the measurement plan is included in the report. The report also includes the continuous measured concentrations, the sampling volumes, the laboratory results and the calculated concentrations. In order to harmonise the reporting requirements there is an overview developed in which is stated which information have to be included in the measurement report and which information have to be available for the competent authority on request.

Italy: The Italian Guidance suggests that the Operator transmits the calibration results (QAL2 and AST reports) to the inspection Authority, along with the date of system implementation of the QAL2 calibration line parameters.

In case of CEMS, the Operator, within the yearly annual self-monitoring report, must include a summary report of the parameters monitored by the CEM, namely:

a. Processing, presentation, and evaluation of results in terms of the number of hours of normal operation, number of hours of transients, average concentration, ELV in concentration; ELV in mass (if provided), mass emissions calculated according to UNI EN 17255, authorized flow rate, and average detected flow rate.
b. Annual data aggregation from monthly data based on daily averages (or different based on BATc constraints).

c. Evidence and reasons for any exceedances of emission limits.

d. Evidence and reasons for any downtime of the analytical equipment.

e. Description and date of calibration/maintenance operations on the equipment.

f. Reference to the CEMS Manual in use.

g. Monitoring of transients: in installations where large combustion plants are present (specifically CTE, thermal power plants, IPPC category 1.1), the following minimum guidelines for managing transients must be taken into account: the Operator must implement the monitoring of combustion plant transients with recording and submission of hourly average concentration values of relevant pollutants, flue gas volumes, respective mass emissions, the number and type of startups with their duration, the type and consumption of fuels used, and any auxiliary steam contributions.

Case studies – IT systems for self-reporting in continuous measurements

Germany: IT automated system sends e-mail alerts to authorities and operator near real time. A yearly report is created and sent to authorities by the operator.

Ireland: All communication and submissions through an allocated IT system LEMA (Licensing, Enforcement & Monitoring Application). Operators report incidents (breaches of licence conditions or Emission Limit Values) through the EDEN portal, which is a licensee facing web-based application which allows licensees interact with the EPA.

Not reporting an incident is a breach of the licence.
Finland: In collected form in monthly or annual reports. QAL1- and AST-reports as they are ready. Results and reports are generally transferred into the governmental reporting system (YLVA) and/or into diary management system (USPA). Real-time automated reporting is not in use. The information is mainly submitted annually to the environmental administration's electronic system.

Italy: In the Lombardy Region, a CEMS network has been established, which purpose is to create a network of CEMS installed at a portion of the most significant atmospheric emission sources in the region. This network aims to centralize the collection and processing of data provided by these systems.

8. SUPERVISORY AUTHORITIES AND ROLE OF ACCREDITED LABORATORIES

The resources of the supervisory authorities are essential to ensure effective supervision and enforcement of environmental regulations, in terms of:

- training needs to improve skills and specific knowledge appropriate to their functions;
- strategies to deal with the scarcity of resources, including a risk assessment appropriate to the potential environmental impact of installations and cooperation with other authorities, enhancing resources and expertise;
- recruitment and partnerships with academic institutions;
- appropriate it tools for processing, storing and analysing data, including the foreseeable evolution of artificial intelligence and machine learning algorithms, in order to increase the efficiency and accuracy of data analysis, allowing authorities to detect patterns, trends and anomalies more effectively;
- developments in automated surveillance programmes, including sensor networks and platforms for remote monitoring of environmental parameters in real time, to identify potential risks and prioritise proactive responses to environmental threats and incidents.

The role of the accredited laboratories is also a key aspect, and they should be involved as qualified third parties in this process, that together with the operator/duty-holder would be (legally) co-responsible and testify on the adequacy of procedures, methodologies, and that results are accurate, reliable, representative and comparable; Any organisation that uses external entities to carry out its calibrations or tests must carefully choose a laboratory that is recognised as competent, to ensure that the results obtained are reliable and recognised externally, both by clients and by national and international authorities.

For this to be feasible, the choice of an external laboratory should, wherever possible, fall on a laboratory accredited according to ISO/IEC 17025. The advantages that accredited laboratories offer over others are extremely relevant and unavoidable in services where credibility is the distinguishing feature.

Accredited sampling and monitoring organisations are responsible for taking representative samples and carrying out analyses in accordance with established standards and methods. Accreditation guarantees that these organisations have the technical expertise, facilities and quality management systems necessary to produce reliable and accurate results.

Operators are responsible for contracting accredited sampling and monitoring organisations to carry out environmental monitoring, and must provide access to their facilities, cooperate with sampling and monitoring activities and ensure compliance with regulatory requirements. Accredited bodies,

on the other hand, are responsible for carrying out monitoring activities in a rigorous and impartial manner.

In fact, since accreditation is a procedure through which the national accreditation body recognises that an entity is competent to carry out certain conformity assessment activities (e.g. tests, calibrations, certifications, inspections) and since this recognition is carried out using internationally accepted standards, guaranteeing the mutual international recognition of accreditations, the advantages are obvious:

- accreditation is legally covered by Regulation (EC) 765/2008, which recognises that this is a public authority activity and is therefore carried out on an exclusive national basis- in these terms, only the national accreditation body can provide these services;
- accredited laboratories, being part of a credibly managed accreditation system and under the permanent surveillance of the National Accreditation Authority, have a much more robust and internationally recognised credibility, which adds substantial value to the services they provide, thus giving companies that benefit from them gains in competitiveness and quality by generating greater confidence in their products and services.

Intercalibration and intercomparison exercises are carried out to assess the consistency and accuracy of measurements carried out by different accredited bodies, involving the comparison of measurement results obtained by different laboratories using the same or similar methods and standards.

Environmental authorities can set predetermined dates for environmental monitoring activities, specifying when sampling and monitoring should take place, or they can act, without prior notice, to check compliance with accreditation regulations and standards.

The BREF- Monitoring of Emissions to Air and Water from IED Installations makes specific reference to self-monitoring and states that "for self-monitoring activities, the use of recognised quality management systems and periodic verification by an accredited external laboratory may be appropriate, rather than formal accreditation itself".

Case studies – Role from accredited bodies

Finland: National reference calibration measurements and interlaboratory comparison are performed in Finland.

Continuous measurements should be subject to periodic measurements by external accredited laboratories to verify the reliability of the results. Accredited laboratories carry out intercomparability procedures with similar laboratories, there may be intercomparability of emissions from the same sector (waste incineration, for example).

The Accreditation body should ensure sampling and measuring equipment must be subject to periodic calibration and that laboratories carry out interoperability procedures with similar

laboratories. These tests could for instance be made in the same stack, and analysing deviations, that could not exceed a certain amount.

Netherlands: The Dutch Accreditation Council is responsible for the quality assurance of the accredited laboratories. As a part of accreditation the laboratories are obliged to participate in the (annual) interlaboratory test. The tests are performed in facilities in Belgium and Germany.

9. CONCLUSIONS AND RECOMMENDATIONS

Monitoring and subsequent reporting is a responsibility of the operators/duty-holders, and implies the assessment by a competent designated authority, what we call in this IMPEL report a "self-monitoring and reporting scheme".

However, EU legislation, and IED in particular, does not entail specific legal provisions enough to ensure credibility of monitoring process and its use in compliance assurance, from the conditions of collection of the samples/measurements that translates the real emission of pollutants to be measured until the systematically and timely assessment by a designated competent authority, empowered to ensure timely correction of non-conformities (or infringements, that should be sanctioned) and prevention of its reoccurrence.

A self-monitoring and reporting scheme should be the first screening to assess legal compliance in a universe of thousands of operators/duty-holders and identify early breaches and (potential) offenders/polluters that should be priority targets for inspection, focusing on preventing more to react less, adherent to the polluter pay principle.

In this context, EU legislation in general, and IED in particular should be clear, detailed and specific, recognising "self-monitoring and reporting scheme" as an autonomous step of compliance assurance monitoring, between permitting and inspection, with binding rules and a designated competent authority with powers, responsibilities, procedures, infringement and preventive and corrective actions as part of compliance assurance monitoring, and specify:

- The involvement of qualified third parties in this process, that together with the operator/duty-holder would be (legally) co-responsible and testify on the adequacy of procedures, methodologies, and that results are accurate, reliable, representative and comparable, starting from the reliability and representativeness of the samplings or measure in situ, considering operation performance conditions of the installation or activity during each sampling parameter monitoring (capacity and characteristics of raw materials and fuels).

- All legally required self-monitoring and reporting data should be brought by the authorities as evidence into court and when there are infringements should be used as a basis for non-compliance actions and prosecution against the facility and by imposing corrective actions, including action to minimise and mitigate any adverse impact to the environment;

- Be used for revision of the permit with a focus on preventing potential non-conformities in time, by more effective means, and taking into account the costs and benefits and the principles of precaution and prevention) or, if necessary, suspension or revocation of permit, prohibiting any operation (or part of it) which poses an unacceptable risk to the environment and/or cannot comply with a permit or other legal requirement.

A thorough analysis of self-monitoring and reporting by a designated competent authority and the communication of such assessment results and follow up to inspectors and permitters (and duty-holders) will ensure a more efficient and effective approach to compliance assurance, by minimizing the risk of different interpretations of complex legal and permit requirements. Its reliability will also ensure a level playing field and credibility of the results.

We hope this report it can support the strengthening in EU and national legislation and a support tool to be used by environmental permit authorities, as well as competent authorities for compliance assessment of self-monitoring and reporting, concerning specifically air emissions but also as input for other emissions or impacts, on water, waste or even biodiversity.

10. BIBLIOGRAPHY

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Annexes

Self Monitoring and reporting on air emissions to self-assess compliance

IED IMPLEMENTATION PROJECT - Subgroup "Self-Monitoring"

Section 1

Information

📃 Under the umbrella of IMPEL https://www.impel.eu/ Supporting IED Implementation Project 2021-2024, runs an IMPEL project that aims to produce a GUIDANCE FOR VERIFICATION OF SELF-MONITORING AND REPORTING ON AIR EMISSIONS focused on Operator self-monitoring, on emissions to air, continuous and non-continuous, focused on the reliability of self-monitoring and its reporting by operators (duty-holders).

This project is connected to Environmental Compliance and Governance, an Initiative from the European Commission included in its 2020-2022 work program among the "Actions for the practitioners' networks with the Commission and the EU Member States", Action n.9: Strategies for verification of self-monitoring and reporting, to be led by IMPEL. This action aims at exploring, supporting, and further strengthening mechanisms and methods to optimise the informed use of self-monitoring data from duty-holders, as a fundamental step in assuring environmental compliance by Member State authorities, together with permitting, surveillance, inspection, and enforcement.

A credible self-monitoring scheme, that allows the duty-holder to self-assess compliance with permit requirements, would decrease the burdens of inspection, improve chances for swift detection of breaches, and thus help to limit environmental damages by making authorities' action more efficient. Timely and effective data evaluation by competent authorities, permitters, and inspectors could lead to targeted action, to ensure correction, prevention, and sanctioning of offences, but also revisions, suspensions, and revocations of permits.

The project team would like to kindly ask the Experts, Permitters, and Inspectors in IMPEL to please support this work and respond to a questionnaire with your views, as Experts, on Self-monitoring and reporting on air emissions from the duty-holder to self-assess compliance with permit requirements. The aim would be to collect information from Experts and organize a workshop on this theme in 2023 and build a guidance document in 2024.

We would be very grateful if you could spread the questionnaire, accessible here, through the Experts, Permitters, and inspectors in your country to get their individual views.

If you have any document(s), preferably in English, that you could share, please provide the link(s), or if not available on the internet, please attach them.

Thank you so much for your support!
Romano Ruggeri, Mário Grácio, Ana Garcia

📆 **DEADLINE**: Please fill in the questionnaire no later than **28th February 2023**.

🏳If you have further technical questions, please contact the Subgroup referents: Romano Ruggeri (rrugger@impel.eu), Mário Grácio (mgracio@igamaot.gov.pt), Ana Garcia (agarcia@igamaot.gov.pt).

1.NAME AND SURNAME

Enter your answer

2.COUNTRY

Enter your answer

3.ORGANIZATION

Enter your answer

4.ROLE (INSPECTOR - PERMIT WRITER - OTHER)

Enter your answer

5.EMAIL ADDRESS

Enter your answer

Section 2

QUESTIONNAIRE

6.**Q1: Periodic measurement - Reliability of data of self-monitoring**

As possible aspects to consider in your reply please consider:

1.1. Who collects samples or analysis or measure *in situ* (operator, laboratory, authority)

1.2. Quality/Accreditation/certification as a requirement for sampling and for analysis

1.3. Who ensures the representativeness of the samplings or measure *in situ* (operator, laboratory, authority) and how (measuring operating/capacity conditions, fuel and materials used)

1.4. External checks by supervising authorities, such as witnessing the sampling or contracting an external measurement, or others

1.5. Periodic direct monitoring versus indirect monitoring (ex: Predictive Emission Monitoring Systems (PEMS), surrogate parameters, mass balances)

1.6. Other subtopics missing?

Enter your answer

7.**Q2: Continuous measurement - Reliability of data of self-monitoring**

As possible aspects to consider in your reply please consider:

2.1. Quality/Accreditation/certification as a requirement for sampling and for analysis

2.2. Data acquisition and processing for continuous monitoring, sealing and check of original data and exclusion from compliance assessment of periods of start-up and shut-down, severe malfunction and maintenance/repair

2.3.External checks by laboratories and calibration with standard reference methods or by supervisory authorities (such as organizing intercalibration exercises, witness the sampling or contracting an external measurement)

Enter your answer

8.**Q3: Reporting to supervisory authorities – periodic measurement**

As possible aspects to consider in your reply please consider:

3.1.Information to be reported (including rules for reporting uncertainty, treatment of data at conclusions about non-conformity and compliance)

3.2.Methods of reporting system to authorities (including if it is an IT automated, description of functionalities for automated analysis of non-conformities - warnings, e-mail alerts to authorities and operator)

3.3.Responsibilities of reporting by Operator and/or Laboratory

Enter your answer

9.**Q4: Reporting from Operator to supervisory authorities – continuous measurement emission system (CEM)**

As possible aspects to consider in your reply please consider:

4.1. Information to be reported (including rules for reporting uncertainty, treatment of data at conclusions about non-conformity and compliance)

4.2. Methods of reporting system to authorities (including if it is an IT automated, description of functionalities for automated analysis of non-conformities - warnings, e-mail alerts to authorities and operator)

4.3. Reporting to supervisory authorities, by operator (periodic manual submission of data; periodic automatic submission of data; near real-time periodic automatic submission of data; fully automated real-time data collection with access to CEMS)

4.4. Encoding data and the methods of data transmission to the supervisory authority

4.5. Responsibilities of reporting by Operator and/or Laboratory

Enter your answer

10.**Q5 Uncertainty of air emissions measurements. Methodology to assess compliance with limit values**

As possible aspects to consider in your reply please consider:

5.1. How the uncertainty is calculated

5.2. How compliance to ELV's is assessed considering the uncertainty of the measures

5.3. How Inspection authorities check compliances

5.4. How the uncertainty is reported within the Lab bulletins

5.5. Distinguish between continuous (CEMS) and periodic measurements

5.6. Availability of Guidelines

Enter your answer

11.**Q6: Analysis from supervisory authorities and dealing with non-compliances**

As possible aspects to consider in your reply please consider:

6.1. Analysis from supervisory authorities

6.2. Content of the results of the analysis communicated to the Operator

6.3. Timing of the communication of results of the analysis to the Operator

6.4. Communication system to operator, including if it is an IT automated and description of functionalities

6.5. Treatment of exceedance of emission limit values (advertisement, prevention, correction, sanctioning/prosecution) from periodic and continuous monitoring

6.6. Connection with air quality measurements, specific pollutants, location of installation,

possible failure of abatement techniques or operating conditions

6.7. Criteria to consider an environmental crime due to emission to air

6.8. Other subtopics missing?

Enter your answer

12.**Q7: Other then Normal Operating conditions**

As possible aspects to consider in your reply please consider:

7.1. Does the operator draw up an OTNOC management Plan? Is there a Guidance available?

7.2. Does the permit impose prescriptions on OTNOC? If yes, which kind?

7.3. Does the operator reports the yearly emissions during OTNOC periods?

Enter your answer

13.USEFUL DOCUMENTS

Upload useful documents as Guidelines at the following link: https://impelnetwork.sharepoint.com/:f:/s/Secretariat/EtP6ypNClnFHvgKc1PLF8aYB3aQa8EdwXF4VFebDOFr2uQ?e=gtxsvz

In alternative, please send the documents to: rruggeri@impel.eu

List below the documents you have provided.

Enter your answer

Section 3

TERMS AND CONDITIONS

14.Do you accept IMPEL's Terms and Conditions?

I have accepted the terms and conditions in the IMPEL privacy policy https://www.impel.eu/privacy-policy/

No, I do not accept. I will inform the IMPEL Secretariat by email to info@impel.eu of my objections.