



**Innovative strategies, methods and tools for occupational risks management
of manufactured nanomaterials (MNM) in the construction industry**

PROPOSAL FOR A EUROPEAN STRATEGY ON MNM OCCUPATIONAL RISK MANAGEMENT IN THE CONSTRUCTION INDUSTRY

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Disclaimer

This document was prepared following extensive consultation with a range of stakeholders (via workshops, meetings, surveys, interviews and document reviews):

- Representatives of the construction sector, including:
 - o European Construction Industry Federation (FIEC);
 - o European Federation of Building and Wood Workers (EFBWW);
 - o OHS Managers from several construction companies.
- Manufacturers of construction products;
- European and Spanish agencies for occupational safety;
- Manufacturers of personal protection equipment;
- Experts in nanosafety;
- Policy makers at European and national (Spain) levels.

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The views expressed herein are solely those of the authors.

EXECUTIVE SUMMARY

The use of Manufactured Nanomaterials (MNM) and nanocomposites in the construction industry is an increasing reality, mostly in cement or concrete products, coatings or insulation materials and to a lesser extent in road-pavement products, building glass, flame retardant materials or textiles. Due to their specific properties, these nano-products might pose new and so far poorly understood health and safety risks to workers. Information about the MNMs in the construction products and their possible nano-specific health and safety issues is generally lacking. As a consequence, it is very difficult for average construction companies to conduct a proper risk assessment, organize a safe workplace for their employees and ensure the compliance with Occupational Health & Safety (OHS) legislation.

The Scaffold project has provided tools and guidance for the risk prevention, protection, assessment and management in relation to MNMs in the construction sector.

The present document describes and analyses the resulting current situation and its context and proposes consequently a European strategy to further improve occupational nanosafety in the construction sector. 5 key issues and strategic objectives, 12 operational objectives and 30 strategic actions are proposed, prioritized and commented (Table 1). Natural leaders of the actions are suggested at European and national levels, e.g. from the construction industry, from the European Commission, from European Agencies or from the Scaffold consortium itself. 5 further options are discussed but are not selected as propositions for the construction sector.

The proposed European strategy includes the long term maintenance, update and further development of science-based operational tools at the European level, and their translation and transcription into national tools. These tools include the followings:

- Guides and toolkit;
- Training and certification programme;
- Consolidated measurement strategies;
- Emission and exposure database;
- Occupational Exposure Limit values (OELs).

The sustainable maintenance, update and further development of these tools represent a considerable effort. Many of the actions proposed are inter-linked and not specific to the construction sector. Therefore, for the sake of efficiency and sustainability, the efforts should be joined and coordinated at the European level and across industrial sectors, ending up with European multi-sectorial tools including sectorial modules and translated into national versions operated at local level. For some actions (e.g. the development of OELs), a European coordination is already in place. For others, the efforts are scattered and duplicated or strongly attached to temporary funding (project-based research). This situation calls for the creation of a European platform of expertise institutes all over Europe that would coordinate the sustainable development, maintenance and update of operational tools for the risk management of MNMs in the industry.

Table 1. Proposed European strategy for occupational nanosafety in construction

Strategic Action	When?	Priority
Strategic Objective 1: Raise awareness, disseminate information on MNMs in construction products		
<i>Op. Objective 1.1: Improve the information on MNMs and related safety issues in Safety Data Sheets, labels and Technical Sheets of construction products</i>		
1. Launch an evaluation study of Safety Data Sheets (SDS) and labels for relevant construction products regarding MNM-related information, update ECHA's guide on SDSs and produce a note for the construction sector	2016	1
2. Launch a regular control of SDS for relevant construction products regarding MNM-related information, report defaults to the competent national authorities	2017-	1
3. Launch an evaluation study of Technical Sheets (TS) for relevant construction products regarding MNM-related information, produce a note and/ or a guide for the construction sector	2016	2
4. Launch a campaign towards manufacturers of construction products promoting clear MNM labelling	2016	2
<i>Op. Objective 1.2: Disseminate information on MNMs in construction products to all stakeholders</i>		
1. Produce a commented list of commercial construction products used in Europe that do and do not contain MNMs; Disseminate it at European and national levels See Op. Objective 2.2: Disseminate actively Scaffold's guides and tools	2016	1
<i>Op. Objective 1.3: Improve the information on MNM-containing products in construction calls for tenders and contracts</i>		
1. Launch an information campaign towards large clients of the construction sector and towards large construction companies so that they request clear signalization of MNM-containing products in the proposals and contracts	2016	1
Strategic Objective 2: Disseminate and implement best practices regarding MNMs in construction		
<i>Op. Objective 2.1: Improve the quality of Safety Data Sheets and labels of construction products regarding MNMs</i>		
1. Perform actions of Op. Objective 1.1 on Safety Data Sheets and labels, here with a focus on best practice		
<i>Op. Objective 2.2: Disseminate actively Scaffold's guides and tools within the construction sector: large & small companies, relevant OSH actors...</i>		
1. Inform key actors on the issue and on Scaffold's results, guides, tools	2015	1
2. Translate, adapt the Scaffold toolkit and handbook and integrate them into national tools / guidance	2015-17	1
3. Ensure regular updates of the scaffold tools and their integration into national tools / guidance	2017-	1
4. Promote social dialogue in construction companies on collective and individual prevention and protection measures regarding MNMs	Always	1
5. Require from OSH controllers to explicitly include nanosafety in the proof of compliance for OSH requirements	2015-	2
<i>Op. Objective 2.3: Ensure the link between standards and regulatory guidance and Scaffold's best practice</i>		
1. Complete the CEN Technical Specification (TS) on occupational RM for MNMs in construction	2015-16	1
2. Ensure that other standards and regulatory guidance make the link to Scaffold's guides and tools	2015-16	2
Strategic Objective 3: Establish OELs and other reference values for MNMs relevant in construction		
<i>Op. Objective 3.1: Promote needs and priorities from construction on MNMs towards actors in charge of OELs</i>		
1. Prioritize the needs (research, assays), as a function of hazard, use, potential for exposure	2015-16	1
2. Inform DG Employment, the Scientific Committee for OELs (SCOEL) and relevant national bodies about priority needs for nano-OELs in the construction sector	2015-16	1
<i>Op. Objective 3.2: Support on-going works on OELs for construction's priority MNMs, incl. background research</i>		
1. Include priority MNMs of the construction sector into the work program of SCOEL and national equivalents	2016-	1
2. Support operational research to provide the data needed to derive the priority nano-OELs for construction	2016-	1
3. Support operational research to provide the alternative toxicology data for MNMs used in construction	2016-	2
Strategic Objective 4: Ensure better adequacy of measurement capacities with assessment needs		
<i>Op. Objective 4.1: Develop strategies and standards to measure the different MNMs with the relevant metrics (number, mass or surface concentration) and at relevant levels for comparison with available occupational limits</i>		
1. Prioritize the needs as a function of MNMs of concern and of gaps between measurement capacities and OELs	2015-16	1
2. Support the development, harmonization, validation of measurement strategies adequate in regard to exposure limits, focusing on the priorities	2016-	1
3. Support the standardization of the measurement strategies developed	2016-	1
<i>Op. Objective 4.2: For some MNMs, develop R&D to design more accurate devices</i>		
1. Evaluate the needs and priorities for new developments	2016-17	1
2. Support operational research to develop the priority measurement devices currently missing	2017-	1-2
Strategic Objective 5: Make available typical exposure data for key construction activities		
<i>Op. Objective 5.1: Develop an operational public database on emission of and exposure to MNMs in construction</i>		
1. Evaluate the options to constitute an operational public database on MNM emission and exposure in construction	2015-16	1
2. Support the development of an operational public database on MNM emission and exposure in construction	2016-	1
<i>Op. Objective 5.2: Feed this database with data from the literature and/or with new experimental data on emission of and exposure to MNMs in construction</i>		
1. Support a review of scientific and technical literature on emission of and exposure to MNMs in construction, so as to feed in the database	2016-17	1
2. Evaluate the remaining key gaps and define R&D actions to fill them	2016-17	1
3. Support operational research to provide key missing data on emission of and exposure to MNMs in construction	2017-	1-2

Op. Objective: Operational Objective RM: Risk Management OEL: Occupational Exposure Limit value

Table of content

EXECUTIVE SUMMARY	3
1. INTRODUCTION	7
2. INDUSTRIAL CONTEXT	8
2.1. General situation of the Construction Sector	8
2.2. Skills, research, innovation and standards in the construction sector	9
2.3. Occupational safety in onsite construction.....	10
2.4. Nanomaterials in the construction sector	11
3. REGULATORY CONTEXT	14
3.1. General OSH policy and regulation	14
3.2. OSH policy and regulation for the construction sector.....	16
3.3. General H&S policy and regulation for MNMs.....	17
3.3.1. REACH and CLP.....	17
3.3.2. Registers of nano-enabled products	17
3.3.3. Safety Data sheets.....	18
3.4. OSH policy and regulation for MNMs (all sectors).....	18
3.4.1. General policy, regulation and guidance.....	18
3.4.2. Occupational Exposure Limit values (OELs)	19
3.5. OSH policy and regulation for MNMs in the construction sector	20
4. TECHNICAL AND OPERATIONAL CONTEXT	21
4.1. Awareness of MNMs in construction products.....	21
4.2. Identification of exposure scenarios and exposure routes.....	22
4.3. Risk Prevention.....	26
4.4. Risk Protection	26
4.5. Risk assessment.....	27
4.5.1. Occupational Exposure Limit values (OELs) and hazard assessment.....	27
4.5.2. Exposure assessment	28
4.5.3. Risk characterization	31
4.6. Risk Management.....	31
5. RESEARCH CONTEXT.....	33
6. SUMMARY OF KEY ACTORS	35
7. PROPOSAL FOR A EUROPEAN STRATEGY	37
7.1. Strategic and operational objectives.....	37
7.2. Options rejected.....	39
7.3. Strategy proposed.....	42
8. CONCLUSION: ORGANIZATION OF THE EXPERTISE AT THE EUROPEAN LEVEL	48
9. REFERENCES	49

Index of appendixes

Appendix 1: Glossary and definitions.....	54
Appendix 2: Overview of stakeholders of the nanosafety research	55

Index of Tables

Table 1. Proposed European strategy for occupational nanosafety in construction.....	4
Table 2. <i>Examples of MNMs used in construction (Lee et al. 2010, in Karjalainen et al., 2012).</i>	12
Table 3. Classification of occupational Exposure scenarios in construction processes	23
Table 4. Exposure Scenarios (ES) identified in construction processes for TiO ₂ , SiO ₂ , CNF, Cellulose NF and nanoclays.....	25
Table 5. Key issues, strategic and operational objectives for improving occupational nanosafety in the construction sector	37
Table 6. Strategic actions deploying strategic objective 1	43
Table 7. Strategic actions deploying strategic objective 2	44
Table 8. Strategic actions deploying strategic objective 3	45
Table 9. Strategic actions deploying strategic objective 4	46
Table 10. Strategic actions deploying strategic objective 5	47

Index of Figures

Figure 1. OHSAS 18001 certified companies in the world	11
Figure 2. Intensity of nano-specific information supply down the user chain from the raw material supplier to those who have to deal with the waste material.....	13
Figure 3: Low awareness of workers and employers of the construction sector regarding the use of MNMs in construction products.....	21
Figure 4. Life Cycle Analysis of construction processes. Example in building construction.....	24
Figure 5: Stakeholders of occupational nanosafety in the construction sector	36
Figure 6: Example of activity-related OSH factsheets (BG BAU, 2012)	41

1. INTRODUCTION

The use of Manufactured Nanomaterials (MNM)s and nanocomposites in the construction industry is a reality, mostly in cement or concrete products, coatings or insulation materials and to a lesser extent in road-pavement products, flame retardant materials or textiles. Despite the current relatively high cost of nano-enabled products, their use in construction materials is likely to increase because of highly valuable properties imparted at relatively low additive ratios, rapid development of new applications and decreasing cost as MNMs are produced in larger quantities (Broekhuizen and Broekhuizen, 2009).

Occupational exposure to MNMs may occur at different stages of the life cycle of the construction products, accidentally or in normal operations. Due to their specific properties, these nano-products might pose new and so far poorly understood health and safety risks to workers. Information about the MNMs in the construction products and their possible nano-specific health and safety issues is generally lacking. As a consequence, it is very difficult for average construction companies to conduct a proper risk assessment, organize a safe workplace for their employees and ensure the compliance with Occupational Health & Safety (OHS) legislation.

The Scaffold project has provided tools and guidance for the risk prevention, protection, assessment and management in relation to MNMs in the construction sector.

The present document describes and analyses the resulting situation and its context and proposes consequently a European strategy for improving occupational nanosafety in the construction sector.

This proposal is based on the following elements:

- The Scaffold reports and a complementary review of the grey literature (construction sector, European Commission, OSH agencies,...);
- The stakeholder consultation described in the disclaimer of the present report;
- The technical, industrial and regulatory expertise of the authors.

2. INDUSTRIAL CONTEXT

In this chapter, we summarize the key elements of the industrial context determining the nanosafety in the construction sector. A more detailed description of this context can be found in Scaffold's roadmap report (Larraza *et al.*, 2015b).

2.1. General situation of the Construction Sector

The overall construction sector is defined in the classification of economic activities as including the following subsectors (Ecorys, 2008):

- *“Manufacturing of construction materials: Suppliers of construction products and components (including wholesale);*
- *Onsite construction: Site preparation, construction of complete buildings, building installation, completion, and rental of construction machinery¹;*
- *Professional construction services (incl. architects, engineering services, cost controllers and building control bodies)”.*

According to the functions given to a construction element, traditionally the construction field has been divided in Building Construction and Civil Construction.

In 2014, the **onsite construction** subsector in Europe represented 14.1 Million jobs, 6,5% of the total amount of jobs and 28,7% of the industrial jobs. It produced a 1211 Bln € output, 8,8% of EU28's GDP (FIEC, 2015).

The **onsite construction** subsector is dominated by SMEs: in 2014, there were 3.0 million enterprises in the subsector, among which 95% employ less than 20 workers (or 99.9% of SMEs, 92% of micro enterprises in 2007). Consequently, *“market concentration in the subsector is relatively low. On average, the four largest enterprises in the EU accounted for no more than one third of total turnover in 2008”* (FIEC, 2015; Ecorys, 2008).

In **Manufacturing of construction materials**, on the contrary, the four largest companies on average accounted for more than half of total turnover in 2008 implying considerable individual power to control the selling price of construction materials.

*“The European **Manufacturing of construction materials** subsector is facing considerable competitiveness challenges with regard to the rising costs of energy and raw materials. On one hand, the absence of a playing field at global level may result in a relocation of activities to countries outside Europe with a less strict regulatory environment. On the other hand, the regulatory environment may drive competitiveness and innovation in the sector if non-EU manufacturers throughout the value chain are required to comply with EU regulations on markets inside the EU; also when functioning as sub-suppliers”* (Ecorys, 2008).

*“In 2007, the **distribution** channels of manufactured construction products consisted of approximately 190,000 wholesale enterprises in the EU27 employing almost 1.5 million persons*

¹ See the roadmap report for a detailed description of the activities of the onsite construction sector and of the related materials.

and generating a € 462bn turnover” (Ecorys, 2008). These numbers have significantly decreased since 2007, due to the financial crisis.

“Subcontracting is a widespread phenomenon in the European construction sector”: subcontracting to smaller specialised entities, or from European, national and regional companies to local companies. *“45% of companies [are] either acting as subcontractors or contracting parties”* (Ecorys, 2008).

2.2. Skills, research, innovation and standards in the construction sector

*“Business expenditures on **research and development** (BERD) amounted to less than 0.5% of turnover in Onsite construction and Manufacturing of construction materials in 2007. The share was lowest in Onsite construction and reached 0.05% of turnover in 2007, which appears to be a significant increase over 2001 levels. Shares were somewhat higher in the various sections of Manufacturing of construction materials but with decreases from 2001-2007. BERD approached almost 2% of turnover in Professional construction services in 2007”* (Ecorys, 2008).

As experienced all along the Scaffold project, English can often not be used to communicate in the (onsite) construction sector at the national level: national languages are essential for this communication.

In a 2008 Community Innovation Survey, *“the share of enterprises which introduced a **technological innovation** during the previous two years was 20% of enterprises in Onsite construction, 30-40% of enterprises in manufacturing of construction materials and 42% of enterprises in Professional construction services. EU27 enterprises were responsible for more than half of all PCT/international patent applications for new processes and products registered at the European Patent Office in 2006”* (Ecorys, 2008).

Standardization is a key issue for the construction sector (construction materials and on-site activities): standards are omnipresent in the large public and private calls that often determine the state of the art in construction. Considering the predominance of SMEs in the construction sector, this effect is reinforced by the major importance of standards for SMEs when integrating new developments: due to their limited resources to watch and sort exploitable novelties in the overwhelming quantity of new knowledge or developments, these new knowledge or developments that do not belong to the core business of SMEs are basically taken into account only when “enforced” as official references through regulation, Safety Data Sheets (SDS) and standards (Scaffold Conference, 2015).

Most of the employees in Onsite construction have at least an upper secondary **education**, with large geographical variation: 61% in the EU15, 84% in EU12, but less than 40% in the Southern European countries, in 2007. *“Over time, the shares of employees in Onsite construction with an upper and post-secondary non-tertiary education or a tertiary education have increased although at a low annual rate in the EU27 from 2004-2008”* (Ecorys, 2008).

2.3. Occupational safety in onsite construction

The European construction sector is dominated by small firms with a high level of subcontracting and rather poor safety record. It was recognized as “*one of the highest risk sectors*” in 2004, (EU-OSHA *et al.*, 2004) and again by EU-OSHA in 2013 (EU-OSHA, 2013a). For instance, In the EU28 in 2014, the sector represented 6,5 % of total employment (and 28,7 % of industrial employment) and in 2012 22.2 % of fatal accidents at work (ENBRI, 2005; Eurostat, 2015). Ecorys (2008) mentioned occupational safety issues in three of its five recommendations of policy measures.

In 2004, six construction bodies including the European Construction Industry Federation (FIEC) and the European Federation of Building and Wood Workers (EFBWW) signed with EU-OSHA the Bilbao Declaration (EU-OSHA *et al.*, 2004), committing themselves to specific measures to improve the sector’s safety and health standards. The FIEC and the EFBWW are engaged in a continuous dialogue on OSH issues through the Sectoral Social Dialogue Committee for Construction.

As a follow up, the European Federation of Engineering Consultancy Associations (EFCA) and the Architects’ Council of Europe (ACE) have provided the Guidance ‘Designing for safety in construction’ to assist their members to comply with the requirements of this declaration and of the regulation (EFCA, ACE).

In 2013, the FIEC and the EFBWW produced conjointly a “Guide for developing a health and safety management system” with step-by-step advice illustrated with examples.

It is generally considered that the construction sector must improve its culture of safety, which is especially difficult to implement in a dispersed sector with very small companies (Delphi WS, 2014): these SMEs mostly do not have OSH departments or formalized OSH management system. OSH management is ensured by the company manager or a deputy person, with the help of:

- public or private OSH consultants,
- external training,
- Safety and Health Construction Coordinators,
- occupational safety controllers.

Nevertheless, the construction sector is worldwide one of the major sectors in terms of certification according to the main and increasingly popular (Figure 1) international OSH Management standard OHSAS 18001 (Calderon, 2015).

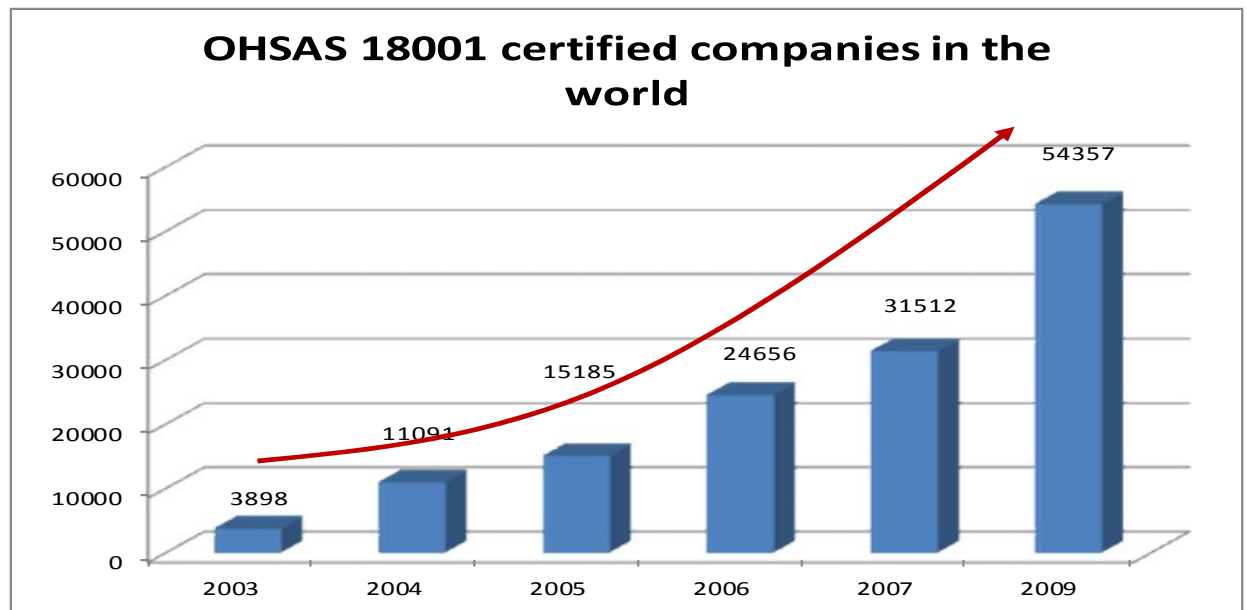


Figure 1. OHSAS 18001 certified companies in the world

2.4. Nanomaterials in the construction sector

There are two “official” definitions for nanomaterials:

- The International Organization for Standards in ISO/TS 27687 defines ‘nanomaterial’ as “*nano-objects with at least one of their three dimensions in the range of 1-100 nm and nano-structured materials comprised of such nano-objects*”. Structures which are intentionally produced are **manufactured nanomaterials (MNM)**.
- The 2011 Commission Recommendation on the definition of nanomaterials (COM, 2011b) defines ‘nanomaterial’ as “*a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50 % or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm-100 nm. In specific cases and where warranted by concerns for the environment, health, safety or competitiveness the number size distribution threshold of 50 % may be replaced by a threshold between 1 and 50 %. [...]*”

Construction materials are also experiencing the incorporation of nanomaterials, in order to change the properties of the matrixes in which they are added. For instance, SiO₂ nanoparticles are incorporated to concrete in order to increase its self-compacting behavior and improve its surface properties reducing the honey-comb effect. Indeed, the use of Manufactured Nanomaterials (MNM) and nanocomposites in the construction industry and related infrastructure industries is already a reality, mostly in cement or concrete products, coatings or insulation materials and to a lesser extent in road-pavement products, flame retardant materials or textiles (see for ex. Table 2, or more in Scaffold’s Roadmap report). Despite the current relatively high cost of nano-enabled products, their use in construction materials is likely to increase because of highly valuable properties imparted at relatively low additive ratios, rapid development of new applications and decreasing cost as MNMs are produced in larger quantities (Broekhuizen and Broekhuizen, 2009). In terms of volume, the

highest use of nanomaterials concerns the Silica fume, with EU wide “a total amount of about 3.6 Mtons of silica fume concentrated in few special construction projects” in 2009. In comparison, van Broekhuizen and van Broekhuizen (2009) estimate the market of TiO₂ cement in the order of 1 kton per year EU-wide in 2009. To our knowledge, due to Nano-SiO₂, the five nanomaterials studied specifically in the Scaffold project (TiO₂, SiO₂, carbon nanofibres - CNF, cellulose nanofibres – CeNF, and nanoclays) account for more than 90% of the total volume of nano-enabled constructions products currently used and also for a large part of the onsite works with nano-enabled constructions products.

Commonly, the incorporation of the nanomaterials is in form of nanoadditives (powder, solutions, suspensions, etc.) into traditional matrixes, for instance, the addition of carbon nanotubes into a polymeric matrix by melt blending.

Table 2. *Examples of MNMs used in construction (Lee et al. 2010, in Karjalainen et al., 2012)*

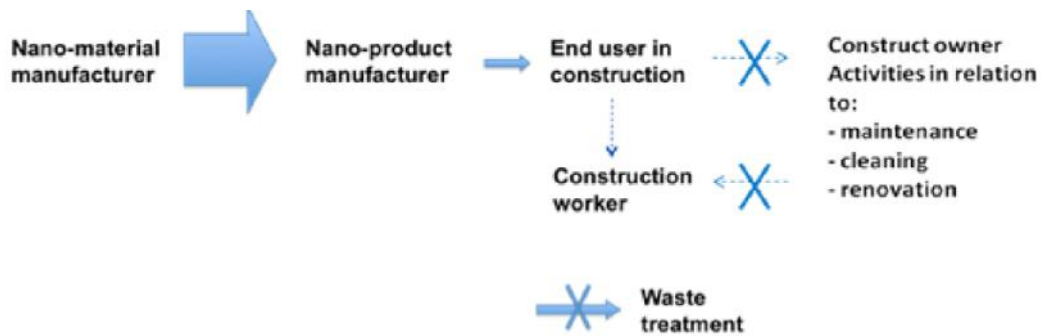
<i>MNMs</i>	<i>Architectural/construction materials</i>	<i>Expected benefits</i>
<i>Carbon nanotubes</i>	<i>Concrete Ceramics NEMS/MEMS Solar cell</i>	<i>Mechanical durability, crack prevention Enhanced mechanical and thermal properties Real-time structural health monitoring Effective electron mediation</i>
<i>SiO₂ NPs</i>	<i>Concrete Ceramics Window</i>	<i>Reinforcement in mechanical strength Coolant, light transmission, fire resistant Flame-proofing, anti-reflection</i>
<i>TiO₂ NPs</i>	<i>Cement Window Solar cell</i>	<i>Rapid hydration, increased degree of hydration, self-cleaning Superhydrophilicity, anti-fogging, fouling-resistance Non-utility electricity generation</i>
<i>Fe₂O₃ NPs</i>	<i>Concrete</i>	<i>Increased compressive strength, abrasion-resistant</i>
<i>Cu NPs</i>	<i>Steel</i>	<i>Weldability, corrosion resistance, formability</i>
<i>Ag NPs</i>	<i>Coating/painting</i>	<i>Biocidal activity”</i>

The use of nanomaterials in construction products is not always well known. Whereas it is well identified for some products, there is some confusion for many others (van Broekhuizen and van Broekhuizen 2009, Figure 2 below):

- Nano-products are sometimes sold as non-nano-products, while non-nano-products are sometimes sold as nano-products².
- Only a very small part of nano-enabled construction products are notified as such to their users through the technical data sheets or the (Material) Safety Data sheets ((M)SDS), and then often only with unclear statements such as “*achieved with nanotechnology*”³.

In its Guidance on nanosafety at work, the European Commission also acknowledges that checking the product labels, the Safety Data Sheets and the Technical Specifications may not clearly establish the material’s status regarding the presence of MNMs (COM, 2014b). For the European Commission, in case of concerns or uncertainty, this status is then to be found by specifically asking the supplier of the product or of a similar product (COM, 2014a).

The coexistence of two “official” definitions for nanomaterials does not contribute to clarity.



Source: van Broekhuizen and van Broekhuizen, 2009. The thickness of the arrow represents roughly the amount of nano-specific information supplied to the next user down the chain.

Figure 2. Intensity of nano-specific information supply down the user chain from the raw material supplier to those who have to deal with the waste material

² “Also quite standard products containing enzymes (that have typical sizes in the nano-regime) or oily dispersions (containing small oil-droplets of nano-size diameter) have been typed nano-. Or products that can be seen as borderline cases, which precursor materials are produced using nano-materials or nano-production processes, but which actual ingredients are no nano-materials anymore” (van Broekhuizen and van Broekhuizen 2009).

³For example, the BASF company PCI sells the mortar “PCI Nanofug” with “Nanotechnology”. But here the technical data sheet precises that this Nanotechnology consists in the good knowledge and exploitation of nanostructures within the mortar, and adds that the company “uses nanoparticles in none of [its] products” (PCI, 2014).

3. REGULATORY CONTEXT

In this chapter, we present the main public policies, regulations and related guidance relevant to the occupational nanosafety in the construction sector.

3.1. General OSH policy and regulation

The key 1989 OSH "Framework Directive" applies to the construction sectors like to almost all other sectors. It *"obliges employers to take appropriate preventive measures to make work safer and healthier. The Directive introduces as a key element the principle of risk assessment and defines its main elements"*, incl. worker participation, priority of eliminating risk at source, and documentation and periodical re-assessment of workplace hazards). *"The new obligation to put in place prevention measures implicitly stresses the importance of new forms of safety and health management as part of general management processes"* (EU-OSHA, 2015b).

"Member States are free to adopt stricter rules for the protection of workers when transposing EU directives into national law. Therefore, legislative requirements in the field of safety and health at work can vary across EU Member States" (EU-OSHA, 2015b).

It is the responsibility of the employers to demonstrate that they properly manage the occupation risks for their employees. For instance, in France the employer has to provide an assessment of the risk for each workplace within the company in a *"Unique Document for risk Assessment"*⁴.

In 2014, the European Commission adopted the Strategic Framework on Health and Safety at Work 2014-2020. This Strategic Framework *"identifies three major challenges concerning health and safety at work:*

- *to improve implementation of existing health and safety rules, in particular by enhancing the capacity of micro and small enterprises to put in place effective and efficient risk prevention strategies,*
- *to improve the prevention of work-related diseases by tackling new and emerging risks without neglecting existing risks,*
- *to take account of the ageing of the EU's workforce"* (COM, 2015).

The Strategic Framework proposes a *"range of actions under seven key strategic objectives:*

- *Further consolidating national health and safety strategies through, for example, policy coordination and mutual learning.*
- *Providing practical support to small and micro enterprises to help them to better comply with health and safety rules. Businesses would benefit from technical assistance and practical tools, such as the Online Interactive Risk Assessment (OiRA), a web platform providing sectoral risk assessment tools.*
- *Improving enforcement by Member States for example by evaluating the performance of national labour inspectorates.*

⁴ Articles "L. 4121-1 to 3 et R. 4121-1 and 2 of the French 'Code du travail', and 'Circulaire n°6 de la Direction des relations du travail du 18 avril 2002 pris pour application du décret n°2001-1016 portant création d'un document relatif à l'évaluation des risques pour la santé et la sécurité des travailleurs'.

- **Simplifying existing legislation** where appropriate to eliminate unnecessary administrative burdens, while preserving a high level of protection for workers' health and safety.
- **Addressing the ageing of the European workforce** and improving prevention of work-related diseases to tackle existing and new risks such as nanomaterials, green technology and biotechnologies.
- **Improving statistical data collection** to have better evidence and developing monitoring tools.
- **Reinforcing coordination with international organisations** (such as the International Labour Organisation (ILO), the World Health Organisation (WHO) and the Organisation for Economic Co-operation and Development (OECD) and partners to contribute to reducing work accidents and occupational diseases and to improving working conditions worldwide" (COM, 2015).

The Strategic Framework "identifies instruments to implement these actions, highlighting for instance the EU funds, such as the European Social Fund (ESF) and the Employment and Social Innovation (EaSI) programme, that are available to support the implementation of health and safety rules" (COM, 2015).

In 2014, EU-OSHA published its Multi-Annual Strategic Programme (MSP) 2014-2020, "which is coherent with European Commission's Strategic Framework on Health and Safety at Work 2014-2020". This Strategic Programme "six priority areas:

- *Anticipating change — through our foresight projects*
- *Facts and figures — gathering and spreading information for researchers and policy-makers through ESENER, OSH overviews and opinion polls*
- *Tools for the management of OSH — primarily through OiRA*
- *Raising awareness of OSH — through the Healthy Workplaces Campaigns and other awareness-raising activities*
- *Networking knowledge — particularly through the development of OSH-Wiki*
- *Networking and corporate communications" (EU-OSHA, 2013b).*

OiRA, the "Online interactive Risk Assessment" mentioned as a priority in the two strategic plans, "is a web platform that enables the creation of **sectoral risk assessment tools** in any language with in an easy and standardised way. It is developed and maintained by the (...) EU-OSHA and it is based on the successful Dutch Risk Assessment instrument (called RI&E) which now exists in more than 172 sectoral variants, each tailor-made to the needs of its particular sector. OiRA platform allows to build easy-to-use and cost-free online tools that can help **micro and small organisations** to put in place a step-by-step risk assessment process – starting with the identification and evaluation of workplace risks, through to the decision making and implementation of preventative actions, to monitoring and reporting" (EU-OSHA, 2015d).

3.2. OSH policy and regulation for the construction sector

The 1992 'Construction Sites Directive'⁵ “lays down minimum safety and health requirements for 'temporary or mobile construction sites'. (...) The Directive requests all responsible persons to establish a chain of responsibility linking all the parties involved, i.e. building owners, clients, contractors and sub-contractors”. Especially, “the client or project supervisor nominates person(s) responsible for the coordination of health and safety [“OSH coordinator”] at sites where several firms are present. A health and safety plan has to be drawn up” (OSH-Wiki, 2015a).

At the national level, the OSH agencies, the controllers and the companies or organizations for professional health insurance for the construction sector are organized with strong national specificities. For instance:

- In France, the general system of controllers is competent, with monitoring and guidance provided by a separate public institute (*Institut National de Recherche et de Sécurité pour la prévention des maladies professionnelles et des accidents du travail - INRS*) and separate with private (often) mutual insurance companies (often mutual insurance funds, like SMA-BTP)
- In Germany, the mutual association of construction workers *Berufsgenossenschaft der Bauwirtschaft (BG Bau)* is in charge of the insurance (on a mandatory and monopolistic base), on-site controls, and monitoring, guidance, training... for the construction sector, while other similar associations are in charge of other sectors (e.g. *Berufsgenossenschaft Rohstoffe und Chemische Industrie -BG RCI* for the chemical industry) and a further institute (*Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung - IFA*) operates at a central level.

Similarly, the precise roles and requirements for the OSH coordinator are defined on a national basis. For instance:

- In France OSH coordinators must have received a specific professional training by a certified organization, with 5-year updates (INRS, 2015b).
- In Belgium, beside a minimum educational level, OSH coordinators must have received a specific training for OSH coordinator or for prevention advisor, with a success in the final examination (Confédération Construction, 2015).

In 2011 the European Commission published a good practice guide providing explanation, good practice suggestions and information about the implementation of the 'Construction Sites Directive' for all stakeholders involved in construction projects (COM, 2011).

The construction sector is not mentioned in the Commission's and EU-OSHA's strategic programmes. An evaluation of all the existing European's OSH regulation, including the ones for the construction sector, is currently running.

⁵ Council Directive 1992/57/EEC of 24 June 1992 on the implementation of minimum safety and health requirements at temporary or mobile construction sites.

3.3. General H&S policy and regulation for MNMs

3.3.1. REACH and CLP

MNMs are not covered by specific regulations but by the general legislation on chemicals, especially REACH⁶ and CLP⁷ (COM, 2012; COM, 2014a; EU-OSHA, 2015d).

Under REACH, “chemical substances imported or manufactured in the EU must in most cases [from a volume of one tonne per year per manufacturer or importer] be registered with ECHA, demonstrating their safe use (...) Depending on its characteristics, any substance may be subject to authorisation or restrictions. REACH applies equally to substances for which all or some forms are nanomaterials. The CLP Regulation provides an obligation to notify to ECHA substances in the forms as placed on the market, including nanomaterials, which meet the criteria for classification as hazardous, independent of their tonnage” (COM, 2012).

These regulations are supposed to bring transparency on chemicals used on the market and to force the production and communication of hazard data on chemicals. There is currently a strong debate whether the 1 ton threshold is appropriate for MNMs, which would be used in rather smaller quantities than other chemicals but would potentially have stronger effects for a given quantity (COM, 2012⁸; ETUI, 2013). A review of REACH by the European Commission concerning among others “*simplified registration for nanomaterials manufactured or imported below one tonne, consideration of all nanomaterials as new substances, and a chemical safety report with exposure assessment for all registered nanomaterials*” is running since 2013 ((COM, 2012) and should be released in the next months. The review currently goes in the direction of precisising the prescriptions regarding MNMs in REACH annexes. It includes an impact assessment of possible amendments of REACH annexes (Puolamaa, 2015).

3.3.2. Registers of nano-enabled products

A consequence of this debate is the creation of national registers of nano-enabled products in three European countries so far (France Denmark, Belgium, with respective entry into force on 01.01.2013, 18.06.2014 and 01.01.2016), with five further countries also considering such a creation. The rules related for these registers vary strongly between the three countries, including in the definition of MNMs and of the concerned nano-enabled products. The REACH review by the European Commission will provide an up-to-date position on this question (Bochon, 2015). In 2012, the Commission considered that “*Current knowledge about nanomaterials does not suggest risks which would require information about all products in which nanomaterials are used*”, but intended to increase transparency, including for “*those nanomaterials currently falling outside existing notification, registration or authorisation schemes*” (COM, 2012).

⁶ Regulation (EC) No 1907/2006 of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). OJ L 136, 29.5.2007.

⁷ Regulation (EC) No 1272/2008 of 16 December 2008 on classification, labelling and packaging of substances and mixtures, OJ L353, 31.12.2008.

⁸ A first position of the European Commission is provided in the 2012 Communication (COM, 2012).

3.3.3. Safety Data sheets

“Primary sources of information are the Safety data sheets (SDS) accompanying the substances/mixtures used in the workplace. Although, according to article 31 of the REACH Regulation, their provision is mandatory only for those substances and mixtures that are classified under the CLP Regulation or meet the criteria set out in Annex XIII of the REACH Regulation as being classified as persistent, bioaccumulative and toxic or very persistent and very bioaccumulative, it is commonly the practice of the chemical industry to provide a SDS for non-classified substances/mixtures as well.” (European Commission, 2014a).

The European Chemicals Agency (ECHA, 2014) has published a guidance document on the compilation of safety data sheets.

3.4. OSH policy and regulation for MNMs (all sectors)

3.4.1. General policy, regulation and guidance

In the field of Occupational Safety and Health too, MNMs are not covered by specific regulations but by *“the same EU and national legislation that ensures the safe handling of conventional chemicals and mixtures”* (COM, 2014a). At the European level, this is essentially the Chemical Agent Directive 98/24/EC⁹. The REACH and CLP legislation on chemicals, and for some MNMs¹⁰ the Carcinogen and Mutagen Directive 2004/37/EC, are also relevant (COM, 2014a, EU-OSHA, 2015d). *“It means that employers are required to assess and manage the risks of nanomaterials at work. If the use and generation of nanomaterials cannot be eliminated or substituted by materials and processes less hazardous, worker exposure must be minimized through prevention measures following the hierarchy of control giving priority to 1) technical control measures at the source, 2) organizational measures, 3) personal protection equipment, as the last resort. (...) Employers together with workers must apply a precautionary approach to risk management and the choice of prevention measures”* (EU-OSHA, 2015d).

Guidance and documentation have been published by the European Commission and the EU-OSHA to help the implementation of this regulation, e.g.:

- Literature review on *‘Risk perception and risk communication with regard to nanomaterials in the workplace’* (EU-OSHA, 2012)
- Fact-sheet on *‘Tools for the management of nanomaterials in the workplace and prevention measures’* (EU-OSHA, 2013c), describing among others control banding tools such as the Dutch Stoffenmanager Nano that has been evaluated in the Scaffold project (Väänänen et al., 2014)

⁹ Council Directive 98/24/EC of 7 April 1998 on the protection of the health and safety of workers from the risks related to chemical agents at work. <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31998L0024>. According to the European Commission (2014a), this Directive applies to MNMs although *“nanomaterials are not explicitly included in or excluded from the scope of the Directive”*.

¹⁰ The International Agency for Research on Cancer (IARC) evaluates carbon black and multi-walled carbon nanotubes (MWCNTs) as possibly carcinogenic to humans (Group 2B): <http://monographs.iarc.fr/ENG/Monographs/PDFs/93-carbonblack.pdf>, *Volume 111 of the IARC Monographs (in press)*.

- Guidance for employers and workers for Safe use of nanomaterials at the workplace (COM, 2014a,b).

Guidance and documentation have also been published by national institutions, e.g.:

- In Spain, Guidance on occupational risk assessment for MNMs using Stoffenmanager Nano (INSHT , 2013) and comparisons of the control banding tools Stoffenmanager Nano and CB Nanotool (INSHT , 2014)
- In France, a guide for evaluation of safety at the workplace (INERIS-CEA-INRS, 2011), a report on current knowledge for the risk assessment of MNMs (ANSES, 2014) and on a own Control Banding tool for MNMs (available in French and English; ANSES, 2011).

3.4.2. Occupational Exposure Limit values (OELs)

“Occupational Exposure Limit values (OELs) are binding or guideline limit values for the concentrations of impurities, such as chemical substances, in the workplace air. Their primary purpose is to protect the workers from the adverse health effects of the impurities. OELs are set both at the EU level and at national level. Depending on the type of the OEL, the value may be strictly health-based, include socio-economic and/or technical feasibility considerations, or it may be based solely on technical feasibility” (Stockmann-Juvala et al., 2014b).

“There are two different types of European OELs: Binding Occupational Exposure Limits (BOELVs) and Indicative Occupational Exposure Limits (IOELVs). IOELVs, which are to be taken into account in the setting of OELs by the EU Member States, are substantially more common (...). BOELVs (...) constitute minimum hygienic standards within the EU for substances with genotoxic, carcinogenic or respiratory sensitising effects, i.e., the Member States are required to set a limit based on, but not exceeding, the value of the BOELV (...)” (GESTIS 2010).

OELs are adopted in application of and for the implementation of the Chemical Agent Directive 98/24/EC and, for some binding OELs, of the Cancer Directive¹¹ and the Asbestos Directive¹² (EU-OSHA, 2015e; IFA, 2015).

European OELs are proposed by the Scientific Committee for Occupational Exposure Limits to Chemical Agents (SCOEL) taking into account scientific data on hazards and feasibility aspects and after a public consultation. The European Commission further studies relevant technical and socio-economic data, consults the tripartite Advisory Committee on Safety and Health at Work (ACSHW) the appropriate European Union institutions before the final adoption and publication of an OEL in a Commission Directive.

The Member States adopt national OELs (legally binding or not) after own evaluation and consultation processes. For instance, in France, an expert committee recommends to adopt or not the values proposes by the SCOEL and the Commission, and the OELs are decided by the Ministry in charge of work.

¹¹ Directive 2004/37/EC of the European Parliament and of the Council of 29 April 2004 on the protection of workers from the risks related to exposure to carcinogens or mutagens at work.

¹² Directive 2009/148/EC of the European Parliament and of the Council of 30 November 2009 on the protection of workers from the risks related to exposure to asbestos at work.

Theoretically, the scientific data on hazards used in the development of OELs could originate (among others) from the REACH dossiers. In the praxis, in order to evaluate the relevance of the hazard data, the hazard assessors working on OELs need the full related hazard study, which is not public in case of REACH. In France for instance, the industry has not been asked for the full hazard studies related to data provided in REACH dossiers, and these data are considered in an indicative manner.

3.5. OSH policy and regulation for MNMs in the construction sector

To our knowledge, there is no specific OSH policy and regulation regarding MNMs for the construction sector.

The only available guidance for occupational nanosafety in the construction sector is the one provided by the project Scaffold, especially the guides for risk prevention, risk protection, for risk assessment, for risk management, the toolkit for risk management, the overall Handbook and a short (4 p) guidance on Nanomaterials in the construction industry (FIOH, 2015).

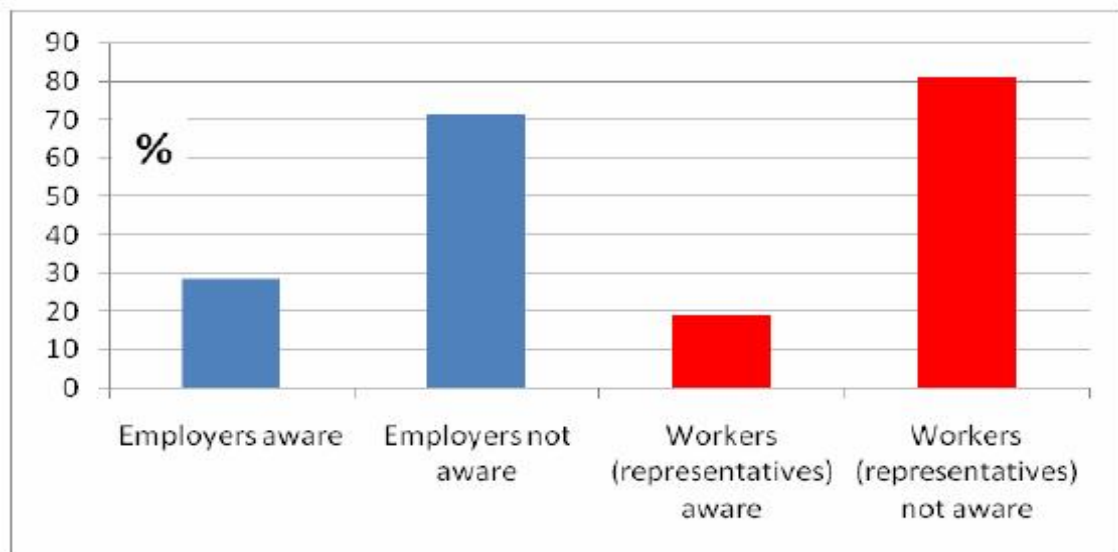
4. TECHNICAL AND OPERATIONAL CONTEXT

In this chapter, we summarize the current technical context and praxis concerning occupational safety related to nanomaterials in the construction sector. A more detailed description can be found in Scaffold's Roadmap report (Larraza *et al.*, 2015). After an introduction about the awareness of MNMs in construction products and the Identification of exposure scenarios, the different components of risk management are described, focusing particularly on the remaining gaps and needs:

- Prevention
- Protection
- Risk assessment, incl. hazard assessment and exposure assessment
- Risk management.

4.1. Awareness of MNMs in construction products

Due to the loss of information down the user chain about the presence of nanomaterials in the different construction products (see § 2.4), a majority of workers and their employers in the construction sector (~75%) are not aware that they may work with nano-products (Figure 3). When the information about the presence of MNMs is available, then with the mention that they represent no risk in the normal use of the product, and the safety measures are not changed in comparison with previous non-nano products (van Broekhuizen and van Broekhuizen, 2009).



Source: van Broekhuizen and van Broekhuizen, 2009

Figure 3: Low awareness of workers and employers of the construction sector regarding the use of MNMs in construction products

Considering the structure of the sector, dominated by SMEs with limited OSH resources and access to up-to-date information, this means that nanomaterials are almost never considered or managed as an occupational safety issue in construction companies.

In the same way, nanomaterials are not primarily mentioned as key issues for the construction sector in the communication of the OSH agencies (e.g. EU-OSHA, 2015a, at European level, INRS (2015a) in France, BG Bau in Germany), which rather list tangible and certain concerns such as: Working at height, Vehicle accidents in the workplace, Asbestos, Musculoskeletal disorders, Exposure to loud noises, Vibration at work.

For those actors who are aware of this issue, a concern often expressed (and especially by trade-unions) is a repetition of the case of asbestos, with ignorance of possible hazards during exposure and effects occurring at large scale ca. 30 years after exposure. This concern is encouraged by the lack of awareness among the employees and managers, the strong lack of knowledge about possible exposure and hazards, and the fact that products are nevertheless released on the market before this knowledge is available and (due to small volumes) often without going through the REACH procedure (FIEC-EFBWW, 2013-2015; ETUI, 2013). This concern is particularly strong for long nanofibers (e.g., certain carbon nanotubes) for which a behaviour similar to asbestos may be suspected.

4.2. Identification of exposure scenarios and exposure routes

Exposure scenarios and exposure routes to MNMs in the industry in general and in the construction industry in particular are well identified. For specific cases, this identification is performed with the help of a Life Cycle Analysis (LCA) of the MNMs along the value chain.

The main exposure route of concern is the inhalation of MNMs as aerosol or fine dust (e.g. emitted from powders), followed by dermal contacts with MNMs as powders or in liquids and finally unintentional ingestion from dust in the air (non respirable fraction) or on the fingers, from accidental ingestion of liquids (drops splitting) or from unintentional contact with food. Concerning dermal contact, *“most studies have shown little to no transdermal absorption through healthy skin. However, the uptake via damaged skin cannot be ruled out”*. (Yokel and MacPhail 2011, in Karjalainen et al., 2012). *“Critical factors affecting exposure to ENMs include the amount of material being used, the ability of the material to be dispersed (in the case of a powder) or form airborne sprays or droplets (in the case of suspensions), the degree of containment, and duration of use. In the case of airborne material, the particle or droplet size will determine the deposition of material”*. (NIOSH 2009, in Karjalainen et al., 2012). Jobs and operations that may increase the likelihood of exposure to nanoparticles are also well identified, e.g. in the construction sector (Schulte et al. 2008, in Karjalainen et al., 2012, see also Table 3, Figure 4 and Table 4):

- *Handling nanostructured powders can result in aerosolization.*
- *Working with nanomaterials in liquid during pouring or mixing operations or where a high degree of agitation is involved can cause the formation of airborne, inhalable, and respirable droplets.* [This concerns activities where NOAA are mixed with other components to fabricate products like mortar, concrete or composites that are afterwards applied in the construction site].
- *Machining, sanding, drilling, or other mechanical disruptions of materials containing nanoparticles can lead to aerosolization of nanomaterials.”*

The lowest potential level of exposure is expected for tasks where the NOAA are embedded in a solid or dispersed in liquids (and no energy is applied).

Table 3. Classification of occupational Exposure scenarios in construction processes

ES (ISO/DTS 12901-2)	Life Cycle Analysis of Construction Processes (LCA-CP) and occupational Exposure Scenarios (ES)	Potential exposure	LEVEL of exposure
STEP 2: CONSTRUCTION WORKS			
Synthesis of NOAA	ES related to cleaning/maintenance tasks	Potential exposure to NOAA	High
Material in powder form	ES related to Tasks that involve the manipulation of <u>nanopowders</u>	Potential exposure to NOAA	High
Material dispersed in a solid matrix	ES related to machining, assembly tasks of materials with NOAA embedded in a solid matrix	Potential exposure to NOAA embedded in the matrix.	Medium
Material in suspension in a liquid	ES related to the manipulation of NOAA in a suspension	Potential exposure to liquid embedded with NOAA	Low
	ES related to the manipulation of NOAA in a suspension providing energy (ej. spraying tasks, grouting)	Potential exposure to liquid embedded with NOAA	Medium
STEP 3: MAINTENANCE			
Material dispersed in a solid matrix	ES related to accidental fire of materials with NOAA embedded in a solid matrix.	Potential exposure to NOAA embedded in the matrix.	Medium
STEP 4: DEMOLITION			
Material dispersed in a solid matrix	ES related to the end of life/demolition of materials with NOAA embedded in a solid matrix.	Potential exposure to NOAA embedded in the matrix.	Medium

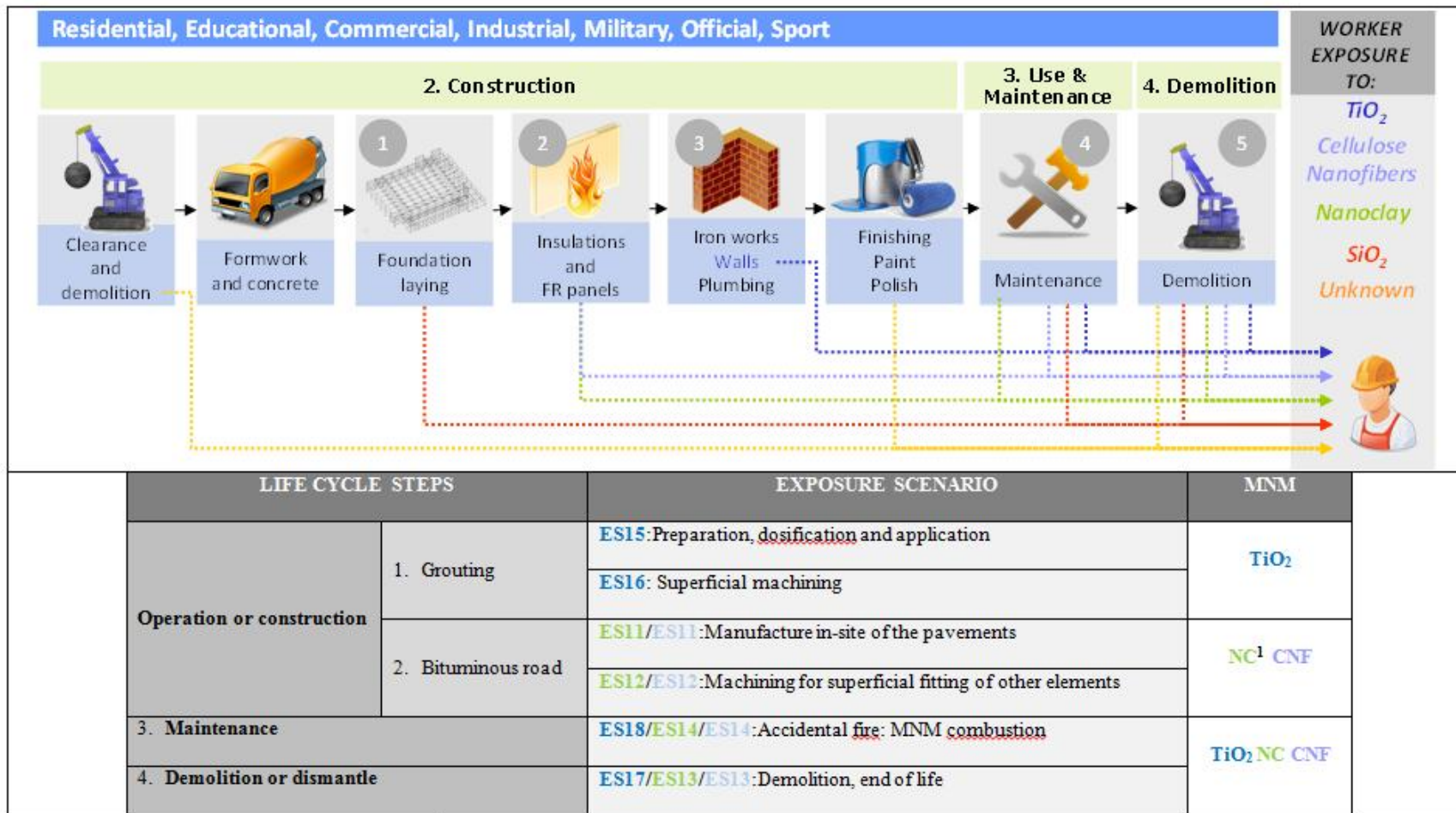


Figure 4. Life Cycle Analysis of construction processes. Example in building construction.

Table 4. Exposure Scenarios (ES) identified in construction processes for TiO₂, SiO₂, CNF, Cellulose NF and nanoclays.

	LIFE CYCLE STEPS OF THE CONSTRUCTION PROCESSES (NOTE: the first step "design" is out of the scope)																				3. USE & MAINTENANCE	4. DEMOLITION					
	2. CONSTRUCTION WORKS																										
	Precursors mixing	Reaction in a spark ignition chamber	Deposition of MNMs in fibers	Packaging	Clearance and demolition	Excavation, demolition, explosion	Drainage	Foundation laying	Elements assembling	Formwork and concrete	Excavation, filling, compacting	Iron work	Grouting	Shotcrete or anchorage	Bituminous road	Formwork	Concrete	Rebar, installation	Qualifications: ventilation, wiring, accesses	Electrical installation			Compacting	Finishing, paint, polish	Insulations and FR panels	Iron Works, Wall, plumbing	Upside infrastructure
1.-MANUFACTURING NMs	NI	NI	NI	ES1 ^(H) ES6 ^(H)																						ES1 ^(H) ES6 ^(H)	
2.-BUILDING CONSTRUCTION					NI			ES7 ^(H) ES8 ^(L)		NI												NI	ES19 ES23 ES20 ^(L) ES24 ^(L)	ES2 ^(L) ES3 ^(L)		ES10 ^(L) ES5 ^(L) ES22 ^(L) ES26 ^(L)	ES4 ^(L) ES21 ^(L) ES25 ^(L)
3.- CIVIL CONSTRUCTION																											
3.1. - Transport-infrastructure																											
Road					NI					NI			ES15 ^(H) ES16 ^(L)								NI					ES18 ^(L) ES14 ^(L)	ES17 ^(L) ES13 ^(L)
Railway					NI					NI							ES7 ^(L) ES8 ^(L)	ES8 ^(L)			NI					ES10 ^(L)	ES9 ^(L)
Bridge						NI					NI						ES7 ^(H) ES8 ^(L)					NI			ES10 ^(L)	ES9 ^(L)	
Tunnel					NI	NI								ES11 ^(H)											NI	ES14 ^(L)	ES13 ^(L)
Harbor							ES7 ^(H) ES8 ^(L)	ES8 ^(L)							NI	ES7 ^(H)						NI				ES10 ^(L)	ES9 ^(L)
Airport					NI		ES7 ^(H) ES8 ^(L)			NI	NI		ES15 ^(H) ES16 ^(L)		ES11 ^(H) ES12 ^(L)						NI	NI	ES19 ES23 ES20 ^(L) ES24 ^(L)	ES2 ^(L) ES3 ^(L)	ES5 ^(L) ES10 ^(L) ES14 ^(L) ES18 ^(L) ES22 ^(L) ES26 ^(L)	ES4 ^(L) ES9 ^(L) ES13 ^(L) ES17 ^(L) ES21 ^(L) ES25 ^(L)	
Metropolitan					NI	NI	NI			NI				ES11 ^(H)			ES7 ^(H)	ES8 ^(L)	ES12 ^(L)	NI					NI	ES10 ^(L) ES14 ^(L)	ES9 ^(L) ES13 ^(L)
3.2. - Hydraulic																											
Dams and levees							ES7 ^(H) ES8 ^(L)	ES8 ^(L)							NI	ES7 ^(L)					NI					ES10 ^(L)	ES9 ^(L)
Channel and sewage					NI	NI								ES11 ^(H)											NI	ES14 ^(L)	ES13 ^(L)
Hydroelectric plants					NI		ES7 ^(H) ES8 ^(L)			NI												NI	ES19 ES23 ES20 ^(L) ES24 ^(L)	ES2 ^(L) ES3 ^(L)	ES5 ^(L) ES10 ^(L) ES22 ^(L) ES26 ^(L)	ES4 ^(L) ES21 ^(L) ES25 ^(L)	
Water Treatment plants					NI		ES7 ^(H) ES8 ^(L)			NI												NI	ES19 ES23 ES20 ^(L) ES24 ^(L)	ES2 ^(L) ES3 ^(L)	ES5 ^(L) ES10 ^(L) ES22 ^(L) ES26 ^(L)	ES4 ^(L) ES21 ^(L) ES25 ^(L)	

Legend: NI - Task where NOAA are not used; ESX(H) - ES where high potential level of exposure is expected; ESX(M) - ES where Medium level of exposure is expected; ESX(L) - ES where Low level of exposure is expected. In grey, operations not involved in the process.

4.3. Risk Prevention

Risk Prevention tends to avoid “upstream” the possibility of exposure to the potentially hazardous compounds, by avoiding the very presence of these compounds in exposure media, e.g. through:

- Substitution of MNMs by conventional particles or by MNMs known as non-hazardous
- Confinement of MNMs in the process, in the product, or in a stable matrix.
- Isolation of potentially hazardous tasks and materials.

Scaffold’s Guide for Risk prevention (Larraza *et al.*, 2015) provides a complete set of recommendations for the construction sector.

The most traditional way is to observe the Safety Data Sheet (SDS) provided by the supplier and use the specified collective and personal protective equipment indicated in each case. This is generally supervised by the OSH staff. However, SDSs very seldom contain information about MNMs (see § 2.4).

Usual prevention measures against conventional dust and chemicals at a construction site fully apply to MNMs, e.g. -against dust-emission- spraying water on the construction place, confining dust to the solid matrices.

Nano-specific prevention measures for the construction sector will essentially concern the steps where MNMs are introduced into the future construction products:

- During the manufacturing of construction products (off site);
- During the preparation of the final construction material from a conventional construction material and a MNM-containing additive (off site on site).

These nano-specific prevention measures are for example:

- Use nanoparticles supported on larger structures (confinement of the MNMs, substitution of the additive).
- Use highly concentrated aqueous suspensions, instead of powdery products (confinement of the MNMs, substitution of the additive).
- Use low energy mixing processes (confinement of the process).

4.4. Risk Protection

Scaffold’s Guides on Risk protection (Boutry *et al.*, 2015) and on health surveillance for workers (Hyytinen *et al.*, 2014) provide a complete set of recommendations for the construction sector, including collective protection, personal protection and medical surveillance.

In this domain, Scaffold did not identify nano-specific gaps and needs, except - especially for the medical surveillance- the identification of construction products containing nanomaterials, due to the lack of information in the SDSs. Hyytinen *et al.* recommend to search for more information in the national databases or registries on nanomaterial-containing products.

Other main -conventional- concerns are:

- For collective protection, the difficulty to apply sufficient ventilation outdoors, e.g. for demolition, and the limited efficiency of a Local Exhaust Ventilation (LEV) for certain activities such as cutting materials with an electric circular saw.
- For personal protection, the leakage through gaps, seams, defects, and interface closure areas, especially for respirators, where filters for small particles induce more resistance to air and then an increased risk of leakage

4.5. Risk assessment

Risk assessment compares information on hazards with information on exposure. The management of occupational risks in the industry actually primarily relies on science-based conventional reference values such as Occupational Exposure Limit values (OELs, see § 3.4.2) to appreciate the acceptability of the exposure measured and then characterize the risk.

Scaffold's Guides on Risk assessment (Vaquero *et al.*, 2015) provides best practice recommendations for the construction sector. But in this domain, Scaffold identified several nano-specific gaps and needs, as described in the following sub-chapters.

4.5.1. Occupational Exposure Limit values (OELs) and hazard assessment

So far, no regulatory OELs specifically addressing nanomaterials have been given by the EU or by any national authority (Stockmann-Juvala *et al.*, 2014b).

For an indication only, *“recommended limit or reference values for the concentration of nanomaterials in the workplace air have been proposed, for example, by:*

- *the Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA) in Germany, by the British Standards Institution (BSI) in the UK, and by the National Institute for Occupational Safety and Health (NIOSH) in the US (IFA 2014a; BSI 2007; NIOSH 2011; 2013, in Stockmann-Juvala et al., 2014b),*
- Scaffold for 5 MNMs used in construction (Vaquero *et al.*, 2015).

In February 2015, the Nordic Federation of Building and Wood Workers has officially requested from the Scientific Committee on Occupational Exposure Limit Values (SCOEL) that the SCOEL develops nano-specific OELs and to define the link between OEL, DNEL and DMEL¹³ in the case of MNMs. The SCOEL is currently assessing the case of TiO₂. JRC¹⁴, ECETOC¹⁵, the MAK Commission¹⁶ and other industrials are also working at propositions.

Besides, a general framework for the development of OELs for nano-objects and their aggregates and agglomerates is under development in the International Organization for Standardization (ISO 2014; Stockmann-Juvala *et al.*, 2014b).

¹³ DNEL (Derived no effect level) and DMEL (Derived minimal effect level) provided by the industry in REACH dossiers.

¹⁴ Joint Research Center of the European Commission.

¹⁵ European Centre for Ecotoxicology and Toxicology of Chemicals, funded by the industry.

¹⁶ MAK: Maximale Arbeitsplatz-Konzentration. The MAK Commission is currently working on TiO₂, SiO₂, ALO, CeO, AGO, Carbon black, Carbon Nano Tubes (Hartwig, 2015).

One important bottle-neck in the development of OELs for MNMs is the low availability of toxicological data on MNMs. *“Soluble or partly soluble nanomaterials may induce hazardous effects mainly due to the toxicological profile of the dissolved ions. However, the majority of nanomaterials being used in the construction sector is consisting of poorly soluble or insoluble nanomaterials, where some of the toxicological effects may be a result of so-called particle effects. (...) A few of the materials have already now been investigated in large numbers of toxicological tests, whereas for other materials there is almost no data available yet. (...) Nanomaterials cannot be considered as one homogenous group, as the hazardous effects are likely to be very different. One of the main concerns at the moment is related to the hazardous effects of fibrous nanomaterials. However, the effects may be very different for different types of fibrous materials. According to the current knowledge, long, rigid fibrous nanomaterials (e.g., certain carbon nanotubes) seem to be significantly more harmful than other types of fibrous materials. The concerns are based on findings of animal studies, indicating a behaviour similar to asbestos, meaning that repeated exposure might in the worst case cause carcinogenic effects”* (Vaquero et al., 2015). Due to the lack of toxicological data, it was not possible to derive substance-specific, clearly health-based OEL proposals for nanofibers, nanocellulose and nanoclays in the Scaffold project (Stockmann-Juvala et al., 2014b).

This knowledge gap has also consequences for the selection of risk management priorities through control banding tools (see § 4.6 p 31). Here again, given the heterogeneity of potential hazards of (even similar) MNMs, the lack of information about nano-materials actually used in construction products makes a relevant hazard assessment more difficult.

Also relevant for the development of nano-OELs is the *“on-going debate in the scientific literature about what are the relevant parameters to evaluate an exposure to nanoparticles. “Number, mass and surface area exposure concentrations have been suggested as metrics for exposures to ENP (...). Particle number concentrations and particle number size distributions are the most commonly used metrics within the reviewed workplace and laboratory studies”*. (Karjalainen et al., 2012). However, some OELs expressed in mass concentrations (mg/m³) correspond to original OELs expressed in surface concentrations (m²/m³) and converted to mass concentrations (Schulte et al., 2015), but with the strong limitation that this conversion is made for one particular nanoparticle of a given size and may be inexact for other nanoparticles of other sizes.

4.5.2. Exposure assessment

Exposure data can be obtained from two sources:

- Own exposure measurements, either on the real site or in controlled simulated conditions (see Karjalainen et al., 2012, § 8.2 for advantages and limits), possibly combined with modelling.
- Exposure databases or emission data combined with modelling, with data reported from similar construction activities. This information can help organize and optimize own measurement, indicating what priority compounds and what range of concentrations should be expected. This information can also help to plan appropriate protection equipment at an early stage, without delaying the works on site.

Concerning exposure or emission databases:

In general and more specifically in the case of the construction sector in spite of the data provided by the Scaffold project¹⁷, *“the information about the level of exposure to [MNMs] is fragmented, most of the studies are rather explorative¹⁸ and the results cannot realistically be used for an estimation of the exposed dose”* (Savolainen et al., 2013).

Exploitable emission data for construction scenarios appear even rarer. Besides, *“predictive exposure models are mass-based and this parameter might be less appropriate in cases where one wishes to evaluate the risks associated with a nanomaterial”* (Savolainen et al., 2013).

The Scaffold project did not perform an exhaustive review of exposure data (whether in real or in simulated situations). Other data may exist that could further be gathered in a directly exploitable way. For example, INERIS has performed over years MNM exposure measurements in simulated conditions (e.g. for drilling), but these data do not seem to be integrated in the sources mentioned. The Strategic Research Agenda on nanosafety (Savolainen et al., 2013) identifies *“a need to obtain an integrated quantitative perspective on the knowledge state of [the] literature [... through] the creation of a database in the field of nanosafety”*.

PEROSH, the European network of 12 Occupational Safety and Health (OSH) institutes, is building a database of occupational exposure (NECID - Nanomaterial Exposure and Contextual Information Database). So far, very few PEROSH data concern the construction sector. Besides, PEROSH's database can be used by OSH institutes and possibly by researchers under strict confidentiality conditions, but is not available or exploitable for site-specific risk assessment. The Nanosafety Cluster's Working Group 3 on exposure also has the ambition to build an exposure database gathering the information produced in the FP7 and H2020 EU research programmes.

Concerning exposure measurements

Scaffold's review *“Available information on MNMs occupational exposure in the construction sector”* (D1.2; Karjalainen et al., 2012) summarizes as follows the current state of exposure measurement for MNMs at the workplace:

“Although many organizations in the world have researched various methods for the workplace exposure assessment of nanomaterials, and different approaches for strategies to workplace measurements have been proposed (e.g., by NIOSH, ECHA, IUTA/BAuA/BG RCI/VCI/IFA/TUD and nanoGEM), a standard or an agreeable methodology has not yet been established. The main reason is the difficulty in precise analysis of airborne particles in workplace, due to the fact that nanomaterials have unique physico-chemical properties, different from those of bulk materials (Park et al. 2009). (...)

¹⁷ The Scaffold project has measured exposure to MNMs in 3 construction scenarios in real case studies (application of coatings, construction of a concrete slab, demolition of fire-resistant panels) and in 5 scenarios at pilot scale (manufacturing self-cleaning mortar filled with n-TiO₂ and n-SiO₂, application of self-cleaning mortar, application of self-cleaning coatings, demolition of structures (cabs) covered with mortar, machining mortar/concretes/polymers filled with MNMs).

¹⁸ Eg. at lab scale, poorly documented in terms of contextual details, or/and possibly affected by confounding factors such as background concentrations, the use of electrical equipment, heaters, diesel aggregates and smoking (Van Broekhuizen et al. 2011; Karjalainen et al., 2012).

The current measuring methodology recommended by research organizations mostly is a modified form of conventional measuring methods for micro-sized materials. Importantly, it is a key point whether the equipment precisely and accurately can measure nano-sized materials (Park et al. 2009). ENPs can be measured in the workplace using a variety of instrumentation (...¹⁹), which vary in complexity and field portability. Unfortunately, **relatively few of the instruments are readily applicable to routine exposure monitoring due to non-specificity, lack of portability, difficulty of use, and high cost.** (NIOSH 2009) (...)

Personal exposure approaches are either based on personal devices and samples or real measurements combined with the recording of personal activity patterns, to allow the calculation of personal exposure (Kuhlbusch et al. 2011). A large number of equipment able to measure nanoaerosols is available on the market. The majority is designed for laboratory use, but **newly developed equipment are easily transportable and easy to use** (Nanosafe-June 2008). **A major drawback of current state of the art measurement devices is their lack of differentiation of background from nanomaterial related particles** (Kuhlbusch et al. 2011). (...)

The size, shape, and morphology can vary between different nanoparticles. **This poses a significant challenge for the measurement methods as the particle properties affect the behaviour of the particles within the measurement instruments and human body** (Leskinen et al. 2012). For ENPs, more profound investigation is needed and different properties, such as particle size distribution, surface area/volume ratio, shape, electronic properties, surface characteristics, state of dispersion/agglomeration, and conductivity need to be studied. **The high complexity and great diversity of ENPs, however, make their characterization very difficult.** (Hristozov and Malsch 2009)

According to Savolainen et al. (2010), some of the real challenges ahead for ENM monitoring and health risk assessment are as follows: (a) to redesign “ENM-capable” instruments already in laboratory use into portable and affordable devices, (b) to expand the sensing technology available for ENM detection by adopting new options with realistic potential for real-time measurement and compact design; and (c) to extend the metrics into new areas such as CNT shape identification and catalytic properties. In the future, it will be increasingly important to have devices providing real-time, on-line data”.

New portable devices have been developed during the last years, e.g. within the FP7 project Nanodevice. Scaffold’s partner Tecnia tested and combined available measurement equipment in controlled and real situations, among others in the 5 case studies of the project. Together with other metrology experts within the consortium such as INERIS, Tecnia came to a more precise analysis of the current technical gaps and needs for exposure measurement:

- The current priority needs do not concern the equipment itself, but the measurement strategy for the different nanoparticles and the relevant parameter (mass concentration, surface concentration, particle concentration, which is determined by the applicable reference values).
- Typically, such strategies combine concentration measure (mass concentration or particle concentration) and, behind, chemical characterization/identification of the nanoparticles trapped in the first step. Or, for fibers (as carbon nanofibers or

¹⁹ “including: condensation particle counter (CPC); optical particle counter (OPC); scanning mobility particle sizer (SMPS); electric low pressure impactor (ELPI); aerosol diffusion charger; and tapered element oscillating microbalance (TOEM)” NIOSH 2009.

nanocellulose), there is no consensus (a standard) about how to collect and analyze the samples in electron microscopy to count the fibers for comparison with the OEL of 0.01 fibers/cm³.

- A large effort would be necessary to establish comprehensive harmonized, goal-focused, particle-specific protocols that can be used in a typical professional context (as opposed to research), and to standardize them as references²⁰.

A prerequisite: knowing which nanoparticles to look for

The discussion above makes clear the importance to know what nanoparticles to look for when launching measurement campaigns. Two major hurdles are identified here.

- 1) For new constructions: here again, given the high MNM-specificity of measurement techniques, the lack of information about nano-materials actually used in construction products (see § 2.5) makes a relevant exposure assessment more difficult;
- 2) For maintenance in or demolition of existing structures: the difficulty is increased by the poor documentation of the construction products in existing buildings. And generic data about typical MNMs emitted from these activities is missing or not organized in operational databases (see the section about “Exposure databases” above in this chapter).

4.5.3. Risk characterization

Risk characterization itself does not present new difficulties *per se*, but is strongly impacted by the difficulties in the former steps: the major challenge here is to organize and describe rigorously the limits of and uncertainties of the assessment.

4.6. Risk Management

The Scaffold project designed the first Risk Management Model (RMM) for nanosafety in construction, using requirements of OHSAS 18001 (structure, elements, etc.) with additional requirements derived from the guidelines established in ISO 31000. It integrates all results from Scaffold. It has been developed into a toolkit, a software tool to be used by OHS professionals to manage nano-risks in construction. The RMM and further recommendations are presented in Scaffold’s Guide for Risk Management (Contreras *et al.*, 2015). The recommendations are applicable to companies of the construction sector, regardless of the size or type of organization. Every subsector involved in construction cycle could apply the MNMs RMM but with different necessities, perceptions and criteria (manufacture, building and civil construction and demolition). Scaffold’s RMM is the starting point of a European technical Specification under preparation (Manufactured nanomaterials (MNMs) in the construction industry - Guidelines for occupational risk management; CEN TC 352/WG 3/PG 5 “Scaffold”).

Scaffold’s RMM includes a control banding tool specifically customized for the construction sector (Marcoulaki *et al.*, 2015). “Control banding is a qualitative or semi-quantitative risk assessment and management approach to promoting occupational safety and health (OSH). It

²⁰ As an exception, for nano-TiO₂, there is a standardized analytical method which allows to specifically measure the target MNM down to the proposed OEL level.

is intended to minimise the exposure of workers to hazardous chemicals and other risk factors in the workplace, particularly in work situations in which information on hazards, exposure levels and risks are limited” (EU-OSHA, 2013). “The outcomes of the tool is not risk levels, but risk priority levels, meaning that in these cases one should be very careful with the substances and check that the control measures are working properly and the best practices are applied at the workplace” (Väänänen et al., 2014). Although control banding tools may still need calibration and validation, e.g. in their exposure assessment components (Savolainen et al., 2013), the tool (Stoffenmanager Nano) tested in construction scenarios by the Scaffold team was found applicable, provided that nanomaterials in construction products can be identified and minimum data on hazards are available (Väänänen et al., 2014).

Scaffold’s results and RMM have been developed into training modules (Power Point presentations) for companies of the construction sector. A further development would be an EU-wide system for the certification of competencies (esp. for company managers and OSH managers) based on Scaffold’s guides and training modules and when necessary on larger multi-sectorial training programs.

5. RESEARCH CONTEXT

The European Commission selected Nanotechnology in the Horizon 2020 framework research Programme (H2020) as one of the six Key-Enabling Technologies (KETs), recommended by the High Level Group (HLG) on KETs and identified as technological priority for Europe. Horizon 2020 will have a strong focus on developing European industrial capabilities in Key Enabling Technologies (KETs). The Leadership in Enabling and Industrial Technologies (LEIT) part of Horizon 2020 will support the development of technologies underpinning innovation across a range of sectors. In order to bridge the gap between nanotechnology research and markets, several research topics have been identified in H2020 as being crucial, also for contributing to other policy areas in nanotechnology, such as safety of nanoparticles, pre-normative research, or research for health, security energy, information society, and environment.

Until recently, European research in Nanosafety mainly focused on hazard, fate and risk assessment. The last framework research programmes FP7 and H2020 have increased the focus on the exploitation of research for operational needs, and especially more recently on the integration of nanosafety in the industrial innovation process through “safe-by-design” approaches. According to this orientation, nanosafety research projects have been specifically dedicated to:

- supporting standardization (nanoSTAIR²¹) and regulatory work (NanoREG, NanoREG II²²),
- developing operational management tools for the industry (Scaffold, NanoMICEX, Sanowork²³), and
- improving risk governance (Topics NMP-30-2015 and NMP-32-2015²⁴).

In line with this orientation, H2020 requires a clear operational open data policy from research projects.

In 2013, the EU Nanosafety Cluster published a strategic research agenda (Savolainen *et al.*, 2013) on the safe use and safe applications of engineered nanomaterials during 2015-2025. This document signalizes only risk control banding tools among risk management tools for MNMs. It recommends the calibration of current risk/control banding tools, quantification of exposure reduction effectiveness of general and nano-specific control measures and strategies, and the development of an adequate risk management integrating a risk-perception and stakeholder-involvement approach.

In 2014-2015, a ‘*Closer to the Market (CTTM) Roadmap*’ was elaborated to help bring “*science-based best NanoSafety practices in industrial and commercial activities*”. It is planned that

²¹ nanoSTAIR (2012 - 21014): Establishing a process and a platform to support standardization for nanotechnologies implementing the STAIR approach.

²² NanoReg (2013 - 2016): A common European approach to the regulatory testing of Manufactured Nanomaterials; NanoReg II (Sept 2015 - 2018): Development and implementation of Grouping and Safe-by-Design approaches within regulatory frameworks.

²³ NanoMICEX (2012 - April 2015): Mitigation of Risk and Control of Exposure in Nanotechnology-based Inks and Pigments; Sanowork (2012 - April 2015): Safe nano worker exposure scenarios.

²⁴ Topics NMP-30-2015 ‘Next generation tools for risk governance of nanomaterials’ and NMP-32-2015 ‘Societal engagement on responsible nanotechnology’ currently running in the ‘*Call for Nanotechnologies, Advanced Materials and Production*’.

dedicated topics in the December 2016-call and next calls will address the bottlenecks in this issue (Falk *et al.*, 2015). This trend is also observed in the multinational research funding scheme ERANET-SINN, now replaced by Safe-Nano Joint Transnational Calls (JTCs): the next call, planned for September 2015, should be dedicated to the integration of safety-by design in the development of industrial nano-enabled products (van Teunenbroek, 2015).

Research on nanosafety, including occupational nanosafety in construction, also occurs in research projects not specifically dedicated to nanosafety, but to the development of nanotechnologies or to sectoral research. For instance, in the H2020 '*Call for Nanotechnologies, Advanced Materials and Production*', the topics "*Fibre-based materials for non-clothing applications*' (NMP-22-2015) and '*Integration of novel nano materials into existing production lines*' (NMP-02-2015) both mention nanotechnologies and construction in their fields of application, and improved safety in their objectives. The Contractual Public Private Partnership "Energy-Efficient Building" (E2B) has a own group dedicated to nanotechnology in construction.

Appendix 2 presents an overview of the main relevant actors of the nanosafety research.

6. SUMMARY OF KEY ACTORS

In this chapter, we summarize the main actors for occupational safety in construction (Figure 5).

Workers have to be fully informed about the nature, properties of and potential risks from MNMs in their construction products, about the safest way to handle them and about the most appropriate personal protective equipment (PPE: respirators, goggles, gloves, coats, etc.). Since they are the ones who at the end apply (or not) most of the risk management measures decide in the company, they should be closely involved in the choice of these measures. **Trade-unions** of the construction industry (EFBWW, national trade-unions), as representative of employees, are key actors.

Managers and OSH managers of construction companies **and/or their OHS consultants**, have the responsibility to ensure safety at work. Large companies rely on own OSH departments to acquire and implement up to date information, whereas SMEs rely more on external OHS consultants (and to some extent to the prescriptions of client large companies): OHS consultants are key stakeholders for the bright diffusion of a nanosafety culture in the construction sector, which is largely made of SMEs. All construction companies have to mandate a **Safety and Health Construction Coordinator** for onsite works. **European and national construction platforms** are also key actors: FIEC (European Construction Industry Federation) and its national members, ISHCCO (International Safety and Health Construction Coordinators Organization), ETPC (European Technological Platform on Construction), ENCORD (European Network of Construction Companies for Research and Development) and the contractual Public Private Partnership (cPPP) “Energy-Efficient Building” (E2B).

Clients of construction companies (**promoters, architects and other building designers, real estate managers**,...) are responsible for the safety on their construction site. The major public promoters (e.g. European Federation of Social Housing, CECODHAS) and private promoters (e.g. European Real Estate Association) operate through large calls with detailed technical specifications, and actually determine the level of best practice required on the whole market, including through sub-contracting by large construction companies. The **general public** is actually also concerned for self-made construction, maintenance or demolition works, but is not specifically targeted in this project.

Manufacturers of construction products have a key role in producing safe(t) products and providing clear, transparent and complete information about the MNMs in the products and the related safety information.)

Manufacturers of protective equipment, exposure measurement devices, etc. are also concerned but with low or no specificity to construction.

Local and **European policy makers, authorities and their controllers, OSH agencies, companies or organizations for professional health insurance**, and **Standardization bodies** are important stakeholders to ensure a strong dissemination and implementation of best practices or of the best operational knowledge.

At the European level, most important public players are:

- The DG Employment, Social Affairs & Inclusion. The DG Employment produced the guides for nanosafety at work for employers and workers (COM, 2014a,b). It also has a funding programme to support the social dialogue and the dissemination and implementation of best practices.
- The European Agency for Safety and Health at Work (EU-OSHA).
- The European standardization body CEN.

At the national level, these actors are national public agencies or institutes (e.g., INRS in France, IFA in Germany, INSHT in Spain), private or public corporate organization or funds (e.g. SMA-BTP in France, *BG Bau* in Germany): see § 3.2 p 16.

Institutes or organizations providing training on occupational safety to the actors mentioned above (OSH managers, OSH coordinators, OSH controllers...) have a key role in disseminating the knowledge and best practices to these actors. These training providers depend strongly on the actors concerned and the countries. For instance, the French institutes INERIS and CEA have jointly developed a training and certification course for nanosafety at work (NANO-CERT, one day for workers, 3 days for OSH managers²⁵).

Finally, the **NanoSafety Cluster** , esp. its working group 3 on exposure, has an important role in linking nanosafety research and operational tools.

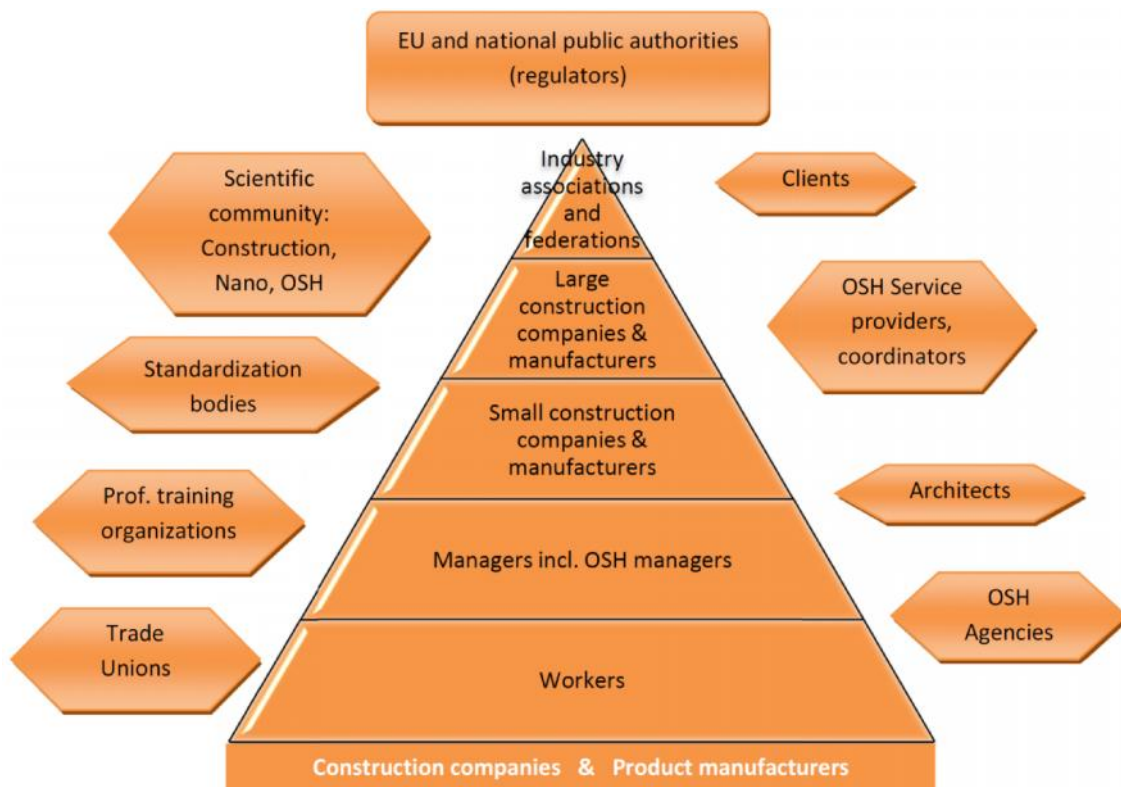


Figure 5: Stakeholders of occupational nanosafety in the construction sector

²⁵ In French and in English; http://www.ineris.com/ineris_formation/detail/1344.

7. PROPOSAL FOR A EUROPEAN STRATEGY

7.1. Strategic and operational objectives

As a first step, the description of the current industrial and the technical contexts (§ 2 and § 3) leads to identify five key issues, five strategic objectives and twelve operational objectives for improving occupational nanosafety in the construction sector.

Table 5. Key issues, strategic and operational objectives for improving occupational nanosafety in the construction sector

RM step ²⁶				Issue	Strategic objective	Challenge with respect to the state of the art	Specific to		Operational objectives	Timing ²⁷		
Pr	Pt	A	M				MNMs	Constr.		S	M	L
X	X	X	X	Awareness, information	Raise awareness, disseminate information on MNMs in construction products	The information about MNMs in the construction products and about specific risk management measures is rare and inappropriate. It does not reach OSH managers and workers.	Yes	No	<ul style="list-style-type: none"> Improve the information on MNMs in Safety Data Sheets, labels and Technical Sheets of construction products. Disseminate Information to stakeholders. Improve the information on MNM-containing products in construction calls for tenders and contracts. 		X	X
X	X	X	X	Safe work culture and practices	Disseminate and implement best practices regarding MNMs in construction	<p>Have the best practices recommended in Scaffold's guides and handbook implemented. Propose Scaffold's RMM and toolkit.</p> <p>This objective goes along with a general objective to increase the culture of safety in construction.</p>	Partly	Partly	<ul style="list-style-type: none"> Improve the quality of Safety Data Sheets and labels of construction products regarding MNMs. Disseminate actively Scaffold's guides and tools within the construction sector: large & small companies, relevant OSH actors (see § 6)... Ensure the link with standards and regulatory guidance. 	X	X	X
		X	X	Exposure limit values	Establish OELs and other reference values for MNMs relevant in construction	No official MNM-specific health-based OELs have been set by European or national authorities. Only indicative reference values are available. This complicates the interpretation of exposure measurement and the subsequent risk assessment.	Yes	Little (NPs concerned)	<ul style="list-style-type: none"> Promote needs and priorities from construction on MNMs towards actors in charge of OELs. Support on-going works on OELs for priority MNMs, incl. background research. 		X	X

²⁶ Pr: Risk prevention; Pt: Risk protection; A: Risk assessment; M : Risk management. X: mainly concerned; x: secondarily concerned.

²⁷ S: short term; M: mid-term; L: long term.

RM step ²⁶				Issue	Strategic objective	Challenge with respect to the state of the art	Specific to		Operational objectives	Timing ²⁷		
Pr	Pt	A	M				MNMs	Constr.		S	M	L
		X	x	Exposure measurement	Ensure better adequacy of measurement capacities with assessment needs	Harmonized or even consensual reference methods are missing to optimize and secure the combination of techniques needed to obtain a measurement enough selective and precise.	Yes	Little (NPs concerned)	<ul style="list-style-type: none"> Develop strategies and standards to measure the different MNMs with the relevant metrics (number, mass or surface concentration) and at relevant levels for comparison with available occupational limits. For some MNMs, develop R&D to design more accurate devices. 		X	X
x	x	X	x	Exposure data	Make available typical exposure data for key construction activities	Very few -if any- exploitable exposure data are available in operational databases to inform about risks to be expected and to help focus the exposure protection and measurement.	Yes	Yes	<ul style="list-style-type: none"> Develop an <u>operational public</u> database on emission of and exposure to MNMs in construction. Feed this database with data from the literature and/or with new experimental data. 		X	X

7.2. Options rejected

In a second step, different options to fulfil the five objectives of the roadmap have been identified and evaluated considering all the context components of nanosafety management in the construction sector (§ 2 to § 6).

We present here the options which were rejected; the options selected are presented in the following section. This presentation also provides additional insight on the rationale of the options eventually selected.

Register(s) of nano-enabled products

Registers of nano-enabled products, as currently existing or decided in France, Denmark and Belgium and being considered in other Member States (see § 3.3.2 p 17), can help raise awareness and disseminate information on MNMs in construction products. Scaffold (e.g. Hyytinen et al., 2014 for medical surveillance: see § 4.4 p 26) indeed recommends to search for more information in the national databases or registries on nanomaterial-containing products.

However, it seems unrealistic to expect from construction small and micro enterprises with very limited OSH resources to look at such a register when buying -or considering to buy- a new construction product (Delphi Workshop, 2014). New knowledge or developments that do not belong to the core business of SMEs are basically taken into account only when “enforced” as official references through regulation, Safety Data Sheets (SDS) and standards (Scaffold Conference, 2015).

This is why the development of a register or of national registers of nano-enabled products is not considered as a priority way to improve occupational nanosafety in construction. The focus is rather set on safety datasheets for the transmission of information about the nano-content of construction products down the user chain.

Registration of nano-exposure data

The mandatory registration of nano-exposure data measured on construction sites would be very useful to make available typical exposure data for key construction activities and thus help focus the case-specific measures for prevention, protection including health surveillance, exposure measurement, risk assessment and risk management, on the actually most relevant parameters. Such a mandatory registration exists in several countries for Carcinogenic, Mutagenic and Reprotoxic (CMR) compounds and specifically for asbestos.

However, such an action would represent a complex and considerable burden for construction companies, especially -again- for small and micro enterprises with very limited OSH resources and should be specifically justified by:

- A particularly high (suspected) level of hazard related to the relevant nanomaterials, like for asbestos and the other CMRs.
- A higher level of potential risk in the construction sector compared to other sectors, if this mandatory registration were to be implemented only in the construction sector.

In the current state of the knowledge, none of these two conditions appears to be fulfilled. For the level of hazard, nanomaterials do not seem to present systematically higher toxicity than conventional compounds. The concerns focus on specific nanomaterials, like some nanofibers that could cause asbestos-like effects (see § 4.5.1 p 27 and more generally Karjalainen et al., 2012 and Stockmann-Juvala *et al.*, 2014a).

This is why the mandatory registration of nano-exposure data on construction sites is not considered as an objective in the proposed European strategy. The focus is rather set on the collection and documentation of existing (but currently scattered and fragmented) data (including from construction companies on a voluntary basis) and, where major gaps remain, on the *ad hoc* production of experimental data in simulated situations and on real sites. Uuksulainen and Väänänen (2014) have proposed a model for the collection of MNM exposure data in construction.

Prescription of MNM-specific Personal Protection Equipment

A precise prescription of MNM-specific Personal Protection Equipment (PPE) could help insure that the most appropriate is used in each situation of a construction site.

However:

- It would be presumptuous to pretend foresee each possible situation and to know *a priori* the most appropriate solution for each situation;
- The PPE issue did not appear MNM-specific (see § 4.4 p 26);
- The choice of the PPE in a company is the responsibility of the management and should be discussed with workers for ex. on such key issues as ergonomics and comfort (which in the end determine the actual utilization of the PPE). It appears important to the stakeholders consulted by Scaffold (Delphi workshop, 2014) that this dialogue takes place: this is a element in the way to increasing the culture of safety in the construction sector. This is also in line with the Strategic Research Agenda's conclusion that the definition of nanorisk management must fully involve stakeholders -especially workers- and take into account their risk perception(s) (Savolainen, 2013): *"Experts and governments often believe that simply providing sufficient information will convince people that the benefits of a new technology outweigh its risks. This opinion assumes that the experts know the true risk, whereas often they do not"*.

This is why precise a prescription of MNM-specific is not considered as an objective in the proposed European strategy. The focus is rather set on dissemination of knowledge, awareness-raising and OSH dialog within the construction companies.

MNM-specific guidance for workers

A MNM-specific guidance for workers of the construction sector could help ensure that nanosafety issues are taken into account in a comprehensive way by the concerned workers.

However, a separate guidance for an issue which does not belong to the core of the construction work would probably often remain unused in the praxis. It seems preferable to integrate nanosafety as a "normal" part of the actually used OSH guidance for workers (Delphi workshop,

2014), from the Safety Data Sheets (SDS) and the Technical Sheets to activity-related OSH factsheets (BG BAU, 2012, Figure 6).

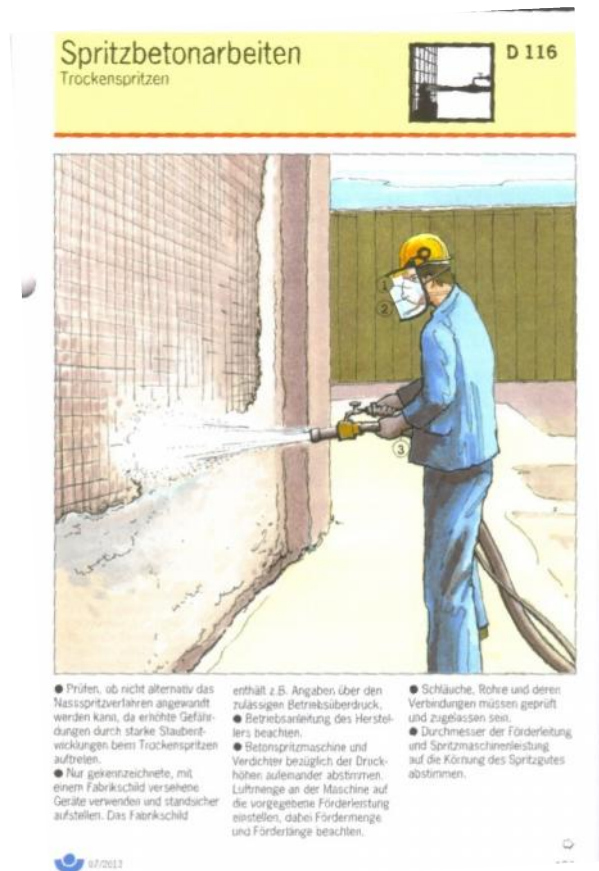


Figure 6: Example of activity-related OSH factsheets (BG BAU, 2012)

MNM-specific safety or OSH regulation

An *ad hoc* safety or OSH regulation for MNMs could be seen as a way to ensure that current needs in nanosafety issues are exactly met.

However:

- The comprehensive description and analysis of the context (§ 2 to § 6, and discussion above in this section) did not identify any regulatory gap directly related to the construction sector. The main gap concerns the absence of Occupational Exposure Limits (OELs) and data on hazards for the relevant MNMs. A larger obligation of registration under REACH for MNMs (i.e. under the current threshold of 1 ton per year per producer or importer) could increase the production of hazard data on these compounds, which in turn could facilitate the establishment of OELs. However:
 - The actual exploitation of hazard data from REACH dossier for the establishment of reference values such as OELs is currently very low (see § 3.4.2 p 19).

- This issue is common to all industrial activities and also partly to consumer safety issues²⁸.
- This issue could also be -at least partly- solved by an adaptation of the REACH annexes as currently considered (Puolamaa, 2015).
- There is a general concern that an accumulation of partly overlapping regulations would make the implementation more difficult and thus would rather bring confusion than improvements (Delphi workshop, 2014),

This is why the priority is rather set, in the strategy proposed, on the integration of solutions within the existing regulatory framework.

7.3. Strategy proposed

Finally, the European strategy proposed by Scaffold to further improve occupational safety in relation to MNMs in the construction sector is presented and further commented in the following tables.

²⁸ The European Commission considers that “most *nanomaterials which are subject to a scientific debate are manufactured or imported in volumes of 1 tonne per year or more*”. *Small volume nanomaterials are mostly used in technical applications such as catalysts or in applications where the nanomaterials are bound in a matrix or enclosed in equipment*” (COM, 2012). These considerations do not fully apply to occupational safety, especially in the construction sector where activities such as mixing of MNMs in a matrix, and drilling and demolition of the matrix where MNMs are bound, might lead to exposure.

Table 6. Strategic actions deploying strategic objective 1

Strategic Objective 1: Raise awareness, disseminate information on MNMs in construction products						
Strategic Action						
European Level	Who should act?	National Level	Who should act?	When?	Priority	Comment
<i>Operational Objective 1.1: Improve the information on MNMs and related safety issues in Safety Data Sheets, labels and Technical Sheets of construction products</i>						
1. Launch an evaluation study of Safety Data Sheets (SDS) and labels for relevant construction products regarding MNM-related information, update ECHA's guide on SDSs and produce a note for the construction sector	ECHA with EU-OSHA	-	-	2016	1	Multi-sectorial issue: the action can be generalized beyond the construction sector
2. Launch a regular control of SDS for relevant construction products regarding MNM-related information, report defaults to the competent national authorities	ECHA with EU-OSHA	Get involved in the action, apply sanctions	Ministries for Work, with OSH agencies	2017-	1	
3. Launch an evaluation study of Technical Sheets (TS) for relevant construction products regarding MNM-related information, produce a note and/ or a guide for the construction sector	EU-OSHA with ECHA	Get involved in the action, bring feedback to producers	Ministries for Work, with OSH agencies	2016	2	
4. Launch a campaign towards manufacturers of construction products promoting clear MNM labelling	EU-OSHA with ECHA	Deploy at national level	Ministries & institutes for construction	2016	2	Ex in France: Centre Scientifique et Technique du Bâtiment (CTB)
<i>Operational Objective 1.2: Disseminate information on MNMs in construction products to all stakeholders</i>						
1. Produce a commented list of commercial construction products used in Europe that do and do not contain MNMs; Disseminate it at European and national levels	FIEC, EFBWW with EU-OSHA, DG Empl.	Deploy action at national level.	Institutes for construction	2016	1	Multi-sectorial issue: the action can be generalized to other sectors. Use among others national registers and databases.
2. See Operational Objective 2.2: Disseminate actively Scaffold's guides and tools						
<i>Operational Objective 1.3: Improve the information on MNM-containing products in construction calls for tenders and contracts</i>						
1. Launch an information campaign towards large clients of the construction sector and towards large construction companies so that they request clear signalization of MNM-containing products in the proposals and contracts	FIEC, EFBWW with EU-OSHA, DG Empl., DG Growth	Deploy action at national level.	Ministries & institutes for construction	2016	1	This action uses the key role of large actors to disseminate best practices, incl. through sub-contracting. Include associations of architects, of cities,... and their media

Table 7. Strategic actions deploying strategic objective 2

Strategic Objective 2: Disseminate and implement best practices regarding MNMs in construction						
Strategic Action						
European Level	Who should act?	National Level	Who should act?	When?	Priority	Comment
<i>Operational Objective 2.1: Improve the quality of Safety Data Sheets and labels of construction products regarding MNMs</i>						
1. Perform actions of Op. Objective 1.1 on Safety Data Sheets and labels, here with a focus on best practice						
<i>Operational Objective 2.2: Disseminate actively Scaffold's guides and tools within the construction sector: large & small companies, relevant OSH actors...</i>						
1. Inform key actors on the issue and on Scaffold's results, guides, tools	Scaffold, FIEC, EFBWW, EU-OSHA	Deploy at national level	National members / organizations	2015	1	Key actors: construction industry (managers, OSH) and large clients, OSH agencies & consultants incl. H&S coordinators, training bodies...
2. Translate, adapt the Scaffold toolkit and handbook and integrate them into national tools / guidance	DG Empl., FIEC, EFBWW, EU-OSHA	Deploy at national level	National members / organizations	2015-17	1	Ex.: BG BAU's factsheets. National language is essential in construction. Follow-up project of Scaffold.
3. Ensure regular updates of the scaffold tools and their integration into national tools / guidance	DG Empl., EU-OSHA	Deploy at national level	National members / organizations	2017-	1	Integrate this action with multi-sectorial tools (ex. for control banding, RMM toolkit, OSH training)
4. Promote social dialogue in construction companies on collective and individual prevention and protection measures regarding MNMs	FIEC, EFBWW, EU-OSHA	Deploy at national level	National members / organizations	Always	1	This dialog is necessary for the choice and the effective use of the most appropriate solutions. This action will contribute to a better culture of safety in construction.
5. Require from OSH controlers to explicitly include nanosafety in the proof of compliance for OSH requirements	DG Empl., EU-OSHA	Deploy at national level.	OSH authorities	2015-	2	
<i>Operational Objective 2.3: Ensure the link between standards and regulatory guidance and Scaffold's best practice</i>						
1. Complete the CEN Technical Specification (TS) on occupational RM for MNMs in construction	CEN, CEN project group	Support at national level (mirror groups)	National standard. Bodies	2015-16	1	On going project CEN TC 352/WG 3/PG 5 "Scaffold". With industry: companies and social partners.
2. Ensure that other standards and regulatory guidance make the link to Scaffold's guides and tools	CEN, OSHA, EU-	Support at national level (mirror groups)	Ministries & national institutes	2015-16	2	Especially the link to CEN TC 352/WG 3/PG 5 "Scaffold"

Table 8. Strategic actions deploying strategic objective 3

Strategic Objective 3: Establish OELs and other reference values for MNMs relevant in construction						
Strategic Action						
European Level	Who should act?	National Level	Who should act?	When?	Priority	Comment
<i>Operational Objective 3.1: Promote needs and priorities from construction on MNMs towards actors in charge of OELs</i>						
1. Prioritize the needs (research, assays), as a function of hazard, use, potential for exposure	EU-OSHA , DG Empl., with FIEC & EFBWW	-	-	2015-16	1	In a follow-up project of Scaffold. Link with the inventory of MNM-containing construction products (Objective 1.2) and the acquisition of exposure data (Objective 5)
2. Inform DG Employment, the Scientific Committee for OELs (SCOEL) and relevant national bodies about priority needs for nano-OELs in the construction sector	FIEC, EFBWW, EU- OSHA	Deploy at national level	National members / organizations	2015-16	1	As already started by the the Nordic Federation of Building and Wood Workers
<i>Operational Objective 3.2: Support on-going works on OELs for construction's priority MNMs, incl. background research</i>						
1. Include priority MNMs of the construction sector into the work program of SCOEL and national equivalents	DG Empl.	Deploy at national level	Ministries for work & nat. committees	2016-	1	As already started at the SCOEL for TiO ₂
2. Support operational research to provide the data needed to derive the priority nano-OELs for construction	MNM producers, ERFA	Support at national level (co-funding)	MNM producers, Nat. Research agencies	2016-	1	E.g. REACH research with full publication or methods and results.
3. Support operational research to provide the alternative toxicology data for MNMs used in construction	MNM producers, ERFA	Support at national level (co-funding)	MNM producers, Nat. Research agencies	2016-	2	E.g. for control banding tools

ERSA: European Research Funding Agencies

Table 9. Strategic actions deploying strategic objective 4

Strategic Objective 4: Ensure better adequacy of measurement capacities with assessment needs						
Strategic Action						
European Level	Who should act?	National Level	Who should act?	When?	Priority	Comment
Operational Objective 4.1: Develop strategies and standards to measure the different MNMs with the relevant metrics (number, mass or surface concentration) and at relevant levels for comparison with available occupational limits						
1. Prioritize the needs as a function of MNMs of concern and of gaps between measurement capacities and OELs	EU-OSHA , DG Empl., with FIEC & EFBWW	-	-	2015-16	1	In a follow-up project of Scaffold. Link with the inventory of MNM-construction products (Objective 1.2) and the collect of exposure data (Objective 5)
2. Support the development, harmonization, validation of measurement strategies adequate in regard to exposure limits, focusing on the priorities	ERSA, DG Empl.	Support at national level (co-funding)	Nat. Research agencies, Ministries for Work	2016-	1	Key issues: - Combination of existing techniques for precision and selectivity - Handable routine device
3. Support the standardization of the measurement strategies developed	DG Empl., CEN	Support at national level	Ministries for Work, NSBs	2016-	1	
Operational Objective 4.2: For some MNMs, develop R&D to design more accurate devices						
1. Evaluate the needs and priorities for new developments	DG Empl.	Deploy at national level	Ministries for work & nat. committees	2016-17	1	Taking into account the objective reached with combination of existing devices
2. Support operational research to develop the priority measurement devices currently missing	ERSA, DG Empl.	Support at national level (co-funding)	Nat. Research agencies, Ministries for Work	2017-	1-2	E.g. REACH research with full publication or methods and results.

ERSA: European Research Funding Agencies

NSBs: National Standardization Bodies

Table 10. Strategic actions deploying strategic objective 5

Strategic Objective 5: Make available typical exposure data for key construction activities						
Strategic Action						
European Level	Who should act?	National Level	Who should act?	When?	Priority	Comment
<i>Operational Objective 5.1: Develop an operational public database on emission of and exposure to MNMs in construction</i>						
1. Evaluate the options to constitute an operational public database on MNM emission and exposure in construction	DG Empl., DG RTD, with EU-OSHA	-	-	2015-16	1	Action to generalize to other sectors. First explore solutions with PEROSH and NSC WG3 on exposure.
2. Support the development of an operational public database on MNM emission and exposure in construction		Support at national level (co-funding)	Nat. Research agencies, Ministries for Work	2016-	1	These actions are in line with the open data policy of the DG RTD.
<i>Operational Objective 5.2: Feed this database with data from the literature and/or with new experimental data on emission of and exposure to MNMs in construction</i>						
1. Support a review of scientific and technical literature on emission of and exposure to MNMs in construction, so as to feed in the database	DG Empl., DG RTD, with EU-OSHA	Support the review	Ministries for work & OSH institutes	2016-17	1	A key is to review and provide the meta-information about the emission and exposure data collected. A similar action is running on hazards within the NanoReg project.
2. Evaluate the remaining key gaps and define R&D actions to fill them		Deploy at national level	Ministries for work & nat. committees	2016-17	1	
3. Support operational research to provide key missing data on emission of and exposure to MNMs in construction		Support at national level (co-funding)	Nat. Research agencies, Ministries for Work	2017-	1-2	A priority could be maintenance and demolition activities, involving dust emission from old materials with -usually- no information on MNMs.

ERSA: European Research Funding Agencies

NSBs: National Standardization Bodies

DG RTD: DG Research and Innovation

8. CONCLUSION: ORGANIZATION OF THE EXPERTISE AT THE EUROPEAN LEVEL

The proposed European strategy includes the long term maintenance, update and further development of science-based operational tools at the European level, and their translation and transcription into national tools. These tools include a management toolkit and guides, a training and certification programme, consolidated measurement strategies, an emission and exposure database and Occupational Exposure Limit values (OELs).

The sustainable maintenance, update and further development of these tools represent a considerable effort. Many of the actions proposed are inter-linked and not specific to the construction sector. Therefore, for the sake of efficiency and sustainability, the efforts should be joined and coordinated at the European level and across industrial sectors, ending up with European multi-sectorial tools including sectorial modules and translated into national versions operated at local level. For some actions (e.g. the development of OELs), a European coordination is already in place. For others, the efforts are scattered and duplicated (e.g. for control banding tools) or strongly attached to temporary funding (project-based research, e.g. on measurement). This situation calls for the creation of a European platform of expertise institutes all over Europe that would coordinate the sustainable development, maintenance and update of operational tools for the risk management of MNMs in the industry.

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Appendix 1: Glossary and definitions

ACE	Architects' Council of Europe
Aggregate	Particle comprising strongly bonded or fused particles where the resulting external surface area may be significantly smaller than the sum of calculated surface areas of the individual components. [ISO/TS 27687:2008, 3.3]
EFBWW	European Federation of Building and Wood Workers
EFCA	European Federation of Engineering Consultancy Associations
ERSA	European Research Funding Agencies
Exposure	Contact with a chemical, physical or biological agent by swallowing, breathing, or touching the skin or eyes. (ISO 12901-1:2011).
FIEC	European Construction Industry Federation
Health hazard	Potential source of harm to health [ISO 10993-17:2002, 3.7]
Health risk	Combination of the likelihood of occurrence of harm to health and the severity of that harm [ISO 10993-17:2002, 3.8]
(M)SDS	(Material) Safety Data sheets. SDS is the current denomination (ECHA, 2014)
Nanomaterial	Material with any external dimension in the nanoscale (2.1) or having internal or surface structure in the nanoscale (ISO/TS 80004-1)
OSH	Occupational Safety and Health
Nano-object	Material with one, two or three external dimensions in the nano-scale [ISO/TS 27687:2008]
NOAA	Nano-objects, and their aggregates and agglomerates greater than 100 nm (ISO/TS 12901-2)
Nanoscale	Size range from approximately 1 nm to 100 nm. [ISO/TS 27687:2008]
NSBs	National Standardization Bodies
Particle	Minute piece of matter with defined physical boundaries [ISO/TS 27687:2008, 3.1]
SCOEL	Scientific Committee for Occupational Exposure Limits to Chemical Agents

Appendix 2: Overview of stakeholders of the nanosafety research

Source: López de Ipiña Peña, 2014, updated June 2015.

Research projects and organizations. A mapping portal for nanotechnology research FP6/7 Projects and organizations can be found at H2020 website²⁹. Moreover European nanosafety research is coordinated by the EU NanoSafety Cluster (NSC). The NSC publishes a yearly European NanoSafety Cluster Compendium, which contains information on all running or recently completed projects funded under the Seventh Framework Programme FP7 and now the H2020 programme (Information on older projects can be found in the previous editions). Additionally, information on research projects - completed, underway or planned - that address environmental, human health and safety issues of manufactured nanomaterials can be also found at OECD database³⁰. It allows users to search by a variety of categories such as the nanomaterial being investigated, the test methods used and the scope of the research area. Research is defined in a broad sense, thus, it includes not only experimental studies, but also projects addressing: i) comprehensive risk assessments of specific substances; ii) risk mitigation measures; iii) regulatory aspects; iv) international standard setting; and v) reports of public dialogues.

Nanosafety cluster: The Nanosafety Cluster³¹, is an initiative from the European Commission, DG Research & Innovation, "Industrial Technologies" Programme, to maximise synergies between research projects on EU or national level addressing all aspects of nanosafety including toxicology, ecotoxicology, exposure assessment, mechanisms of interaction, risk assessment and standardisation. Standardization has been identified as a key element in the field of nanosafety, and included within the scope of Dissemination Working Group.

European Technology Platforms, European Innovation Partnerships and other related EC initiatives. European Technology Platforms (ETPs) are industry-led stakeholder fora that develop short to long-term research and innovation agendas and roadmaps for action at EU and national level to be supported by both private and public funding. ETPs span a wide range of technology areas and have to date played an important role by developing joint visions, setting Strategic Research and Innovation Agendas and contributing to the definition of the research priorities including those under the Research Framework Programmes. Horizon 2020 recognises the role of ETPs as part of the external advice and societal engagement needed to implement the Programme. Current picture of ETPs consists in 40 ETPs, 30 individual ETPs and 2 cross ETP initiatives. Several of them are relevant to the nanotechnology research Community: e.g. ENIAC (Nanoelectronics), SusChem (Sustainable Chemistry), Nanomedicine, ETP on innovative medicine, TPIS (Industrial Safety) and Nanofutures.

NANO futures³² initiative is an European Technology Integrating and Innovation Platform (ETIP), multi-sectorial, cross-ETP, integrating platform, with the objective of connecting and

²⁹ http://ec.europa.eu/research/industrial_technologies/pdf/ec-nanotechnology-research-mapping_en.pdf

³⁰ <http://www.oecd.org/env/nanosafety/database>

³¹ <http://www.nanosafetycluster.eu/>

³² <http://www.nanofutures.info/about>

establishing cooperation and representation of Technology Platforms that require nanotechnologies in their industrial sector and products.

European Innovation Partnerships (EIPs) are a new approach to EU research and innovation. EIPs act across the whole research and innovation chain, bringing together all relevant actors at EU, national and regional levels in order to: 1) step up research and development efforts; 2) coordinate investments in demonstration and pilots; 3) anticipate and fast-track any necessary regulation and standards; and 4) mobilize 'demand' in particular through better coordinated public procurement to ensure that any breakthroughs are quickly brought to market. EIPs are launched only in areas, and consist only of activities, in which government intervention is clearly justified and where combining EU, national and regional efforts in R&D and demand-side measures will achieve the target quicker and more efficiently: 1) Active and Healthy Ageing, 2) Agricultural Productivity and Sustainability, 3) Smart Cities and Communities, 4) Water and 5) Materials. All of them may involve nanotechnology research.

Research carried out by Public-Private Partnership (PPP), proposed by the European Commission in 2008 to develop new technologies for the vitally important manufacturing, construction and automotive industries, also include significant research in the field of nanotechnology. In H2020, contractual Public-Private Partnerships (cPPPs) can be used extensively for the implementation and deployment of the KET. They help industry to directly participate in the definition and implementation of research and innovation priorities. The three cPPPs connected with the area of nanotechnology (LEIT - Nanotechnologies, Advanced Materials, Advanced Manufacturing and Processing, and Biotechnology) are : [Energy-efficient Buildings \(EeB\)](#), [Factories of the Future \(FoF\)](#) and [Sustainable Process Industries \(SPIRE\)](#).

European, national and regional research funding agencies. Horizon 2020 is the main financial instrument from the EC, for funding research over 7 years (2014 to 2020). H2020 will be complemented by further measures to complete and further develop the [European Research Area](#). Within the Leadership in Enabling and Industrial Technologies part of Horizon 2020 (LEIT), a specific section covers research on nano-sciences and nanotechnologies, including environmental, safety and health issues (EHS). Links with national and regional research funding agencies in European Union can be found at CORDIS (National R&D information service³³).

SIINN ERA-NET and Safe-Nano Joint Transnational Calls (JTCs): The ERA-NET³⁴ on Nanosafety (Safe Implementation of Innovative Nanoscience and Nanotechnology - SIINN) promotes the safe and rapid transfer of European research results in nanoscience and nanotechnology (N&N) into industrial applications. National and regional resources are virtually pooled to create a transnational programme of research. In order to strengthen the European Research Area and to coordinate N&N-related R&D work, the project has the aim of bringing together a broad network of ministries, funding agencies, academic and industrial institutions to create a sustainable transnational programme of joint R&D in N&N.

³³ http://cordis.europa.eu/national_service/home_en.html

³⁴ <http://www.siinn.eu/en/>

R&D activities in the Member and Associated States of the EU in the area of N&N remain largely uncoordinated and fragmented, resulting in the sub-optimal use of available resources, such as human resources, research equipment and funding. Since available data on their toxicological behaviour is often scant, unreliable or contradictory, the SIINN Project will focus on ways of remedying this situation. The SIINN-ERA-NET has also joined the EU NanoSafety Cluster.

SIINN started on August 1, 2011 and has been running for three years. It has prepared three calls for proposals and disseminates the knowledge acquired during the lifetime of the project. SIINN established a link to NanoSTAIR project for guidance on standardization.

SIINN is now replaced by Safe-Nano Joint Transnational Calls (JTCs). Its first call is expected in September 2015.

NMP NCP Network. The NMP Network of National Contact Points (NCPs)³⁵ is in operation since the beginning of the 5th Framework Programme which began in 1998, is a valuable resource available to the scientific and industrial community of Europe interested in utilizing the expertise of the nationally appointed experts in order to produce high quality research and technological developments.

The NMPTeAm2 project is funded by the European Commission under the NMP Thematic area of the Cooperation Programme of the Seventh Framework Programme. NCP's from 15 countries are involved in the NMPTeAm2 project. All NMPTeAm2 partners are officially nominated NMP National Contact Points (NCPs) in their countries. The NMP TeAm 2 project aims at assisting the NMP NCP Network to provide good quality and high standard services to the proposers and therefore helping simplify access to FP7 calls, lowering the entry barriers for newcomers, and raising the average quality of submitted proposals. A section of the project website (NMPTeAm Headlines) contains examples of projects dealing with NMP and FP7 and presenting relevant information on related areas. The project nanoSTAIR has been linked as a method to guide researchers in the standardisation process.

The NMP TeAm Partner Search Facility³⁶ has been established by the network on NMP NCPs in order to offer best support to its clients. This web service is strictly focused on the open calls for proposals of the key enabling technologies Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing of H2020 and related actions like FET open and ERA-NETs like SIINN and M-ERA.NET.

³⁵ <http://ec.europa.eu/research/participants/portal/page/nationalcontactpoint>

³⁶ <https://www.nmp-partnersearch.eu/index.php>