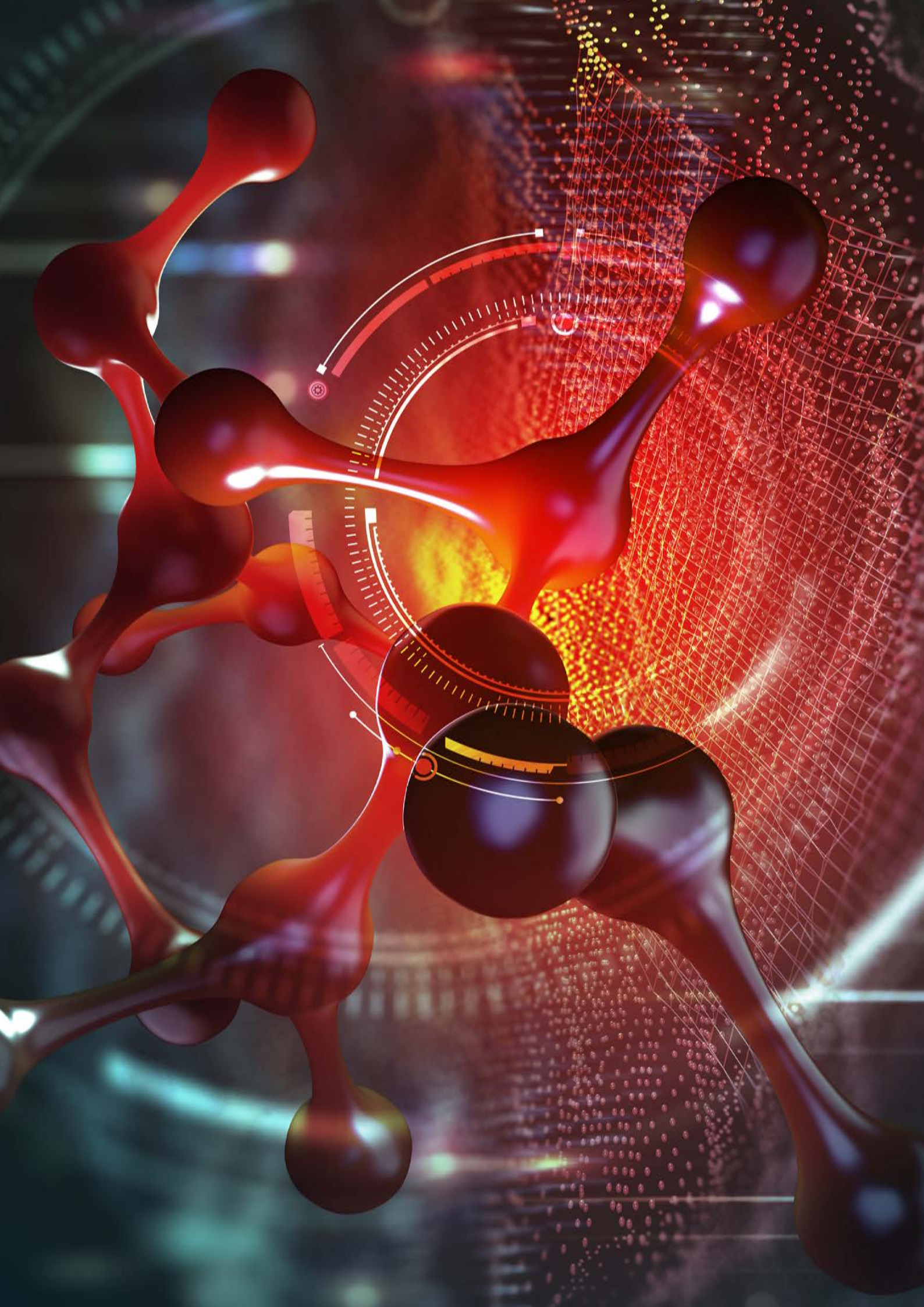
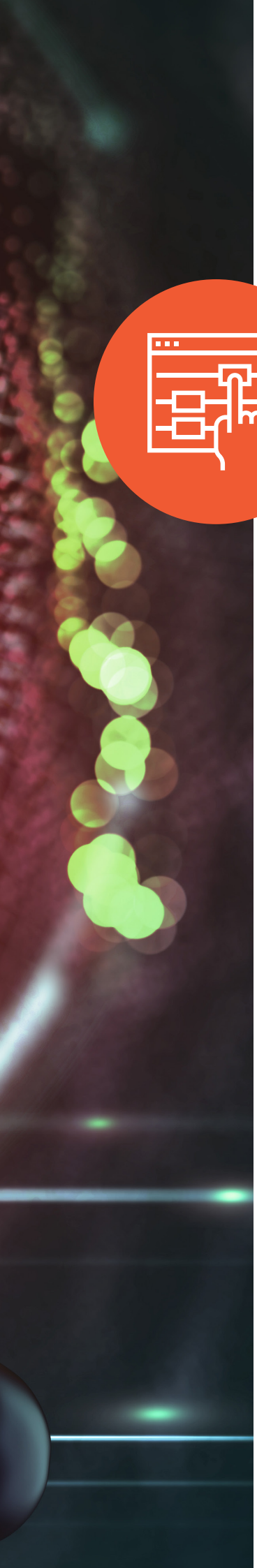
Governance brief 3

PRECAUTIONARY APPROACHES AND THRESHOLD VALUES TO ASSESS EXPOSURE OF PARTICLES AND NANOMATERIALS IN THE WORK ENVIRONMENT

Gaps and recommendations for Occupational Safety and Health regulatory research

Gov4Nano
meeting the needs of nanotechnology





INTRODUCTION

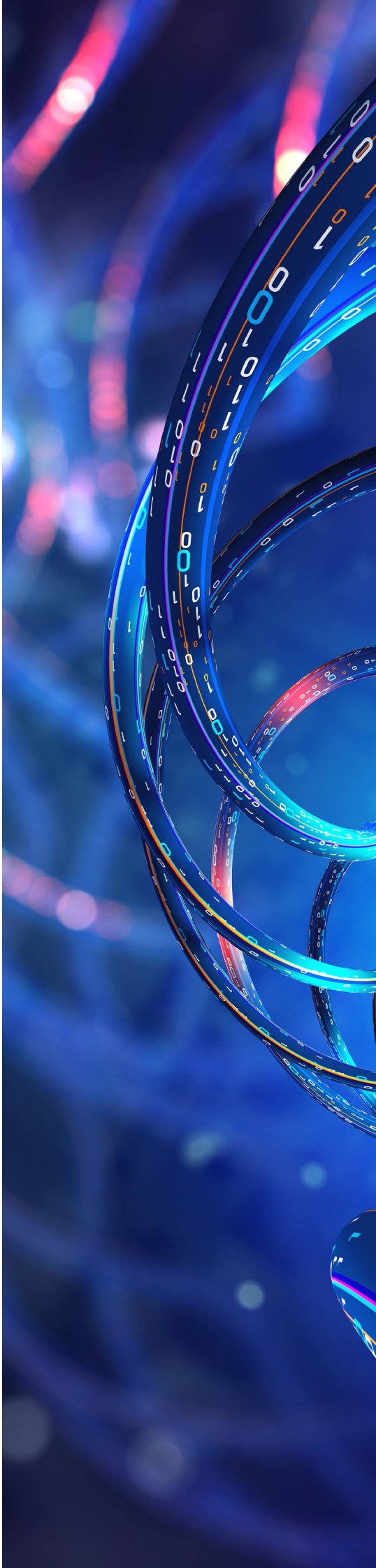
This brief report provides a synthesis of critical gaps and roadblocks, and recommendations on ways forward in research and policy setting on Occupational Safety and Health (OSH) aspects of nanomaterials, with a focus on issues related to risk acceptability, precautionary approaches and threshold values to assess exposure.

The ambition of this document is twofold: to inform future research actions from OSH experts and authorities; and to provide suggestions for the development of risk governance methods and models within a group of European projects dealing with this topic.

The brief is an outcome of the research activity on the topic by three European projects, including a specific consultation of experts from different research organizations and occupational health and safety authorities in Europe, performed through workshops held in 2021 and 2022 and follow up interactions. Details on the methodology are reported in Gov4Nano deliverable 5.6: Report on case studies for Risk Governance available on **www.gov4nano.eu**.

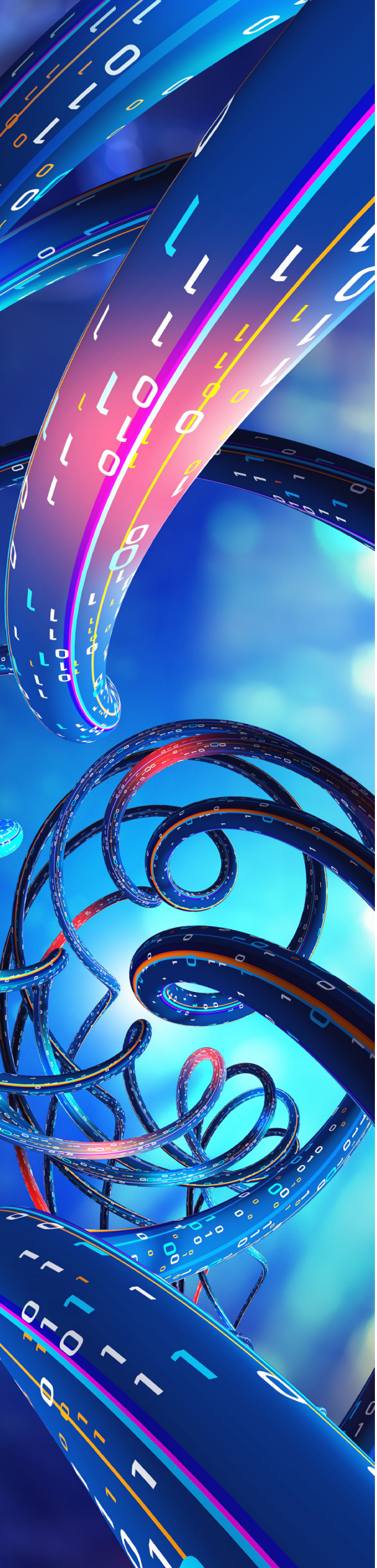
It is part of a series of initiatives organized by the **Gov4Nano project**, in cooperation with the **RiskGONE** and **NANORIGO** projects, to discuss governance issues in the development of nanomaterials, with the goal to promote the safety and sustainability of innovation in nanomaterials in Europe.

BACKGROUND



Nanoparticles possess various new properties, and their industrial use creates new opportunities, but they also present new risks and uncertainties. When particle size is decreased to the nanoscale range, physical and chemical properties often change with consequent new product opportunities. For the same reason nanoparticles may also present health hazards that differ from those of the substance in bulk form, and may require different test methods for hazard, exposure and risk assessment from their bulk material counterparts (WHO, 2017).

Almost two decades of intensive research and development activities on nanomaterials has led to a growing number of industrial processes and products, an increasing exposure of workers and consumers. In parallel, there has been the development and publication of standards and good practices on risk assessment, management and communication from different type of organizations, and as well the introduction of specific normative requirements (e.g., REACH).
There are still many gaps related to identifying, characterizing, establishing the potential hazard, and evaluating potential occupational exposures for many types of nanoparticles in different kinds of application. Moreover, rapid innovation on emerging and more complex advanced materials (such as multi-component nanomaterials or nanosystems) may lead to new, unforeseen and as of yet unregulated risks. Though uncertainties remain and there is not yet a clear consensus of the scientific community on concerns and risks of some specific nanomaterials, there have been no recorded major incidents with (products containing) nanomaterials in recent years.



THE PROBLEM AT STAKE

Risk management measures are applied in any work environment using and producing nanomaterials, according to the requirements of existing legislation, to ensure the highest protection of workers and consumers. Current methods for occupational exposure assessment methods are valid and relevant to nanomaterials.

Nevertheless, there are acknowledged weaknesses to purse risk assessment and management of nanomaterials, both in terms of methodological approaches and operating procedures. Analysis performed by the three projects shows the need for further work on the following aspects (Gov4Nano, Del 5.2).

- Common international criteria, procedures and methods for risk evaluation
- Common international approach to risk management
- Providing knowledge and resources on risk management to stakeholders

Risks can relate to all different sources of nanoparticles (Roebben, 2014), including natural, incidentally produced, or intentionally produced by an engineering and manufacturing process. Though we focus here on the latter, as this type of risks are expected to be controlled by developers, manufacturers, and producers, distinguishing amongst these different sources is one of the challenges in risk management of nanomaterials. Therefore, the use of nanomaterials in manufacturing processes, at the R&D and production level, requires the capacity to address uncertainties in terms of scientific knowledge and technical operations, and to cope with potential (novel) Occupational Safety Health risks. And uncertainties hinder the implementation of efficient and harmonized practices and processes to manage nanomaterials exposure at the workplace, including setting and measuring occupational thresholds (or risk acceptability) values and limits.

GAPS AND ROADBLOCKS

In this context, we identified a set of critical gaps and roadblocks to quantify exposure, and determine and measure specific threshold levels for nanomaterials, here listed in order of the importance given by experts:

NEED FOR IMPROVEMENTS IN METHODS, TECHNIQUES AND EQUIPMENT FOR PHYSICO-CHEMICAL CHARACTERIZATION OF NANOPARTICLES AND EXPOSURE ASSESSMENT

There is a huge number of NMs that should be investigated, and their risks profile is strongly influenced by both chemical and physical characteristics.
There is a need for further improvements in:

- characterization of physico-chemical properties, to inform risk assessment
- harmonization of measurement methods, to improve comparability of results
- development and validation of reliable and cost-efficient exposure assessment methods (nano-specific)
- increasing the access to facilities and competences (e.g., including contract organizations) that use and make available nano-specific methodologies for exposure assessment

Studies on the health effects of particles should be complemented and supported by experiments to determine their physico-chemical properties. This might be true also for particulate matter in general (beyond nanoparticles, as usually defined in normative contexts). For example, it was observed that particles of nearly identical chemical composition, but different morphology may show unexpected differences in the acute inhalation toxicity testing.

CHALLENGES IN APPLYING OCCUPATIONAL EXPOSURE LIMITS FOR SOME TYPE OF NANOMATERIALS

These challenges are related to physico-chemical characterization, toxicity testing, and in particular long-term effects/chronic toxicity, combined with the huge number of available nanomaterials complicate hazard assessment. In particular, the parameters for toxicity testing have become very numerous and the assessment of toxicity of nanomaterials is long and cumbersome. Thus, this makes difficult also the definition of criteria for evaluating risk acceptability of nanomaterial, including the application of existing occupational exposure limits.
There is a need for further improvements in:

- developing comprehensive (nano-specific) hazard data for many substances
- availability and reliability of hazard data (specific toxicity-health effects data)
- public and reliable databases on toxicity and hazard data
- validated hazard band and/or OEL for specific substances

LACK OF CONSENSUS ON THE MOST APPROPRIATE METRIC TO ASSESS EXPOSURE

Different physico-chemical characteristics might be responsible for health effects of nanomaterials (this could be true for any type of ultrafine particles). Besides the traditional mass-based metric, also surface area, particle numbers, solubility and other aspects might be relevant[1].
There is a need for further improvements in:

- analysis of metrics determining health effects, such as number size distribution and specific surface area of particles
- relationships between metrics used in toxicity studies and sampling metrics in the workplace.

LACK OF GUIDANCE ON SAFE USE OF NANOMATERIALS

Available standards might not always be fit for purpose and a case-by-case approach is often needed for risk analysis of nanomaterials.
There is a need for further improvements in:

- purpose and focus of available guidance (a lot of guidance available, it is often unclear what to use, which one is supported by authorities)
- validation of exposure assessment tools
- predictive risk assessment
- safe by design approaches
- risk communication to workers, including training
- guidance on material handling procedures

SOCIO-ECONOMIC AND STRATEGIC FACTORS

Stakeholders need to understand each other better and cooperate to advance towards harmonized risk management approaches in production and use of nanomaterials.
There is a need for further improvements in:

- sharing of data between research and innovators
- cooperation between safety experts, regulators and innovators in developing, supporting, accepting guidance
- insights into populations at risk
- prioritization of the research on health effects of NMs, to better support regulation

1 Work from ECHA suggests that the right metric to choose is the one which is "correlated with the health effect of concern" (ECHA, 2012). While OECD (2012) recommends that dose is not only reported in the traditional mass-based manner, but that also surface area- and particle number-based PSDs must be reported in toxicological studies.

WAY FORWARD

The key to move forward is to establish what research and policy actions should be undertaken to overcome the gaps and roadblocks identified and who should be responsible for their implementation.

A key issue regards threshold values to determine risk acceptability, including the definition of precautionary risk bands (control banding – ISO/TR 18637: 2016), and the possible refinement of existing (bulk) occupational exposure limits for specific nanomaterials.
Some European countries (e.g., the Netherlands and Denmark, see NFA, 2021 and Mihalache, 2017), are currently evaluating the development of OELs for some specific nanomaterials (and more broadly ultrafine particulate material). However, the setting of OEL is a complex (research and policy) process, that needs availability of a huge amount of hazard and exposure assessment data, including epidemiological studies, that might not be available. The development of precautionary exposure limits for groups of nanomaterials, based on common physico-chemical characteristics, has been proposed as an alternative to nanomaterial specific OELs determination.
We refer here to the work on health-based nano-reference values, that distinguish nanomaterials in different risk categories. This approach is still in development. As an example, in its simplest form it considers three different characteristics of nanomaterials, and the related health effects: high-aspect ratio, biopersistent or poorly soluble nanoparticles and soluble or non-biopersistent nanomaterials.
Given these assumptions, we identified the following **ways forward** into research activities and policy settings on OSH aspects of nanomaterials, here listed in order of the importance given by experts:

PROMOTE A GROUPING APPROACH IN OCCUPATIONAL EXPOSURE LIMITS SETTING

There are challenges in evaluating risk acceptability of nanomaterials and applying occupational exposure limits for some types of nanomaterials. This requires policy actions to sustain and promote:

- research to support grouping of nanomaterials having equivalent or similar risk profiles: identify parameters and criteria, and collect and analyse toxicity and hazard data
- experts and multi-stakeholder initiatives to compare and validate grouping and banding approaches, possibly across regulatory domain
- consideration of the principle of one substance – one assessment', across normative frameworks[2]

2 See the *Chemicals Strategy for Sustainability Towards a Toxic-Free Environment* (EC, 2020), where it is suggested to move towards the principle of 'one substance – one assessment' across normative frameworks, to improve industry acceptability and people's trust in regulations. See https://environment.ec.europa.eu/strategy/chemicals-strategy_en

- precautionary, pragmatic approach to risk management of nanomaterials. This might include acceptance of health-based reference values at regulatory level, as provisional or complementary occupational exposure limits

FOSTER PROGRESS IN EXPOSURE ASSESSMENT

A better understanding of characterization and toxicity aspects of nanomaterials, improved models and techniques for hazard and exposure assessment, in particular long term, could help to improve risk management and safe handling of nanomaterials.
This requires policy actions to sustain and promote:

- establish exposure database with broad data contribution and validation, based on multi-disciplinary cooperation
- improve cost-effective and multi-parametric strategies for exposure assessment, including techniques to distinguish NMs from background natural or incidental NMs
- develop and validate exposure measurement methods
- understand relationship between definition of health-based reference values and practical exposure measurements at the workplace

FURTHER RESEARCH ON IMPLEMENTATION OF RISK MANAGEMENT AT THE WORKPLACE

This requires policy actions to sustain and promote:

- conduct bio-monitoring studies on exposed workers, integrated with exposure measurements,
- epidemiological studies, following cohorts to get more insight into the workers' exposure and the effects on workers' health
- research on effectiveness of exposure measurement and monitoring systems

COOPERATION AND GUIDANCE

Stakeholders lack knowledge and guidance on risk management. There are significant socio-economic and strategic factors to address.
This requires policy actions to sustain and promote:

- Design of simplified risk management guidance, based on (validated) tiered approaches
- Multi-disciplinary cooperation to support harmonization of practices for occupational safety (e.g., reference values)
- Training and awareness raising campaigns, in particular on potentially hazardous NMs, at those involved in research and production of NMs
- Initiatives to increase mutual trust amongst all involved stakeholders

FINAL REMARKS

This brief provides a synthesis of risk governance issues on nanomaterials, gathered and shared with experts and stakeholders.

A series of needs, and proposals for ways forward in research and policy setting on Occupational Health and Safety related to nanomaterials have been identified, to inform future research actions from OSH experts and authorities.

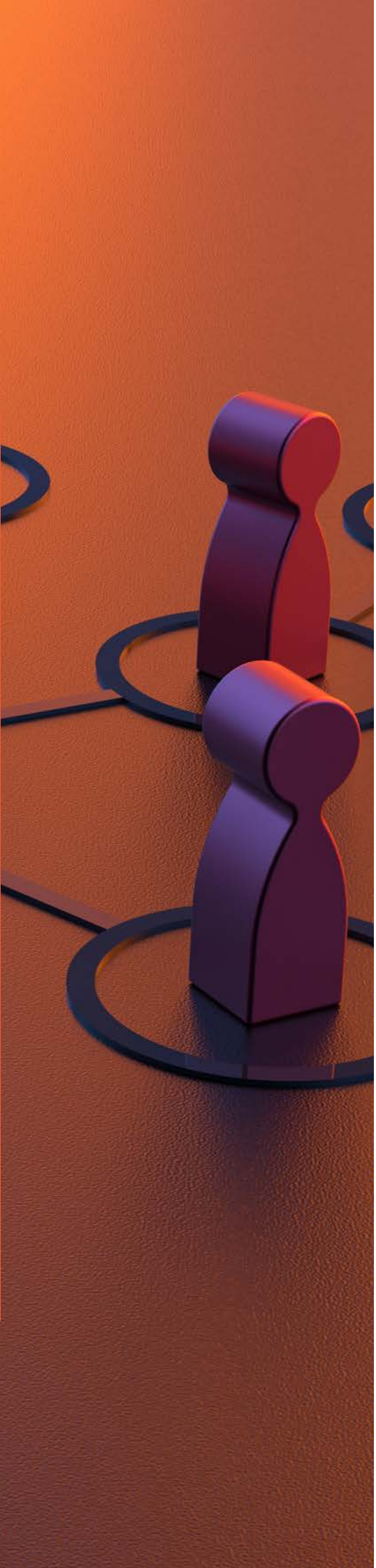
Different attitudes emerged when considering how to address uncertainties concerned with risk management of nanomaterials:

- Moving forward with pragmatic simple solutions, based on available information, versus waiting to act until more evidence and a sufficient level of confidence is achieved
- The importance of strategy setting versus the importance of methods.

Other concerns and questions remain open, and might deserve further attention in follow-up activities and future analysis:

- How to collect and harmonize exposure data?
- Which strategies to use for setting and validating exposure data, through multi-parametric measurement methods?
- To what extent are health-based nano-reference values valid?
- How to improve availability and access to formal classification and grouping of substances?
- What are the specific needs of companies to support risk management in the workplace?
- Which risk management tools are currently performing well?
- What are the best pragmatic strategies, their applicability and limitations?
- How to improve guidance on risk management?

Some of challenges identified are not specific for nanomaterials, but relevant for any new and emerging material.



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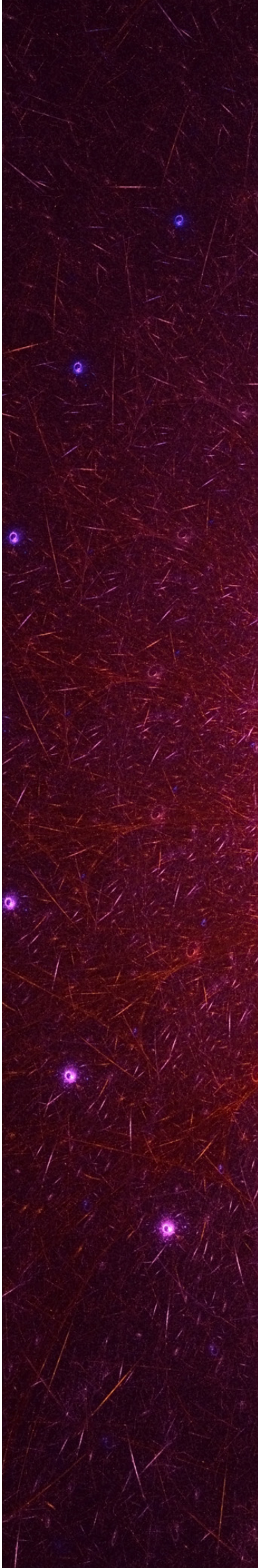

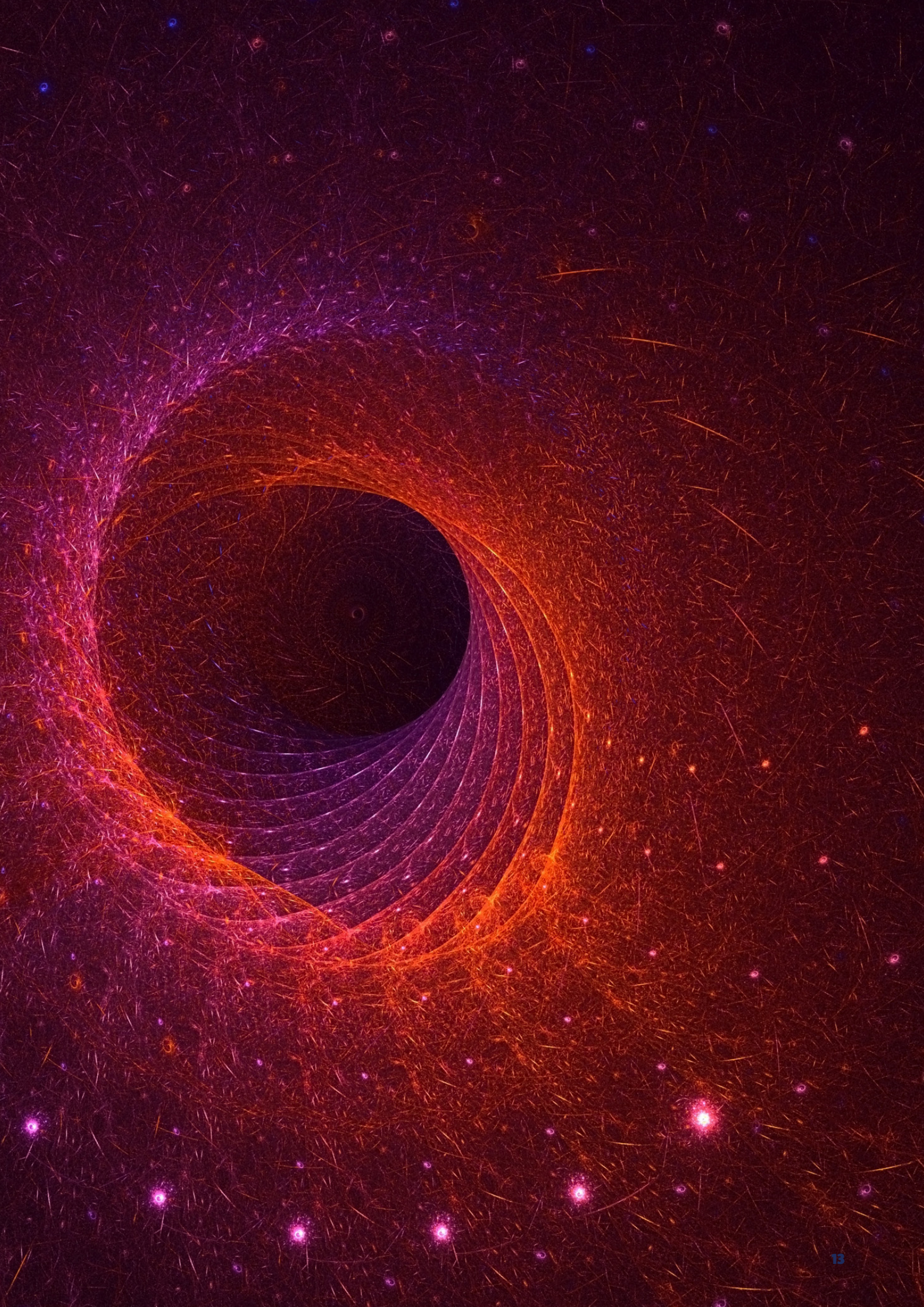

Brief: Precautionary approaches and threshold values to assess exposure of particles and nanomaterials in the work environment

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