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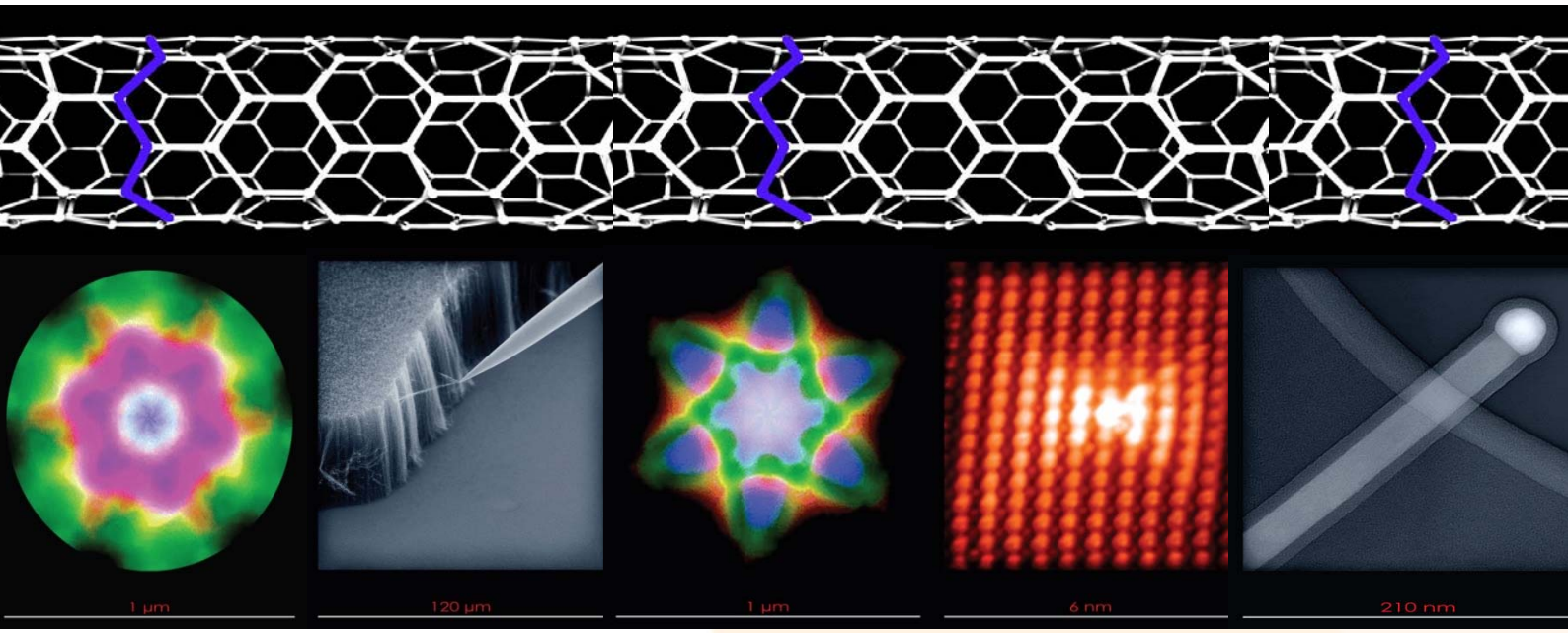

Risk perception and risk communication with regard to nanomaterials in the workplace

European Risk Observatory
Literature Review

European Agency for Safety and Health at Work

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1. Introduction

Nanotechnology has the potential to lead to the development of a broad range of new materials that are widely portrayed as bringing huge benefits to society, from novel medicines that effectively target the site of disease or infection to techniques for bringing clean water to underdeveloped societies and combating global warming. The reality of this type of hyperbole is debated, with 'misguided promises that nanotechnology can fix everything' given as one factor that may result in a backlash against this new technology (3i, 2002). However, many believe that nanotechnologies have the potential to:

- deliver improvements for consumers;
- help to sustain continued recovery and growth in the manufacturing industry; and
- contribute to the effort to tackle global challenges (e.g. Beddington, 2010; Look et al., 2010; UK Government, 2010).

The Woodrow Wilson inventory of nanotechnology-based products currently lists 1,317 consumer products, produced by 587 companies, located in 30 countries; the largest category is 'Health & Fitness', totalling 738 products, many of which are cosmetics and sunscreens (Woodrow Wilson, 2011).

The prefix 'nano' means dwarf, and a nanometre is 10^{-9} of one metre. Nanotechnology has been defined as the 'design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale' (BSI, 2005). On 18 October 2011, the European Commission adopted a Recommendation on the definition of nanomaterial (EC, 2011) according to which:

- "Nanomaterial" means 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%.
- By derogation from the above, fullerenes, graphene flakes and single wall carbon nanotubes with one or more external dimensions below 1 nm should be considered as nanomaterials."

This followed a call from the European Parliament to the European Commission for the introduction of a comprehensive, science-based definition, harmonised at the international level (EP, 2009a). This was however considered challenge (Bowman, D'Silva & van Calster, 2010), not least because, as was emphasised by the European Commission's Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), particle size is a continuum and there is no scientific reason for choosing a particular upper size limit for nanomaterials (SCENIHR, 2010). The SCENIHR indeed highlighted that it is not feasible to identify one nanometre size at which material properties abruptly change, and the term nanomaterial 'neither implies a specific risk nor does it necessarily mean that this material actually has new hazard properties compared to its constituent parts'. This contrasted with the British Standards Institution's definition (BSI, 2007): a nanomaterial has 'one or more external dimensions, or an internal structure, on the nanoscale, which could exhibit novel characteristics compared to the same material without nanoscale features', where nanoscale is defined as 'having one or more dimensions of the order of 100 nm or less' (OECD, 2008; ISO 2008), whereby ISO and OECD set a lower limit at 1 nm. Several other definitions exist, a selection of which are reproduced in Annex 1 of SCENIHR (2010).

The definition from the Recommendation by the European Commission mentioned above should be used as a reference for determining whether a material should be considered as a 'nanomaterial' for legislative and policy purposes in the European Union. Seeing the fast pace of technological development and scientific progress, this definition will be subject to a review by December 2014, in particular with regard to: whether the number size distribution threshold of 50% should be increased or decreased; and whether to include materials with internal structure or

surface structure in the nanoscale (such as complex nano-component nanomaterials, including nano-porous and nano-composite materials that are used in some sectors).

Still, the huge variety in size, shape, surface chemistry and coating means that, even for one chemical type such as titanium dioxide (one of the most prolifically used nanomaterials already on the market), the number of possible forms of nanoparticles is very large, which greatly complicates the risk assessment required to ensure the health and safety of workers (and the general public) who are handling or using nanomaterials and products that contain them (Tervonen et al., 2009). The nature of the hazards and how they should be controlled in the workplace might need to be assessed for each form of a nanomaterial, or alternatively, an understanding acquired of the contribution of the different physical and chemical properties of nanomaterials to creating health effects, hazards and issues for risk management in the workplace. A number of studies report progress with these issues; for example, one study funded by the United Kingdom's Department for Food, the Environment and Rural Affairs (DEFRA) has considered the physicochemical factors that influence the ability of nanoparticles to penetrate into mammalian cells, and highlighted the gaps in knowledge that require more detailed investigation (Hankin et al., 2008).

The wealth of proposed benefits that may come from nanotechnology arise due to the novel properties that engineering materials at this scale can bring. As the size of a particle is decreased, the surface area per unit mass increases, with more atoms on the surface of the particle and hence increased surface reactivity. Furthermore, the number of particles per unit mass increases exponentially with decreasing size. Whilst this reactivity is usefully deployed to engineer materials with novel properties, a further consequence is that their biological properties may be enhanced or changed relative to the material in a larger particulate form (Warheit, Reed & Sayes, 2009). There is also the potential for generating novel structures such as nanotubes and fullerenes (or bucky balls), which are tubes or hollow spheres of carbon atoms linked in hexagonal and pentagonal arrays, the properties of which may also be very different from those of the basic material, in this case, carbon. Such considerations have led to the hypothesis that nanoparticles may have different toxicological properties and different hazard potential from their larger counterparts (Oberdorster, Stone & Donaldson, 2007).

In successive governmental and academic reviews, the need to understand the hazards of nanomaterials has been emphasised (e.g. in the Progress Report published by the United Kingdom’s Government, 2006), and a large number of scientific publications have reported the results of investigations of the potential toxicity of nanomaterials in many different assay systems, ranging from isolated human or animal cells grown in culture to experimental animals, with different experimental outputs. Examples of approaches taken have been summarised in many reports and reviews (e.g. NRCG Task Force 3, 2006; Stone, Johnston & Schins, 2009; Dhawan & Sharma, 2010; OECD, 2010a). The major responses in isolated cells and tissues noted in many studies are oxidative stress and inflammation, with the small size, large surface area and capacity of nanoparticles to generate reactive oxygen species contributing to the inflammation and lung injury observed in animals following inhalation of materials that may be relatively inert in larger forms (Nel et al., 2006). Indeed generation of reactive oxygen species and the overwhelming of natural anti-oxidant defences is one of the best-developed paradigms for explaining the toxicity of nanoparticles observed in living systems. It has also been shown that some nanoparticles may have genotoxic effects and induce DNA damage (Doak et al., 2009; Petersen & Nelson, 2010; Sargent, Reynolds & Castranova, 2010). Surface coating or aggregation may modify all of these effects of nanoparticles. Many of the effects of nanoparticles are associated with their increased surface area, and when the dose-response curve is expressed as a function of surface area rather than mass, it assumes the same curve (Beckett et al., 2005). Much of the scientific research carried out to date on the potential toxicity of nanomaterials has focussed on local toxicity in, for example, the lung and skin, as well as on the likelihood of their transport to distal organs, but cardiovascular effects such as thrombus formation and heart attack may also result from exposure to nanomaterials as well as ultrafine materials found in air pollution (Mills et al., 2009).

In the Royal Society and Royal Academy of Engineering report of 2004 (RS & RAE, 2004), it was suggested that nanotubes might deserve special toxicological attention, largely due to their potential to induce similar health effects to asbestos. Maynard and colleagues subsequently emphasised that fibre-shaped nanomaterials may present a potent inhalation hazard that should be evaluated as a matter of urgency (Maynard et al., 2006). They warned that failure to do so

might have devastating consequences on both human health and public perceptions of the nanotechnology industry. These concerns stimulated research into this novel type of nanomaterials, with results suggesting that some types of nanotubes might induce similar effects as asbestos when for example injected into experimental animals (Donaldson et al., 2010); to induce these effects the nanotubes had to have a high aspect ratio of length to diameter, and be rigid in structure, so that they did not generate balls resembling cotton wool but remained as long fibres *in vivo* (Poland et al., 2008). As a result, the European Commission (EC, 2008a), as well as the Health and Safety Executive (HSE, 2011) recommend that 'nanosciences and nanotechnologies (N&N) research activities should be conducted in accordance with the precautionary principle, anticipating potential environmental, health and safety impacts of nanotechnology and nanomaterials (N&N) outcomes and taking due precautions, proportional to the level of protection, while encouraging progress for the benefit of society and the environment'. The European Trade Union Confederation's first resolution on nanotechnologies and nanomaterials also stated that the precautionary principle must apply to nanotechnologies (ETUC, 2008). However there is still disagreement in terms of what the precautionary principle means in practice (EC, 2010a).

The Organisation for Economic Cooperation and Development (OECD) established a Working Party on Manufactured Nanomaterials (WPMN) in 2006 to help Member States address the safety concerns arising from engineered nanomaterials; recent activities of the OECD are summarised in their publication (OECD, 2010c).

The potential for human exposure depends on the way the nanomaterial is being used and is likely to be greater for 'free' nanomaterials for example being handled in powder form in the workplace and potentially becoming airborne, than for nanomaterials embedded in a structure or product. However, even when nanomaterials are embedded, exposure may occur in certain conditions, for example in workplaces where the products are further handled and processed (for example ground or polished) or at the end of a material or product's life, during disposal, potentially again presenting hazards to waste and recycling workers. Techniques for measuring exposure to nanomaterials in working environments are being optimised, for example through a number of European Commission-funded projects. The major challenge in these studies is how to distinguish and assess exposure to the specific target nanoparticles from other ambient ultrafine particles coming from workplace sources such as heaters or external sources such as from traffic passing the site. Workplace exposure to nanomaterials has been the subject of a previous European Agency for Safety and Health at Work review (EU-OSHA, 2009a).

To control exposure to nanomaterials in the workplace, the most effective approach is to contain the processes involving the sources of the materials (EU-OSHA, 2009a). The suitability of engineering controls has been the subject of only a few studies, but these conclude that well-designed, properly installed and used ventilation and exhaust systems can provide adequate protection for workers, with monitoring and maintenance to avoid leakages and breaches from air filters. Filtration of the exhaust systems with multi-stage high efficiency particulate air filters is generally recommended (e.g., HSE, 2011). The effectiveness of personal protective systems frequently used to filter air in the workplace, which commonly depend on, for example, fibrous filters as found in respiratory protective masks, has yet to be fully evaluated. Diffusion, mechanical filtration and electrostatic attraction are potentially effective against nanoparticles (Brown, 1993). Nevertheless, effective worker protection requires knowledge within the workplace that nanomaterials are being handled; this is straightforward for dedicated nanomaterials' facilities, where the materials are, for example, being manufactured, but organisations lower on the supply chains may not always be fully aware of the constituent components of materials that are being handled and for example, cut or fabricated into products. Unknowingly, these workers may be at risk of exposure to nanomaterials.

There is therefore considerable scientific uncertainty involved in evaluating the risks of handling engineered nanoparticles in the workplace. A recent report by the Government of the United Kingdom (UK Government, 2010) stated that there was 'insufficient evidence to carry out robust risk assessments of many existing nanomaterials'. A qualitative uncertainty analysis (Grieger, Hansen & Baun, 2009) which systematically screened 31 reports and articles published by leading scientists and authorities on the potential risks of nanomaterials found that 'knowledge gaps pervade nearly all aspects of basic Environmental, Health and Safety (EHS) knowledge, with a well-recognised need for improved testing procedures and equipment, human and environmental effect and exposure assessments and full characterisation of nanomaterials'.

This complicates development and implementation of proportionate regulatory measures by legislators (Franco et al., 2007). Currently there is no regulation specific for nanomaterials (Bard et al., 2008) and many regulators generally consider that existing regulatory frameworks could cover the risks associated with nanomaterials (EC, 2008b). In 2009, the EU Parliament disagreed, and requested that the EU Commission reviews legislation such as the workers' protection legislation and REACH[1], to ensure that the particular features of nanomaterials are adequately addressed by the legislative frameworks, and information to consumers and workers is improved, with appropriate labelling that indicates the presence of nano-sized ingredients, regardless of risks (EP, 2009a). How REACH handles nanomaterials is therefore being examined and will depend on how the legislation is implemented over the coming years as well as the outcomes of discussions in the REACH Competent Authorities Subgroup on Nanomaterials (CASG Nano) (Breggin et al., 2009). The European Commission considers that REACH covers nanomaterials, since it covers all chemicals under its 'substance' definition (ECHA, 2010), but the details of how it applies to nanomaterials remain to be defined. For example, some nanomaterials may be manufactured in quantities that do not meet the tonnage trigger for registration under REACH and at the low tonnage levels, the testing data required (on health effects) are rather modest. This has suggested to some that concerns over the increased biological activity of nanomaterials will not be adequately covered by REACH as it stands, particularly if they are considered as the same substance as the bulk form. Testing approaches for larger forms of chemicals may not address the potential toxicity of nanoparticles satisfactorily, and therefore test guidelines may need to be modified.

Overall therefore, considerable uncertainty remains about the hazards and risks to workers of handling nanomaterials in the workplace. How these risks are communicated to and perceived by workers and employers is the topic of this review.

1.1. Aims and structure of the report

The review aims to:

- Summarise the general principles and theories of risk perception and communication, referring to relevant trends and current guidance on these topics. The potential for applying these principles for workers and employers involved with nanomaterials industry is explored where possible.
- Identify the stakeholders involved in risk perception and communication for nanomaterials in the workplace, and appraise relevant research, studies, surveys and risk communication initiatives that have been done to date at national and international levels, highlighting key examples as appropriate.
- Consider the gaps in knowledge and limitations of the risk communication initiatives in this area, and suggest ways these might be addressed, with a view to proposing how to communicate with workers and employers on the potential risks of nanotechnologies and highlighting the difficulties involved.

The review was carried out by a multi-disciplinary team, drawn from four EU countries (Denmark, France, Poland and the United Kingdom), with expertise in risk communication as well as in risk science and nanomaterials toxicity, and is divided into seven chapters, providing an introduction to the nanomaterials topic (chapter 1), a review of the general principles and theories on risk perception (chapter 2) and on risk communication (chapter 3), examples of challenges and difficulties linked to communication of risks and benefits of nanomaterials (chapter 4), a summary of relevant activities on risk communication for nanomaterials (chapter 5), conclusions (chapter 6) and recommendations that can be drawn from the studies and literature (chapter 7).

[1] http://ec.europa.eu/enterprise/sectors/chemicals/reach/index_en.htm

1.2. Method

The information in this report is drawn from searches of the published literature, Internet and grey literature[2]. These searches were based on the keyword 'nanomaterials', with the specific focus on: how risks have been communicated to different societal groups, focussing on workers and employers; studies and surveys that have been done to date on the perception and communication of the risks of nanomaterials; strategies and practices that have been used to date by official organisations at national, EU and international levels, as well as at sectoral level and by professional associations, to communicate the potential risks and benefits associated with producing or handling nanomaterials. The European Agency for Safety and Health at Work's (EU-OSHA) Focal Points[3] were contacted via a questionnaire in 2010 in order to help the authors of this report to access risk perception surveys and risk communication initiatives taking place in the EU countries with regard to nanomaterials, and primarily focused on workers and employers.

[2] Grey literature is authoritative primary scientific report literature in the public domain, often produced in-house for government research laboratories, university departments, or large research organisations, and yet often not included within major bibliographic commercial database producers.

[3] EU-OSHA's Focal Points are nominated by each government in Member State, Candidate and European Free Trade Association (EFTA) countries as EU-OSHA's official representatives and are usually the national authority for safety and health at work. They represent EU-OSHA's main safety and health information network and support EU-OSHA's initiatives with information and feedback and they work with national networks including government, workers' and employers' representatives.

2. Current trends and scientific theories on risk perception of nanomaterials

Understanding emerging trends in perceptions of nanomaterials is critically important for those who regulate risks for three main reasons. First, in the scientific context of uncertainty about almost every aspect of nanotechnology (definition, characterisation, toxicity, exposure levels) studying risk perception is a good way to grasp approaches and attitudes toward nanomaterials and to adapt the promotion of workers' safety and health measures. Secondly, because like biotechnology, nanotechnology will be affected by how the public reacts to its development and marketing, stakeholders have an interest in being able to predict public opinion. Thirdly, many of the factors that can heighten dread, feed conflict and delay appropriate prevention measures to be in place are present in relation to nanomaterials. We know from risk perception theory that risk characteristics such as lack of knowledge, lack of transparency, involuntary nature of exposure or delayed or uncontrollable effects, all of which could be relevant for nanomaterials, are predominant factors in 'high risk' judgment (Slovic, 2000). As long as there is 'insufficient evidence to carry out robust risk assessments of many existing nanomaterials' (UK Government, 2010), it will be important strategically to understand risk perception.

2.1. General principles and scientific theories on risk perception: questions for nanomaterials

For many years, recommendations to communicate risks were based on a model of communication developed in the 1940s by Shannon and Weaver about transmission (Shannon, 1948; Weaver & Shannon, 1963). In this approach, the negative public attitudes toward science were believed to be caused by a lack of adequate knowledge. This centred on information needs and the capacity to transfer, and was a mechanistic sender-receiver model. However individuals do not respond predictably to technical data and improving their understanding of the meaning of a message is not merely a question of providing more information or knowledge. Messages can become distorted by a person's existing perceptions, values and beliefs. Interference can also occur from other messages a person perceives to be related even when they are not. When considering risk perception, risk is not conceptualised as a simple mathematical function of event likelihood and severity of harm. Threshold values and other scientific notions often have no meaning to lay-people. A wide range of theoretical perspectives (technical, economical, psychological, sociological) has been developed about these phenomena, which form the basis of a multi-disciplinary risk perception theory. In the 1960s, pioneering work was carried out on the patterns of risk-benefit decision-making. Starr (1969) showed that acceptability of a risk is roughly proportional to the benefits associated with this risk and it is improved when the risks arose due to voluntary activities. This helps to explain our acceptance of risks associated with, for example, car driving or exposure to medical x-rays. In general, people dislike losses much more than they like gains. Individuals also have problems in interpreting numbers, especially low probabilities (Tversky & Kahneman, 1974), such that the frequency of rare risks tends to be over-stated. Conversely, the frequency of common risks tends to be understated (Fischhoff, Bostrom & Jacobs Quadrel, 1993). People also tend to give more importance to outcomes rather than probabilities (Finucane et al., 2000).

Therefore many specific factors influence risk perception and acceptance. Most depend on the qualities attributed by the perceiver to the source of risk. These have been identified by psychometric studies. They explain why some risks trigger higher states of concern than others, regardless of their assessment and 'tangible' likelihood or consequences. These factors are: the possibility of severe and irreversible consequences; whether the risk is unfamiliar or invisible, accidental or chronic; the characteristics of exposure (e.g. involuntary exposure), and several other risk characteristics, all of which are summarised in Table 1. Some factors dominate over others leading to apparent inconsistencies; for example whether exposure is voluntary may dominate over whether the damage is definitely fatal. Generally the factors that tend to determine the level of concern are dependent on both the positive and negative effects a technology may have, and the values or emotions of an individual. Their evaluation of risk takes place in a complex decision-making process where objective and scientific knowledge is not the key factor in risk assessment or acceptance leading to differences in opinion about the acceptability of a risk. Slovic (2000) has further summarised the factors into three main characteristics that drive

risk perception - the benefits associated with the risks, the catastrophic potential and the level of knowledge about risks. These factors are broadly similar throughout the world. They are present in relation to nanomaterials.

Table 1: Risk perception: Key characteristics and level of concern

Factors	Low risk perception factors i.e. factors decreasing perceived risk	High risk perception factors i.e. factors increasing perceived risk
Benefits	High benefits	Low benefits
Choice of exposure	Voluntary	Involuntary
Type of risk	Chronic – kills one person at a time	Catastrophic – kills large numbers of people all at once
Familiarity	Old risk	New (unfamiliar or novel source)
Catastrophic potential	Common – a risk that people have learnt to live with	Dread – a risk that evokes an emotional fear response
Visibility of exposure	Visibility	Invisibility
Individual control	Possible	Not possible
Origin	Natural source	Man-made
Risk management ability	No possibilities a priori[4]	Lack of effective measures
Knowledge about risks	Known to the individuals exposed (possible precaution)	Not known to the individuals exposed
Uncertainty	Known to science	Not known to science
Manifestation	Immediate or reversible damage	Delayed or irreversible damage
Damage	Definitely not fatal	Definitely fatal
Fair distribution of damage	Equitably distributed	Not equitably distributed
Damage visibility	Anonymous victims	Victims identifiable
Victims	Adult males	Children and women
Social or scientific status	Consensus possible	Controversial

Source: adapted from Slovic, 2000

[4] The lack of human possibility to control or manage risk tends to improve risk acceptance and decrease risk perception.

Risk perception factors depend not only on the general characteristics of a risk; perception is also affected by socio-demographic attributes, psychological disposition and the perceived context associated with risk events (communication, management and control). Thus, risk perception is rarely directly correlated to a strict assessment of potential gains and losses, but varies depending on the type of activity or on the individual. This does not mean that people are irrational. A mixture of technical knowledge, common-sense reasoning, personal experience, social communication and cultural traditions shape perceptions (Douglas & Wildavsky, 1982). Rather than a single data process, risk perception is more relevant to social representations. If the danger is real, we can claim that risk is a socio-psychological construct: definitions of risk depend on how the likelihood of a hazard is specified and measured; how undesirable the outcomes are and how individuals define their reality (Renn et al., 1992).

Social amplification and attenuation of risk (Kasperson et al., 1988; Kasperson, 1992; Pidgeon, Kasperson, & Slovic, 2003) occurs when hazard–related messages interact with social context (‘social arena’) in ways that can increase or reduce perceptions of risk and shape risk behaviour. How risk is appraised depends on the individuals, groups and organisations that receive, interpret, pass or provide information about risks. It varies with media coverage, pressure group activity, protest movements, the volume of information, and symbolism, contesting claims or dramatisation. These social amplification or attenuation phenomena lead to definition of the level of concern within the risk agenda. Proponents of this concept suggest that trust, which can be defined as 'confidence in the reliability of a person or a system' (Giddens, 1990), plays a major role in shaping opinions and risk decisions. According to Schuler (2004) 'trust is the cornerstone of risk communication because it influences public attitudes and behaviours'. Moreover, the 'low levels of public trust in government present real challenges for governments communicating the risks of upcoming technologies like nanotechnology'. It seems therefore, that risk acceptance depends more on the public’s trust in the source of hazard-related messages rather than on the estimate of the level of risk itself. Yet as Slovic claimed (2000), trust is fragile and once lost, it is very difficult to restore. Known as the asymmetry principle, negative events can undermine trust and overshadow good news. Trust can also be eroded by 'denial of the public's concerns' and the 'manipulation of the public opinion over the benefits and risks of technology' (Schuler, 2004).

Amplification phenomena may have important consequences; for example the loss of confidence in institutions, and it is a serious cause of concern for regulators. Furthermore confidence in industry and government is declining in many countries (Löfstedt, 2005), leading some to talk about 'post-trust societies'. Some of the explanations for this suggested by Löfstedt are: the 'sheer number and size' of recent regulatory scandals, the increasing concentration of political power and the media amplification with 24-hour television and the Internet, offering alternative sources of information. A number of other factors have a critical impact on levels of trust, notably competence, fairness and efficiency (Renn & Levine, 1991). Perceived competence relates to the degree of technical expertise; fairness refers to the acknowledgement and adequate representation of all relevant points of view; efficiency is about the right allocation of financial resources. Consistency and sincerity are other conditions: consistency relates to the strength of arguments based on experience and previous behaviour; sincerity involves honesty, objectivity, openness and equity, all of which are conditions for legitimacy.

The implication is that risk perceptions are not uniform across technologies, countries and time. For communicators, being able to manage the risk decision-making process in a rapidly evolving environment will require understanding of a wide range of risk perceptions and trust levels.

2.2. Current trends in perception of nanomaterials

An unprecedented amount of effort is being invested in research into the public perceptions of the risks and benefits associated with nanotechnology. Most research is exploring public opinion in the general population rather than the workplace. In 2009, a literature review counted 22 available risk perception surveys about nanotechnology carried out in the past decade, primarily in Europe, North America and Japan (Satterfield et al., 2009). To apply to communicating risks about nanomaterials, the results need to be carefully considered and expanded by further research.

Today, a large fraction of the public still knows very little about nanotechnology. The Eurobarometer survey carried out beginning 2010[5] shows that a majority of Europeans (54%) have never heard of nanotechnology (EC, 2010c). Another study of public familiarity with nanotechnologies based on comparable surveys in North America, Europe and Japan showed that more than 51% of all participants, who were asked about their knowledge of this new class of technology, reported knowing 'nothing at all', and nearly 30% 'just a little'. Only 20% claimed to know 'some' or 'a lot' about nanotechnology (Satterfield et al., 2009). There has been no clear trend of increasing familiarity over the period 2004 - 2009: in 2005, about 75% of the EU population had a poor knowledge (from nothing to little) of nanotechnology (EC, 2005b). However, there are important differences between countries (EC, 2010c). In some Scandinavian countries (Norway, Denmark, Sweden), public awareness seems to be higher than elsewhere: at least three quarters of respondents have heard of nanotechnology, while some countries have only a quarter of respondents having heard of it (e.g. Portugal, Malta). In the US, 47% of participants reported no knowledge.

The awareness is significantly dependant on socio-demographic data. Gender is a factor (54% of men compared to 39% of women have heard of nanotechnology) as is educational level (EC, 2010c): those who have heard of nanotechnology are managers or left school to go into full-time education or are everyday users of the Internet, while those least familiar with nanotechnology left school early and are non-users of the Internet.

An interesting finding is despite this low level of knowledge, the public expects benefits to predominate over risks for nanotechnology (Satterfield et al., 2009): even though a large minority of those surveyed gave 'don't know' responses or remain unsure about nanotechnologies (40% in Europe), more participants judged that the benefits would exceed the risks than the reverse in nine of the surveys that asked this question. In Eurobarometer 2010 (EC, 2010c), 50% of respondents expect benefits for people. Concerning risks, only 27% consider nanotechnology as not good for them and their family, while 37% consider nanotechnology is good for them. These results contradict the usual findings, particularly the fact that when risk objects are 'new', 'unknown to science' or 'not observable', they are generally judged as highly risky. In a European online public consultation (EC, 2010b), NGOs were the only respondents who said that risks were higher than benefits.

However scientists also express concerns. A comparison between two recent national surveys among nanoscientists and the general public in the US shows that, even if experts are in general more optimistic than the public about benefits of nanotechnology (Scheufele et al., 2007), scientists express greater concerns than the lay public about two areas of potential risks from nanotechnology: pollution and new health problems (Scheufele et al., 2007; EC, 2010b). In a Taiwanese survey (Cheng et al., 2009), which compared the perceptions of nanotechnology between the general population, workers and experts, the percentage of experts who were 'very worried' about the potential risks of inhalation exposures to nanoparticles was twice as high as that of the general population or workers, whilst more than 80% of workers were worried about the adverse health effects of dermal exposures to nanoparticles. This does not mean that the public should be more alarmed about the environmental or health-related risks associated with nanotechnologies than they currently are, but rather, that there is a serious communication and perception gap between scientists and workers as members of the public. This may partly arise due to the ongoing debate in scientific and policy circles about risks. This debate needs to be voiced more broadly.

Risk/benefit awareness is increasing with the expansion of businesses producing or employing nanomaterials (EC, 2010b). In the European Commission's public online consultation (EC, 2010b), various stakeholders perceived the risk-benefit equation for nanomaterials differently (see Table 2). Respondents had to indicate their main concern about the current state of development

[5] The SPECIAL EUROBAROMETER N°341 covers the population of the respective nationalities of the 27 European Union Member States, resident in each of the Member States and aged 15 years and over. 26,671 interviews were realised by TNS and partners between January and February 2010 to represent the whole territory of the countries surveyed according to EUROSTAT. Based on questionnaire, all interviews were conducted face-to-face in people's homes and in their national language.

of nanotechnologies. For individuals and organisational respondents, the major concerns were the possible toxicity of poorly understood nanomaterials, as well as their possible effects on workers' health and the environment, followed by the lack of adequate information provided to the public on potential benefits and risks. Businesses' major issue of concern was not occupational hazards but the existence of obstacles to innovation. In businesses, concerns also vary with the size of companies. The results of the NanoRoadSME's European survey on the potential of nanomaterials in small and medium-sized enterprises (Steinbeis Europa Zentrum, 2005) show that few SMEs are concerned with health and safety questions associated with nanoparticles (less than with nanomaterials properties or economical potential). Moreover, this survey shows that SMEs also think that public acceptance of nanomaterial is not a problem (in general and for their business) as only 3% agree with the statement that 'Public social acceptance is considered as a barrier for the application of nanomaterials'. The authors of the report suggest that 'this shows that there is a lack of awareness on the potential risks of such aspects for the nanomaterial branch among SMEs'. In this context the lack of knowledge or concern about occupational health and safety hazards of nanomaterials in SMEs would appear to be a significant challenge for risk communication and risk management.

Table 2: Level of concerns about risks of nanomaterials in the European Union

Group	Concerns	
	Possible toxicity	Possible effects on workers' health
Individual researchers	70%	63%
Individual non- researchers	65%	70%
Research organisations	79%	75%
Businesses	47%	52%
NGOs	90%	90%

Source: adapted from European Commission, Public online consultation, 2010b

Based on stakeholders' answers, the major considerations about risks can be described. In addition to the concerns about health and safety, a number of specific attitudes and challenges about risk communication appear (see Table 3).

Table 3: What stakeholders say and do on nanotechnology communication

	What they say	What they do
Industry	Risk assessment is adequate	Setting guidelines
Start-ups	Assessing risk is expensive	Reluctant to raise safety issues
NGOs	Focus on risk	Ask for more testing/regulation
Regulatory bodies	Knowledge development is strategic	Enhancing current regulation
Insurers	Dialogue on risk	Worrying publicly

	What they say	What they do
Researchers	Funding is needed	Studying public attitudes
Media	Enthusiasm, suspicions	Wondrous prospects/Haunting stories
Consumers	Magic, out of control	Disorientation

Source: European Commission, Communicating Nanotechnology, 2010d, p.27

The area of application of the technology also affects risk perception. In European consultation (EC, 2010b), the perception of the associated risk in areas such as information and communication technologies (ICT), energy, construction, aerospace and protective equipment was modest or non-existent. Whereas, nanotechnology as well as food, environment, agriculture, biotechnology and cognitive science were perceived to be areas of high or very high associated risk. Potential technological solutions to recognised societal problems, such as alternative electricity generation or water treatment, tend to meet with approval (EC, 2010b). In such cases, citizens may accept a reasonable level of risk. Biotechnological or medical applications to enhance or improve humans engender far more concern. A recent analysis of Internet discussions in Germany shows that between '20% and 25% of product-based posts, depending on the subject area, assess the use of nanotechnology as non-beneficial' (Böl et al., 2010). Nanomaterials in the food industry are a special example that raises a lot of concern amongst the public. Risk perception studies have shown that the use of nanomaterials in food packaging is less of a concern than nanoparticles added to food for consumption (Siegrist et al., 2007a); acceptance of nanomaterial ingredients in cosmetics is higher than in food (Böl, 2009); consumers are also more positive to non-food applications such as medicine (IRGC, 2008; Max-Planck, 2010; Stilgoe, 2010; Böl et al., 2010).

For workers, risk perception of nanomaterials may also depend on the material's descriptors and how these compare with materials used in the past: e.g. mass, particle number, morphology, surface area. Some workers may not think that they are at risk when handling nanoparticles because of their comparatively small mass, compared with well-known risks associated with the same chemical in a larger form (Drais, 2009). Conversely, the fear about handling carbon nanotubes may increase because of the association of their fibre morphology with that of asbestos. Overall therefore, risk perceptions towards nanomaterials result from a combination of the application-specific risk / benefit calculations and the adaptation of existing value frameworks to novel hypothetical scenarios. The current situation and level of risk awareness may however change with future events and as the technology evolves.

In risk perception theory, it is commonly accepted that the greater the level of familiarity with risk objects, the greater is the belief in benefits versus risks. In most studies on general risk perception, when gaining familiarity, the proportion of respondents judging that 'benefits exceed risks' increases. However, the expectation that such benefit judgments will further increase with knowledge should be treated with caution, as the studies below show opposite findings.

A study of nanotechnology judgments and cultural biases found no support for the familiarity hypothesis, which proposes that acceptance, increases with knowledge (Kahan et al., 2009). For example, undecided individuals appear to absorb the attitudes of those with whom they perceive that they share values. A recent study about medical applications of nanotechnologies showed that giving information about risks and benefits may initiate two opposite types of reaction: positive responses in people who were already informed about the technology, but negative responses amongst those lacking such knowledge (Shipman, 2010). The impact of providing balanced information appears to be surprising: whilst provision of risk information increases risk perception and provision of benefit information increases benefit perception, provision of balanced risk-benefit information amplifies the perception of risk (Fischer & Frewer, 2009). When presented with risk / benefit information, 42% of study participants became more negative about the technology, 46% did not change their attitudes and only 12% became more positive (those who were highly educated). Some individual dispositional factors seem to influence the public's perceptions about nanotechnologies and whether they react positively or negatively to them:

'Persons of diverse values are inclined to construe whatever information they are furnished with in opposing ways that reflect their cultural predispositions toward risk generally' (Kahan & Rejeski, 2009, p. 4). Researchers speak about a 'risk of cultural polarisation': they caution against assuming that acceptance will spontaneously emerge when information is provided on the risks and benefits of nanotechnology (Scheufele & Lewenstein, 2005).

A further problem is that scientific knowledge is needed to gain an understanding of technologies such as nanotechnology. Moreover, the gap in knowledge between people from different educational levels tends to increase such that the level of nanotechnology knowledge is increasing in the qualified population but is decreasing in the unqualified population (Corley & Scheufele, 2010). These phenomena call into question the knowledge transmission and information strategies developed by scientists, public authorities and stakeholders: they have to reconsider the translation of laboratory results and the use of different information or news sources. On this subject, the analysis of internet-based discussion in Germany found 'the assessment of nanotechnology in reviewed online discussions is more negative overall than the general population's appraisal recorded in surveys' (Böl et al., 2010). There is therefore a need for further studies to examine the impact on perception of information exposure between various levels of familiarity to nanotechnologies and how individual characteristics (including gender, race, cultural world views, religion) affect risk perception. This is critical for the development of communication strategies. A large portion of the public is still unwilling to make a risk versus benefit judgement; therefore suggesting that risk judgement is highly malleable and could move in either direction (Satterfield et al., 2009).

Table 4 summarises the nanomaterials risk perception literature that describe a number of specific - and sometimes contradictory - phenomena, some of which contradict some long-standing findings about risk perception in general. The persistence of uncertainties about nanomaterials effects may be a reason for this. It can be concluded that, when communicating about nanomaterial risks, it is important to be aware of the generally limited knowledge of the general public, and that understanding and perceptions differ significantly between countries, organisations and workplaces (producers, users, etc.). People, including workers, are very easily influenced by their social group's shared values, particularly in relation to technology and the environment. An assessment of workers' attitudes and likely behaviour should be included in workplace risk assessment. Indeed, if workers do not perceive risks to be serious then risk control measures that rely upon these perceptions to exhibit specific safe behaviours are unlikely to be effective. Supervision and training is, therefore, required which will need to include appropriate risk communication. See Chapter 3 for guidance on how to achieve this whilst taking into account peoples' perceptions.

Table 4: Key findings of studies about perception of nanomaterials

Key findings	References
1. Public knowledge about nanotechnologies is very limited. Most people are not familiar with the terms nanotechnologies or nanomaterials There has been a limited increase in familiarity over the period of time of the surveys (2004 - 2009)	EC, 2005b, 2010b, c, d Currall, 2009 Helland et al., 2006 RS & RAE, 2004 Cobb & Macoubrie, 2004 Scheufele & Lewenstein, 2005 Satterfield et al., 2009
2. Despite low level of knowledge, the public expects benefits to predominate over risks Judging that benefit will exceed risks increases significantly with level of familiarity	Petersen & Anderson, 2007 Satterfield et al., 2009 Siegrist et al., 2008 Max-Planck, 2010; Stilgoe, 2010

Key findings	References
Balance depends on applications (food, medicine) Public is more optimistic about NT in US than in Europe	Burri & Bellucci, 2008 Gaskell et al., 2004
3. Many members of the public remain uncertain about the risks and benefits associated with nanotechnologies.	Satterfield et al., 2009 Cormick, 2009
4. Beyond risk appraisal, greater familiarity with nanotechnologies does not lead automatically to a more positive attitude[6]. Attitudes toward nanotechnology depend on other factors than familiarity.	Kahan et al., 2009 Shipman, 2010
5. Experts are more concerned than the public with regard to pollution and 'new health problems' of nanomaterials (contrary to the situation with others risks) There is growing concern about risk to workers	EC's Public Online Consultation, 2010b Cheng et al., 2009 Scheufele, Corley et al., 2007
6. When lacking knowledge, people use 'heuristics' to assess the risks and benefits. Appraisal can be affected, for example, by religious beliefs and other cognitive schemes or frames. Factors such as perceived naturalness, personal control/influence, etc. influence risk perception.	Kahan et al., 2009 Lin et al., 2008 Scheufele et al., 2007 Siegrist et al., 2008 Rozin et al., 2004
7. Cultural predispositions and perceptual filtering influences (negatively or positively) how new information is received and assessed Attitudes toward nanotechnologies tend to polarise in accordance with prior attitudes toward technology and the environment	Kahan et al., 2009 Powell, 2007
8. Trust in institutions involved in using or regulating nanomaterials improves perceived benefits	Siegrist et al., 2007a Siegrist et al., 2007b Cheng et al., 2009

[6] As other risks, attitude towards nanotechnologies is not only a question of risk assessment. Beyond risk perception, attitude (line or stand that influence action) is linked to several factors independent from familiarity

2.3. Media framing of nanomaterial risks

Framing is a concept broadly used to designate certain schemes of representation: frames select, organise and interpret an event or issues. Individuals and organisations usually use previous experience as a framing device for both reasoning, making judgments and public communication. The well-known 'story telling' narrative approach used by politicians is an example of framing. The word framing is used to refer to the active process of framing as well as to the result itself. Framing theory has been used to analyse studies about public communication and public understanding of nanotechnology (Anderson et al., 2009).

The media is more than just a source of information about risk; it helps shape public opinion and how issues are initially framed (Honig Priest, 2009; Morgan, 2005). The book by Anderson et al. (2009) deals with issues surrounding risk communication to the public by and through the media explaining the reasons why certain stakeholders rather than others set and reinforce the news agenda through recognising what makes a good science story and pushing certain issues to be more visible in media.

As attitudes to risk are volatile, one of the most urgent needs for nanotechnology risk communication is message framing. Indeed, for information processing, the salience of nanotechnologies applications and risks has a large impact (Kahan et al., 2009; Schütz & Wiedemann, 2008).

Dominant news frames of nanotechnology have been identified in newspapers from the United States, the United Kingdom, The Netherlands and Denmark; the majority of articles follow feature narrative styles. The frames are mainly 'scientific discovery and projects', 'social implications and risks of nanotechnology', 'science fiction and popular culture', 'science and technology policy', 'business stories' and 'educational and career advice'. In relation to all articles, the percentage of risk-related articles has remained below 20% over the past ten years (Nielsen, 2010).

Some framing studies of newspapers have also looked at the dominant article tone that is weighing benefit and risks (Wilkinson et al., 2007). In general, newspaper articles have reported on nanotechnology in a passive tone with no evaluation of benefits and risks. In articles where there is a tone, the positive and optimistic tone about benefits clearly outweighs the negative and pessimistic outlooks. In a very small percentage of news articles with perceived risks mentioned, similarities are highlighted between nanotechnology and genetically modified organisms or biotechnology, pointing to a need for new tighter regulations, or the articles discuss earlier mistakes or side effects of other technological introductions such as asbestos (Nielsen, 2010).

In addition to press coverage, nanotechnology has attracted coverage in the mass media, such as the Internet and television programs. As with newspapers, popular mass media framing of nanotechnology has generally been optimistic. The number of television programs or websites devoted entirely to nanotechnology remains limited and restricted to educational purposes.

So far, media coverage of nanotechnology has been presented to the public in different ways that vary according to the main roles and status with which the public views nanotechnologies. News stories seem to be designed to present information to the public in three dominant frames: as laypersons, consumers and stakeholders (Leinonen & Kivisaari, 2010). Each of these ways of framing conveys a different image of what nanotechnology is and supports an alternative argument for why engagement is important (Wickson, Delgado & Lein Kjølberg, 2010). These last authors believe that if a socially responsible development of nanotechnologies is to take place, a different frame is required which considers the public as a citizen. For responsible research, informed citizens are required, that is, people who are empowered to actively engage in democratic shaping of science and technology in order to meet social needs and accommodate plural values.

Wickson Delgado & Lein Kjølberg (2010, op. cit.) claim: 'Understanding the significance, implications and utility of different ways of framing nanotechnology for the public or workers, and being sensitive to how these frames support different nanomaterials and justifications for why engagement is important, is necessary for the development of a more nuanced discussion on exactly who or what we are referring to when we are talking about risks and prevention'. Rogers-Hayden and Pidgeon (2007) felt, just four years ago, that dialogue about nanotechnology had yet to be framed.

2.4. Implications for risk communication on nanomaterials

Emerging nanotechnologies and their associated uncertainties pose a new set of challenges for researchers, governments, industries and citizen organisations that wish to develop effective communication strategies early in the development of the technology. Faced with deciding how to approach this for nanotechnologies, communicators firstly have to challenge the traditional science and technology communication approach called the 'deficit model', according to which the public must understand science in order to accept it. As claimed by the European Commission (2010d) 'the deficit model is no longer working well and seems completely obsolete'. The 'scientific understanding of the public' has now become more important than the 'public understanding of science' (Bonazzi & Palumbo, 2007). Data on the levels of public awareness and opinion of nanomaterials are needed to identify the concerns and the factors that influence public judgments.

Communicators need to engage in an open dialogue with the different stakeholders including the public and integrate all of their viewpoints into decision-making processes (see Section 3 of Chapter 3 for further information and guidance). A balanced risk-benefit communication approach is required and increased transparency in risk governance systems will result in risk benefit assessment also becoming more transparent (Piegorsch & Schuler, 2008; Pidgeon et al., 2008).

A special place needs to be made for scientists in the communication strategy. Research in the US has shown that research (particularly university-based) scientists are one of the handful of groups that the public most trusts for information about nanotechnology, much more than government bodies, regulatory agencies, industry or the news media (Scheufele et al., 2007). Although there may be differences between countries, people such as doctors, health professionals and university researchers emerge as the most convenient and trusted sources of information about risks (Berube, 2010; see Table 5). The relatively low level of attention that health and environmental risks of nanomaterials have received in the mass media currently provides a unique opportunity for industry, university scientists or other recognised stakeholders to take a leadership role in communicating the risks and benefits, and engaging with the public in a meaningful dialogue about nanotechnology and nanomaterials. However, Anderson et al. (2009) invites scientists to consider to what extent they themselves create controversy, through their particular use of language and the very different perspectives scientists and journalists have towards, for example, detail, use of technical language, timescales and peer review.

Table 5: Top 5 trusted sources for information about health and safety risks

Rank	Sources
1	Doctors and health professionals
2	University researchers
3	Family members
4	Friends and acquaintances
5	Industrial researchers

Source: Berube, 2010

Mass media and new information technologies (the Internet, blogs, wikis and social networking) appear to be an effective way to develop knowledge amongst members of the public since the level of familiarity with nanotechnology correlates with the amount of time spent surfing the web (Corley & Scheufele, 2010). In fact, nearly 70% of the adult US population state that they consult the web to find information on scientific topics. However, neutrality of search results from the Internet is not guaranteed since the most used keywords for searching the web are those suggested by search engines: e.g. the suggested links to nanotechnology medical applications websites are disproportionate to other links (Ladwig et al., 2010). The framing of search engines

on the web that influence public opinion could be developed into a strategy for risk governance. Increasing the profile of specific links in selected topics could influence public opinion. The rapidly growing use of the Internet for scientific information research gives a special place to its abilities and as a tool for risk communication. Despite the Internet still being behind television in the list of favourite media for information about risks (see

Table **6**), its use needs to be studied further.

Table 6: Favourite media sources for information about risk to health and safety

Rank	Sources
1	TV programmes
2	Internet: ▪ news accumulators ▪ personal accumulators ▪ health blogs ▪ social networking sites ▪ wiki sites
3	Radio programmes
4	Newspapers

Source: Berube, 2010

To conclude, five areas have to be considered for nanomaterial risk communication: the perception-specific mechanisms, the cultural attitudes, the way the risk is framed, the role of the media and the place of scientists. All these aspects inter-relate and contribute to shaping the public perception and acceptance of risks (Schuler, 2004). Faced with persistent uncertainties about characteristics, applications, hazards and measurement of nanomaterials, these aspects have to be combined to communicate. Full consideration is needed into how guidance is adapted to, and how initiatives take account of, these aspects. Above all the imperative is to avoid the recurrence of past problems or crises in the face of uncertainties, as the European Environment Agency (EEA, 2001) suggests (see box below).

Twelve late lessons from early warnings

1. Acknowledge and respond to ignorance, as well as uncertainty and risk, in technology appraisal and public policymaking.
2. Provide adequate long-term environmental and health monitoring and research into early warning systems.
3. Identify and work to reduce ‘blind spots’ and gaps in scientific knowledge.
4. Identify and reduce interdisciplinary obstacles to learning.
5. Ensure that real world conditions are adequately accounted for in regulatory appraisal.
6. Systematically scrutinise the claimed justifications and benefits alongside the potential risks.
7. Evaluate a range of alternative options for meeting needs alongside the option under appraisal, and promote more robust, diverse and adaptable technologies so as to minimise the costs of surprises and maximise the benefits of innovation.
8. Ensure use of ‘lay’ and local knowledge, as well as relevant specialist expertise in the appraisal.

9. Take full account of the assumptions and values of different social groups.
10. Maintain the regulatory independence of interested parties while retaining an inclusive approach to information and opinion gathering.
11. Identify and reduce institutional obstacles to learning and action.
12. Avoid ‘paralysis by analysis’ by acting to reduce potential harm when there are reasonable grounds for concern.

3. Review of general principles and scientific theories on risk communication

3.1. Why risk communication for nanomaterials is important

Many of the factors, discussed in Chapter 2 on risk perception, for example uncertainty and lack of familiarity, which can heighten public concern/dread, are present in relation to nanomaterials. This can lead to the social amplification of risk, and feed conflict. The lack of reliable and accurate technical data on the topic and the debates that have taken place within the scientific community to provide a clear, universally acceptable, definition for nanomaterials (CST, 2007; Petersen et al., 2009; Alford, 2009; SCENIHR, 2010), provides a fertile ground for confusion, controversy and delay in putting control measures in place (IRGC, 2010) and for opposing sides to draw contradictory and sweeping conclusions (Max Plank Institute, 2010), leading to misunderstandings that can foster public and stakeholder distrust (Bostrom & Löfstedt, 2010). Moreover, the nano-brand is fragile and could easily be damaged by a public scare (Stilgoe, 2007), even by something using the nano-label that does not include what would generally be considered to be nanomaterials in the product, for example, the Magic-Nano bathroom cleaner that was recalled 'when six people were hospitalised with respiratory disorders after using the product within days of its release onto the German market' (Stilgoe, 2006).

There is however a strong consensus of the importance of nanomaterials risk communication, including public engagement to counter negative perceptions and to address the concerns of society (often raised by novel science or emerging technology), so as to gain public trust and acceptance thereby securing the long term development necessary for the benefits of nanomaterials to be realised (Burchell, Franklin & Holden, 2009; EC, 2001; EPA, 2007; Framing Nano Consortium, 2010; House of Lords, 2009; Jakl et al, 2009; NanoKommission, 2008; Schuler, 2004). An effective open and balanced dialogue with all concerned parties about potential risks and benefits is widely recognised as key to enabling responsible, healthy and sustainable development of nanotechnology (Brekelmans, 2009; Bostrom & Löfstedt, 2010; EPA, 2007; Framing Nano Consortium, 2010; Pidgeon et al, 2008; Piegorsh & Schuler, 2008; RS & RAE, 2004; UK Government, 2010).

The European Commission (2008a), in its code of conduct for responsible nanosciences and nanotechnologies (N&N) research, recognises both the need for 'a high level of public health, safety, environmental and consumer protection' and 'the need to identify and address safety concerns (real or perceived) at the earliest possible stage'. This code of conduct also includes the need for risk communication.

Extracts from the European Commission Code of Conduct, (EC, 2008a)

The governance of N&N research activities should be guided by the principles of openness to all stakeholders, transparency and respect for the legitimate right of access to information. It should allow the participation in decision-making processes of all stakeholders involved in or concerned by N&N research activities.

Member States should cooperate with the Commission in order to maintain an open and pluralistic forum for discussion on N&N research at Community level as a means to stimulate the societal debate about N&N research, encouraging the identification and discussion of concerns and hopes and facilitating the emergence of possible initiatives and solutions. Accordingly, Member States should enhance communication on benefits, risks and uncertainties related to N&N research.

With due respect for intellectual property rights, Member States, N&N research funding bodies, research organisations and researchers are encouraged to make easily accessible and understandable, by lay people as well as by the scientific community, all N&N scientific knowledge as well as related information such as relevant standards, references, labels, research on impacts, regulations and laws.

Member States should encourage private and public sector laboratories to share best practices in N&N research, with due respect for the protection of intellectual property.

N&N research organisations and researchers should ensure that scientific data and results are duly peer-reviewed before being widely disseminated outside the scientific community in order to ensure their clarity and balanced presentation.

Highlighting the need to devote due attention to the societal aspects of nanotechnology, the Commission:

(a) calls upon Member States to pursue an open and proactive approach to governance in nanotechnology R&D to ensure public awareness and confidence;

(b) encourages a dialogue with EU citizens / consumers to promote informed judgement on nanotechnology R&D based on impartial information and the exchange of ideas;

(c) reaffirms its commitment to ethical principles in order to ensure that R&D in nanotechnology is carried out in a responsible and transparent manner.

In addition to the recognition of the need for good risk communication about nanomaterials, calls to governments to do so is widespread across sectors (Grobe, Doubleday & Hale, 2007; Mayer, 2002; Nanomed, no date; RS & RAE, 2004; RS & RAE, 2006; UNEP, 2009) and includes both those who wish to 'guarantee that the development of nanotechnology is not impeded by public opinion' and those who wish 'to ensure it is not too readily and blindly accepted' (Wood, Jones & Geldart, 2003).There is also some evidence that the public wants to engage in dialogue about nanotechnology (Stilgoe, 2007). There is even the view that if the involvement of the public in the decision making process is successful regulation would become redundant (Loveridge, 2002). Greenpeace and others have insisted they would 'strongly object to any process in which broad public participation in government oversight of nanotech policy is usurped by industry and its allies' (Friends of the Earth, 2007).

A project carried out by the Inter-Departmental Liaison Group on Risk Assessment in 1997-8 (ILGRA, 1998) also found that 'communication is of fundamental importance in the regulation of risks. It allows people to participate in, or be effectively represented in, decisions about managing risks. And it plays a vital part in putting decisions into practice - whether helping people to understand regulations, informing them and advising them about risks they can control themselves, or dissuading them from antisocial and risky behaviour.' The project also found that 'good regulation reflects society's informed values and preferences' enabling 'people to participate in decisions, and to assist willingly with compliance' and that 'this can only be achieved by communication - both listening to and engaging people, as well as informing them'.

Due to the high uncertainty regarding the health and safety risks of nanomaterials (as explained in Chapter 1), the application of the precautionary principle (PP) is recommended (EC, 2008a). However there is also some evidence (from a limited study with 44 lay people in a workshop format) that the public does not always support this view and may 'reject an overly precautionary approach' (ScienceWise, 2010a). Nevertheless minimising worker exposure is considered, by most, to be a sensible precautionary approach (Schmid, 2006; HSE 2011; NanoKommission, 2008; NIOSH, 2009; Ostiguy et al., 2009). For this to be effective workers need to understand the need for prevention and control measures, how to use them correctly and be motivated to do so. There are also calls for greater communication and collaboration amongst industry, in both directions through supply chains (also sometimes referred to as the value chain), with government and with the academic community to avoid duplication of efforts, share information and to facilitate the development of best practice (Borm, Houba & Linker, 2008; Framing Nano, 2010; Jakl et al., 2009; NanoKommission, 2008; UK Government, 2010;).

There are many benefits from good risk communication; those given by the OECD (2002) include:

- people being 'informed of how to protect themselves and how to distinguish between reliable and unreliable information';
- risk managers gaining 'a better idea of the concerns and preferences of consumers [and other] stakeholders';
- enhancing 'an atmosphere of trust and mutual respect that is essential for co-operation and joint problem solving, in particular in crisis situations'.

There are, however, some dissenting voices (Sylvester, Abbott & Marchant, 2009), and it would appear that there are those who question whether government action can achieve the goals of: 'ensuring that public opinion does not mistakenly view nanotechnology as dangerous, restoring public trust in government, and increasing the legitimacy of government action through increased public participation' and ask whether government action is 'more likely to increase existing divisions over nanotechnology's future'. For example in a survey (Helland, Kastenholz & Siegrist, 2008) of 40 Swiss and German producers of nanomaterials or products containing nanomaterials, 14 of them felt that there was room for improvement in their inclusion of stakeholder concerns in product development and exactly the same number felt that this was not important. The findings of the French national dialogue described in Chapter 5 shows that others question whether government actions can be unbiased and not used to push people to accept the decisions already taken.

The next section describes the available generic guidance that could be followed to achieve effective risk communication about nanomaterials in the workplace or elsewhere.

3.2. Relevant guidance and research about risk communication

'Decisions about communication involve much more than just the choice of words and numbers'
Bennett, United Kingdom's Department of Health, 1997

According to Berube (2010) 'risk communication manages how a potential hazard is represented to multiple audiences'. Good risk communication requires dedicated effort, training and resources to build insights and will not compensate for failings or shortcomings elsewhere, such as a poor underlying scientific evidence base (Bouder & Lofstedt, 2010). It 'demands consistency and clear focus throughout' and 'requires both expertise and experience' (OECD, 2002). There are a wide range of approaches to risk communication (from simple leaflets to citizen juries) with different characteristics serving different requirements and audiences (Bouder & Löfstedt, 2010). Risk communication is not simply the provision of information (ILGRA 1998); it is a two-way process by which all sides can learn something from one another (Bennett, 1997; ScienceWise ERC, 2009).

Risk communication will not necessarily resolve conflict, guarantee understanding or cause people to behave in certain ways, but it can clarify the nature of disagreements, restrict their scope, help people make more informed choices and minimise resentment caused by people feeling excluded from decisions that affect them (Bennett, 1997). Risk communication can help: build trust, allow better decisions to be made on how to address risks, ensure smoother implementation of risk management policies, empower and reassure the public, help prevent crises developing and manage them when they do (ECHA, 2010). OECD (2002) states that 'risk communication should not be seen as an attempt to convince people, such as the consumers of a chemical product, that the communicator has done the right thing'. The principal function should be to assist stakeholders to arrive at a balanced judgement in relation to their own interests and values (IRGC, 2006; OECD, 2002).

Risk communication is not easy, either in general (IRGC, 2006) or specifically in relation to nanotechnology (Anderson et al., 2009); it requires resources (OECD, 2002; ECHA, 2010), needs to be carefully managed (ILGRA, 1998) and can still fail to give the desired outcome (Bennett, 1997). In addition, an increasingly sceptical public could derail even genuine efforts at transparency (Taylor, 2006). Guidance on risk communication for chemical risk management (OECD, 2002), aimed primarily at communication with consumers, but also with workers, makes clear that following all the advice given does not guarantee success.

- **Planning risk communication**

Risk communication is required at different stages of risk management or a decision-making process (ILGRA, 1998; IRGC 2006). OECD (2002) refers to it as 'an indispensable component of the risk management process throughout all its stages' from identifying the problem (sometimes referred to as framing the issue – a concept discussed in detail in Chapter 2), setting objectives, analysing the options, implementing a decision and evaluating the outcome. Any risk communication program should be tailored according to the stage of the risk management

process at which it is taking place and integrated into the decision making process (ILGRA, 1998; Jenkin, 2010). It also needs to be transparent, frequent and accurate (Max Plank Institute, 2010).

Risk communication is likely to be most effective if it is done proactively (Max Plank Institute, 2010); accuracy, relevance and getting the timing right is also essential (OECD, 2002; ECHA, 2010) because attitudes and beliefs, once formed are resistant to change (RS & RAE, 2004) and these will shape how new information is perceived (OECD, 2002) making it very difficult, if not impossible, to take any real dialogue forward. Unfortunately timeliness is commonly neglected (OECD, 2002) and a small study into scientists' experiences of working with the media in the nanotechnology field found that scientists generally adopt a reactive rather than a proactive stance (Petersen et al, 2009).

Before any communication exercise the evidence first needs to be assembled, acknowledging and considering any possible uncertainty (EEA, 2001), to 'demonstrate a credible basis for the position being taken' (RRAC, 2009). It is then necessary to identify the audience(s) by finding out who the different groups are that may be affected by the risk(s) i.e. benefit or suffer loss, have relevant expertise and whose co-operation is crucial. The communication method, approach and content needs to be tailored to the targeted groups (IRGC, 2006; Langford et al., 1999; NanoKommission, 2008) taking into account the diversity of information needs, expectations, perceptions, concerns and possible underlying reasons such as value systems (Berube et al., 2010; Renn, 2010; RRAC, 2009; EC, 2010d).

When regulatory bodies decide that people should make their own decisions about how to deal with risk, the communications requirements are generally, as stated by ILGRA (1998), to:

- understand the information people need to help them make decisions;
- ensure that unbiased information is available to them;
- advise and help support decision-making.

The effect of risk communication in this situation will depend on the intended audience's ability and motivation to process the message (Renn, 2010). A motivated audience, who receives a message such that it is able to process the information contained within it, is more likely to make a considered and balanced decision. If an audience is not able to process the information or it perceives it to not be particularly relevant to them then they are likely to form an opinion or attitude on the basis of an emotional/reflex reaction to a prompt (cue) or by finding a 'good-enough' solution based on intuition, experience or an educated guess (heuristics).

When a decision is made to regulate the activities of individuals or industries to protect those exposed to the risk, according to ILGRA (1998) there is a more complex set of communication requirements that include:

- gaining consensus on the level of risk that one person/group may impose on another;
- devising regulations generally accepted as fair and reasonable;
- ensuring that all involved understand the regulations and how to comply with them;
- ensuring that those at risk have access to information about: the risks, the controls put in place, and what they themselves can do to limit risk;
- monitoring and improving the rules, their relevance and acceptance, and compliance with them.

For emerging technology it will almost certainly be necessary to respond to new information about the likelihood or nature of risks or sudden media interest. Section 5 of ILGRA (1998) deals with responding to new information about risks explaining that it is useful to first screen issues to identify fright factors that might escalate the issue to a scare, such as those found in Table 1 all of which, as explained in Chapter 2, are applicable to nanomaterials.

Risk communication is also needed in crises, often under severe time constraints, so it is important that all the information is at hand and a system is established for detecting a crisis forming (EEA, 2001). ILGRA (1998) recommends being prepared in advance for a crisis by considering likely scenarios, identifying who the key stakeholders are likely to be, having the infrastructure, systems and procedures in place, including having trained authorised spokespersons available at short notice. ECHA (2010) gives similar recommendations but also

points out that the primary focus in a crisis should be the protection of the public and that this is much easier if relationships are already established with the key stakeholders.

For nanomaterials, risk is highly uncertain and therefore it is important that those responsible for managing risks are not only competent but also recognised as such. There is also the potential for controversy in relation to nanomaterials, and some already exists, so it is also important to justify risks in terms of potential benefits and the acceptability of risks from an ethical and moral perspective (OECD, 2002).

- **Building trust in the source**

Whatever the situation the audience needs to trust the messenger (Bennett, 1997; Walls et al, 2004; Berube et al., 2010; ECHA, 2010). The lower the levels of trust the more information that may be demanded from different sources (ter Huurne & Gutteling, 2009). Therefore equal emphasis needs to be given to thinking about how the messenger comes across as to what they say (ILGRA, 1998). In addition, trust can, unfortunately be very easily undermined for example by different organisations disagreeing in public. A perceived lack of agreement can 'create media coverage featuring duelling scientists and polarise public opinion' (Honig Priest, 2009). At the very least a confused scientific debate about risk can exacerbate some of the difficulties that people have in evaluating new information (IRGC, 2009). Guidance by RRAC (2009) recommends that organisations clearly establish what authority they have to communicate about a specific risk and then work together with other organisations that have an interest to reach consensus about who will take the lead and how they will relate to one another. However this is at odds with the recommendation that for transparency scientists need to debate both positive and negative aspects in full view of the public (Max Plank Institute, 2010).

It may be more effective to enlist the help of, or work through, partner organisations that may be better positioned to communicate with the intended audience (RRAC, 2009). It is valuable, therefore to identify those stakeholders with both interest and influence and actively seek to build relationships with them (ECHA, 2010) such as trade associations, suppliers and customers. Risk communication could be developed for delivery by different organisations to coincide with key events when businesses are seeking external advice for example when starting-up, developing a new product or expanding, training or recruiting new staff (McKinney, 2002). ECHA (2010) suggest that trust can be usefully built by regular communication about routine risks.

- **Enabling the receptor to act**

A random survey of the Dutch population (466 responses containing a wide range of educational and employment experiences including a few who had direct or indirect experience of an industrial accident) conducted by ter Huurne and Gutteling (2009) clearly indicated that not only does institutional trust influence people acting appropriately as a result of risk communication but so does a person's trust in themselves (perceived self-efficacy). They therefore concluded that an objective of risk communication should not only be to build trust in institutions but also to motivate people to trust in themselves to adequately deal with specific risks. Information about risks also needs to be personally relevant as this contributes to the adoption of risk-preventing behaviours and is more likely to establish long-term changes in behaviour (Kahlor, 2007).

One communication model, referred to as AIDA (EC, 2010d), recommends that communication materials need to gain people's **Attention,** arouse their **Interest**, provoke a **Desire** that changes their attitude and trigger an **Action** that leads to a change in behaviour. It adds that this can be achieved when people use interactive materials either web-based or physical at permanent exhibitions or road shows that create an emotional and/or thoughtful response.

When confronted with a hazard, according to a study by Lion, Meertens and Bot (2002) most people first require information about the nature and consequences of the hazard, followed directly by what they could do personally to prevent it from occurring, or how to influence the course of action of the risk if it were to occur. Only when the consequences were not considered to be personally controllable did people want to know what official agencies could do or had done about it. People need to know where they can obtain additional information, which by the way needs to be readily available and accessible (Anderson et al., 2009; ILGRA, 1998; Jakl et al., 2009; Max Plank Institute, 2010; RS & RAE, 2006; ter Huurne & Gutteling, 2009).

Finally, when communicating about risk it is important not only to succeed in conveying the right message but also to 'guard against choosing the wrong message' by 'taking too narrow a view' (Bennett, 1997).

- **Communication approaches**

A wide range of risk communication approaches are available, such as leafleting/mail shots, use of the Internet, presentations, seminars, citizen panels, expert hearings and press conference (OECD, 2002; Cabinet Office (UK), 2008; Berube et al., 2010, ECHA, 2010). Guidance is available (OECD, 2002) to help choose the appropriate approach on the basis of the stage of the risk management process, the target audience and the nature of the risk in terms of uncertainty and potential for controversy. One study found that for example that mail shots have only limited impact and that seminars are almost five times more effective (Rakel et al., 1999).

With regards to risk communication in workplaces, as nanomaterials are an emerging technology the sector contains a large number of SMEs. While in larger organisations, it generally is a senior manager responsible for occupational health and safety who is in charge of categorising the information for the workplace, in small companies it is the owner who generally does so. Therefore, the flow of information down to the workplace depends on their sense of what is or is not important (Gervais, 2006). Communication initiatives aimed at companies handling nanomaterials therefore need to target these individuals and make a convincing argument as to the importance of the issue in a format that takes account of the fact that they are very busy and have many other demands on their time.

One survey into the information needs of SMEs, for example, found that the information needed to be concise (no longer than four pages), well structured, focused on the most important hazards and what actions need to be taken, and clearly from an official source (McKinney, 2002). It was also shown that SMEs make more use of labels and posters than leaflets (EU-OSHA, 2003) and tend to favour verbal face-to-face communication (Gervais, 2007). Safety inspection visits were found to have a strong impact in improving the management of risk in SMEs and the resulting view that health and safety is financially beneficial, which is fortunate as SMEs are also strongly influenced by business success (Vickers et al., 2003). Inspectors therefore need to be provided with risk communication materials on nanomaterials so that they can pass on the key information.

Workers in SMEs also tend to rely upon other more experienced workers for information about risk(s) (EU-OSHA, 2003). So these workers need to be included in any communication initiative. For an external person to effectively communicate about risk they need to be able to command a similar level of respect as experienced workers and be able to challenge any ingrained attitudes.

Another important target group are opinion leaders and opinion makers (EC, 2010d) i.e. 'those people who are most concerned about the issue as well as most articulate about it' (Lazarsfeld, Berelson & Gaudet, 1944) as, according to Berube et al., (2010), 'if opinion leaders are provided with accurate information, there is a greater likelihood that the public will be well informed'. Those who are able to cascade information to others, known as multipliers (EC, 2010d), are also a good target audience. In the case of nanomaterials in the workplace these would be for example, regulatory inspectors, trade associations, suppliers, training providers and trade unions. Another source of information for SMEs are their customers some of whom may impose health and safety requirements on their suppliers. (Vickers et al., 2003).

- **Content of the message**

ILGRA (1998) emphasises the need to keep messages simple, and this is particularly relevant for SMEs (Gervais, 2006), but also stresses the importance to avoid patronising the audience. For guidance on developing message content the reader is referred to OECD (2002) who recommends:

- being clear about the intentions and making them central to the message;
- simplifying messages as much as possible without being inaccurate or excluding any relevant information;
- never assuming technical knowledge about an issue;

- starting with simple messages (general information) and gradually adding more complex issues (specifics);
- anticipating the interests and viewpoints of the target audience(s);
- understanding the socio-political and cultural context;
- placing risk in social context;
- pointing out the importance of exposure and dose;
- only using numerical probabilities in conjunction with verbal equivalents.

In relation with the last bullet point above, there is little point discussing numerical criteria for acceptable risk if the audience questions whether a new technology is justifiable on moral grounds; or discussing technical issues if the audience questions the competency of the organisations responsible (OECD, 2002). This is of particular relevance to emerging risks such as nanomaterials. Calman and Royston (1997) have produced a verbal and visual 'community risk scale' to illustrate probability in terms of the size a community needs to be before it is affected to help explain probabilities. For example a 1 in 10 probability will affect someone in a family whereas a 1 in million someone in a city and 1 in a billion a major continent such as Africa.

There are also benefits of using a narrative approach i.e. stories incorporating context, history and meaning. Stebbing (2009) discussed this approach with reference to Leggett and Finlay (2001) who found that stories through figurative language and imagery could minimise the barrier posed by scientific language. Stebbing explains that the use of narrative can 'assist in clarifying the ethical dimensions of risk' referencing Finucane and Satterfield (2005). She goes on to say that a contextual, emotionally and morally rich narrative can trigger both analytical and experiential modes of processing information that are important for risk / benefit analysis referring to Gregory and Slovic (1997) and Satterfield, Slovic and Gregory (2000). Berube et al. (2010) also recommends the use of narrative to reach inexpert audiences but also points out 'risk has a negative valence and will not result in a positive association with whatever technology is being discussed'.

Finally, all the aspects relating to ethics and risk-benefit assessment needs to be reliably addressed (Max Plank Institute, 2010; Anderson et al., 2009; RS & RAE, 2006).

Various surveys described in Chapter 2 show that almost half the population do not know what is meant by nanomaterial or nanotechnology and that there is a particularly low level of knowledge in SMEs. It has been shown that an increase in knowledge is usually accompanied by better arrangements to manage risk (Rakel et al., 1999). Any risk communication about nanomaterials needs to begin by first explaining what the nano prefix means and how it affects a material's properties. It is also important to clearly explain what is already known about potential health risks and that where uncertainties still exist a precautionary approach to prevent exposure is necessary. As explained in Chapter 2, people tend to underestimate familiar risks, therefore for some materials at the nanoscale, where people are very familiar with the base name such as silver for example, it may be difficult to convince them of the need to take precautions so the unique properties need to be emphasised. One survey, described in Chapter 2, indicated that a large proportion of people are worried about dermal exposure to nanomaterials therefore this could be a useful starting point in terms of first explaining how to reduce this risk and then pointing out that there are other routes of exposure, such as inhalation, and how to control these too.

Much of the important aspects for risk communication mentioned above are captured in Renn's 16 guiding principles for risk communication (Renn, 2008), whereas the Risk and Regulation Advisory Council (2009) provides a useful starters guide. Guidance on what risks should be communicated, when and how in relation to chemical risks, particularly under the REACH regulation[7], is given in the European Chemicals Agency guidance (2010).

[7] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), *OJ L 396*, 30.12.2006, p. 1–849. Available at: http://eur-lex.europa.eu/Result.do?T1=V2&T2=2006&T3=1907&RechType=RECH_naturel&Submit=Search

Guiding principles for risk communication (Renn, 2008):

1. Be clear about your intentions and make them the central message of your communication effort.
2. Simplify your message as drastically as you think you can do without being inaccurate
3. Place your simple messages in the beginning of a text and gradually add the complex issues.
4. Anticipate the interests of your target audiences and design your communication program to match their needs.
5. Devise different communication programs for different target audiences.
6. Messages should be distributed on different channels and feedback communication should be stimulated and encouraged as much as possible.
7. Be honest, complete, and responsive in the composition of your message.
8. Try to escape from role expectations by using a personal approach and by framing the communication to the personal experience of the addressed receiver.
9. Allocate enough time for packaging your message, but do not change your message in order to make the package more attractive.
10. Be careful in selecting the right cues for appealing to the peripheral audience without offending your central audience.
11. Explain the risk rationale to your audience and demonstrate the logic and adequacy of this rationality without claiming superiority.
12. Place risk in social context and report numerical probabilities only in conjunction with verbal equivalents.
13. Institutional performance is the major key to trust and credibility. The more you can demonstrate that you did a good job, the more you can expect trust in your message.
14. Risk managers have to learn from the public as much as the public can learn from them.
15. You can only convince the receivers of your message if it addresses their concerns and interests.
16. Encourage or initiate attempts to conduct a rational discourse, in particular for third level debates.

Finally it is important to evaluate any risk communication initiative in order to demonstrate that it has been effective (ScienceWise-ERC, 2010b; Bennett, 1997; CST, 2007; Cabinet Office (UK), 2008) and the results recorded and disseminated (ECHA, 2010). This should be done 'in terms of content, process and outcome in relation to effectiveness in achieving the prescribed goal, efficiency (costs in proportion to accomplishments) and learning of all involved' (OECD, 2002). Success can also be assessed in terms of outputs – number and content of communication media; outtake – what people have learnt (taken home with them) and outcomes – changes in attitude and behaviour (EC, 2010d). Comprehensive guidance on the evaluation of public participation can also be found in Warburton, Wilson and Rainbow (no date).

3.3. Relevant guidance on public dialogue

Public dialogue is a specific type of risk communication that can be used to find common ground on which to build consensus on contentious issues (Honig Priest, 2009), inform policy and build participants' confidence in the decision-making process (ScienceWise-ERC, 2009). It should be about 'encouraging wide-ranging debate about and deliberation upon substantive issues raised' (Anderson et al., 2009). It renders decision-making more open and transparent and helps lead to better quality outcomes (Fiorino, 1990). It should not restrict decisions to choosing between a limited set of alternatives but help participants to set the agenda (ScienceWise-ERC, 2009). Government bodies are increasingly engaging with the public to inform political or regulatory decisions particularly in relation to emerging technology for which policy and regulations are

absent or unclear. For this reason it is often referred to as 'upstream' engagement (ScienceWise-ERC, 2010b). However, moving public engagement upstream will fail if deficits in public knowledge, understanding and trust are not also adequately tackled (Rogers-Hayden & Pidgeon, 2007).

Scientists (particularly those working in the life-sciences) expressed the view, during a sociological analysis of their understandings, perspectives, judgements and experiences, that public engagement was 'a means of democratically addressing publicly-defined priorities and improving the ways in which scientific research and clinical activities are undertaken, as well as helping to define the questions that scientific researchers might address' (Burchell, Franklin & Holden, 2009). Public dialogue is most effective when there is a clearly explained and recognised benefit that can be obtained from any new technology, as is the case for medical applications of nanomaterials, but success is compromised if those benefits appear to be very uncertain or not likely to be realised in the short-term (Jenkin, 2010), for example the use of nanomaterials in food and renewable energy.

Public dialogue according to ScienceWise-ERC (2009) and others such as Renn (2008) is not:

- one-way communication or 'information gathering';
- representative - participants do not formally represent their geographic area or discipline;
- a talking shop with no policy purpose;
- about the public actually making decisions;
- about simply supporting or seeking acceptance for preconceived policies.

The principles of public dialogue as described in this section could be used by any organisation to engage with workers to inform policy, processes or procedures. However ScienceWise (2010a) points out that 'the enthusiasm for involving the public more closely in decisions about science policy may not be universally shared' and in 'some parts of the academic community, it may be perceived as an assault on academic autonomy' or 'on pure science values'. Furthermore, 'as traditional gatekeepers between the experts and the public, the media might not be sympathetic to such new forms of engagement' and 'some may consider it incompatible with democracy in that ministers should be responsible to parliament not to a small group of people in a citizens jury'. However for effective risk communication it is important for all stakeholders to be more involved in the process (RS & RAE, 2006; CST, 2007).

Some scientists have expressed their concerns that these approaches 'cannot claim to be representative and do not provide any guide as to where the weight of public opinion lies' (Burchell, Franklin & Holden, 2009). Berube et al. (2010) goes further stating that public engagement models, whilst well intended are often 'deficient in reaching their idealised goals because of inadequate sampling procedures, lack of demonstrable impacts and costs' and that they 'may improve the process of decision-making but not necessarily produce better policy'.

The guiding principles for public dialogue on science and technology-related issues as outlined by ScienceWise (2009) include:

Context - being clear about the context of the dialogue in terms of the objectives, how it will feed into policy (including what policy-makers need from these activities to ensure that the outputs are useful to them), be funded, resourced and conducted.

Scope - including the aspirations of all stakeholders, and focused on specific issues, framing them, where appropriate in consultation with the participants, being clear about the extent to which participants will be able to influence outcomes and involving an appropriate number and demographic cross-section of the population so as to give robustness to the eventual outcome.

Delivery - conducting the dialogue competently and fairly, providing information and views from a range of perspectives and allowing sufficient time for participants to familiarise themselves with the information, think about it and discuss the issues.

Impact - ensuring that the recommendations are directed towards those best placed to act upon them and that participants views are taken into consideration such that they and the wider public can see how they have influenced policy or decisions.

Evaluation - ensuring that lessons are learnt and disseminated about both the process and outcome in relation to the original objectives and expectations of all the stakeholders.

Incorporating the results of public dialogue activities into policy is not straightforward. Effective mechanisms need to be developed for incorporating the views of stakeholders in governance (Max Plank Institute, 2010; RAE & RS, 2006). It is also important to provide feedback to explain to the participants what happened because of the initiative (Framing Nano consortium, 2010; (UK), 2008). Information on sustaining public involvement is given in ScienceWise (2010c).

- **Expert involvement**

Guidance is found in ScienceWise (2010d) on how to commission and make the best use of 'expert' advice in public dialogue and within the wider policy-making process, looking in some detail at the practical aspects and potential challenges, including those caused or influenced by cultural issues. The report explains the importance of fully considering the role of the experts during the planning phase and ensuring that there is fair representation of the range of views that may exist. The benefit of doing this is that certain experts such as doctors and scientists score highly in terms of public trust (see Chapter 2).

Experts need to have an appropriate depth of relevant knowledge, be respected in their field (i.e. trusted) and be able to communicate their knowledge. They also need to be fully briefed and the briefing may differ in detail from that for lay participants to whom they need to be properly introduced. A group of 30 scientists, when questioned (see Burchell, Franklin & Holden, 2009) stated that their primary role was 'that of a relatively passive scientific expert who responds to public participants questions' but some also felt that there was the 'potential for scientists to act as advocates to more deliberately direct the course of the dialogues'.

The same study found that ensuring that there is the motivation for experts (and the organisations they work for) to participate in the process could be a problem as it can be seen as a time-consuming distraction from their core scientific activities. Public engagement was 'universally seen to be under-incentivised and under-rewarded, potentially detrimental to research and professionally stigmatising'. This is echoed by Featherstone, Wilkinson, and Bultitude (2009) who found that the rewards for experts involved in public engagement were unclear. Feeding back the results to the scientific community via conferences, journal publications or other scientific platforms is therefore essential to ensure that their contributions are recognised and valued.

Another challenge is aligning expert input to the needs and input of the lay participants, which can be hindered by the use of specialist technical language or specific definitions given by them to words in general use that may have much broader definitions for non-expert participants. A number of phrases commonly used by experts such as 'you can't argue with the facts…'; 'the evidence is incontrovertible'; 'if you've studied this as long as I have…' need to be avoided as they tend to shutdown discussions. Experts may also question the value of input from lay people into a highly scientific field (ScienceWise, 2010d).

- **Engaging with the participants**

A report by ScienceWise (2010d), describes a number of case studies, exploring the potential challenges, including those outlined above, in more detail. They also propose as a first step to get the participants, (with help from the facilitators who may need to provide options), to review their own information needs and say what they believe they may require and in what format. This can provide more focus rather than overwhelming participants at the beginning with large amounts of information, due to the assumption that they know nothing but need to know everything. This approach also helps ensure against accusations of bias in the provision of information. The report also points out that sometimes it becomes apparent as the dialogue progresses that it is necessary to bring in new or different expertise.

Guidance on widening public involvement in dialogue is provided by ScienceWise (2010b). This document explains the reasons why policymakers may wish to widen participation in terms of numbers of participants or a broader demographic, cultural and/or ethical representation. Those reasons of relevance to this review are:

- when investigating areas of uncertainty and associated risks a wider participation can make the process more searching, reducing the chances of missing anything of importance;

- to increase understanding among as many people as possible and turn this into influence by creating a crowd-effect and generating media attention;
- to provide credibility of findings for political decision makers;
- to provide legitimacy for the policy or decision among citizens (securing a mandate), building trust and making policies and decisions more defensible in the case of, for example, a later legal challenge;
- to explore a range of different views, groups or types of citizens who may be affected.

The report then goes on to make various recommendations including how to avoid certain pitfalls. Those of relevance to this review are:

- simply involving a larger number of people does not in itself guarantee a greater diversity of views as it depends who they are. Furthermore as soon as an event starts, the participants are likely to influence each other and cease to behave as isolated individuals with separate opinions;
- the extent of understanding and acceptance depends on the methods used rather than the fact of involvement per se. A wider audience will be reached if subsequent campaigning complements the dialogue, with communication of the conclusions and how they were reached.

IRGC (2009) also cautions that an excessive emphasis on including participants from all demographics can slow down the process, leading to inefficiency and diminished trust in the process.

- **Assessing the costs and benefits of public dialogue**

The costs and benefits of public dialogue are given in some detail in ScienceWise (2010e), including those for some major public dialogue initiatives and how they were evaluated. The report also describes some of the risks that can lead to unintended or indirect costs of public dialogue such as creating opposition, hijacking of the process by a minority group and a source of occupational stress for staff who are unable to handle the high levels of support the public may demand or conflicts that arise between the people participating in the dialogue. The report then proposes a framework (and various criteria) for evaluating public dialogue initiatives, explaining what should be evaluated, how, why and when.

A tool is also available that can be used to define any organisation (including policy-making authorities) in terms of their current engagement preferences and character, i.e. how natural public engagement is, and on this basis to select approaches and frameworks for public dialogue that are most likely to work for them (ScienceWise, 2010f).

3.4. Risk communication issues specific to nanotechnology and nanomaterials

According to Macnaghten, Kearnes and Wynne (2005), public engagement has 'become part of the orthodoxy of twenty-first century science policy, and nanotechnology has arrived at precisely the moment to make it a test case for this new type of governance'. Unfortunately the strong competition in the nanotechnology industry results in the need to get a product to market as quickly as possible and also means that most producers are concerned about commercial confidentiality (Framing Nano Consortium, 2010). This can lead to:

- limited information on risks;
- limited access to information about the composition of products;
- limited access to workplaces for measurements of exposure;
- contracts prohibiting the chemical analysis of purchased raw nano-materials.

A resolution passed by the International Conference on Chemicals Management 'encourages the wider dissemination of human health and environmental safety information in relation to products containing nanomaterials, while recognising the need to protect confidential business information' (UNEP, 2009). RS & RAE, (2006) expect it to be possible for safety information to be put in the public domain in a way that does not reveal proprietary information about the composition of individual products. IRGC (2009) points out that 'an excessive focus on confidentiality may reduce trust in risk management and in decision-makers by raising suspicion that the shield of confidentiality is being used to advance or protect particular interests without adequate justification' but balance this by also pointing out that 'excessive transparency may not respect the need to protect legitimate interests'.

One of the objectives of the French national programme for health at work for the period 2010 - 2014, is to strengthen the national regulations towards a compulsory declaration of nanoproducts manufactured or imported before they can be put on the market, and to 'improve the information to workers likely to be concerned by exposure to waste containing nanoparticles' (Ministère du Travail, de la Solidarité et de la Fonction publique, 2010). The European consumers' organisation (BEUC), and European consumer voice in standardisation (ANEC) have together established an inventory of products claimed to contain nanomaterials or to have been made using nanotechnologies and that are available on the European market. A first, short version of the inventory was published in June 2009 but a long, updated version was published in early November 2009 based on research carried out between September and October 2009. This new inventory showed that 'some of the products initially promoted as including nanoingredients in June 2009 subsequently abandoned such claims, possibly indicating a change in the perception of market advantage or fears of negative public perception' (Degallaix & Giovannini, 2009).

Good practice and standardised labelling of products containing nanomaterials would also be helpful (RS & RAE, 2004; UNEP, 2009; Framing Nano Consortium, 2010). The European Parliament (2009b) called for 'an inventory of the types and uses of nanomaterials on the market, including safety aspects' as well as for 'better consumer information in the form of mandatory labelling indicating 'nano ingredients' regardless of risks' (Brekelmans, 2009; EP, 2009b) such as that required by the EU Cosmetics Directive[8], the first European legislation to do so. According to BSI (2007) a common approach to labelling could 'help to avoid confusing or inappropriate use of the term 'nano'' and 'should take into consideration the level of knowledge and understanding of those who are intended to read the label, in order to avoid any misinterpretation that could lead to confusion and misuse of products'. BSI (2007) also states that 'openness and transparency should accompany the responsible introduction of new technologies to the marketplace' and that 'labelling, as part of this approach, helps consumers to make informed choices'. However some concerns have been raised about the additional costs associated with labelling requirements and the potential creation of trade barriers (D'Silva & Bowman, 2010).

Still, one purpose of risk communication is to enable consumers, whether public or professional, to safely use products. The guidance provided by BSI (2007) contains advice on the provision of appropriate information for use differentiated between professional and non-professional users. Detailed guidance is also available on how to supplement safety data sheets with nano-specific data, such that they contain the information necessary to ensure the safe handling of nanomaterials and of products that contain nanomaterials (VCI, 2008).

A further difficulty is the lack of adequate training programmes and the high cost of those that do exist; seen as two of the most important barriers to the supply of skilled people in the field (UK Government, 2010). There is, therefore, an opportunity to provide materials to training organisations to enable them to incorporate risk communication about nanomaterials into their courses. Developing entirely new courses is not necessarily needed as existing job-related training could be adapted (Jakl et al., 2009). Training courses and exercises on risk communication are also needed for scientists (Berube et al., 2010; IRGC, 2006). For an example of such a course specifically aimed at risk communication in the occupational setting see the

[8] Regulation (EC) No 1223/2009 of the European Parliament and of the Council of 30 November 2009 on cosmetic products (Text with EEA relevance), *OJ L 342*, 22.12.2009, p. 59–209. Avalaible at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:342:0059:0209:EN:PDF

British Occupational Hygiene Society one day course (BOHS, 2010), and more particularly in the field of nanotechnology, the international advanced six-day course on public communication and applied ethics of nanotechnology (RAE & NIA 2009) developed under the EU 6th framework NanoBio-RAISE project.

Since future generations are those most likely to be affected by emerging technologies (in the workplace) it is therefore important that ways are sought to involve them in public engagement and to consider their possible education and training needs (UK Government, 2010). The Framing Nano Consortium (2010) also found that there were 'very few practical aids and learning materials available to support teachers'. One notable exception is the German Chemical Industry Association (VCI) NanoBox programme, which provides teaching materials for schools that include lesson plans and experiments. A whole chapter of the GENNYSIS project (Max-Planck Institute, 2010) is devoted to specifying higher education needs to create a successful nanotechnology industry and includes requirements on communicating about risks.

Further challenges for nanotechnology risk communication were listed by IRGC (2006) lists, as summarised below, and are also in line with the recommendations of EEA (2001):

- gap in the communication of interdisciplinary research results between science communities;
- gap in communicating the state of the art in science and development between the scientific community and regulators, NGOs, the media and the public;
- gap in communication between the risk management agencies and the public of the implications and intentions for regulation and control;
- gap in communication of sufficient background information to enable relevant parties to conduct their own risk-benefit comparison or make a balanced reflection about the social and ethical acceptability of the likely positive and negative impacts;
- gap between the pace of risk communication and the speed of technological development.

The wide diversity of nanotechnology applications and nanomaterials also poses a challenge (Max-Planck, 2010). This has led to calls for public engagement to be more focused on specific applications rather than on nanotechnology in general' (Nordman & Rip, 2009; Schuler, 2004). As stated by RS and RAE (2004) 'issues rarely become matters of concern merely because of the underlying science or engineering. More typically they are associated with specific applications'.

Finally, Framing Nano Consortium (2010) cautions that 'nanotechnology engagements deal with difficult and unfamiliar technical questions, which take time to understand' and there is therefore the danger of having the same debate repeatedly. Finding a way of observing a learning curve by building on previous work will therefore be a key to progress, which requires 'deciding what information to communicate, how and where to share it with the public'.

A Delphi exercise run by Framing Nano Consortium (2010) identified the following priorities for risk communication, which are in tune with the European Environment Agency's twelve 'late lessons from early warnings' (EEA, 2001):

- make available to the public clear and transparent descriptions of the approach to regulation and funding, and to anticipating benefits, costs and risks;
- make clear where there are uncertainties in what is known;
- make available to the public information on who has the responsibility to regulate and support nanotechnology;
- make available to the public a range of scientifically informed opinions of the technology, i.e. pros and cons;
- foster communication between the main players and provide enough means to organise this communication;
- enhance the ability to communicate scientific findings and their meaning.

The next chapter describes and analyses various current and past nanomaterial risk communication and associated initiatives that draw to a lesser or greater extent upon elements of the good practice guidance described in this chapter.

4. Examples of challenges and difficulties of risk communication with nanomaterials

In this chapter some of the complexities and pitfalls of risk communication of nanomaterials are discussed, providing examples wherever possible, which exemplify how reporting science within the frame of 'nanoparticles' and marketing products with the 'nano-brand' may cause misunderstanding or confusion, and lead to overstatements and unsubstantiated generalisations. An analysis of information in material data sheets is provided.

4.1. Communication based on limited scientific evidence

The complexity and diversity of nanoscale forms of chemicals can lead to the generation of misleading information on their properties and result in ambiguity in risk communication. Toxicological investigation of environmental ultrafine particles and engineered nanoparticles has expanded greatly in the last decades. This has led to a greater understanding of the spectrum of toxic potencies of different particles and that the effects associated with fine and nano-sized particles of different chemical composition, size and shape differ tremendously. A feature of nanomaterials is that many nanoparticles are designed to be chemically inert, non-volatile and insoluble in biological and ambient environments. Toxic effects of insoluble materials are not well understood but many investigations have demonstrated that properties such as size, shape, crystal phase and chemical composition greatly influence their interactions with biological systems, and if we fail to recognise this, risk assessment will be unreliable. Consequentially, risk communication may generate confusion and lead to underestimation of the risks with consequent damage to health and the environment. In other instances it may also lead to unjustified fears. This makes risk communication on nanomaterials more difficult than for traditional chemicals.

Measures have been proposed to avoid misinformation and ensure that risk assessment in the working environment is based on sound evidence. Aitken et al. (2009) reminded their research colleagues who publish and review papers on the human health impacts of engineered nanomaterials, and who communicate with the media, the public and decision-makers, to:

- ensure that all descriptions of nanoparticle hazards recognise the intrinsic heterogeneity of nanoparticles and discuss the uncertainty of alleged causality;
- ensure that there is a convincing and scientifically sustainable link between any nanoparticle exposure and any pathological outcomes putatively associated with that exposure;
- ensure that sufficient physical and chemical characterisation data are provided on the nanoparticles in question to support valid data interpretation and comparison.

The triggering event for the expression of their concern was a paper published with a title that suggested that the inhalation of nanoparticles was the cause of seven serious cases of lung and pleural injury in workers in a small factory in China (Song, Li & Du, 2009). It was reported that nanoparticle structures were identified during histological examination of lung biopsies and pleural fluid from the affected workers. Aitken et al. (2009) questioned whether the observed structures were particles that had been inhaled or resulted from a biological host-reaction. They therefore questioned whether the conclusion about a relationship between inhaled generic nanoparticles and the observed effects was justified.

Aitken et al. (2009) raised the following concerns:

- The type of severe lung injury described had not been reported before following any nanoparticle exposure, except possibly for Teflon fumes, which may consist partly of nano-sized particles.
- The magnitude, nature and composition of the occupational exposure were not measured.
- The composition of the nanoparticles found in the biological samples was not analysed.
- The exposure was chemically very complex.
- The nanoparticle surfaces may have adsorbed toxic gaseous species.

- The workers were spraying large quantities of polyacrylate powder in an unventilated space.

Overall therefore, the study offered only tentative evidence for an association between exposure to a specific nanoparticle and the health effects observed. However, the paper appeared in a reputable scientific journal, proposing a causative link between nanoparticles and an evolving severe, even fatal, lung condition. Aitken et al. (2009) suggested that this type of exaggeration could bring the peer review process into question and misinform public dialogue on nanoparticle toxicity. The process in which scientific observations are made, and hypotheses are formulated and developed into accepted concepts or theory, should be based on critical review, re-testing and consensus building. A single paper or single observation may not be accepted as sufficient evidence of an effect in the scientific community even if it is published in a peer-reviewed journal. The article by Song, Li & Du (2009) mentioned above and accompanying press release emphasising the speculated association between 'nanoparticles' and pulmonary disease may have promulgated a myth of generalised nanoparticle toxicity, and potentially misled the public and the media into believing there is some reason to fear all 'nanoparticles'. Regulation of chemicals usually involves careful balancing of different data, uncertainty and extrapolation. Communicating to a wider audience on the degree of certainty of an observation published in a scientific paper to a wider audience, and in how far this observation can be generalised, is a very complex matter.

4.2. Ambiguous use of the 'nano' word and poor product labelling

According to the Scientific Committee on Emerging and Newly Identified Health Risks, by most definitions available, manufactured (or engineered) coatings with thicknesses at the nanoscale are also nanomaterials (SCENIHR, 2010). Products that produce such coatings could also be argued to be nanomaterials in spite of the fact that they may not contain nanoparticles at all. Such products, marketed with the ‘nano’ brand, have been identified on the consumer market. In 2006, 'Magic Nano' coating products sold directly to consumers caused more than 153 incidences of severe lung disease or breathing distress in Germany, Switzerland and the Netherlands. A comprehensive toxicological investigation of the products was published (Pauluhn, Hahn & Spielmann, 2008). The authors studied the toxicity of 'Magic Nano Glass & Ceramic' and 'Magic Nano Bath' in inhalation experiments in rats and found that 'Magic Nano Glass & Ceramic' was significantly more toxic than 'Magic Nano Bath'. The product was reportedly analysed by the German Verband der Chemiches Industrie (a chemical industry association), but the full chemical analysis has not been published. However, it was claimed that the product did not contain nanoparticles. The toxic ingredient (or combination of several ingredients) and the precise mechanism of toxicity remain unknown (German Federal Institute of Risk Assessment, 2006). Because all of the spray ingredients do not seem to have been stated in the Safety Data Sheets (SDS), it is possible that the product contained toxic ingredients that represented less than 1% of the total content, in which case it was not required to be listed. In the aftermath of the Magic Nano incident, there was considerable discussion in the media and in scientific fora of what lessons could be learnt. Better communication of opinion and data from the industry and trade organisations, who did not much participate in the discussions, might have created greater reliability of and trust in the findings communicated and less damage to the 'nano brand'.

Scientists have investigated the respiratory toxicity of aerosols from a small selection of 'nano-sprays' that were sold to Danish consumers (Nørgaard et al., 2010). One of these was severely toxic at doses to which humans might potentially be exposed. It induced lethal damage in the lungs, including bleeding and atelectasis when tested in mice. After a careful chemical analysis of the product and toxicological testing of a possible reconstructed chemical composition, the toxic agent was identified as perfluoralkylsilane (Nørgaard et al., 2010). This chemical seems to form a nano-thin coating on the sprayed substrate. The investigation urged the Danish Environmental Protection Agency to issue a recommendation for withdrawal of the product from the market (because the product was not labelled as hazardous, as it should have been) and a warning against similar products.

It is a general problem that labelling, risk assessment and communication is incorrect, misleading or non-existant. Historically people have been harmed and the environment damaged many times

for this reason. It has been demonstrated the public has greater expections and less fear associated with 'nanotechnology' than with concepts such as 'chemical manufacturing plants', 'surface impregnation of building materials', 'water disinfection' or 'chemical fertilisers' (Currall et al, 2006, Siegrist et al., 2007b). 'Nanomaterials' seem to have much better reputation than 'chemicals'. When nanoparticles are associated with adverse effects this may threaten public acceptance, and hence, the commercial value of the 'nano' brand. This may be the reason why major cosmetics producers have been cautious with marketing with the 'nanolabel' although many cosmetics on the market contain nanoparticles; why producers of old nanomaterials such as silica fume and pigments have been reluctant to refer to their products as 'nano'; and why, in spite of major investments in nanotechnology research, it took five to ten years before nanosafety research was made a priority in Europe and the USA.

4.3. Challenge of communicating complex risk messages

A company, that supplied nanoproducts to the Danish consumers and SMEs, was contacted by an individual who warned that a company's spray product with photoactive titanium dioxide (TiO_2) might be dangerous. He asked the supplier to voluntarily withdraw the product from the market. The spray was used for treating windows to make them dirt resistant. According to the foreign manufacturer, the spray product contained less than 1% nanosized TiO_2. The deposited TiO_2 nanoparticles would oxidise organic deposits on the glass under exposure to solar ultraviolet radiation, which should keep the window dirt free. The individual warned that if the photoactive component was deposited on the skin it might cause skin damage. The supplier asked a toxicological laboratory for advice. Since there is documentation for the safe use of TiO_2 in cosmetics applied to the skin (e.g. sunscreens), up to levels of 25%, the toxicological laboratory judged that it was unlikely that any health effects would occur after accidental deposition of the window spray on the skin (Poulsen, 2008). However, after some time the discussion reached the printed media. The supplier was afraid that it was difficult to communicate the information to the media and that further media attention would be detrimental to his business. The company therefore chose to withdraw the product from the market (Poulsen, 2008).

This case illustrates the difficulties in communicating complicated hazard information and uncertainty to the public and workers. Workers who daily handle substances, including nanomaterials, at work and receive certain health and safety information through SDS and other workplace sources (e.g. product labels, work instructions) will be confused if they are presented with conflicting information from other sources, such as the media. It is important that enough time and attention is allowed for communicating complicated risk assessment issues and controversial information. Risk assessment is not 'black and white' and it is important that uncertainties are dealt with for ensuring an effective precautionary approach in the workplace.

4.4. Poor information on nanomaterials in Safety Data Sheets (SDS)

Safety data sheets (SDS) are an important information tool for the safe handling of chemicals at workplaces but they do not always provide adequate information about nanomaterial risks to companies and workers lower in the supply chain. In 2007, three toxicologists examined the quality of 30 SDS for nanomaterials available on the market within the framework of a project of the Nordic Council of Ministers (Schneider et al., 2007). The SDS were retrieved between June 2006 and January 2007. They were either for products made by European manufacturers or for products available on the European market as identified by the Google search engine. The SDS in six categories of materials were evaluated:

- 8 SDS for silica;
- 4 SDS for titanium dioxide;
- 2 SDS for zirconium dioxide;
- 11 SDS for carbon nanotubes;
- 2 SDS for C60 fullerenes;

- 3 SDS for cadmium-based quantum dots.

The toxicologists designed a check-list containing evaluation criteria based on the instructions 'Guide to the compilation of safety data sheets' in the annex of the EC Directive 2001/58/EC[9]. Each SDS was evaluated against the checklist, focussing on whether the toxicological information was reasonable and accurate in relation to published scientific data.

The toxicologists drew the following conclusions:

- In general the identification of the substance and company were adequate.
- In general the material composition was well described.
- The EINECS number for many materials was missing – mainly in SDS designed for non-EU countries.
- Some CAS numbers were missing.
- R-phrases were missing and inconsistently listed in many SDS.
- Classification and labelling were missing many times due to lack of available toxicity test results for the substance or compound in question.
- Test results were often missing or only available for acute toxicity and irritancy endpoints, but the references were missing.
- Most of the carbon nanotube (CNT) materials were identified as graphite.
- First aid and fire-fighting measures were provided but in some cases it was uncertain whether the measures were adequate due to lack of relevant information and classification.
- The quality of the proposed handling, storage and exposure control / personal protection measures varied between SDS for the same types of material.
- Descriptions of physical and chemical properties, conditions and materials that should be avoided were very different between the SDS.
- All SDS lacked descriptions of the dustiness of the material.
- Some SDS had well described lists of exposure limit values and toxicity tests, but for some materials the toxicological properties varied.
- Very little ecological information was available in the SDS.
- Only a few of the SDS were available in the Nordic languages.

This investigation showed that the quality of the information was very variable. Two principal problems were identified. Firstly, there was a shortage of data to inform the SDS: there were not sufficient published toxicological and physical characterisation data on the nanomaterials in the scientific literature. There was also a lack of data on whether the properties of the nanomaterials were different from those composed of larger particles.

Secondly the instructions in the EC Directive 2001/58/EC were not appropriate for the risk assessment of nanoparticles. For instance the Directive recommends that dustiness information is included in the SDS. However since this is not mandatory, dustiness data are rarely mentioned in the SDS, although this property is just as important for nanomaterials in powder form as vapour pressure is for volatile organic compounds (for which there is a requirement for reporting in the SDS).

This review of SDS showed that in 2006-2007 CNTs were usually identified as graphite in the SDS. Since then, there have been scientific reports that CNTs may be more hazardous than

[9] Commission Directive 2001/58/EC of 27 July 2001 amending for the second time Directive 91/155/EEC defining and laying down the detailed arrangements for the system of specific information relating to dangerous preparations in implementation of Article 14 of European Parliament and Council Directive 1999/45/EC and relating to dangerous substances in implementation of Article 27 of Council Directive 67/548/EEC (safety data sheets) (Text with EEA relevance), *OJ L 212*, 7.8.2001, p. 24–33. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2001:212:0024:0033:EN:PDF

graphite: some types of carbon nanotubes have been reported to have some biological effects similar to asbestos (Takagi et al. 2008; Donaldson et al. 2010). For this reason the perception of the hazards of CNTs has changed, and a superficial review of new SDS reveals that the major European manufacturers today do not identify them as graphite. In the USA, CNTs were registered as a chemical entity in the Toxic Substance Control Act Inventory (TSCA) in 2008, which has had legal consequences for their classification in the USA.

Problems with the usefulness of information of SDS have also been pointed out by the Austrian Central Labour Inspectorate (ACLI, 2009) and by Borm et al (2008). Often, the quality of the information in SDS was found to be poor, not specific enough or sometimes not even accurate. SDS often lacked information on particle size and data on dustiness were scarce. Errors regarding the identification of substances and risk phrases were found and it was questioned whether the control measures recommended were effective. Many times essential scientific data were judged to be missing in the listing of test results. It is likely that much of the information in SDS and other information materials specifically designed for the workplace is difficult to understand or even useless for the recipients in the workplace. SDS were often only available in one language (usually English).

In June 2007 the EC Directive 2001/58/EC was superseded by REACH[10] and in January 2009 the European Regulation (EC) No 1272/2008 on Classification, Labelling and Packaging of Substances and Mixtures (CLP Regulation)[11] came into force. Under the scope of these regulations, new requirements for information on nanomaterials, including in SDS will most likely be formulated. CNTs are in the ECHA 'List of pre-registered substances' (ECHA, 2011) and they will, thus, be subjected to the risk assessment under REACH. This will impact on discussions about the classification of CNTs, on risk perception and risk communication about CNTs as well as on recommendations for their safe handling and exposure control measures.

4.5. Conclusions

Most media coverage of nanotechnology is framed within technological and industrial development. People seem to have expectations of greater benefit and less risk with 'nanotechnology' than with 'chemicals' although of course in the end nanomaterials are one kind of chemicals. Perhaps the emotional value of the concept 'nanotechnology' is at risk. This may be the background for the great media coverage of the MagicNano event. This may be the reason why a Danish company withdrew a nano-product from the market upon media coverage of unsubstantiated warnings and why scientists are worried that the mention of nanoparticles in a scientific report in conjunction with a workplace accident may lead to unjustified fear. SDS are important instruments for risk management in the workplace: As discussed in this chapter and pointed out in our survey (see chapter 5 and Appendix 2) the Austrian Central Labour Inspectorate (ACLI, 2009) and Borm et al (2008) also identify problems with the usefulness of information of SDS for nanomaterials.

[10] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), *OJ L 396*, 30.12.2006, p. 1–849. Available at: http://eur-lex.europa.eu/Result.do?T1=V2&T2=2006&T3=1907&RechType=RECH_naturel&Submit=Search

[11] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, *OJ L 353*, 31.12.2008, p. 1–1355. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:353:0001:1355:en:PDF

5. Activities on risk communication and perception for nanomaterials

This chapter explores stakeholders, both primary and secondary, and their ability to influence the risk communication agenda with respect to nanomaterials. Partly the content of this chapter is based on information provided in 2010 by EU-OSHA national Focal Points[12] on national activities on risk communication on nanomaterials and nanotechnology.

5.1. Stakeholders in relation to nanomaterials

Nanotechnology encompasses many disciplines (medicine, engineering, aerospace, nanocomposites, food and cosmetics) and many types of stakeholders. Risk assessment and communication has to address both health and environmental hazards, societal perceptions as well as legal and ethical implications. Effective mechanisms are therefore required for the provision of clear interdisciplinary information and sharing of knowledge about risk related issues among stakeholders.

When communicating about risk it is beneficial to identify who are the key stakeholders, including which organisations are influential and trusted, what each group needs to know, the sources of information they can / are likely to use, and the mechanisms available through which they can exchange information with one another. There is no simple solution to 'who' and 'what'; it depends on the hazard, how much is known about it (true or false) and the stakeholders. While the information provided in Chapters 2 to 4 will guide risk communicators on how they should approach the task, judgement of their particular issue will always be required.

A stakeholder, in this context, is a person, group, or organisation who has a financial or other interest in a nanotechnology and seeks or merits a voice in decision-making.

In this chapter the concept 'key stakeholder' is restricted to those who have strong direct financial or social interests in nanotechnology and those who are or should be targets N&N risk communication because their health and well-being may be at risk due to the use of N&N at the workplace.

Employers, workers and producers are defined in this review as key stakeholders (section 5.2) because they have a direct influence on how risks are handled and communicated at workplaces within the EU. The EU Commission, EU Parliament and EU Member States are also key stakeholders because they are the ones responsible for the legislation, which forms the framework for how risks are communicated, and in some cases are themselves active in the risk communication. Other parties, such as trade associations, trade unions, and other organisations are described as 'other stakeholders' (section 5.3).

Many governments, international institutions, trade associations, trade unions, industries and other organisations have set up useful approaches for risk communication on N&N for reaching many interested stakeholders. At present, information about risks is available from many sources in different formats (guidance, brochures, websites etc).

Cooperation between stakeholders may be a fruitful way for producing balanced information, to access formal and informal communication channels, to gain authority, credibility and widen the audience. An example of cooperation between social partners was the collaboration between two Danish Sectorial Work Environment Councils and the Danish University and Property Agency. The cooperation resulted in the production of a booklet (Kristensen et al. 2010), which contains practical information for identifying risks nanomaterials in the workplace. The booklet is useful for deciding on measurement strategies and risk management. A risk assessment tool, based on

[12] EU-OSHA Focal Points are nominated by each government in Member State, Candidate and EFTA countries as EU-OSHA's official representative and are usually the national authority for safety and health at work. They are EU-OSHA's main safety and health information network and support EU-OSHA's initiatives with information and feedback and work with national networks including government, workers' and employers' representatives.

control banding, for use in the workplace by work environment practioners, managers and workers is described. Some research projects financed by the EU Framework Programme involve the participation of social partners and other stakeholders, or information dissemination activities directed to them. Businesses cooperate mainly via their trade associations (e.g. the European Chemicals Industry Council - CEFIC, Producer Association of Carbon Nanotubes in Europe - PACTE) and increasingly participate in scientific projects in cooperation with trade unions and NGOs. Many other examples of stakeholder's cooperation are mentioned further in the following sections.

5.2. Key stakeholders and their activities

5.2.1. Employers and workers

Employers and workers are key stakeholders for the communication of occupational health and safety risks of nanomaterials as they encounter nanomaterials in the workplace. Employers are required by law within the EU, to keep workers informed of risks to their safety and health in the workplace, and of the measures required to eliminate or, if not possible, to reduce the risks to a minimum (Directive 89/391/EEC[13], Directive 98/24/EC[14], REACH[15], Regulation (EC) 1272/2008 on classification, labelling and packaging of substances and mixtures (CLP)[16]. The employer is required to ensure that the workplace, materials and chemicals used are safe and to follow the hierarchy of control measures for protecting the workers from workplace risks. Employers have to make available up-to-date Safety Data Sheets (SDS) to workers; to keep a register of hazardous substances; to ensure that chemicals are correctly stored and labelled; to provide appropriate information, instruction and training to employees or contractors; to monitor exposure levels and provide health surveillance where necessary; to assess and control potential risks to workers; to maintain records of risk assessment reports, instruction and training; to consult workers on the introduction of new technologies; as well as to inform and consult workers and allow them to take part in discussions on all questions relating to safety and health at work. It is also the employer's obligation to keep up to date with the latest technology and science in workplace design and prevention.

Workers also have responsibility for their own safety and health and that of other persons who may be affected by their work activities. This includes following instructions provided by the employer and proper use of machinery, materials, dangerous substances and protective equipment. Workers should cooperate with their employer and inform them of risks to safety and health, to enable the employer to maintain a safe workplace.

As discussed in Chapters 2 and 3, effective risk communication targeted to workers should be based on careful consideration and identification of the recipients' level of technical understanding, emotional anticipation and capacity to act and take decisions.

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[13] Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work, *OJ L 183*, 29.6.1989, p. 1–8. Available at: http://eur-lex.europa.eu/Result.do?T1=V1&T2=1989&T3=391&RechType=RECH_naturel&Submit=Search

[14] 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 (fourteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC), OJ L 131, 5.5.1998, p. 11–23 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1998:131:0011:0023:EN:PDF

[15] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), *OJ L 396*, 30.12.2006, p. 1–849. Available at: http://eur-lex.europa.eu/Result.do?T1=V2&T2=2006&T3=1907&RechType=RECH_naturel&Submit=Search

[16] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, *OJ L 353*, 31.12.2008, p. 1–1355. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:353:0001:1355:en:PDF

5.2.2. Producers, importers and suppliers

Producers, importers and suppliers are key stakeholders who expect revenues from their investments in this new technology. They have an obligation to provide information down the supply chain to end users but are also employers with responsibility to manage risk. They need to operate under a legislative framework that creates a level playing field, is not unduly restrictive and enables the sharing of information whilst protecting commercial interests.

Under the REACH regulation[17], responsibility is laid on industry to manage the risks from chemicals and to provide health and safety information on substances for dissemination within supply chains. Manufacturers and importers are required to gather information on the properties of chemicals, to allow their safe handling, and to register this information with the European Chemicals Agency (ECHA) in Helsinki. They have to identify and manage the risks linked to the substances they manufacture and market, which means that they have to provide information, such as SDS, to ensure effective risk management by downstream users.

Some chemical companies produce information materials to communicate the potential risks and benefits associated with producing, using, handling or disposing and recycling of nanomaterials; e.g. guidance documents, leaflets, Codes of Conduct (CoC) and best practice advice. These information materials are designed for workers, occupational safety and health specialists and contractors. With some exceptions, only major chemical companies have published such information material. Examples of such activities are given below in alphabetical order:

BASF has prepared special guides for the safe manufacture of nanoparticles in workplaces (BASF, 2008). Through its nanotechnology CoC, BASF communicates very actively with their workers in four ways (BASF, no date (a)):

- Direct talks between employees and supervisors;
- Dialogue events (organised with labour unions and Works Council, on innovations, politics, occupational safety and toxicology of nanoparticles);
- Nano contact point - place where workers can receive information about safe work with nanoparticles;
- BASF Media (e.g. company newspaper and intranet).

The main principles and commitments of BASF CoC are as follows:

- Careful identification and evaluation of any potential risks related to the use of nanotechnologies to ensure that the appropriate measures to safeguard humans and the environment are taken.
- Early identification of the sources of risks in occupational settings and elimination or mitigation of these risks using the appropriate measures.
- Development of a scientifically based database for the assessment of potential risks as well as for improving and refining product-based testing and assessment methods.
- Transparency in safety procedures along the whole supply chain.
- Marketing of products only if safety can be guaranteed on the basis of all available scientific information and technology.
- Economic considerations do not take priority over safety and health issues and environmental protection.
- Commitment to transparency and engagement in public debate.
- Immediate disclosure of new findings to authorities and the public.

[17] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), *OJ L 396*, 30.12.2006, p. 1–849. Available at: http://eurlex.europa.eu/Result.do?T1=V2&T2=2006&T3=1907&RechType=RECH_naturel&Submit=Search

BASF has also published a 'Guide to safe manufacture and for activities involving nanoparticles at workplaces in BASF AG' (BASF, no date (b)) and a webpage 'Safety for our employees'.

http://www.basf.com/group/corporate/en/sustainability/dialogue/in-dialogue-with-politics/nanotechnology/employees

Bayer has introduced the 'BayCare' (Bayer, 2009), which is a comprehensive product stewardship program designed to help customers reduce environmental impact of the use of nanomaterials specifically, to improve the health and safety of workers as well as improving the sustainability of customers' businesses. Bayer works diligently to facilitate responsible handling of products throughout their life cycle, from research and development through production, packaging, distribution, storage, handling, recycling and disposal. Bayer has also prepared a similar Code of Good Practice to that produced by BASF (Bayer, 2010).

Environmental Defence and **DuPont** have been working together since October 2005 to develop a nanotechnology risk framework for the responsible development, production, use and disposal of nanomaterials. The companies aim to develop this framework in an open, transparent manner with other groups, businesses and institutions who are also working to assess the potential risks and benefits of nanomaterials. The framework was published in 2007 after public consultations (DuPont, 2007). The feedback from 35 companies, institutions, industrial associations and authorities is available on the framework's website (www.nanoriskframework.com). This framework is based on a six-step process for identifying, managing, and reducing potential environmental and occupational safety and health risks of engineered nanomaterials across all stages of a product's lifecycle. These steps are to:

- describe material and application;
- profile lifecycle(s);
- evaluate risks;
- assess risk management;
- decide, document, and act;
- review and adapt.

The framework contains a tool to organise, document and communicate the current understanding of a particular nanomaterial's potential risks and how to mitigate them. DuPont has prepared three case studies reflecting how to fill in the worksheet correctly for different nanoparticles (light stabiliser, carbon nanotubes and nano-sized zero-valent iron). This initiative is translated into Chinese, French, Spanish and some materials are in Portuguese.

Evonik Degussa, another producer, has a company policy for nanotechnology containing six principles, three of which relate to risk communication: communication in the supply chain, dialogue with stakeholders and transparency. Evonik is committed to making nanotechnology transparent for the public and therefore takes part in dialogues and discussion platforms with consumers, environmental associations, relevant authorities and international organisations (Wiegand & Evonik, 2009). The company has also published a guideline (Evonik, 2009) related to the responsible handling of nanotechnology.

Nanocyl is one of the largest producers of carbon nanotubes (CNTs) worldwide. It published a report about risk assessment and risk communication of their products, mainly addressed towards industrial users of CNTs (Luizi, 2009).

Large companies have designed new innovative tools for communicating risk information; for example, BASF, Bayer and DuPont described above. These initiatives are accessible not only for the companies' own employees but also for all interested stakeholders and they communicate messages that are generally short and clear about nanomaterials' risks. The most frequent forms of communication initiatives are: guidance, leaflets and CoCs.

Evonik and BASF are examples of large companies who are receptive to the possibility for dialogue about the risk connected with N&N in the workplace. Two-way communications initiatives may be a good way for finding acceptance, consensus and for adapting their risk communication to the needs and requirements of the recipients of the information. The case

studies prepared by Dupont and Environmental Defense are useful communicating tools especially for occupational safety specialists. It is interesting that this initiative was organised jointly by the well-known environmental organisation and Dupont and that several parties were engaged during the evaluation process. This probably increased credibility and trust.

Although some companies' guidance and reports contain elements of risk communication only directed towards the workplace, they also try to communicate with other parties (e.g. public, environmental associations, relevant authorities and international organisations) and disseminate information mainly about the benefits of their technologies.

All risk communication initiatives identified in this literature search were from large chemical companies. This may indicate that an effort is required to raise the capacity and motivation of SMEs to undertake appropriate communication actions directed towards the workplace.

5.2.3. EU Member States

Several EU Member States are committed to the responsible development of nanotechnologies, including workplace safety and health, and have an N&N strategy in place, or under development, which also addresses risk communication. These countries play an important role in stimulating dialogue between N&N producers, users and national institutions, and in setting the scene with useful communication opportunities and tools. Their Governments support a number of research activities on the environmental and health impacts of nanomaterials and, as a result, guidance documents on risk assessment and risk management of N&N as well as on how the current legislation aplies to N&N have been published. Austria, France, Germany, the Netherlands and the United Kingdom, for example, are very active in addressing the various issues related to the regulation of nanomaterials.

Some of the most relevant examples of risk communication initiatives on nanomaterials in the workplace available in the EU Member States are presented below.

Several government ministries in **Austria** (Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, Ministry for Transport, Innovation and Technology, Ministry of Health, Ministry of Labour, Social Affairs and Consumer Protection, Ministry of Science and Research) jointly with employers and worker organisations have established the Austrian Nanotechnology Action plan (Lebens Ministerium, 2009), implementing the European Action plan (EC, 2005a) (see 5.2.4). The core of the Austrian Action Plan consists of 50 recommendations for specific measures aimed at nanomaterials to be taken at national, European and international level. These recommendations grew out of a consensus reached among the stakeholders involved, and will be implemented by the end of 2012 at the latest. In 2009, the Central Labour Inspectorate carried out an interview-based survey ('Use of Nano at the Workplace') in Austrian companies (ACLI, 2009), dealing with nanomaterials and how they are used in workplaces. The main result was that the amounts of nanomaterials being produced or used, and the number of employees dealing with them, are currently rather low in Austria. The survey also highlighted SMEs' need for more support on how to manage nanomaterials in the workplace by means of, for example, guidance and consulting and measuring services. It was noted that the existing guidance documents were not always reliable and of variable quality, and that the SDS – when provided – did not allow a safe risk management of nanomaterials. The need to raise the awareness of labour inspectors, occupational physicians and external OSH experts for nanomaterials and their risks was also emphasised in order to enable them to address these risks when advising companies.

The **Danish** National Research Centre for the Working Environment has published information for the management of the risks posed by nanomaterials in the workplace on its website (NRCWE, 2010).

Two **French** initiatives on public dialogue of nanotechnology, 'The public debate on development and regulation of nanotechnologies' (a large government initiative on communication of the industrial applications of nanotechnologies) and the Nanoforum organised by the Conservatoire National des Arts et Métiers, are examples of bringing the debate for and against nanotechnology to a broader audience. These are discussed in more detail in Section 5.5 of this chapter. In addition, two of the priorities included into the national programme for health at work for the period 2010-2014 'Plan Santé au travail 2010-2014' concerned risk communication on nanomaterials:

improving the information to workers likely to be exposed to waste containing nanoparticles; and strengthening the national regulations towards a compulsory declaration of manufactured or imported nanoproducts (Ministère du Travail, de la Solidarité et de la Fonction publique, 2010). The Prevention and Precaution Committee of the Ministry for Ecology and Sustainable Development also published a report on the hazards and risks of nanotechnologies (Ministère de l'Ecologie et du Développement Durable, Comité de la Prévention et de la Précaution, 2006). The Institut National de Recherche et de Sécurité (INRS, 2009) has drawn up a good practice guide for the protection of workers exposed to nanomaterials, and the French Agency for Environmental and Occupational Health and Safety (AFSSET) published a report on the effects of nanomaterials on the environment and human health (AFSSET, 2006).

The **German** Federal Government initiated the NanoDialogue in 2006 and established the NanoKommission, a central, interdisciplinary and multi-stakeholder dialogue platform in which representatives of Ministries at federal and Länder level and of higher federal authorities, from the scientific community, industry, trade unions and NGOs (environmental and consumer organisations, churches and a women's organisation) worked together. The objective was to promote the responsible use of nanomaterials in line with the precautionary principle, thereby preventing risks while supporting sustainable innovation, and to advise the Federal Government. A report and recommendations of the first phase 2006-2008 of the work of the NanoKommission was published (BMU, 2009). This report defines the five principles for the responsible use of nanomaterials which address all of the elements required for proper risk communication:

Principle 1: Definition and disclosure of responsibility and management (good governance);

Principle 2: Transparency with regard to nanotechnology-related information, data and processes;

Principle 3: Commitment to dialogues with stakeholders;

Principle 4: Establishment of risk management structures;

Principle 5: Responsibility within the value chain.

The activities of the NanoKommission were concluded by the publication of a second report covering its achievements during the phase 2009-2011 (BMU, 2010). In this second phase, the issues discussed included: the implementation of the five principles established in the first phase; approaches for preliminary, integrated benefit-risk assessment of nanomaterials; the need for regulation; and the development of a shared paradigm for sustainable, green nanotechnologies.

In parallel, in 2007, the Ministry for Education and Research (BMBF) started the 'Nano Initiative - Action Plan 2010' (BMBF, 2007) which set up a unified framework across German government departments, involving six further Ministries (Environment (BMU), Labour and Social Affairs (BMAS), Food, Agriculture and Consumer Protection (BMELV), Defence (BMVg), Health (BMG) and Commerce and Technology (BMWi)). This action plan set up the basis to:

- accelerate the transfer of nanotechnology research into innovations and to widen nanotechnology to further industrial sectors. Industry dialogues were started to inform about the use of nanotechnology and to support SMEs in its use;
- remove innovation obstacles and improve conditions through early coordination of different fields of politics;
- lead an intensive dialogue with the public on the benefits and risks of nanotechnology. The intention was to address possible health and environmental effects, to develop a strategy on environmental risks of insoluble nanoparticles, and to use modern means of information and participation of the public.

A second Action Plan 2015 was published in 2011 (BMBF, 2011). One of its objectives is to intensify communication and to foster dialogue on N&N, in particular through: specific information media for pupils and students on the one hand, and for the interested lay public on the other hand; exhibitions and information campaigns; a dialogue process on nanotechnology development and applications, starting with the cosmetics and textile sectors; and a more specific a platform for dialogue, NanoCare (www.nanopartikel.info), in which citizens can have a direct exchange with the experts involved in research projects on the risks of N&N funded by the BMBF. NanoCare gathers 16 partners from German academic institutions and the industry. Within NanoCare, a database for the public and other stakeholders was developed; events were organised to bring together interested stakeholders, such as policy-makers, NGOs, the general

public (two stakeholder events and three citizen dialogs were organised); information materials such as brochures and reports was published on the Internet, including information on health effects of nanoparticles in the workplace.

Another example of dialogue on occupational safety of nanomaterials is the Dialog-Forum Nanomaterialien am Arbeitsplatz (BAuA, 2011), which was organised by the German Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA) in Dormund in January 2011 with 200 participants from companies and public authorities. The focus of the event was how BAuA can contribute to the provision of research and practical advice for responsible handling of nanomaterials in the workplace.

The Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) has also published web pages entitled 'Ultrafine aerosols and nanoparticles at the workplace' (http://www.dguv.de/ifa/en/fac/nanopartikel/index.jsp). Their general purpose is to inform on possible hazards from manufactured nanomaterials and, based on the precautionary principle, to provide advice on the use of protective measures and on workplace measurements. The conclusion is drawn that existing protective measures that have proven effective against ultrafine dusts are also effective against nanoparticles. To assess the effectiveness of protective measures, benchmark levels for the particle number concentration of nano-objects in the workplace air are derived and proposed.

In **Italy**, seven Research Programs on Nanotechnology and OSH were conducted between 2008 and 2010. The most relevant for risk communication is 'NanOSH Italia', founded by the Italian Ministry of Health and Istituto Superiore Prevenzione e Sicurezza sul Lavoro (ISPESL). The AIRI (Italian Association for Industrial Research) Network and Nanotec information technology (www.nanotec.it) are acting as a bridging point connecting the Italian players in N&N in industry, public research, and governmental institutions, with the mission of promoting nanotechnology and its applications. The network is actively engaged in fostering a multi-stakeholder dialogue for responsible R&D in nanotechnology and is a participant in the Committee for Nanotechnology of UNI, the national regulatory organisation.

In the **Netherlands**, six guidance documents on nanomaterials were found: two in English on “Good uses of nanomaterials in the Netherlands” (Born et al, 2008) and “Exposure to nanomaterials in consumer products” (Wijnhoven et al., 2009); and four in Dutch (see Appendix 2). These reports address all aspects of nanotechnology in the Netherlands, including OSH. They were prepared by Ministries, the Netherlands Center for Occupational Diseases, the Social and Economic Council of the Netherlands, the National Institute for Public Health and the Environment (RIVM) and/or independent academic researchers. The target groups include OSH specialists, N&N specialists, Dutch policy-makers, workplaces as well as the public.

“Good uses of nanomaterials in the Netherlands” reports on a survey of workplace practices with nanoparticles (Borm et al., 2008). Twenty-six companies (11 SMEs) and 11 academic workplaces that handled nanoparticles were visited and managers or occupational safety specialists were asked about workplace practices. Some larger companies involved in nanotechnology in the Netherlands, such as Philips or ASML, did not participate. The results showed a clear awareness of the potential risks of nanomaterials among the participants. Almost all (92%) of them had performed, or were in the process of performing, a hazard and risk assessment analysis. Most had concluded that the procedures and measures in place fully covered the potential risks of exposure and 25% reported that the company had a policy dealing with potential exposure to nanoparticles. However, the content and background of the chosen policies differed widely, and seemed to be based on 1) pre-emptive choice of specific nanoparticles; 2) the general exclusion or handling of nanomaterials as a toxic substance; 3) choices of the physical form of the nanoparticles. The decision not to use nanoparticles as powders, but only in a matrix, or the approach to disperse nanopowders as quickly as possible in liquid appear to be most dominant good practices in general occupational hygiene policies. It was reported that a number of guidelines were used but there was a request for independent advice on occupational hygiene practices. It was suggested that a virtual centre of expertise be established that could merge the competence and power of available institutions. Such a centre could also disseminate the most recent know-how on best practices. Deficiencies in communication down the chain of producers and users were identified. SDS usually did not give information on the presence of nanoparticles and the potential hazards of nanoparticles in their product, and potential risks were very hard to recognise for downstream users.

The information material produced by the **United Kingdom's** Health and Safety Executive is an example of government sponsored information on risk management in the workplace, such as the recently revised 'Risk management of carbon nanotubes' (HSE, 2011). This report is a good example of risk communication initiatives directly addressing OSH and appropriately targeted at workplaces. It is concise and contains clear, well-judged and relevant information based on recent scientific findings. It communicates clear principles, messages and instructions on how to handle nanomaterials safely.

At the moment, there is very little information on whether these different risk communication initiatives have been successful in raising awareness for the risks of N&N and for the need for appropriate prevention measures in workplaces, and whether the risk perception and risk management have changed in the workplace as a result. Most of the activities related to risk perception and communication on N&N relevant to workplaces have been conducted by government authorities, national agencies, labour inspectorate, or OSH institutes and generally involved trade associations, trade unions and industry. Examples of public dialogues were found, for example in Germany and in France. Whereas the German dialogue seems to have involved government departments, industry, trade unions and NGOs, the French dialogue was an attempt at communicating with a broad population and a variety of stakeholders in France. Some complications that may occur during dialogue and the conditions for success are discussed in section 5.5..

5.2.4. The European Commission (EC)

The European Commission (EC) published an Action Plan (EC, 2005a), which is structured into eight main areas, one of which concerns public health, safety, environmental and consumer protection. Building on achievements, the EC then considered a second Action Plan. To this end, the EC conducted a consultation to collect the views of both nanotechnology experts and the public regarding the benefits, risks, concerns and levels of awareness of nanotechnologies (EC, 2010b). Over a period of three months, more than 700 responses were received. The respondents indicated the level of risk they expect from nanotechnologies in comparison to other technologies and sectors. The report concluded that there was "a good or very good perception of EU governance related to nanotechnologies in terms of stakeholder consultation and setting research priorities".

In parallel, the EC recommendation on a 'Code of Conduct for Responsible Nanosciences and Nanotechnologies Research' (CoC) was adopted in 2008 (EC, 2008a), relevant extracts of which can be found in Section 1 of Chapter 3. A public consultation on the need to revise this CoC was opened in October 2009 and concluded in January 2010 (EC, no date). This consultation was open to all stakeholders interested in nanosciences and nanotechnologies research. Member States were consulted separately from this public consultation. The CoC was generally welcomed by industry as an 'effective hybrid regulation mechanism' that can be used as a 'basis for global dialogue' and can 'prevent trade conflicts and stimulate equal protection of workers and consumers'. Still, over 65% mentioned that they would welcome "adaptation or change", less than one fifth thought that the CoC brought "enough added value in the EU nanoresearch-landscape" and only 44% already followed the CoC although over 66% knew about its existence (Table 7). Other comments were variable however from a complete indifference to a need for a new guidance (national organisations arguing that national guidelines and regulations are in place – exemplary from Germany), with some going so far as to suggest a need for mandatory measures (exemplary EuCheMs - European Association for Chemical and Molecular Sciences). Positive comments, to the effect that the CoC as prepared was good, were also received from two chemical industry associations: EuCheMs and CEFIC. Table 7 shows some statistics for some of the questions asked in the consultation.

Table 7: Selected results from the EC consultation on the Code of Conduct

	% yes Policy* (n=6)	% yes CSOs* (n=6)	% yes RTD* (n=19)	% yes Industry (n=18)	% yes All (n=49)
Did you know the existence of the Code of Conduct prior to the present consultation?	50,00	50,00	47,37	66,67	55,10
If Yes, Do you or Does your company/organisation already follow the Code of Conduct?	16,67	33,33	42,11	44,44	38,78
Do you agree with the following statement? 'The Code of Conduct brings enough added value in the EU 'nanoresearch- landscape' and does not need to be revised'?	0,00	16,67	36,84	16,67	22,45
Compared to the 7 principles underlined in the Code of Conduct, would you suggest adaptation or change to the principles?	83,33	83,33	42,11	66,67	61,22
Do you believe that there are more fields of nanosciences and nanotechnologies where research should not be concluded?	16,67	83,33	21,05	33,33	32,65
Do you believe that there are more fields of nanosciences and nanotechnologies where research should be more appropriately regulated?	66,67	100,00	57,89	27,78	53,06

***** Policy: Policy makers at national level; CSOs: NGOs; RTD: Research and development
Source: European Commission, no date

Subsequent analysis of the stakeholders' attitudes including information from country reports was made in an EU project (Grobe, Kreinburger & Funda, 2011). Three hundred and four European and international experts contributed to the survey between August and October 2010 and about 150 took part in qualitative interviews or focus groups. The authors stated that despite the large and inhomogeneous sample, the results were surprisingly unambiguous:

- There was a broad general support (80%) for the EU's CoC principles.
- The CoC was considered as an appropriate instrument for complementing regulation.
- Only 15% thought that the CoC was 'not useful at all' for them.
- Only 20% stated that their organisation had adopted the CoC.
- Of EU Member States, only the Netherlands has so far formally adopted the CoC.
- Only 21% of the participants were aware of governmental activities to enforce the CoC.
- Only half of the key experts had heard about the CoC before the survey.

The authors concluded that:

- there was a broad support for the principles and the CoC as an appropriate tool; and
- dissemination and communication were insufficient and adoption was far from successful at Member State and organisational levels.

For improving awareness and dissemination, it was suggested that: all stakeholders should be involved in re-writing the EU CoC and a transparent dialogue process should be conducted in an atmosphere of mutual trust and should be adapted to the different Member States' situations.

The EC should make compliance with the CoC mandatory. In the framework programmes, templates should be prepared to promote the EU CoC principles with communication of examples of its application. It was suggested that workshops should be organised for top managers of e.g. industrial companies and research institutes, to encourage open discussions of N&N legislation, standards and nano safety. Companies should incorporate the EU CoC into their quality assurance programmes and exert business pressure throughout the supply chain, and safety officers in organisations should convert the EU CoC into easy-to-follow rules. A weakness in 'hybrid regulation' was reflected in the survey comments, that in contrast to regulation, it may be unclear when the CoC applies and when it does not. In some countries there are other CoC or similar guidelines and the question remains as to which one applies when.

The EC also held an Open Consultation on a 'Strategy on communication outreach in nanotechnology' (EC, 2007), in which public and other stakeholders were invited to comment on the results and report from a workshop held by the EC in Brussels, in February 2007. This paper shaped recommendations for future European funding calls on appropriate communication and innovative approaches to engage the European civil society in a dialogue on nanotechnology. Experts in the field of science communication shared success stories, best practices and challenge stories, to give different audiences a 'voice' in the policy-making process. As a result, a set of recommended activities for Europe were outlined, which included the need for nanotechnology risk communication.

In 2010, the EC opened an ambitious dialogue with the public on the opportunities, risks and uncertainties associated with nanotechnology through the initiative called the '**Nanotech communication roadmap** (EC, 2010d). It aims to build pathways that will both inform citizens and allow them to feed their opinions back to the EC, using a variety of media, including television and other press outlets, working with schools, museums, special events and road shows. It is hoped that the initiative will promote good governance through inclusive policy debate, and improve confidence in the EC as an impartial, transparent and trustworthy communicator on nanotechnology.

Through another project, **Nanoyou** (http://nanoyou.eu/), the EC aims to increase young people's understanding of nanotechnology and engage them in dialogue about its ethical, legal and social implications.

The EC Directorate-General for Research and Innovation (DG Research) brought new focus on risk communication. As stated by Mr Christos Tokamanis (Head of the Unit 'Nano and converging Sciences and Technologies' DG Research), 'the EC takes this whole communication effort on nanotechnology so seriously, that it now wants to prepare for an appropriate dialogue among stakeholders about the social challenges of nanotechnology: this has been the focus of two further publications issued at the beginning of 2008 and of other projects launched during 2009-2010 with special emphasis on television and web media, as well as on young people. Reaching the right audiences, with the appropriate message and means is of essence. All these dialogue efforts will culminate into the European Platform on Nano Outreach and Dialogue (NODE): it will deal with a specific system of mechanisms to enliven and coordinate the continuous and open dialogue on nanotechnology within the whole EU society, empowering both EC and Member States with a very challenging tool for delivering technical democracy on nanotechnology' (EC, 2010 d). All these EU communication initiatives in nanotechnology were collected in the report entitled 'Communicating Nanotechnology – Why, to whom, saying what and how?' (EC, 2010d). It contains three main parts, which jointly make a communications roadmap in Europe for publicity (Where are we now? Where do we want to be? How do we get there?). The main asset of this report is that EU communication activities are mentioned but even within this large report (188-page report plus a 68-page annex), there is no mention of communication initiatives to the workplace.

Last but not least, the EC is probably the world's largest financer of research and development (R&D) into nanotechnology. In the last decade, the 5th, 6th and 7th Framework Programmes for research and technological development (FPs) have funded several research projects on the health and safety of nanomaterials, many of which include risk communication components (see text box below).

Risk communication on N&N in the EU Framework Programs

The 'NanoSafety cluster' was launched under FP7 to coordinate these activities, provide synergy and avoid duplication within the research projects funded by the EC and others (Riediker and Katalagarianakis, 2010). Among the specific objectives of the NanoSafety cluster several are relating to risk communication as follows:

- To facilitate the formation of a consensus on nanotoxicology in Europe;
- To provide a single voice for discussions with external bodies;
- To provide a forum for discussion, problem solving and planning R&D activities in Europe;
- To provide industrial stakeholders and the general public with appropriate knowledge on the risks of nanoparticles and nanomaterials for human health and the environment.

Most of the projects funded under the FPs related to health impact of N&N and including risk communications involve research institutions, but the industry, social partners and NGOs are also largely represented among the participants to such projects. An example is the NanoCap (www.nanocap.eu) consortium that consisted of five environmental NGOs, five trade unions and five universities. NanoCap (the acronym for Nanotech Capacity Building NGOs) was a three-year project running from 2006 - 2009, the purpose of which was to deepen the understanding of environmental health and safety risks and ethical aspects of nanomaterials. It included a structured discussion between environmental NGOs, trade unions, academic researchers and other stakeholders. A series of focused working conferences were held, in which structured stakeholder engagement took place. The universities generated scientific input for the conferences. As a result of discussions, NGOs and trade unions were able to develop their policy positions.

The results of NanoCap have to date been communicated with stakeholders through different activities and documents:

- Five Working Conferences with invited stakeholders;
- Meetings/discussions with industry, authorities, other stakeholders;
- Website - www.nanocap.eu;
- Electronic newsletters;
- Public final conference.

No consensus statements about risks at the workplace or risk communication have been forthcoming from the NanoCap project, but many of the social partners and NGO's have made statements and taken positions on the risks of N&N, probably as a consequence of their involvement (www.nanocap.eu). Many communication tools were used during the project (although no evaluation of their success were found). Industry representatives were invited to meetings and discussion panels. An interactive communication e-tool on nanotechnologies (NanoVirtualium) has also been generated within the framework of the NanoCap project. The main aim of the NanoVirtualium is to help society grasp the scientific background and potential applications of nanotechnology and explore the related environmental, health (risk and benefits), regulatory and ethical issues.

NanoSmile was initiated in the frame of the EU project NanoSafe2, carried out by a consortium consisting of producers, academic and government partners, and was then supported by FP7 European iNTeg-Risk project. The NanoSmile website contains easily comprehensible information on different safety aspects, many of which are relevant for risk management in the workplace (www.nanosmile.org).

Examples of other relevant projects funded by the EU are provided in Table 8. The level of activity in in N&N risk communication in these projects reflects the EC's will to support communication with their stakeholders and the public and to inform them on the results of EU funded projects. The most common communication means used in these projects are workshops and reports. However, these may not be accessible or relevant directly to workers since they are frequently produced by scientific experts for other scientists. Therefore, elements of N&N risk communication to workplaces can be difficult to find in such projects.

Table 8: Examples of N&N risk communication actions in EU projects

Project	Partners	Aims	Communication actions
NanoImpactNet www.nanoimpactnet.eu FP7 Coordination Action	**Science**: 24 partners from European academic and government institutions.	Facilitate collaboration between research projects; Communicate results to stakeholders and their needs back to researchers; Help implement the EU's Action Plan for Nanotechnology.	Workshops for different kinds of stakeholders; Conferences; NanoImpactNet Reports and Publications on risk communications: e.g. identified stakeholders and their interests in the field of HSE impacts of nanomaterials (Hart et al., 2009); How stakeholders can be involved in NanoImpactNet and how companies can make data accessible (Hart et al., 2009); Stakeholders and their Interests - Wrapped up in nano: how to inform the public about nano-enhanced food contact material (Hunt et al, 2010).
ObservatoryNANO www.observatory-nano.eu FP7 Coordination Action	**Science and industrial associations:** 16 partners from European academic institutions and industrial associations	Create a European observatory on nanotechnologies to present reliable, complete and responsible science-based and economic expert analysis, across technology sectors; Establish dialogues with decision makers and other stakeholders regarding the benefits and opportunities versus the barriers and risks of nanomaterials.	An annual report of the project's activities for the wider public; The ObservatoryNANO symposium, held annually, which features presentations from project partners of all work packages in addition to a number of invited speakers; Newsletter.

Project	Partners	Aims	Communication actions
FramingNano www.framingnano.eu FP7 Coordination Action	**Science, consulting companies:** 6 partners from European academic institutions and consulting companie companies.	General aim: Defining a governance framework aimed at supporting responsible development of nanotechnology. Communications aims: - Foster an international dialogue - Communicate and disseminate, in a suitable form and to the widest possible audience, project objectives, findings and outcomes. - Establish an international multi-stakeholder network on project themes	FramingNano Project reports: FramingNano Final Report: The FramingNano Governance Platform; FramingNano Executive Summary; FramingNano Stakeholder Consultation Report; FramingNano Mapping Study on Regulation and Governance of Nanotechnologies. Newsletter; Delphi Consultation (the main aim is to gather stakeholders' views and expectations in relation to environmental, health and safety issues and on ethical, legal, and social issues related to nanotechnology); National workshops (Switzerland, United Kingdom, Netherlands, Germany and Czech Republic); International multi-stakeholders workshop; Final International Conference
The **EU NanoSafety Cluster** includes information's about existing EU FP6 and FP7 projects that are addressing all aspects of risk and nanosafety. **www.nanosafetycluster.eu**			

5.2.5. The European Parliament (EP)

The European Parliament (EP) is also active in the debate and establishing duties in the safe development of N&N and adopted a report on the regulatory aspects of nanomaterials (EP, 2009a). The report requested tighter controls on nanotechnology, including the application of the 'no data, no market' principle contained in the REACH Regulation (No. 1907/2006). The report also called specifically on the EC to evaluate REACH concerning:

- simplified registration for nanomaterials manufactured or imported below one tonne;
- consideration of all nanomaterials as new substances;
- a chemical safety assessment for all registered nanomaterials, featuring exposure assessments.

Following the report, the EP adopted a resolution on regulatory aspects of nanomaterials (EP, 2009b), in which the EP called on the EC to consider the need to review worker protection legislation concerning inter alia:

- the use of nanomaterials only in closed systems or in other ways that exclude exposure of workers for as long as it is not possible to reliably detect and control exposure;
- a clear assignment of liability on employers arising from the use of nanomaterials;
- whether all exposure routes (inhalation, dermal and other) are addressed.

The EP also asked the EC to compile an inventory of the different types and uses of nanomaterials on the European market; to make this inventory publicly available and to report on the safety of these nanomaterials.

Finally, the EP called for the EC to launch an EU-wide public debate on nanotechnologies and nanomaterials and their regulation, and to pay special attention to the social dimension of the development of nanotechnology; furthermore it considers that the active participation of different social partners has to be ensured from the earliest possible stage.

The EP has also published a 'Human Enhancement Study' (EP, 2009c), which attempts to bridge the gap between visions of human enhancement (HE), the relevant technology and modern scientific developments (including nanotechnology). It outlines possible strategies of how to deal with HE in a European context, identifying a reasoned pro-enhancement approach, a reasoned restrictive approach and a case-by-case approach as viable options for the EU.

5.2.6. EU scientific committees

The **Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), and the Scientific Committee on Consumer Safety (SCCS)** produced several opinions that relate to the health and safety of nanomaterials, e.g. their use in cosmetics (SCCP, 2005; 2007) legislative needs, definitions (SCENIHR, 2010) and research needs (SCENIHR, 2009). SCENIHR also published two documents in relation to the risk assessment of nanomaterials (SCENIHR, 2006; 2007).

5.2.7. Community agencies

The **European Chemicals Agency (ECHA)** is central to the REACH regulation as it is responsible for coordinating the duties REACH introduces for EU-based businesses, and manages the registration, evaluation, authorisation and restriction of chemical substances. ECHA also manages the tasks under the European Regulation (EC No. 1272/2008) on Classification, Labelling and Packaging (CLP) of chemical substances and mixtures. It manages the databases necessary to operate REACH, co-ordinates the in-depth evaluation of chemicals and runs a public database in which consumers and professionals can find hazard information. If the ECHA, in cooperation with the Member States, identifies a potential risk to human health or the environment, Competent Authorities of Member States evaluate the relevant substance(s). This evaluation may lead to authorisation requirements or restrictions, such as product labelling, handling restrictions and exposure limits. ECHA is presently in the process of developing

guidance on nanomaterials placing special attention on their characterisation as new types of chemical substances. ECHA is also compiling an inventory of nanoproducts included in REACH registration dossiers and notified under CLP. The inventory, planned to be delivered to the EC in 2011, was requested by the EC in response to the EP communication on nanomaterials adopted in 2009.

The **European Food Safety Agency (EFSA)** has advised on the use of nanomaterials in foods, primarily in support of the EC's regulatory activities. They provide information that is valuable for risk assessors at all levels. The Scientific Committee of EFSA presented a draft guidance document of engineered nanomaterial applications in food and foodstuffs for public consultation in 2011 (EFSA, 2011).

One of main objectives of the **European Agency for Safety and Health at Work** (EU-OSHA) is to collect, analyse and disseminate information for improving OSH conditions in the EU. EU-OSHA is very active in surveying different aspects of risks of occupational exposure to nanomaterials and already in 2005 its European Risk Observatory had identified nanotechnology as an important emerging risk (EU-OSHA, 2005). In its expert forecast on emerging chemical risks, nanoparticles were again identified as the top emerging risk (EU-OSHA, 2009b), following to what workplace exposure to nanomaterials was explored in more depth in a literature review (EU-OSHA, 2009a). EU-OSHA is also developing a database of company case studies on the safe management of nanomaterials. The database will be available from EU-OSHA's website [18] in 2012.

5.3. Other stakeholders and their activities

Other stakeholders, such as trade associations, trade unions or non-profit organisations, play an important role in disseminating information on the safety of nanotechnology in the workplace. Both trade associations and unions are very active in such communication.

5.3.1. Trade associations

In several European countries, producers and suppliers are collaborating through their trade associations on risk assessment as well as on the provision of overall communication frameworks and communications on specific risks. Chemical industry associations are working both nationally and internationally in this area. Several associations have long experience of risk assessment of other chemical substances. They often involve occupational safety specialists in their activities. In the information materials surveyed for the production of this report, the risk communication messages are usually well structured, clear and short. Such guidance is probably more appropriate for the workplace and more effective because the information it contains is restricted to risk management in the workplace, and does not contain general information for other stakeholders or the public. This manner of risk communication increases worker confidence with the new technology and encourages a sense of responsibility for their own health and safety. Examples are discussed below.

The **European Centre for the Ecotoxicology and Toxicology of Chemicals (ECETOC)** is a pan-EU industrial organisation that has published several documents on the risks of nanotoxicology (http://www.ecetoc.org/risk-assessment-of-innovation). Their risk communication initiatives are primarily targeted at member companies, but ECETOC is also an active provider of information and opinion to the EU, national governments and the OECD.

The **European Chemicals Industry Council (CEFIC)** has established a working group dedicated to nanomaterials. The group issued a position paper on nanotechnology (CEFIC, 2006), and is actively participating in the relevant ISO, CEN, and OECD working groups. They have also published a report on the 'Responsible Production and Use of Nanomaterials' (CEFIC, 2010). This guidance is a tool to share best practice on how companies can apply 'Responsible Care'

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http:osha.europa.eu

principles to producing, processing and using nanomaterials safely. It is intended to be an evolving tool, which will be updated as more companies use it, provide feedback and share experiences. CEFIC held its first Europe-wide event on nanotechnology in June 2008. The purpose of the workshop was to discuss how to foster responsible development of sustainable innovations based on nanotechnologies and how to achieve greater transparency and engagement with civil society (CEFIC, 2008).

The **German Society of Chemical Industry (VCI) together with the German Federal Institute for Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA))** published a document summarising earlier initiatives dedicated to nanomaterial safety for health and the environment (VCI, 2008). The information included in the report concerned nanomaterial risk assessment, safe working and handling of nanomaterials, standards, research about nanoparticles etc. The guidance was prepared to support VCI affiliates, and customers in the supply chain, with the aim of managing the health, safety and environmental aspects of nanomaterials throughout the life cycle, and generally promoting good product stewardship for nanomaterials.

Other industrial associations have also prepared guidelines for their members; e.g., the **German Paint and Printing Ink Association** has published a guidance document to inform its members on the responsible handling of nanoscale materials in the workplace (GPPIA, 2010). They state that they manufacture products, which are technically safe and pose no risk to human health or the environment when used as intended. They are committed to the German Responsible Care initiative (http://www.responsible-care.de) and to the fundamentals of the NanoDialogue of the German Federal Government.

The **Producer Association of Carbon Nanotubes in Europe (PACTE)** has established a 'Code of Good Conduct' describing its members' intentions to fulfil their commitment for promoting human health and environmental safety while realising economic benefits of nanotechnologies (PACTE, 2008).

The **United Kingdom's Chemical Industries Association (CIA)** has announced the launch of the Nanotechnologies Supply Chain Forum (www.cia.org.uk). The forum aims to bring stakeholders together to aid policymakers to establish a regulatory framework for the safe commercialisation of nanotechnologies.

The **American Chemistry Council, Japanese Chemical Industry Association,** and the **Nanotechnology Industries Association** also contribute to risk communication through their policies, provision of guidance and stewardship activities (Medley, 2009), often providing significant and timely information for nanotechnology risk evaluation and risk management.

5.3.2. Trade unions

While they also assert the potential of nanotechnology bringing major benefits to society, trade unions recognise the use of nanotechnology as potentially harmful for workers. The **European Trade Union Confederation** (ETUC) has published two resolutions on nanotechnologies and nanomaterials, which present their position and initiatives with regards to worker protection and proposes measures. The first resolution addresses marketing, worker protection, research and development (R&D), the legislative framework in the EU, consumer protection and the application of precautionary principles (ETUC, 2008). Their position on worker protection is relevant for risk communication and can be summarised as follows:

- Amend Chemical Agents Directive 98/24/EC[19] to require employers to implement risk reduction measures for substances not proven to be harmless;
- Involve workers and their representatives in the assessment and reduction of nanomaterial-related risks;

[19] 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 (fourteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC), OJ L 131, 5.5.1998, p. 11–23 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1998:131:0011:0023:EN:PDF

- Improve worker information about nanomaterials that may be present in products which they are handling: safety data sheets must state whether nanomaterials are present;
- Provide training and health surveillance for workers exposed to nanomaterials.

ETUC also 'calls on the European Commission and Member States to ensure real participation by European citizens in the debate on these new technologies'.

The main objective of their second resolution on nanotechnologies is to call for the protection of workers exposed to nanomaterials in all businesses (ETUC, 2010). As such it is more technical than communicative and incorporates new issues related to the technical and regulatory developments on the definition of nanomaterials, the need to adjust the legislative framework to integrate the principles of hygiene and traceability, and the role of standardisation.

The **European Trade Union Institute (ETUI)** organised a training course 'Nanotechnologies and sustainable development' in October 2010 (ETUI, 2010). This training was prepared for trade union officers, policy makers and other stakeholders with experience in trade union activities related to nanotechnologies. The course was designed to get a mutual understanding of the state of nanotechnologies and also allowed participants to share their own experiences in the field in order to have a comprehensive understanding of how issues surrounding nanotechnologies and nanomaterials are being tackled in the European countries.

The **Danish Confederation of Trade Unions** (**LO**) has published a 'Greenbook on Nanotechnology' (LO, 2010) that highlights that there are considerable uncertainties about how to handle nanomaterials safely in the workplace and that this may jeopardise the anticipated economic and social outcomes of nanotechnology. Among others, the LO recommends stronger efforts for the dissemination of research findings, guidance and advice to Danish workplaces.

The **Spanish Trade Union Institute for work, environment and health** (Instituto Sindical de Trabajo, Ambiente y Salud - ISTAS) published a leaflet and a short, practical informative booklet on nanomaterials in the workplace and workplace prevention measures (ISTAS, no date).

5.3.3. Organisations

Many organisations publish guidance, research findings and opinions, which are often available for download free of charge from their web sites. Those not already mentioned are briefly described here.

The **Organisation for Economic Co-operation and Development** (**OECD**) has established a working party on manufactured nanomaterials, within which is a programme on the safety of manufactured nanomaterials (OECD, 2010c). The aims of this programme are to ensure that the international approach to hazard, exposure and risk assessment is of a high, science-based standard and becomes harmonised. This programme also promotes international co-operation on the human health and environmental safety of manufactured nanomaterials, and involves safety testing and risk assessment of manufactured nanomaterials (OECD, 2010b). The working party includes many organisations such as the International Labour Organisation (ILO), the United Nations Environment Program (UNEP), the United Nations Industrial Development Organisation (UNIDO) and the World Health Organisation (WHO) with the World Bank as observers. The working party has published several publications on OECD's website that will have a profound significance for regulation, testing, risk management and international harmonisation including:

- Compilation and Comparison of Guidelines related to Exposure to Nanomaterials in Laboratories (OECD, 2010d);
- List of Manufactured Nanomaterials & List of Endpoints for Phase One of the Sponsorship Programme for the Testing of Manufactured Nanomaterials: Revision, (OECD, 2010e)
- Current Developments/Activities on the Safety of Manufactured Nanomaterials, (OECD, 2011).

In addition, the OECD has also run awareness raising workshops on nanotechnology and manufactured nanomaterials for developing and transition countries.

The **World Health Organisation** (**WHO**) is currently developing Guidelines for 'Protecting Workers from Potential Risks of Manufactured Nanomaterials' (WHO, 2011). These aim 'to

facilitate improvements in occupational health and safety of workers potentially exposed to nanomaterials in a broad range of manufacturing and social environments' and cover elements of risk assessment, risk management and overall contexts. It is stated that the guidelines 'will provide recommendations to improve occupational safety and protect the health of workers using nanomaterials in all countries and especially in low to medium income countries'.

The **Nordic Council of Ministers** published a report in 2007, 'Evaluation and Control of Occupational Health Risks from Nanoparticles', on the risk assessment and management of nanoparticles in the workplace (Schneider et al., 2007). The report, which is available on the Internet, was directed to occupational health and safety professionals, to give an overview of the state of the art at that time.

The **Environmental Nanosciences Initiative** was set up in the United Kingdom by the National Environmental Research Council (NERC), Department for the Environment, Food and Rural Affairs (DEFRA) and the Environment Agency (EA) to provide a mechanism to assess the risks posed by nanoparticles. A number of the 19 research objectives directly relate to understanding risks to health of nanomaterials. To answer many of the questions requires basic nanosciences research into fate and behaviour, toxicology and ecotoxicology of nanomaterials. The initiative will provide small exploratory awards to researchers, and the data will be used to build the evidence base to inform the development of government policy. Some results from funded projects have been made public on the website of the initiative (http://www.nerc.ac.uk/press/releases/2009/25-nano.asp).

The **International Risk Governance Council (IRGC)** has published a few reports concerning Nanotechnology Risk Governance. In their White Paper, IRGC sets out recommendations for the risk governance for nanomaterials (IRGC, 2006). The main objectives for IRGC were 'to develop and make available specific advice for improving risk governance, to provide a neutral and constructive platform on the most appropriate approaches to handling the risks and opportunities of nanotechnology and, if possible, to enable all actors to reach a global consensus'.

IRGC's document 'Risk Governance of Nanotechnology Applications in Food and Cosmetics' (IRGC, 2008) describes the applications of nanomaterials in food and cosmetics, summarising research on public perceptions and reviewing the regulatory background and legal requirements for the risk assessment of nanomaterials. The report highlights risk assessment studies for three sample nanoparticles: synthetic amorphous silica, titanium dioxide, and encapsulated vitamins. The study also provides the currently available codes and frameworks that provide guidelines for risk assessment, management and communication such as: Responsible Care, the EC Code of Conduct for Responsible N&N Research (see 5.2), Responsible Nano Code initiated in the United Kingdom and Nano Risk Framework started by DuPont and Environmental Defence. The report states that such voluntary codes offer an alternative to regulation.

The **U.S. National Institute for Occupational Safety and Health (NIOSH)** recently issued an updated and expanded edition of 'Approaches to Safe Nanotechnology' (NIOSH, 2009). This reiterates NIOSH's interim recommendations that employers should take sensible measures to control occupational exposures in the manufacture and industrial use of engineered nanomaterials. The guidance reviews what is presently known about nanoparticle toxicity, process emissions, exposure assessment, engineering controls and personal protective equipment. The document serves a dual purpose: it is a summary of NIOSH's current approach and interim recommendations; and secondly it is a request from NIOSH to occupational safety and health practitioners, researchers, product innovators, manufacturers, employers, workers, interest group members and the general public to exchange information that will ensure that no worker suffers any impairment of safety or health as nanotechnology develops. **NIOSH's Nanotechnology Research Centre (NTRC)** communication actions are presented in NIOSH (2010). NIOSH has also prepared a brochure on safe nanotechnology in the workplace (NIOSH, 2009), which provides a good introduction to the risks of nanomaterials for employers, managers, and safety and health professionals. NIOSH invites all partners and stakeholders to provide input and feedback on the National Nanotechnology Initiative (NNI) and the NNI National Strategic Plan (NNI, 2011) including contributing to education-related activities such as the 'development of materials for schools, undergraduate programs, technical training, and public communication, including outreach and engagement' and 'research directed at identifying and quantifying the broad implications of nanotechnology for society, including social, economic, workforce, educational, ethical, and legal implications'.

The U.S. **Environmental Protection Agency (EPA)** is committed to keeping the public informed of the potential environmental impacts associated with nanomaterial development and applications. As an initial step, EPA is developing a dedicated web site to provide comprehensive information and enable transparent dialogue concerning nanotechnology. In addition, EPA has been conducting outreach activities by organising and sponsoring sessions at professional society meetings, and speaking at industry, state, and international nanotechnology meetings. EPA has already taken steps to obtain public feedback on issues, alternative approaches, and decisions through public meetings. EPA has made a commitment to continue to work collaboratively with all stakeholders, including industry, other government entities, public interest groups and the general public, to identify and assess potential environmental hazards and exposures resulting from nanotechnology, and to discuss EPA's roles in addressing issues of concern. EPA's goal is to earn and retain the public's trust by providing information that is objective, balanced, accurate and timely, and by using transparent public involvement processes. The **United States (U.S.) Department of Energy** has set out its approach to nanomaterial environmental, safety and health issues in a collection of good practice guides for laboratory workers, with information on the safety and health effects related to nanomaterials, risk assessment, nanoparticle measurement etc. (U.S. Department of Energy, 2008).

The **Institut de Recherche Robert-Sauvé en Santé et en Sécurité du Travail (IRSST), the Commission de la Santé et de la Sécurité du Travail (CSST) and NanoQuébec** have jointly published a best practice guide which sets out a step-by-step prevention strategy for risk assessment and exposure control for both workers and researchers who use or manufacture nanoparticles (IRSST, 2009). They favour a preventative approach aimed at minimising occupational exposure to nanomaterials when their risks cannot be precisely established. This document illustrates (at the time of writing) the current state of knowledge on the risks of nanomaterials and makes recommendations for controlling risk factors to prevent human exposure in the workplace.

The **Royal Society, Insight Investment, the Nanotechnology Industries Association and the United Kingdom Nanotechnology Knowledge Transfer Network** are the founding organisations of the 'Responsible NanoCode' (Responsible Nano Code, 2007). The founding partners established a specific working group in 2007 composed of representatives from industry, business, academia, and civic society, for the preparation of this CoC. This Responsible Nano Code will work in two ways:

1. Organisations will be encouraged to adopt the seven principles of the Responsible Nano Code. They can also refer to the examples of good practice that provide suggestions as to how each principle might be implemented. In addition, a benchmarking process will be designed to assess the extent to which they are achieving best practice and to help them continuously improve.

2. A group of organisations (to be determined) involved in nanotechnology will be benchmarked to assess the extent to which they are operating according to this Framework; this group may include both companies that adopt and do not adopt the Code. The intention is for this benchmarking process to be undertaken by an independent group of stakeholders (to be defined).

The seven principles of the Responsible Nano Code are:

1. Board Accountability;

2. Stakeholder Involvement;

3. Worker Health & Safety;

4. Public Health, Safety & Environmental Risks;

5. Wider Social, Environmental, Health and Ethical Implications and Impacts;

6. Engaging with Business Partners;

7. Transparency and Disclosure.

Friends of the Earth (FoE) International is a federation of environmental organisations, with member groups in over 72 countries. FoE is one of the NGOs most active in the debate on nanotechnology. It has published various reports and positions papers on the subject (www.foei.org):

- Nanomaterials, Sunscreens and Cosmetics: Small Ingredients, Big Risks, May 2006.

- Out Of The Laboratory And On To Our Plates: Nanotechnology in Food and Agriculture, April 2008.
- Mounting evidence that carbon nanotubes may be the new asbestos, August 2008.

5.3.4. Networks

Collaborative networks are another source of information on risks of nanomaterials. They also encourage the exchange of ideas and help set the agenda for research. They can provide a useful platform through which stakeholders can reach target audiences.

The **International Council on Nanotechnology (ICON)** is the best known of several partly academic clearing-houses for nanosafety data. It is an international, multi-stakeholder group committed to developing and communicating information on the potential environmental and health risks of nanotechnology, with the aim of fostering risk reduction while maximising societal benefit. ICON is composed of individuals from academia, industry, government and non-governmental organisations from countries with high levels of nanotechnology research and development activity. ICON is technically driven and does not engage in advocacy or commercial activities. It organises forums and events to explore health and environmental risk issues in nanotechnology; it has an open electronic knowledge database for accessing peer-reviewed publications in nanotechnology; it provides high-quality technical information relevant to decision makers in nanotechnology and organises a proactive communications platform that translates complex scientific data into material easily understood by many stakeholders (http://icon.rice.edu/).

The **Society for Risk Analysis** is a multidisciplinary, scholarly, international open forum, based in the U.S., for anyone interested in risk analysis. The Society's nano risk group arranged a workshop held in 2008 and is preparing five white papers in this area (http://sra.org/events_2008_nanorisk_workshop.php).

The **Nanotechnology Knowledge Transfer Network (NanoKTN)** in the United Kingdom is an example of a national industrial organisation that informs on nanotechnology risks. Its primary aim is to encourage collaboration and knowledge transfer between the key players in industry, start-up companies, SMEs, mostly through the organisation of events:

(www.laboratorytalk.com/news/nak/nak002.html).

The **Substance Information Exchange Fora (SIEF)** under the REACH Regulation are collaborative networks of producers and importers for preparation of REACH documentation. They are encouraged to actively participate in communication of hazards and risks.

5.3.5. Examples of joint initiatives

NanoCare (www.nanopartikel.info) and **GoodNanoGuide** (www.goodnanoguide.org) are examples of platforms set up jointly by academics, industry and governments, who all contributed their expertise.

The NanoCare project aims to broaden knowledge about synthetic nanomaterials with regard to the potential impacts of nanomaterials on human health. Data created within NanoCare were interpreted together with additional information from the literature and are provided on their web site (see Table 8). This publication of nanotechnology safety aspects helps to satisfy the increasing information needs of the public. Furthermore, the results were presented to and discussed with the public, politicians and NGOs at dialogue events.

The GoodNanoGuide is another collaborative platform designed to enhance the ability of experts to exchange ideas on how best to handle nanomaterials in an occupational setting. It fulfils the need for exchange and dissemination of up-to-date information about current good workplace practices, highlighting new practices as they develop. It is a wiki site which allows entries from authorised specialists and non-specialists, and provides risk management schemes and an occupational health and safety reference manual for laboratories and workplaces. The GoodNanoGuide is the result of a joint effort by the International Council on Nanotechnology (ICON), the United Kingdom based Safenano, the Institute for Work and Health, the US NIOSH,

University of Wisconsin's Centre for Nanotechnology, InterNano, the United Kingdom Institute of Occupational Medicine, the Canadian IRSST and others.

5.4. Communication tools

The most common communication approaches include guidance in the form of leaflets, brochures and reports, as well as conferences and discussion platforms, education and training books. Some of the material is available in printed form and some can be downloaded from the Internet.

In general, websites are major communication tools widely used by different organisations (alone or with broaden collaboration) to communicate on risks and benefits of nanotechnology. Websites are generally designed to make nanotechnology hazard and risk information accessible to society. Both HSE professionals and workers who seek advice on nanomaterials' risks often visit such websites, looking for regulatory information, science as well as discussion and opinion. Multiple stakeholders within the international community contribute, share and discuss information related to nanomaterials' occupational safety, and databases of resources are available (e.g. publications, expert's blog reports). Websites can also be used to gather information on stakeholder perception of risks via online questionnaires and surveys, and many of these websites have already been mentioned including SAFENANO (www.safenano.org), GoodNanoGuide (www.goodnanoguide.org), Nano&Me (www.nanoandme.org) and NanoSmile (www.nanosmile.org). The website Time for Nano (http://www.timefornano.eu/) aims to engage with the public, particularly young people, about the benefits and risks of nanotechnology, and provides educational materials. Science centres in Italy, United Kingdom, Belgium, France, Germany, Finland, Portugal, Poland and Turkey will organise 'Nanodays', events with demonstrations, experiments, games, meetings and discussions about nanotechnology. The SAFENANO website is rich in information that monitors developments on Nano EHS, especially on the work environment. Especially interesting are the comments, chronicles and blogs. The Nanowerk website (www.nanowerk.com) is a rich source of information on different aspects of nanotechnology mainly for industry, and academic researchers. It also provides in depth analysis and scientific evidence regarding potential risks. Details of a wide selection of these websites and online databases, their aims, achievements, target audiences and founders are given in the table in Appendix 1.

5.5. Comparative study of two approaches: Potential conflict in risk communication with regards to nanomaterials

As can be taken from the previous sections of this report, there have been several efforts to communicate the risks associated with nanomaterials to public audiences. The case history below highlights problems that have been encountered in these risk communication activities.

Two recent French public debates on the risks of nanotechnologies obtained opposing findings highlighting the importance of communications and of proper preparation when informing citizens. Much can be learnt from comparing the Nanoforum organised by the Conservatoire National des Arts et Métiers (CNAM) from 2007 to 2009 with the national public debate organised under the auspices of the Public Debate National Commission (CNDP, 2010) from late 2009 to early 2010. The main characteristics of these two initiatives are compared in Table 9.

The Nanoforum was an experimental scheme organised by CNAM at the request of the French Health Ministry. It was designed to engage society with the issues of nanotechnologies (in terms of their definition, uncertain risks and benefits). A steering committee was set up, bringing together representatives from the relevant authorities (health, research, environment, and industry), researchers, associations, and economic stakeholders. Its aim was to give the public authorities an overview of the issues raised by nanotechnologies. Various public debating models were analysed: conferences with an educational focus, citizens' conferences, etc. The Nanoforum was then defined as a place for identifying issues and for debating the scientific, ethical, and social aspects raised by these new technologies. Eight sessions were organised, dedicated not only to the use of nanoprocesses in various industrial sectors (e.g. cosmetics, construction, food), but also to e.g. local governance, nanomedicine, and worker protection. Although its resources were of a modest scale and centred on Paris, this initiative, which was spread over one and a half

years, with nearly 200 people attending each session, yielded positive direct and indirect effects. Priority scientific uncertainties were identified, research networks were set up, and new forms of governance were explored. Originally destined to continue unchanged, the Nanoforum was stopped by the implementation of a national public debate.

The later national public debate on development and regulation of nanotechnologies was ambitious, resulting from one of the most major negotiation processes to be conducted in France in recent years, under the Green New Deal thrashed out at the French 'Grenelle' Talks on the environment. This national public debate emerged from a commitment written into a bill or 'draft law' (Article 42, Law 2009-967 of 3rd August 2009). The debate, commissioned by seven ministries, was entrusted to the Public Debate National Commission (CNDP), a government body set up to involve the public in major infrastructure projects (e.g. hazardous industrial sites, railways). The CNDP decided to organise the debate itself, assisted by two public relations agencies, over a five-month period (October 2009 to February 2010), at a cost of 3 million euros. Seeing how uninformed the public was about the subject, the commission decided to reach out to the public in cities where industries or laboratories working on nanotechnologies were located. The main motivation was to inform citizens about the various industrial applications of nanotechnologies and to collect any thoughts they might wish to express. Seventeen cities were chosen for the topical meetings, combining the technical subjects related to the local activities, and also nanotechnology in general. However, out of 17 meetings, 8 were disturbed or cancelled. By the end of the debate in February 2010, only 3,216 participants had attended the meetings (instead of the 10,000 expected), and 169,717 visits had been made to the website. Officially, 'the debate did not enjoy the success that was expected of it'. Seen by nanotechnology's opponents as a 'promotional tour', the debate ended in failure. Some NGOs blocked participation in the public debate in order to denounce a debate on the development of nanotechnologies that they considered served no purpose since the decision had already been taken. It is true that the French Ministry for Research had announced, in May 2009, the setting up of a funding plan worth 70 million euros (Nano-INNOV), and that the public debate was arriving late, after Nano-INNOV had already been decided. Access to the meetings was supervised and sometimes controlled by the police. Topics were very general and the content technical. Few participants were satisfied with the relatively restricted conditions of exchange (time-limited). Many issues (military, individual freedom, etc.) were omitted (CSO, 2009). Furthermore the commitment made by the French government to translate the findings of the consultation into a political decision within three months of the report being submitted had not been honoured directly, at the time of writing this report. Various demands were expressed (e.g. moratorium, law for controlling production and use of nanotechnologies, measures for informing about and identifying products containing nanomaterials) but have remained in abeyance. Only the information collected prior to the debate, comprising about fifty 'stakeholders' notebooks' (representing collections of the opinions and positions of the main stakeholders in nanotechnologies), was acknowledged as having been useful, summarising the questions raised by the dissemination of nanotechnologies.

For the CNDP, 'the debate is not over'; its report pinpoints a number of problems related to the organisation of the debate:

- Schedule, date, and timing were poorly chosen (example of feedback comments received: 'after everything had already been decided');
- Scope of the subject was too broad as it addressed the development and regulation of nanotechnologies in general;
- Closely controlled access to and nature of the technical debate;
- Format of the discussions too limited (allowed about three minutes per person).

Any public discussion requires adjustments to be made and fair conditions to be laid down for participants to interact without constraint. In this second example, these conditions were not satisfied. For an NGO, this does not mean that public dialogue is impossible but rather that 'there is no miracle recipe or procedure for public consultation!' This demonstrates how difficult it is to place the debate in a context in which democracy is not only representative (based on representations) but also participative (based on the concept of stakeholder, regardless of status).

Table 9: Comparison of the conditions for public debate in the two recent French examples

Experiences Conditions	Nanoforum 2007-2009	National Commission Public Debate 2009-2010
Commissioning body	Health Ministry	Environment Ministry
Leader/Moderator	Independent	Appointed by the Government
Subject	Use of nanotechnologies	Consequences of nanotechnologies (promises versus risks)
Participation	Free, broad	Access filtered in certain cities
Scientific openness	Various different experts	Administrative and technical control
Sessions	Regular	Occasional
Taking the floor	Free, sharing experiences and skills	Timed (experts and public), confrontation
Controversy	Accepted	Feared
'Transparency'	Strong	Information on meetings limited
Context	Before investment decision	After investment decision
Assessment	Positive	Negative (except for the 'stakeholders' notebooks')

5.6. Summary

Overall, this section of the review has highlighted some of the relevant, representative examples of risk communication activities carried out by and for different stakeholders. These examples do not represent an exhaustive survey. The communication activities and the methods and motives differ between different types of stakeholders. Some of the material is available in printed form and some can be downloaded from the Internet. The most common communication approaches include websites, leaflets, brochures and reports, and conferences and discussion platforms. Although much of this material contains very useful information, effective risk communication for workers requires more than provision of information on the web or in leaflets, and involves four key steps: (i) understand the issue and risks; (ii) determine the communication needs i.e. what needs to be communicated, by whom and to whom; (iii) establish and implement a risk communication strategy, which (iv) is then evaluated and reviewed. The European Code of Conduct and the French open dialogues are two of very few risk communication initiatives that have carried out all four steps in full including evaluation that could be accessed and discussed here.

Another complication is that most risk assessors think that there is only little information available on the risks of N&N and, in particular, that little is known on generic principles for the toxicity of nanomaterials. Risk communication on N&N risks on a more general level should encourage a precautionary approach and will imply communicating an extent of uncertainty. Before starting communicating, decisions should be made as to whether it is more meaningful to communicate about N&N in general or to focus on more specific types of nanomaterials. Alternatively it may be more effective to communicate on specific issues, such as in the United Kingdom's HSE guidance 'Risk management of carbon nanotubes' (HSE, 2011). Because the general public has only a

vague understanding of what nanomaterials are, it is important that risk communication is adjusted to the conceptual, the socio-political and cultural landscapes of the recipients. Very little seems to have been done in mapping the receptiveness of employers and employees in the workplace. It is important to understand how risk management and practices in the workplace are affected by risk communication, especially consideration of communicating vague information with a high degree of uncertainty.

Many EU Framework programmes and projects on nanomaterials include an element of risk communication, but few of these communication initiatives are directly relevant or appropriate for the workplace. Much of the risk communication material has been prepared by scientists for other scientists, regulators, occupational safety specialists, toxicologists rather than for workers and employers, and has been disseminated through conferences and scientific publications.

Although not always directly targeted at workers or workplaces, good examples of risk communication have been initiated: such as activities by BASF to engage with its workers through one-to-one conversation, dialogue events, and printed and web-based media and the EC's Nanotech Communication Roadmap, a dialogue with the public via a range of approaches such as television and road-shows. The effectiveness and success of these initiatives will depend on the research and preparation underpinning them (in line with the four key steps above), and honest evaluation and review of their achievements and the lessons that can be learned.

Conflict can arise in or as a result of risk communication, and consideration of the issues is important for effective future progress. A very relevant example of conflict for risk communication for nanomaterials is the French public dialogue initiative, and comparison with the French Nanoforum can lead to important lessons for the future (summarised in Table 9). These lessons can be summarised as the need for free sharing of experiences and views, in an atmosphere where openness and transparency are encouraged and controversy is accepted. The perception that issues have been 'pre-judged' can be particularly counter-productive.

In conclusion, policy makers interested in risk communication for nanomaterials workers should adopt existing, successfully tried and tested processes, gaining an understanding of the nature of their audience, their values and concerns, and learning from previous initiatives as evaluation of them is published. Their participation and visibility in public debates and dialogues are also important for engendering trust and openness, and building confidence in this new technology.

6. Conclusions

The aim of this review was to summarise the general principles and theories of risk perception and communication, exploring how these might be applied for workers and employers working with nanomaterials. Relevant research, studies and surveys that have been done to date have been considered, with the aim of highlighting risk communication approaches that would be applicable to workplaces involved with nanomaterials, and in the process, discussing the challenges and difficulties that can and have been encountered. The conclusions of the review are brought together in these conclusions with knowledge gaps highlighted as appropriate. Recommendations specific to nanomaterial risk communication in the workplace are proposed in Chapter 7.

The current position for risk communication of nanomaterials is one of very limited knowledge with many uncertainties of nanomaterials' hazards remaining despite the research, mentioned in the introduction, to investigate potential risks. Lay people and some workers generally have minimal knowledge and understanding of nanomaterials and are therefore unable to reach an informed stance. Even the 'experts' do not know, with any certainty, the benefit/risk balance for nanomaterials. The fact that materials, with essentially the same name, can have vastly different properties at the nano-scale can cause confusion and misunderstandings. People generally expect risks from dangerous substances to increase with quantity, whereas nanomaterials are often handled in smaller quantities, which can add to this potential for confusion.

As an emerging scientific area, nanomaterials have several inherent characteristics (e.g. uncertainty, lack of familiarity, potentially delayed and irreversible health effects, man-made) that are likely to engender concern, mistrust or fear. There is therefore the potential for controversy, which varies with sector and application within that sector, for example medical applications for the purpose of curing disease generally meet with public approval whereas medical application for improving human performance do not, nor do the use of nanotechnology in food, as discussed in Chapter 2, although there has, as yet, not been an outright rejection of the underlying technology. The huge scope, novelty, excitement about promised benefits coupled with the uncertainty and low current level of understanding in a rapidly changing scientific field also poses significant challenges for risk communication.

How the risks and benefits of nanomaterials are framed has a major impact on risk perception but no clear guidance of how to do this has been revealed by the available literature reviewed; only tentative proposals for framing can therefore be made in Recommendations (Chapter 7). Nanotechnology is, at the moment, most often framed, by both the media and general public, in terms of benefits. To ensure this continues and to make safe and fruitful progress in the development and application of nanomaterials, a precautionary approach is recommended by many regulators; most agree that this should take the form of tightly controlling the release of nanomaterials to the environment and the exposure of both workers and the general public to ensure that if serious hazards are subsequently identified, exposure has been minimised. It will also be important to communicate and discuss not only the potential risks of nanomaterials with workers, but also the uncertainties currently surrounding the field of their hazard characterisation.

There is wide recognition that an effective, balanced and meaningful dialogue between all stakeholders is needed and this is embedded in the European code of conduct for responsible nanosciences and nanotechnologies research. A key stakeholder group that must be engaged during this process is the layperson, in the guise of the public, workers, and potential product users. Another key group are opinion leaders and opinion makers, who are able to influence other peoples' attitudes and hence behaviours, and information multipliers. In the case of nanomaterials in the workplace these would be for example, regulatory inspectors, trade associations, suppliers, training providers and trade unions. Another source of information for SMEs are their customers some of whom may impose health and safety requirements on their suppliers.

Open and honest communication with the aim of developing a sound understanding of the risks and benefits will be key for all of these stakeholders. Guidance on how to conduct effective risk communication, which could usefully be applied in the occupational health and safety setting although not necessarily specifically written for that purpose, has been described and discussed in Chapter 3. The guidance has been most usefully summarised by Renn (2008) (reproduced in Chapter 3), the central message of Renn's guiding principles being to anticipate the interests of the target audience and design the messages and communication program to match. For

example, the low level of knowledge about nanomaterials in SMEs suggests that they might be a focus of risk communication initiatives.

Risk communication for nanomaterials faces particular challenges and examples provided in Chapter 4 highlight some of the difficulties that can result from ineffective communication. Several examples of such conflicts have been discussed, including labelling of product and descriptions of relevant hazard information in safety data sheets (SDS). Some reports and stakeholders have highlighted that there are problems with information in SDS. One of the major challenges to risk communication is the huge complexity of nanomaterials even for one parent chemical. This may require that risk communication describes the material(s) in question fully, takes into account whether exposure to free nanomaterials is likely, and explains the nanomaterial's toxicity and where it stands in the toxicity spectrum between the extremes of potentially highly toxic and harmless. Any link made between exposure to a particular nanomaterial and any health outcomes needs to be robust, convincing and scientifically sustainable. Misinformation and mis-labelling during risk communication can compound all of these issues.

In other industrial sectors (e.g. nuclear), strategies for engaging effectively with stakeholder groups, framing and delivering information about risk have however been established. These have been drawn upon, to varying degrees, to support numerous past and ongoing, international, European and national, initiatives to communicate information on nanomaterial risks and benefits to stakeholders. A relevant, non-exhaustive representative sample of such initiatives has been described in Chapter 5. Some have been more successful than others and the reasons for their lack of success can be traced back to not following the guidance outlined in Chapter 3. Analysis and comparison of the few major initiatives that were found highlights some useful lessons that can be learned (Chapter 5), and in particular emphasises that the recommendations from other areas of risk communication apply within the nanomaterials arena i.e. timeliness, free-sharing, open exchange of views between participants, acceptance of controversy and the perception that discussions were welcomed before decisions, empowering participants to feel involved and valued.

Many initiatives, a few of which take the form of public engagement or dialogue, are aimed at researchers or the public as consumers rather than at people potentially exposed in an occupational setting. One notable exception is the Nanosmile website which aims to provide accessible and interesting, multi-media information for workers as well as the public. Furthermore, as highlighted in Chapter 5, some industries and industry associations have developed guidance targeted at risk management in the workplace, although some initiatives have focussed on business opportunities rather than responsibilities to control risks to workers or the environment. Some Trade Unions have also produced information material on how to manage risks of nanomaterials in workplace.

Initiatives have, at the time of writing, primarily taken the form of exhibitions, web-based materials or events. Other literature is dominated by documents in English, intended for a specialist audience, such as scientists and health professionals, rather than the general public or workers. Currently the primary source of information for workers on nanomaterial risk management is that contained in material safety data sheets (SDS). Unfortunately, the quality and usefulness of the information is not often sufficient for the purposes of effective risk communication and management, since it is often not specific to nanoscale versions of the material but relies on unjustified extrapolations from the bulk form of the chemical. In particular, SDSs often prove to be difficult to use for SMEs, who therefore tend to favour one-to-one verbal information from regulators, colleagues or suppliers. Therefore ways of making effective uses of these approaches are needed for these types of organisations. Targeting the right individual in these organisations is key, as is the recognition of the many other demands on their limited time. The information therefore needs to be concise, focussed and from a trusted, official source.

Collaboration and cooperation between stakeholders can be a powerful tool for risk communication; although opportunities exist for interested stakeholders to co-operate through trade associations, trade unions, online forums and other networks, this is currently self-selecting, i.e. participation is not representative of all groups but rather based on those with the greatest interest, enthusiasm or business drivers, rather than greatest needs for risk information. This means that for example, workers directly involved with nanomaterials may not be participating. Regulators, industry, trade associations and unions are currently the most active groups providing information and communicating about risks in relation to occupational health and safety. How this information is received will depend partly on how well the recipients trust the providers.

Risk communication can help build trust between stakeholders and allow better policy to be made, but it is not a panacea, nor will it necessarily resolve conflicts that arise, guarantee understanding or cause people to behave in certain ways. Chapter 3 has summarised the main aspects of the guidance available in the literature, which if followed will help ensure that any risk communication is as effective as possible. To date, there has only been limited conflict between stakeholders, although the potential exists. Currently public perception and the effects of increased information appear to be contradicting long-standing findings about risk perception, specifically that certain groups of people become more concerned about the risks with increased provision of information. This should have positive outcomes for risk communication initiatives. As these continue and new ones are developed, the format chosen should increasingly inform decisions that employers make about workplaces and support them in implementing adequate prevention measures; and empower individual workers to exert personal control over their own situations and environments. This is more likely to ensure long-term success of workplace initiatives.

7. Recommendations

The EC recommendation on a definition of nanomaterials adopted in October 2011 will certainly greatly contribute to aid risk communication. However, when communicating about risks and benefits of nanomaterials, consideration is still needed on how to overcome the potential for confusion caused by the fact that materials with essentially the same name have vastly different properties at the nano-scale as at the macro-scale; and that even one same type of nanomaterial (e.g. carbon nanotubes) may have different properties, depending on its size, morphology, coating, etc.. The terminology employed to communicate on nanomaterials may therefore need to be refined and made more specific; when communicating to workplaces, it may for example be questioned whether it is useful to use the generic label of nanomaterials, when some are particles and others are fibres; some are toxic, others not; some are explosive, others not, etc.

In the nanomaterial field, good risk communication practice should be followed in planning, delivering and evaluating any initiatives, the value of which is readily highlighted by comparison of some of the successful and unsuccessful initiatives carried out to date. Different risk communication approaches should be used depending on whether risks are routine, highly uncertain or potentially controversial. Risk communication needs to be accessible, tailored to the target audiences (user-centred) taking into account their different information needs and preferences, concerns and value systems. Good use should be made of influential and trusted intermediaries. In the occupational setting it is crucial that key information is retained and acted upon. The burgeoning literature on worker involvement, behaviour modification and a mental-model approach to risk communication may therefore provide useful insights and a fruitful source of further guidance for communicating about nanomaterial risks in occupational settings.

Research is needed to reduce uncertainties about potential risks, thereby reducing confusion and the potential for controversy. Relevant research findings should be made widely available, whilst respecting justifiable commercial concerns, to enable consistent risk communication and also to reduce duplication of effort. In so doing authors need to avoid over-stating preliminary conclusions or suggesting unjustified links to nanomaterials as causative agents, as discuss in Chapter 4. However, the critical need is for development of risk communication strategies that can handle the uncertainties surrounding the potential hazards of nanomaterials, since it is probable that until a clear understanding of the relationship between toxicity and physicochemical properties of nanomaterials is developed, knowledge of the risks associated with new emerging nanomaterials will continue to lag behind their generation. Development of such a strategy is not straightforward, with no guarantee of success, and no clear risk communication guidelines specific to nanomaterials are yet available in the literature. The value of applying generally applicable good practice in risk communication, as outlined in chapter 3, to the nanomaterials arena should not however be underestimated. Consideration is needed on how to apply these principles in the occupational health and safety setting to enable employers to engage effectively with workers to empower them so that together they can manage, monitor and communicate about nanomaterial risks to health, safety and the environment. Most importantly, risk communication strategies for nanomaterials will need to be able to adapt to facilitate reframing and redefining of the issues as they change with the development of the technology and emergence of new nanomaterials; it will need to be vigilant and to actively seek new knowledge and information based on good quality scientific research and analysis.

One of the issues to consider as risk communication strategies are devised is the existing level of knowledge in the workplace; surveys indicate that almost half the population does not know what is meant by nanomaterial or nanotechnology, and that there is a low level of knowledge in SMEs. Therefore any communication needs to begin by explaining what these terms mean and how the worker is potentially going to encounter them.

Communicating about the risks of nanomaterials to workers with persistent uncertainties will also require adaptation of the approaches taken to the social concerns of each target group, structure and organisation. The individuals or organisations providing the information need to be recognised as competent, and as much consideration is needed of how the messenger comes across as the messages themselves. Trust needs to be built carefully and alliances between stakeholders forged through openness, transparency, accountability and demonstrable independence. People place high levels of trust in scientists, such that their contribution to risk communication is very valuable, but their involvement is not straightforward. Many of the organisations that companies may look to for advice and guidance are not necessarily thought of

as being associated with scientists. Furthermore, it needs to be taken into account that people tend to adopt the attitudes and behaviours of those with whom they share values. Scientists may be trusted, but people may not always be able to identify with them in terms of shared values.

The target audience in the workplace can be individual workers or selected multipliers, who are trusted colleagues and can effectively cascade information to others. The communication strategy should involve a two-way process, not just provision of information to the workers, and should be relevant and timely for the workplace(s) in question. The discussion needs to be framed carefully; as explained in Chapter 2, people tend to underestimate common or familiar risks, and therefore for some nanomaterials, where people are very familiar with the base name such as silver for example, it may be difficult to convince them of the need to take precautions. Therefore the unique properties of the nanomaterial need to be emphasised.

The approach taken for risk communication also needs careful planning. One communication model, referred to as AIDA (EC, 2010d) suggests the following stages: gaining the audience's attention; arousing their interest; provoking a desire to change their attitude and triggering actions that will lead to the behavioural changes. Depending on the situation, a narrative approach may work well, in which information is made personally relevant in order to help get messages across, perhaps involving specific examples with which workers are familiar. One survey indicated that a large proportion of people are worried about dermal exposure and so this could be a useful starting point in terms of first explaining how to reduce this risk and then pointing out that there are other routes of exposure such as inhalation, which may be more critical, and how the workers should control this. Wherever possible, eye-catching but ill-researched or half-hearted gimmicks should be avoided.

Evaluation of the risk communication strategy developed should be carried out and lessons learned and shared. Collaboration, exchange of information, ideas and concerns should be encouraged and stimulated in workplaces. Obstacles to success of the strategy need to be identified and ways to address them developed. Worker engagement needs to be continuous and sustained as their concerns may shift as the science of nanomaterials is rapidly developing. This will require initial and on-going development and provision of training and educational materials that are up to date and appropriate for the different audiences: workers, employers and occupational safety and health professionals including risk communication for scientists and policy-makers.

Policy-makers have the opportunity to define how nanomaterials are framed so as to promote the sensible management of risk. Once this frame has been found it needs to be used consistently among stakeholders. There needs to be a clear process by which risk communication initiatives influence policy otherwise stakeholders will not engage. Regulators and policy-makers need to engage with industry, trade unions and consumer associations, sharing the responsibility for risk communication activities in order to develop science-based risk management policies. Even with all this in place, an emergency or crisis in public confidence could still occur. It is important, therefore, to plan for this eventuality in terms of who will take the lead, seeking assurances in advance of how other organisations will support the plan so that, in a crisis situation, they are prepared to react quickly and provide clear consistent messages directly to the public.

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Appendix 1: Internet web portals and platforms for risk communication

Website	*Founder*	Aims	*Achievements, communication tools*	*Target audiences (stakeholders)*	*FAQ*
www.safenano.org	Institute of Occupational Medicine, United Kingdom	▪ providing nanotechnology safety services to industry, academia and government, ▪ understand, explain and minimise the risks of working with nanomaterials.	Newsletters, database, SafeNano's Discussion panel (blogs and forum), SafeNano's Guidance Documents on Nanoparticle Health Risks	OSH specialist, government regulators, researchers (academic, governmental, industrial), NGO's, citizens	Yes
www.nanosmile.org	NanoSafe, iNTeg-Risk (FP7) project	▪ contribute to the understanding of risks related to nanomaterials, make science comprehensible in order to facilitate Public dialogue; ▪ disseminate information and gaps of working with nanomaterials; ▪ clarify and diffuse expertise on Nano Risk Assessment & Management.	Five very good prepared thematic modules: PRECAUTIONS; METROLOGY, HEALTH, ENVIRONMENT, GUIDELINE Modern communication's tools (cartoons videos, animations quiz) CEA (Commissariat à l''énergie atomique) training session,	Three level of stakeholders (from public to expert)	No
www.goodnanoguide.org	ICON, nanoAlberta - British Columbia Nanotechnology Alliance, Nanotech BC, Industry Canada, IRSST.	▪ establish a process wherein different stakeholders within the international community contribute, exchange and discuss knowledge related to occupational safety with nanomaterials; ▪ create a modern, interactive forum that fills the need for up-to-date information and remains current as new practices develop	Newsletters, experts' participation, nanotechnology risk resources, forum (community), Protocols on: government guidance documents, nanotechnology standards, operation specific, research facility specific, organisational control systems	OSH professionals within large SME's, government regulators, science workers (academic, governmental, industrial), NGO's, public	Yes
http://www.nanoceo.net	Volunteer citizen organisation in Wisconsin	▪ educate the community about nanotechnology issues, through events, meetings, and website,	Newsletters, conference, meetings and workshops with/for citizens (example Nano Café with experts),	Citizens	No

Website	*Founder*	Aims	*Achievements, communication tools*	*Target audiences (stakeholders)*	*FAQ*
		▪ facilitate citizen engagement and societal dialogues about nanotechnology's implications for the benefit of the general public. ▪ inform the community about risk regarded to nanotechnology.	Nanorisk resources (references to research papers, articles, and books). Comments on governments' initiatives and create citizens friendly summary.		
www.crnano.org	Center for Responsible Nanotechnology is non-profit research and advocacy think tank established by Mike Treder and Chris Phoenix	▪ engages publicity to better understand the implications of molecular synthesis and to focus on the real risks and benefits of the –nanotechnology; ▪ creation and implementation of wise, comprehensive, and balanced plans for responsible use of nanomaterials.	Communications in four languages: English, Spanish, Portuguese, Chinese, Newsletters, Nanorisk resources (references to research papers, articles, and books), CRN blog.	OSH specialist, government regulators, researchers (academic, governmental, industrial), NGO's, citizens	Yes
www.nanoandme.org	Department for Business Innovation and Skills, Esme Fairbairn Foundation Prepared by The Responsible Nano Forum	▪ provide balanced information about nanotechnologies, ▪ open space for everyone to discuss, comments and debate on the most important issues in the nanotechnology fields (also safety issues).	Debate in 17 categories with another stakeholders, 'Your views' – place to post thoughts about nanotechnology, Vote for the most relevant ideas.	citizens	No
www.nanotruck.de	The Federal Ministry for Education and Research	▪ provide information-campaign about nanotechnologies, ▪ inform the public about the benefits and potential risks of nanotechnology, ▪ show new perspectives and modern possibilities of application for nanotechnology.	nanoTruck's tour, High-Tech from the Nanocosmos.	General Public, schools and SME's as specific target groups	No
The other most popular are: www.nanoregnews.com, www.nanoparticlelibrary.net www.nanoaction.org, www.nanowiki.info, www.nanoarchive.org, www.nanoforum.org, www.nanoandme.org, www.nanotechnologydevelopment.com, www.nanoker-society.org, www.icpc-nanonet.org, www.nanoforumeula.eu, www.nanonet.pl.					

Appendix 2: Focal Point information request

Consultation on risk perception and risk communication with regard to nanomaterials in the workplace

The questionnaire reproduced below was sent to EU-OSHA's Focal Points in 2010 in order to help the authors of this report to access risk perception surveys and risk communication initiatives taking place in the EU countries with regard to nanomaterials, and primarily focused on workers and employers.

Appendix 2 contains:

- The questionnaire sent to the Focal Points;
- The analysis of their answers

Please note that the authors of the review do not accept responsibility for the integrity of the website links provided by the Focal Point responders.

Questionnaire

A. GUIDANCE ON RISK COMMUNICATION

1. In your country, do you know of any guidance (e.g. principles, codes of conduct, guidance documents, procedures) for risk communication of nanomaterials to *workers or employers*? Please include reference to all sources of information (e.g. national, regional, sectoral, from trade associations, unions, workers' compensation bodies for occupational accidents and diseases).

For each of them, could you please summarise:

a. Who developed the guidance?

b. Who were the target audience and main stakeholders?

c. What were the key messages of the guidance?

d. How were the messages in the guidance communicated (e.g. on the internet, as leaflets, dialogue / meetings)?

e. Any reviews or feedback on the guidance, particularly identifying the strengths and weaknesses of the guidance and how they were assessed.

f. Please provide a reference to the guidance (e.g. document, web-link, URL).

g. Please provide a contact person for the Topic Centre to ask for further information if necessary.

2. If in your country there is no specific guidance on risk communication of nanomaterials for workers or employers, do you know of guidance developed for other audiences, for example the general public or for protection of the environment? Please include reference to all sources of information (e.g. national, regional, sectoral, from trade associations, unions, workers' compensation bodies for occupational accidents and diseases).

For each of them, could you please summarise:

a. Who developed the guidance?

b. Who were the target audience and main stakeholders?

c. What were the key messages of the guidance?

d. How are the messages in the guidance communicated (e.g. on the internet, as leaflets, dialogue / meetings)?

e. Any reviews or feedback on the guidance, particularly identifying the strengths and weaknesses of the guidance and how they were assessed.

f. Please provide a reference to the guidance (e.g. document, web-link, URL).

g. Please provide a contact person for the Topic Centre to ask for further information if necessary.

B. RISK COMMUNICATION INITIATIVES

1. In your country, have any risk communication initiatives (campaigns, debates etc.) targeted at *workers or employers* with nanomaterials been conducted? Please include reference to all sources of information (e.g. national, regional, sectoral, from trade associations, unions, workers' compensation bodies for occupational accidents and diseases).

For each of them, could you please summarise:

a. What were the main messages communicated?

b. Who were the target audience and main stakeholders?

c. How were the outcomes of the initiatives communicated (e.g. on the internet, as leaflets, dialogue / meetings)?

d. Which organisations developed these initiatives and prepared the information material?

e. Any reviews or feedback on the initiatives, particularly identifying their strengths and weaknesses, and how they were assessed.

f. Please provide a reference to the initiatives (e.g. document, web-link, URL).

g. Please provide a contact person for the Topic Centre to ask for further information if necessary.

2. If in your country there have not been any risk communication initiatives (campaigns, debates etc.) targeted at workers or employers, do you know of such initiatives for other audiences? Please include reference to all sources of information (e.g. national, regional, sectoral, from trade associations, unions, workers' compensation bodies for occupational accidents and diseases).

For each of them, could you please summarise:

a. What were the main messages communicated?

b. Who were the target audience and main stakeholders?

c. How were the outcomes of the initiatives communicated (e.g. on the internet, as leaflets,

dialogue / meetings)?

d. Which organisations developed these initiatives and prepared the information material?

e. Any reviews or feedback on the initiatives, particularly identifying their strengths and weaknesses and how they were assessed.

f. Please provide a reference to the initiatives (e.g. document, web-link, URL).

g. Please provide a contact person for the Topic Centre to ask for further information if necessary.

C. SURVEYS ON RISK PERCEPTION

1. In your country, have there been any surveys on the perception of risks from nanomaterials in the workplace? Please include reference to all sources of information (e.g. national, regional, sectoral, from trade associations, unions, workers' compensation bodies for occupational accidents and diseases).

For each of them, could you please summarise:

a. What were the questions asked in the surveys?

b. Who were the target audience and main stakeholders?

c. What were the main results of the surveys?

d. How were the outcomes of the surveys communicated (e.g. on the internet, as leaflets, dialogue / meetings)?

e. Who developed the surveys and wrote their reports?

f. Any reviews or feedback on the surveys, particularly identifying their strengths and weaknesses and how they were assessed.

g. Please provide a reference to the surveys (e.g. document, web-link, URL).

h. Please provide a contact person for the Topic Centre to ask for further information if necessary.

2. If there have not been any surveys on the perception of risks from nanomaterials in the workplace, have there been any surveys on the perception of risks of nanomaterials to the general public or the environment? Please include reference to all sources of information (e.g. national, regional, sectoral, from trade associations, unions, workers' compensation bodies for occupational accidents and diseases).

For each of them, could you please summarise:

a. What were the questions asked in the surveys?

b. Who were the target audience and main stakeholders?

c. What were the main results of the surveys?

d. How were the outcomes of the surveys communicated (e.g. on the internet, as leaflets, dialogue / meetings)?

e. Who developed the surveys and wrote their reports?

f. Any reviews or feedback on the surveys, particularly identifying their strengths and weaknesses and how they were assessed.

g. Please provide a reference to the surveys (e.g. document, web-link, URL).

h. Please provide a contact person for the Topic Centre to ask for further information if necessary.

D. Other Initiatives

1. In your country, have there been any other initiatives, studies or projects aimed at risk communication for nanomaterials in the workplace? Please include reference to all sources of information (e.g. national, regional, sectoral, from trade associations or unions, workers' compensation bodies for occupational accidents and diseases).

For each of them, could you please summarise:

a. The aims of the initiative or study.

b. Who developed the initiative or study?

c. Who were the target audience and main stakeholders?

d. What were the key outcomes of the initiative or study?

e. How were any recommendations from the initiative or study communicated (e.g. on the internet, as leaflets, dialogue / meetings)?

f. Any reviews or feedback on the initiative or study, particularly identifying their strengths and weaknesses and how they were assessed.

g. Please provide a reference to the initiative or study (e.g. document, web-link, URL).

h. Please provide a contact person for the Topic Centre to ask for further information if necessary.

2. *If there have not been any initiatives, studies or projects* aimed at risk communication for nanomaterials in the workplace in your country, have there been any other initiatives or studies aimed at risk communication for the general public or for protection of the environment? Please include reference to all sources of information (e.g. national, regional, sectoral, from trade associations or unions, workers' compensation bodies for occupational accidents and diseases).

For each of them, could you please summarise:

a. The aims of the initiative or study.

b. Who developed the initiative or study?

c. Who were the target audience and main stakeholders?

d. What were the key outcomes of the initiative or study?

e. How were any recommendations from the initiative or study communicated (e.g. on the internet, as leaflets, dialogue / meetings)?

f. Any reviews or feedback on the initiative or study, particularly identifying their strengths and weaknesses and how they were assessed.

g. Please provide a reference to the initiative or study (e.g. document, web-link, URL).

h. Please provide a contact person for the Topic Centre to ask for further information if necessary.

E. ADDITIONAL INFORMATION

1. What do you believe are the main challenges for risk communication of nanomaterials to workers and employers? Please explain your reasoning.

2. In your country, is the strategy for communicating risks on nanomaterials to workers and employers different to those for other materials? Please explain.

3. In your opinion, for which nanomaterials are risk perception and risk communication most important (please add 'X' before the relevant item)?

Carbon Nanotubes
Fullerenes
Other carbon nanoparticles
SiO_2
Nanoclays
TiO_2
ZiO_2
Chromium Oxide
NiO_2
AlO_2
FeO_2
Carbon black / industry fumes
Metal powder
Other product areas – if so, please describe which

4. In your opinion, for which nanomaterials used in the workplace are there gaps in the risk perception and communication (please add 'X' before the relevant item)?

Carbon Nanotubes
Fullerenes
Other carbon nanoparticles
SiO_2
Nanoclays
TiO_2
ZiO_2
Chromium Oxide
NiO_2
AlO_2
FeO_2
Carbon black / industry fumes
Metal powder
Other product areas – if so, please describe which

5. Please provide any additional information that you think would be relevant for the Topic Centre's review (for example guidance on risk communication, or risk perception surveys, focused on other types of technologies).

Focal Points questionnaire return analyses

The analysis of the data received in 2010 from the Focal Points (Table 10) shows that national strategies are constructed or planned in several EU Member States and that these are mainly based on activities of their national institutes for occupational and health, ministry departments, labour inspectorates, trade unions, and trade associations or industry. As a result, guidance documents on risk assessment and risk management of nanotechnology as well as on the implementation of current legislation, mainly based on REACH, have been published.

European and national strategies and policies for nanomaterials are created by:

- Policy-makers (such as governments, national and international authorities, regulatory agencies, social partners)
- Industry, business and professional organisations (mainly in relation to the chemical industry);
- Research institutions and foundations (mainly focused on law, sustainable development and nanotechnology);
- Non-governmental organisations and consumer, public health, environmental, labour organisations.

Often national strategies and policies grew out of on-going international discussions, with a particular focus on the results of EU or international working groups such as:

- EU: Working group on nanomaterials in REACH (CASG Nano);
- EU: European Chemicals Agency (ECHA);
- EU: Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR);
- OECD (Organisation for Economic Co-Operation and Development): Working Party on Manufactured Nanomaterials, in cooperation with ISO (International Organisation for Standardisation).

In many European countries regulation of nanomaterials is based at present on existing laws and regulations applicable to chemical substances. This is in accordance with the information given in the Communication from the European Commission 'Regulatory Aspects of Nanomaterials' from 2008 (EC, 2008) according to which nanomaterials are included in the definition of “substance” and must therefore fulfil REACH’s requirements (Registration, Evaluation and Authorisation of Chemicals) and worker protection legislation relevant to chemical substances. The most active in the field of risk perception and communication about nanomaterials are, not unexpectedly, those countries where nanotechnology is more developed and/or nanomaterials are produced on a larger scale. A few countries refer to ECHA as an efficient source of information about the risk of nanomaterials to workers or employers. This is in particular the case of smaller countries in which the production of nanomaterials is relatively low, as:

- research on health and safety of nanomaterials is very expensive; and
- developping national strategies and policies can also be very time consuming and expensive.

Some countries may therefore want to take full advantage of solutions worked out at EU level.

- **Table 10: Summary of Focal Point answers (received in 2010)**

Country	Answers
AUSTRIA	
A.1.	a. Currently information initiative is planned by AUVA, which shall be addressed to workers and employers. c. In Austria, there is currently no specific guidance on risk communication. General information about risks of nanomaterials are provided in a nano-dedicated section on the website of the Labour inspection. In the frame of the implementation of the Nano Action Plan, a project called 'Guidelines for safe use of Nanomaterials at the workplace' is on-going. It will be finalised by end of August 2010. f. http://www.arbeitsinspektion.gv.at/AI/Arbeitsstoffe/nano/default.htm
A.2.	a. The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management together with the Ministry for Transport, Innovation and Technology, the Ministry of Health, the Ministry of Labour, Social Affairs and Consumer Protection, the Ministry of Science and Research, and social partners established the Austrian Nanotechnology Action plan, implementing the European Action plan. b. Target audience and stakeholders are the public authorities as well as the Austrian social partners. c. The core of the Action Plan consists of 50 recommendations for specific Austrian measures to be taken at national, European and international level. These recommendations grew out of a consensus reached among the stakeholders involved and will be implemented by the end of 2012 at the latest. f. http://www.umweltnet.at/article/archive/7033 http://www.umweltnet.at/filemanager/download/60006/
B.1.	a. Within the above mentioned Austrian Nanotechnology Action plan the need for further knowledge was emphasised. Concerning OSH the following activities are highlighted: o Create the foundations for measuring nanoparticles, especially in the atmosphere of contaminated workplaces o Determine methods, parameters and strategies for measurement at workplaces. Projects for exposure measurement at the workplace. o Create exposure scenarios for workplaces o Prepare health-related (provisional) guide values /exposure concentration for (classes of) nanomaterials (workplace). o Record-keeping obligations concerning nano exposure in hazardous jobs and for exposed employees, accessible only to authorities.

Country	Answers
	o Develop simple, inexpensive instruments for measurement f. http://www.umweltnet.at/article/archive/7033 g. Within the Nano Action Plan, a debate also started for workplace safety and health. Within the Labour Inspection, internal information has been regularly communicated since 2008 at annual meetings of labour inspectors. The website or the Labour Inspectorate was additionally provided with a Nano section. http://www.arbeitsinspektion.gv.at/AI/Arbeitsstoffe/nano/default.htm In the scope of the implementation of the Nano action Plan, together with AUVA (Austrian accident insurance board), an event 'Nanotechnology and Workers Safety and Health' will be organised and take place on 31st of March 2011. It will focus on information for prevention experts in the field of OSH.
B.2.	g. Radio Ö1 and the Austrian Environment Agency (UBA) were running a Dialog targetted at the general public with a focus on nanotechnology, in 2007-2008. The initiative was called 'Risiko: Dialog'. It is planned, as a spin-off of the Nano Action Plan, to create a 'Nano Information Plattform' (NIP). It will provide mainly the general public and consumers with information on nanotechnology. The work is coordinated by the Ministry of Health and operated by the Austrian Agency for Health and Food Safety (AGES). It is planned to go online by the end of 2010.
C.1.	In 2009, the Central Labour Inspectorate carried out an interview-based survey in Austrian companies addressing nanomaterials on how they use them at their workplaces. It was finalised by end of 2009. ('Use of Nano at the Workplace'). The main results were: amount of nanomaterials produced or used and also number of employees dealing with them (currently rather low in Austria). Mainly, nano is used in surface treatment and/or coating operations. One company is producing Carbon Nanotubes. Exposure: for users, mainly to suspensions; in the case of producers, also to powders. The quality of information materials on nano was found to be poor and not specific enough (SDS!) e.g. users did hardly know about sizes of used materials. Companies do need support for safe use. Report can be downloaded from the website of Labour inspection ('Umgang mit Nano im Betrieb') at: http://www.arbeitsinspektion.gv.at/AI/Arbeitsstoffe/nano/default.htm There is, in the current of implementation of the Nano Action Plan, on-going work on a project 'Guidelines for safe use of nanomaterials at the workplace'. It will be finalised by end of August 2010.
D.2.	Within the Institut für Technikfolgenabschätzung (ITA) project 'Nanotrust' is an initiative that provides information on possible health and environmental risks and on societal aspects of nanotechnologies. Nano Action Plan and (English) website Nanotrust: http://nanotrust.ac.at/nano.ita.en/index.html

Country	Answers
E.1.	The main challenge will be to raise awareness for nanotechnologies as technology of the future without creating unnecessary fears.
E.2.	Nanomaterials are communicated in the same way as other substances. The Austrian OSH legislation provides for a sufficient framework to tackle nanomaterials.
E.3.	According to the survey conducted in Austria and mentioned above, these substances are currently produced or used in Austrian companies mainly, (as well as nitrites).
E.5.	In Austria in 2009/2010, the 'Austrian Nanotechnology Action plan' was elaborated. It was adopted as a memorandum of understanding of the Austrian government. Four working groups (Health and Workers Protection, Environment, Science and Research and Economy) elaborated the status quo in Austria concerning nanotechnology. On that basis, recommendations for future activities were given; some of them are also dealing with risk communication. The recommendations comprising five main fields (Legal requirements, Information Strategies, Qualification and Awareness raising, Risk Assessment, Risk Management and Research) are the core of the Action Plan. In part 3 of the Action Plan Document a comprehensive Analysis of the status quo concerning nanomaterials in Austria is given. The implementation of the recommendations has started. Therefore diverse activities also in the field of risk communication are on-going. Some of them are already finalised. In particular a Nano Information Platform is foreseen. English version of the Action Plan is available: http://www.umweltnet.at/article/archive/7033 A pdf will also be added. In Austria, a 'Nano-Plattform' was founded in 2008 under the lead of the Austrian Ministry of Environment. It brings together experts from ministries, NGOs, social partners and research to discuss, share information and support cooperation. Usually there are 4 meetings per year. It also functioned as plenum to join the work on the Nano Action plan and will guide the implementation of the recommendations.
CYPRUS	
A.1.	No national guidance on nanomaterials is currently available in Cyprus.
A.2.	The European Chemicals Agency (ECHA) is in the process of developing guidance on nanomaterials. a. ECHA b. Industry, Competent Authorities for REACH c. ECHA's guidance is currently being prepared (not yet finished).

Country	Answers
	e. As soon as the guidance will be finished it will be available on the ECHA website at http://guidance.echa.europa.eu/guidance_en.htm
B.1.	Short informative publications on the issue have been prepared by an officer of the Department of Labour Inspection and published in various magazines of professional organisations in Cyprus. a. General information on nanomaterials and the new evolving risk at the workplace. b. Employers, workers and consumers. c. Employers and workers got a general understanding of the issue. d. The Department of Labour Inspection (DLI)
D.2.	a. Provide general information to the public. b. The DLI. c. The general public. d. Diffusion of general information on nanomaterials to the public.
E.1.	Nanomaterials present a new evolving risk at the workplace. A lot of new products are prepared containing nanomaterials and the employers, employees and the public should be fully aware of their risks.
E.3.	Carbon Nanotubes Fullerenes Other carbon nanoparticles SiO2 TiO2 Carbon black / industry fumes
E.4.	Gaps in the risk perception exist for all the nanomaterials shown.

Country	Answers
FINLAND	
A.1.	No national guidance on nanomaterials is currently available in Finland. ECHA is drafting a Guidance Document on the communication of information on the risks and safe use of chemicals. There is coordination group on the safe use of engineered nanomaterials established by the Ministry of Social Affairs and Health. This group meets regularly and is now in the process to provide guidance on safety of these materials mainly to regulators. The other organisations represented in the group are the Finnish Institute of Occupational Health (FIOH), Ministry of Education, Ministry of Environment, Ministry of Agriculture and Forestry, Finnish Environment Institute, Institute for Food Safety, and the Finnish Agency for Health and Consumer Protection (competent authority on safety of chemicals to humans). In addition, the Academy of Finland and TEKES, funding organisation for technology-oriented research in Finland are also represented.
B.1.	- The Finnish Institute of Occupational Health (FIOH) has made an initiative to study risk perceptions of nanotechnologies (i.e. an application for a research project), but sources of external funding are still open. - Delphi Foresight Study - Questionnaire Survey and Establishment of a Database for Risk Trends Associated with New Technologies in Finnish Workplaces - Jenni Rantala, Kai Savolainen and Marita Luotamo, Finnish Institute of Occupational Health, Report for the Finnish Work Environment Fund, 2009: this study has explored evaluation of new and emerging risks by experts of various technology fields.
B.2.	A Nordic Tour on Nanosafety is planned to be organised by FIOH and NIVA in October/November 2010. This will be a one-day workshop aimed at regulators and stakeholders, and it will be organised in all five Nordic Countries. In Finland it is supported by the Government.
D.1.	- A book: Työ ja terveys Suomessa 2006. Uudet teknologiat, uudet riskit. Marita Luotamo, Anna-Liisa Pasanen and Kai Savolainen (Work and health in Finland 2006. New technologies, new risks.) In Finnish. Työterveyslaitos (Finnish Institute of Occupational Health), Helsinki, 2007. Pages 401-409. - Nanosafety in Finland - a summary report. Raivio, T. et al. Tekes Review 224/2008, Helsinki 2008
D.2.	Planning of such activities is on-going within FIOH.
E.1.	The main challenges are public information on the potential health hazards of these materials, emphasising that most likely only few are hazardous but that these have to be identified reliably, emphasising that challenges related to hazard/risk prevention are identifiable and also possible to carry out.

Country	Answers
	A really important challenge is to convince especially employers that exploring the safety of engineered nanomaterials is not something that prevents commercialisation of these materials and products, but that this is an essential part of any nanomaterial/nanotechnology development and which is vital for the success of engineered nanomaterials and nanotechnologies.
E.3.	Carbon Nanotubes Fullerenes Other carbon nanoparticles SiO2 TiO2 ZiO2 Chromium Oxide NiO2 Metal powder Other product areas – Nanofibres
E.4.	Gaps in the risk perception exist for all the nanomaterials shown.
E.5.	FIOH has decided to establish a nanosafety centre at least for the following five years with about 30 person years of resources. This centre will deal with all of the issues explored in this questionnaire. Also relevant: activities of the Advisory Committee on Safety and Health at Work (ACSH) dealing with chemicals (Working Party on chemicals), see document EMPL-2009-2051-EN.
GERMANY	
A.1.	**-BAuA/VCI-Guidance for handling and use of nanomaterials at the workplace** a. Federal Institute for Occupational Safety and Health (BAuA) and the German Chemical Industry Association (VCI) b. Environment, Health and Safety (EHS)-Experts c. In spring 2006 the Federal Institute for Occupational Safety and Health (BAuA) and the German Chemical Industry Association (VCI) conducted, among VCI member companies, a joint survey on occupational health and safety in the handling and use of nanomaterials.

Country	Answers
	The purpose of the survey was to obtain an overview of occupational health and safety methods currently applied in the chemical industry in activities involving nanomaterials. d. Brochure, Internet, meetings e. OECD (2009): Series on the safety of manufactured nanomaterials, Number 10, Identification, Compilation and Analysis of Guidance Information for Exposure Measurement and Exposure Mitigation: Manufactured Nanomaterials (ENV/JM/MONO(2009)15) www.olis.oecd.org/olis/2009doc.nsf/LinkTo/NT00003006/$FILE/JT03267097.PDF f. www.baua.de/cae/servlet/contentblob/717966/publicationFile/48357/guidance.pdf g. Federal Institute for Occupational Safety and Health (BAuA) **- Responsible Use of Nanotechnologies - Report and recommendations of the German Federal Government's NanoCommission for 2008** (Chapter II.3.2: Five basic principles for the responsible use of nanomaterials) a. German Federal Government's Nano-Commission b. Occupational Safety and Health Experts, Members of the prevention services c. Five basic principles for the responsible use of nanomaterials: Principle 1: Definition and disclosure of responsibility and management (good governance) Principle 2: Transparency with regard to nanotechnology related information, data and processes Principle 3: Commitment to dialogues with stakeholders Principle 4: Establishment of risk management structures Principle 5: Responsibility within the value chain d. Internet, NanoCommission dialogs http://www.bmu.de/english/nanotechnology/general_information/doc/44143.php f. Report and recommendations of the German Federal Government's Nano-Commission for 2008 (Chapter II.3.2: Five basic principles for the responsible use of nanomaterials, p. 55) http://www.bmu.de/english/nanotechnology/general_information/doc/44143.php g. Federal Institute for Occupational Safety and Health (BAuA) **- Responsible use of nanomaterials (Position paper)** a. German Social Accident Insurance - DGUV (Expert committee on nanotechnologies)

Country	Answers
	b. Occupational Safety and Health Experts, Members of the prevention services c. The paper refers to the principles for responsible use of nanomaterials recommended by the German Federal Government's Nano-Commission and the precautionary principle. Its general purpose is to raise awareness on safety and health at the workplace. A framework for target-oriented preventive activities of the German Social Accident Insurance and their institutions is provided. d. Internet, press releases f. http://www.dguv.de/inhalt/praevention/themen_a_z/nano/index.jsp g. German Social Accident Insurance DGUV **- Ultrafine aerosols and nanoparticles at the workplace (webpage)** a. Institute for Occupational Safety and Health of the German Social Accident Insurance in Sankt Augustin/Germany (IFA) b. Environment, Health and Safety (EHS)-Experts c. The general purpose of the document is to inform on possible hazards from manufactured nanomaterials and, based on the precautionary principle, to advise on protective measures and on workplace measurements. One major point is the conclusion that up to now protective measures that have been proven to be effective against dust are also effective against nanoparticles. To assess the effectiveness of protective measures benchmark levels for the particle number concentration of nano-objects in the workplace air are derived and proposed. d. Internet, meetings, conferences e. The methodology for deriving benchmark levels is discussed in the ISO/TC 229 JWG 3 PG 6 and it is agreed to include this as an example in the final document (Nanotechnologies – Guide to safe handling and disposal of manufactured nanomaterials – Part 1: Guide to safe handling and disposal of manufactured nanomaterials, ISO/PDTS 12901-1.) http://www.dguv.de/ifa/en/fac/nanopartikel/index.js g. German Social Accident Insurance DGUV **- Working Safety in Laboratories (BGI 850-0e)** a. German Workers Compensation Board of the Chemical Industry (BG Chemie) b. Environment, Health and Safety (EHS)-Experts c. When defining protective measures it is stated in chapter 3.5 'Taking the course of reaction and new materials into account' that nanomaterials with not sufficiently known properties should also be treated as new materials. d. Internet, Parts of this document are included in the TRGS 526, which is a governmental regulation. f. BGI 850-0 Sicheres Arbeiten in Laboratorien (Nanomaterials see chapter 3.5)

Country	Answers
	http://bgi850-0.vur.jedermann.de/index.jsp g. Berufsgenossenschaft Rohstoffe und chemische Industrie **- Working Safely in Laboratories (BGI 850-0e)** a. Federal State Hessen, Hessisches Ministerium für Wirtschaft, Verkehr und Landesentwicklung, Wiesbaden b. Environment, Health and Safety (EHS)-Experts c. OSH-issues concerning nanotechnology / nanomaterials are described. d. Internet. f. Hessen-Nanotech: Informationsplattform Nano-Sicherheit http://www.nano-sicherheit.de/ g. HA Hessen Agentur GmbH, Wiesbaden, info@hessen-agentur.de **- Sichere Verwendung von Nanomaterialien in der Lack- und Farbenbranche - Ein Betriebsleitfaden (in German)** a. Federal State: Hessen b. Environment, Health and Safety (EHS)-Experts c. OSH-issues concerning the safe use of nanomaterials in the lacquer and colour industry are described. d. Internet. f. Sichere Verwendung von Nanomaterialien in der Lack- und Farbenbranche - Ein Betriebsleitfaden http://www.hessennanotech.de/mm/Betriebsleitfaden_NanoFarbeLacke_Vorab.pdf g. Hessisches Ministerium für Wirtschaft, Verkehr und Landesentwicklung; HA Hessen Agentur GmbH, Wiesbaden, www.hessen-agentur.de **- Nanomaterialien: Arbeitsschutzaspekte (in German)** a. Federal State: Baden-Württemberg Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg b. Environment, Health and Safety (EHS)-Experts c. OSH-issues concerning the safe use of nanomaterials are described. d. Internet.

Country	Answers
	f. Nanomaterialien: Arbeitsschutzaspekte http://www.lubw.badenwuerttemberg.de/servlet/is/56759/ g. Hessisches Ministerium für Wirtschaft, Verkehr und Landesentwicklung LUBW Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg, Karlsruhe **- Nanowissen Bayern: Eine Informationsplattform zu Chancen und Risiken der Nanotechnologie für Umwelt und Gesundheit (in German)** a. Federal State: Bayern Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit b. Environment, Health and Safety (EHS)-Experts c. OSH-issues concerning the safe use of nanomaterials are described. d. Internet. f. Nanowissen Bayern http://www.nanowissen.bayern.de/index.htm Nanowissen Bayern - Gesundheitsschutz und Arbeitsschutz http://www.nanowissen.bayern.de/gesundheitsschutz_arbeitsschutz/index.htm g. Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit, Erlangen, poststelle@lgl.bayern.de **- CENARIOS® - das erste Risikomanagement- und Monitoringsystem für Nanotechnologie** a. Industry: TÜV SÜD and Innovationsgesellschaft, St. Gallen, Switzerland b. Environment, Health and Safety (EHS)-Experts c. The CENARIOS® risk management system was especially developed for risk assessment in the nanotechnology sector. It covers the risks associated with the design and development, production and use of nanotechnology products and focuses on the following risk categories: - Risks for staff producing and handling nanotechnology products (occupational health and safety), both at the level of producers of basic nanomaterials and at level of companies which use and further process these nanomaterials. - Production-related risks for the surroundings of the company and the environment; The two previously mentioned risk categories are also referred to together as HSE risks. - Consumer risks resulting from the use of nanotechnology products, which may affect company staff, users and third parties. d. Internet/dialogs.

Country	Answers
	f. CENARIOS® (webpage) http://www.tuev-sued.de/anlagen_bau_industrietechnik/technikfelder/risikomanagement/nanotechnologie?dtree=1 Certification Standard CENARIOS® http://www.tuev-sued.de/uploads/images/1219824286015340810363/CENARIOS_Zertifiziergrundlage_e.pdf g. TÜV SÜD **- Responsible Production and Use of Nanomaterials** a. Industry: The German Chemical Industry Association VCI b. Environment, Health and Safety (EHS)-Experts c. The German Chemical Industry Association VCI has issued a series of documents. They provide guidance on all aspects of a good product stewardship on nanomaterials. d. VCI-Stakeholder-Dialogs in Germany http://www.vci.de/default~cmd~shd~docnr~116378.htm f. http://www.vci.de/default~cmd~shd~docnr~122306~lastDokNr~-1.htm g. Verband der Chemischen Industrie e.V. (VCI), Frankfurt am Main, dialog@vci.de **- Bayer Code of Good Practice on the Production and On-Site-Use of Nanomaterials** a. Industry: Bayer AG b. Environment, Health and Safety (EHS)-Experts c. The scope of the 'Code of Good Practice' is targeted at the production and use of nanomaterials including on-going maintenance and disposal activities. Nanoparticles unintentionally generated in other chemical processes, which fall into the nanoparticle size distribution, are already covered by existing work and protection practices. d. Internet. f. Bayer Code of Good Practice on the Production and On-Site-Use of Nanomaterials www.sustainability2007.bayer.com/en/Bayer-Code-of-Good-Practice-on-the-Production-and-On-Site-Use-of-Nanomaterials.pdfx g. Bayer AG, Leverkusen www.bayer.de/de/homepage.aspx **- Bayer's Nanomaterial Stewardship** a. Industry: Bayer AGb. Environment, Health and Safety (EHS)-Experts

Country	Answers
	c. BayCare is a comprehensive product stewardship program designed to help customers reduce environmental impact and improve the health, safety and sustainability of customers' businesses. Bayer works diligently to facilitate responsible handling of products throughout their life cycle, from research and development through production, packaging, distribution, storage, handling, recycling and disposal. d. Internet. f. http://baycareonline.com/our_commitment.asp Nanomaterial Stewardship: http://baycareonline.com/nano_stewardship.asp g. Bayer AG, Leverkusen,www.bayer.de/de/homepage.aspx **- Guide to safe manufacture and for activities involving nanoparticles at workplaces in BASF AG** a. Industry: BASF AG b. Environment, Health and Safety (EHS)-Experts c. This guideline is intended for application during manufacture and activities involving free nanoparticle dust and products containing nanoparticle dust at the workplace. d. Internet. f. Guide to safe manufacture and for activities involving nanoparticles at workplaces in BASF AG: http://www.basf.com/group/corporate/en/function/conversions:/publish/content/sustainability/dialogue/in-dialogue-withpolitics/nanotechnology/images/BASF_Guide_to_safe_manufacture_and_for_activities_involving_nanoparticles.pdf Webpage 'Safety for our employees': http://www.basf.com/group/corporate/en/sustainability/dialogue/in-dialogue-with-politics/nanotechnology/employees g. BASF AG. Contact: http://www.basf.com/group/corporate/en/sustainability/dialogue/in-dialogue-with-politics/nanotechnology/contact **- Nano Guideline 'Responsible Handling of Nanotechnology at Evonik'** a. Industry: Evonik Degussa GmbH b. Environment, Health and Safety (EHS)-Experts, employees, neighbours and customers c. Evonik follows the international principles of Responsible Care®.

Country	Answers
	In the manufacture of nanomaterials Evonik provides the maximum possible protection for people and the environment by closed-plant production; for handling of these materials, additional technical precautions are used such as filters, extraction systems, and, if necessary, personal protective equipment. Regular measurement of particulates in the workplace and routine medical check-ups ensure that these measures are effective. Evonik is engaged in open dialog on the opportunities and risks of applied nanotechnology. As part of this approach, Evonik freely provides information on the nanomaterials it produces and uses, and shoulders its share of responsibilities in the value chain. d. Internet. f. Evonik's Nano Guideline 'Responsible Handling of Nanotechnology at Evonik' http://nano.evonik.com/sites/dc/Downloadcenter/Evonik/Microsite/Nanotechnology/en/Nano%20Guideline_e.pdf Webpage 'Nanotechnology at Evonik' http://nano.evonik.com/sites/nanotechnology/en/Pages/default.aspx g. Evonik Industries AG, Essen, http://www.evonik.de
B.1.	**German Government: NanoDialogue (NanoCommission)** In 2006 the NanoDialogue was initiated by the Federal Government and a so called 'NanoCommission' was established where stakeholders from authorities, industry, trade unions and NGOs tried to get a common understanding on opportunities and risks of nanotechnology. The NanoCommission had the mandate to develop a report within two years by the end of 2008. Three working groups discussed important aspects of the development of nanotechnology. Available at: www.bmu.de/files/pdfs/allgemein/application/pdf/nanokomm_abschlussbericht_2008_en.pdf The German NanoCommission (2009-2011) agreed on the work programme for the running period and installed four expert working groups to deal with specific subjects, i.e. implementation of the principles adopted in phase 1 (2006-2008), benefit and risk potentials of nano products taking two examples, regulation in the context of nanomaterials and further development of criteria on concerns and relief. Conference 'NanoDialog 2009-11 Zwischenstand' (February 2010, Berlin): http://www.oekopol.de/de/aktuell/nano/Programm.php NanoCommission: www.bmu.de/gesundheit_und_umwelt/nanotechnologie/nanodialog/doc/42655.php **German Government: Nano Initiative - Action Plan 2010**

Country	Answers
	Since 2007, the 'Nano Initiative - Action Plan 2010' gives a framework across all government departments. The leading Ministry 'Education and Research' (BMBF) started this initiative, together with six others (Environment (BMU), Labour and Social Affairs (BMAS), Food, Agriculture and Consumer Protection (BMELV), Defence (BMVg), Health (BMG) and Commerce and Technology (BMWi)). The NanoDialog Project is part of this action plan. BMBF: Nanotechnology - A Future Technology with Visions http://www.bmbf.de/de/nanotechnologie.php Report: Status Quo of Nanotechnology in Germany (2009) http://www.bmbf.de/pub/nanode_report_2009_en.pdf **Industry: German Chemical Industry** Association VCI: Stakeholder-Dialogue: Workshop 'Verantwortlicher Umgang mit Nanomaterialien' [Responsible handling of nanomaterials] (September 2008) Workshop Nanomaterials 'Industry supply' (March 2008) Workshop Nanomaterials at the workplace II (April 2007) Workshop Nanomaterials at the workplace I (September 2005) http://www.vci.de/default~cmd~shd~docnr~116378.htm **Other conferences from various stakeholders** 05.11.2009, A+A 2009, Düsseldorf: Workshop – Sicherer Umgang mit Nanopartikeln und Nanotechnologie, http://www.aplusa.de/cipp/md_aplusa/custom/pub/show,fair,aplusa09/lang,1/oid,8521/event_id,190/~/Web-EventsDatasheet/events_datasheet 29.09.2009, BGIA-Fachgespräch, Hennef: 'Sicherer Umgang mit Nanomaterialien' 16. - 17.06.2009, Berlin: NanoCare Abschlussveranstaltung 29.11.2008, Dresden: Bürgerdialog NanoCare: Nanotechnologie sicher gemacht 17.09.2008, Berlin: Workshop Gesprächsstoffe: 'Verantwortlicher Umgang mit Nanomaterialien' 26.05.2008, Berlin: Fachgespräch 'Kleiner ist besser? Chancen und Risiken der Nanotechnologie'

Country	Answers
	12.04.2008, Hamburg: Bürgerdialog NanoCare: Sichere Herstellung von Nanomaterialien 10. - 11.04.2008, München: 1. Internationaler Behördendialog für Bundes- und Länderbehörden aus Deutschland, Österreich, dem Fürstentum Liechtenstein und der Schweiz 06.11.2007, Düsseldorf: Dialog NanoCare - Verantwortlicher Umgang mit Nanomaterialien 04. - 06.05.2007, Schwerte: Tagung 'Nanotechnologien zwischen Nutzen und Risiken für Umwelt und Gesundheit - Für einen verantwortlichen Umgang mit den neuen Nanotechnologien' 17.04.2007, Ludwigshafen: BASF-Symposium zur Expositionsmessung luftgetragener Nanopartikel am Arbeitsplatz 09.11.2006, Gießen: Jahreskongress der Hessischen Landesregierung: 'Hessen im Dialog: Nano - Hier ist die Zukunft'; Dokumentation des Kongresses 10.05.2006, Berlin: econsense-Dialogveranstaltung: 'Chancen nutzen - Risiken managen. Weichen stellen für eine nachhaltige Nanotechnologie' 11. - 12.10.2005, Bonn: Tagung 'Dialog zur Bewertung von synthetischen Nanopartikeln in Arbeits- und Umweltbereichen' im Bundesumweltministerium: Internet page of the conference: 'Dialog zur Bewertung von synthetischen Nanopartikeln in Arbeits- und Umweltbereichen'
C.2.	**Federal Institute for Risk Assessment (BfR):** BfR (2010): Gaby-Fleur Böl, Astrid Epp, Rolf Hertel: Wahrnehmung der Nanotechnologie in internetgestützten Diskussionen; Ergebnisse einer Onlinediskursanalyse zu Risiken und Chancen von Nanotechnologie und Nanoprodukten www.bfr.bund.de/cm/238/wahrnehmung_der_nanotechnologie_in_internetgestuetzten_diskussionen.pdf Further projects: Wahrnehmung der Nanotechnologie in internetgestützten Diskussionen (BfR-Wissenschaft 04/2010 vom 12.03.2010) BfR-Delphi-Studie zur Nanotechnologie (BfR Wissenschaft 04/2009 vom 16.06.2009) BfR Consumer Conference Nanotechnology (BfR-Wissenschaft 03/2009 vom 17.04.2009) Public Perceptions about Nanotechnology (BfR-Wissenschaft 01/2009 vom 12.03.2009) Risikowahrnehmung beim Thema Nanotechnologie - Analyse der Medienberichterstattung (BfR-Wissenschaft 07/2008 vom 24.11.2008) http://www.bfr.bund.de/cd/3862?index=78&index_id=7585

Country	Answers
	Federal Ministry of Economics and Technology: Prof. Dr. Bernd Steffensen, Nicola Below, Stefanie Merenyi: Neue Ansätze zur Risikokommunikation - Produktinformationen vor dem Hintergrund von REACh, GHS und Nanotechnologie (2009) http://www.sofia-darmstadt.de/fileadmin/Dokumente/Studien/2009/RiKoReNa_Netzversion.pdf
D.1.	- Research strategy - Health and environmental risks of nanomaterials UBA (Federal Environment Agency), BfR (Federal Institute for Risk Assessment) and BAuA (Federal Institute for Occupational Safety and Health) have developed a joint research strategy that addresses especially health and environmental risks of engineered nanoparticles. The strategy was finalised in December 2007. http://www.baua.de/cae/servlet/contentblob/717962/publicationFile/48347/research-strategy.pdf - Survey on production and handling of nanomaterials In spring 2006 the German Chemical Industry Association (VCI) and the Federal Institute for Occupational Safety and Health (BAuA) conducted, among VCI member companies, a joint survey on occupational health and safety in the handling and use of nanomaterials. The purpose of the survey was to obtain an overview of occupational health and safety methods currently applied in the chemical industry in activities involving nanomaterials. The results of the survey were published in October 2007 (Gefahrstoffe - Reinhaltung der Luft 10/2007, pp. 419-424, in German) and April 2008 (in English). http://www.baua.de/cae/servlet/contentblob/717958/publicationFile/48346/questionnaire.pdf http://www.baua.de/cae/servlet/contentblob/717960/publicationFile/48348/survey.pdf BAuA-webpage 'Nanotechnology' (project reports and ongoing research projects) www.baua.de/cln_103/en/Topics-from-A-to-Z/Hazardous-Substances/Nanotechnology/Nanotechnology.html - Committee on Hazardous Substances (AGS) The German Committee on Hazardous Substances (AGS) has included nanomaterials as a topic into its working plan. The first step is a monitoring phase that will result in the identification of necessary actions. The UAIII is currently preparing a summarising report on the known and presumed health hazards of nanomaterials. - Institute for Occupational Safety and Health of the German Social Accident Insurance in Sankt Augustin, Germany (IFA): Ultrafine aerosols and nanoparticles at the workplace (webpage) See Section A

Country	Answers
E.1.	With the help of nanotechnology, chemical and physical properties of materials are modified by enlarging their surface. This could possibly result in new risks for human health and environment. Today, there are large gaps of knowledge and it will take several decades of scientific work to fill them. As a consequence, there is need for raising awareness with regard to occupational safety and health. However, this holds also true for all other new materials or chemicals in use with insufficient knowledge on risk for humans and the environment. We already know that health risks from nanomaterials will be different with regard to the nature of the material. This applies to toxicological properties as well as to their dustiness. Toxicological findings from fine and ultrafine dusts, fibres and chemical substances (bulk) provide a good starting point for risk characterisation and risk assessment of nanomaterials. In occupational safety and health the precautionary principle and established dust reduction measures can serve as a solid ground for prevention. In this context, the main challenges for risk communication of nanomaterials to workers and employers are: a) to communicate the need for OSH measures based on the precautionary principle - like for other chemicals with data gaps on risks for humans and the environment, b) to reach a differentiated treatment of nanomaterials in workplace risk assessment with regard to their specific toxicological properties and release into workplace air, c) to replace the current opinion that nanomaterials consist of free primary ultrafine particles. Most frequent materials show agglomerates and aggregates with nanostructured surfaces. d) to make clear that - as a consequence of the formation of agglomerates and aggregates - dusts generated from nanomaterials at workplaces are usually fine (and not ultrafine) and that established measures for dust prevention are effective, e) to clarify that the number concentration of measured particles does not give a direct information on possible risks to human health, f) to accomplish a risk characterisation for humans and the environment of new developed nanomaterials at an early stage to have safety of products and production and to avoid later problems, g) to advertise for awareness and appropriate OSH measures in order to balance between ignorance and over-evaluation of risks for humans and the environment from nanomaterials.
E.2.	No. In Germany the topic 'nanomaterials at the workplace' is treated as a sub-item of workers protection against hazardous substances in questions of legislation, codes of practice and specific support of branches. A separation is not justified based on the current scientific knowledge.
E.3.	Carbon nanotubes

Country	Answers
	There is a need for a systematic risk assessment or priority setting for nanomaterials at workplaces. Such a procedure has not been conducted in Germany yet. The growing quantity of information from European chemical safety regulations (CLP, REACH, Authorisation of specific product groups, e. g. biocides) will lead to a differentiation of risk perception and communication in the next years. Beyond this, particular efforts are necessary to motivate businesses and research institutions for an early risk assessment of new nanomaterials previous to the legal demands.
E.4.	Committee on Hazardous Substances (AGS) - Assessment and Risk Communication for Carcinogens Risk assessment: announcement 910, Risk figures and exposure-risk relationships in activities involving carcinogenic hazardous substances, June 2008 http://www.baua.de/cae/servlet/contentblob/665100/publicationFile/48361/Announcement-910.pdf Risk communication: http://www.baua.de/cln_094/de/Themen-von-A-Z/Gefahrstoffe/Risikobewertung/Risikobewertung.html (in German) May be important for nanomaterials, which generate respirable, granular biopersistent particles without known significant specific toxicity (GBP) or biopersistent fibres.
NETHERLANDS	
A.1.	Information on nanomaterials is currently available in the Netherlands in different websites: 1. Exposure to nanomaterials in consumer products National Institute for Public Health and the Environment (RIVM) This investigation has been performed by order and for the account of Food and Consumer Products Safety Authority, within the framework of V/340370: Health risks of the application of Nanotechnology in consumer products, Letter report 340370001/2009, S.W.P. Wijnhoven | S. Dekkers | W. I. Hagens | W. H. de Jong, http://www.rivm.nl/bibliotheek/rapporten/340370001.pdf 2. Answers to policy questions http://www.ser.nl/~/media/DB_Deeladviezen/2000_2009/2009/b27741/b27741_4.ashx 3. How to deal with nanomaterials in the workplace.

Country	Answers
	Paul Borm, Remko Houba en Fenneke Linker http://docs.minszw.nl/pdf/35/2008/35_2008_3_12183.pdf 4. Chemical Risks Cancer caused by work? http://www.beroepsziekten.nl/book/export/html/1378 5. Nanomaterials http://www.arboportaal.nl/stoffencentrum/stoffen/h-z/nanodeeltjes-1 6. Good uses of nanomaterials in the Netherlands, Borm P, Houba R and Linker, Nano4All, 15-10-2008 www.nano4all.nl
SLOVAKIA	
B.2.	c. Seminar Nanomaterials – its behaviour in biological systems d. Ministry of Agriculture of Slovak Republic
C.2.	Peter Šimon: Risk assessment by using nanotechnologies in the food and feed area http://www.land.gov.sk/sk/index.php?navID=193&id=1225
E.5.	Mainly three offices attend to enquiries related to health and risk assessment of nanomaterials: 1. Slovak Academy of Science, that participates in the project The risk assessment of Engineered Nanoparticles on Human and Ecosystem Health: Understanding the Problem 2. Slovak Medical University, which is a member of the European network NanoImpactNet 3. Institute of Physical Chemistry and Chemical Physics, Faculty of Chemical and Food Technology of Slovak technical University
SPAIN	
A.1.	The INSHT does not have a specific campaign for risk communication on nanomaterials but, within research projects on nanoparticles, it has published or developed some general information documents: - Nanopartículas. Un riesgo pequeño. (Nanoparticles. A small risk?). Seguridad y Salud en el Trabajo, 52,: 33-44. Celia Tanarro y Virginia Gálvez

Country	Answers
	Also, information documents specifically about toxicology and risk assessment: - Evaluación del riesgo por exposición a nanopartículas mediante el uso de metodologías simplificadas. (Risk level assessment of nanoparticle exposure by control banding). Celia Tanarro (NTP in press) - Toxicología de las nanopartículas. Seguridad y Salud en el Trabajo, 56,: 6-12. Virginia Gálvez y Celia Tanarro - Risk assessment of nanoparticle exposure by control banding, (update of the previous model). Seguridad y Salud en el Trabajo, Celia Tanarro (in press).
B.1.	The INSHT, within its training activities, organises a seminar on particles and nanoparticles risks, toxicology and exposure and risk assessment (10 hours) The target audience of the seminar are Occupational Hygiene Professionals. Some regional authorities have organised some meetings and requested the INSHT collaboration to give talks in the field of nanoparticles: a. Risk of nanoparticles at workplaces. b. Occupational Hygiene Professionals. c. Instituto de Seguridad y Salud Laboral de la Región de Murcia, Instituto Cántabro de Seguridad y Salud en el Trabajo, Instituto Gallego de Seguridad y Salud laboral
E.1.	The main challenge is to be able to make the risk of nanoparticles exposure a “visible” risk for workers and employers. Mainly, it is important that the new available information on toxicology, risks, assessment methods and even health surveillance that is being generated so quickly could reach the people exposed to nanoparticles and the health and safety professional at the same rate that it is generated. That way all the new findings on risk control, technical measures and assessment methodologies could be useful for worker’s health protection.
E.3.	Carbon Nanotubes SiO2 TiO2
E.4.	The main problem could be not only which nanomaterial is being used, but where it is being used. For instance in research laboratories, the workers are aware of the materials they are using and also of their potential risks in general. While in other places, especially if the nanomaterial is also being used as bulk material, the workers might not even be aware that they are using nanomaterials.

Country	Answers
UNITED KINGDOM	
A.1.	In the United Kingdom, nanomaterials (along with other hazardous substances) in the workplace are regulated under the Control of Substances Hazardous to Health Regulations 2002 (as amended). COSHH implements the Chemical Agents Directive (CAD) into United Kingdom's law. The principles of risk assessment are embedded in COSHH and apply to nanomaterials. Data gaps exist, making it difficult to undertake a comprehensive risk assessment and the regulatory response is to take a precautionary approach. The regulations and guidance is aimed at both employers and employees, more information on COSHH can be found at: http://www.hse.gov.uk/coshh/index.htm The Health and Safety Executive (HSE) is the United Kingdom's Government Body having responsibility for this legislation. HSE now has a dedicated website for nanotechnology which contains guidance on understanding the hazards of nanomaterials, and HSE has also published specific guidance on the risk management of carbon nanotubes. More information can be found at: http://www.hse.gov.uk/nanotechnology/index.htm Currently, HSE is working in partnership with the Universities Nano Safety Forum to produce generic guidance primarily aimed at employers and managers, although employees and health and safety professionals may also find it useful. Start-up companies using or manufacturing nanomaterials may also find it useful. It is anticipated that the guidance will be launched in July 2012. When launched, this will replace the specific guidance for carbon nanotubes. Should research results demonstrate that a given material poses a particular risk HSE will issue guidance as appropriate, working with regulators from other EU and OECD counties, industry, trade bodies, unions etc. The Dangerous Substances and Explosive Atmospheres Regulation (DSEAR), which implements ATEX in the United Kingdom, may also be relevant to some nanomaterials. Substances capable of forming explosive atmospheres fall under DSEAR and the requirements of this Regulation to assess and manage the risk of explosion. Again, data gaps exist and the regulatory response is to take a precautionary approach.
A.2.	HSE works with OGDs and agencies to provide a 'cross-government' approach to dealing with these new technologies. And these are listed below: Department for Business Innovation & Skills http://www.bis.gov.uk/go-science/science-in-government/key-issues/nanotechnologies Department for Environment, Food and Rural Affairs – Defra www.defra.gov.uk

Country	Answers
	Food Standards Agency www.food.gov.uk Medicines and Healthcare Products Regulatory Agency, www.mhra.gov.uk
B.1.	There is an on-going discussion with stakeholders, in particular focusing on start-ups and new businesses, most of which are Small, Medium Enterprises (SMEs). A good relationship with universities and other academic institutions developing nanotechnologies has been built.
B.2.	The wider issue of nanotechnology is of interest to the wider community and there has been a lot of consumer activity in this area. See: www.nanoandme.org and www.Which.co.uk
C.1.	In 2010/2011 HSE devised a survey/feedback form to ascertain the number of UK workplaces/workers handling engineered nanoparticles, the types of nanomaterials used, the quantities used and how they are used. It also sought to seek levels of awareness of the potential health and safety issues of nanotechnology. The survey was needed to inform HSE's understanding of the size of the UK workforce which handles engineered nanoparticles so that a sensible risk-based approach for the regulation of these new materials can be developed. The target audience was universities and industry. HSE received 76 forms back from universities and, at time of writing, the results are being collated. HSE does not have any results from industry.
D.1.	See comments in B RISK COMMUNICATION INITIATIVES above. HSE's focus will be on small start-ups and small businesses.
E.1.	The challenges to all regulators are to engage early with industry and establish trust so that the full potential of these technologies can be optimised safely without over-regulation.
E.2.	Technically the same risk assessment approach is applied for nanomaterials, but as the hazards of nanomaterials are not fully understood, a precautionary approach is applied.
E.3.	All of them – but in terms of toxicity but we believe that most research has been undertaken on carbon nanotubes (silver nanoparticles were added to the list).
E.4.	All of them
E.5.	United Kingdom's Voluntary Reporting Scheme for engineered nanoscale materials Website: http://www.defra.gov.uk

Glossary

Hazard[20]	Potential source of harm, where harm is physical injury or damage to the health of people, or damage to property or the environment.
Heuristics	Experience-based techniques for problem solving, learning, and discovery. Heuristic methods are used to speed up the process of finding a good enough solution, where an exhaustive search is impractical. Examples of this method include using a 'rule of thumb', an educated guess, an intuitive judgment, or common sense.
Narrative	The use of stories (spoken or written) with a plot, characters, emotion and context to help make information relevant to the intended audience when explaining something so as to get a specific message across.
Risk[20]	Combination of the probability of occurrence of harm and the severity of that harm. The term 'risk' is generally used only when there is at least the possibility of negative consequences.
Risk communication[21]	Exchange or sharing of information about risk between the decision-maker and other stakeholders. The information can relate to the existence, nature, form, probability, severity, acceptability, treatment or other aspects of risk. It can take many forms (such as written, verbal or pictorial), may include a wide range of different sources of information and may involve many different types of organisation.
Risk management[21]	Coordinated activities to direct and control an organisation with regard to risk.
Risk perception[21]	Way in which a stakeholder views a risk based on a set of values or concerns, which depends on the stakeholder's needs, issues and knowledge and can differ from the risk indicated by test data.
Stakeholder[22]	A person, group, or entity, such as a commercial corporation, that has a financial or other interest in a policy or program and seeks or merits a voice in decision making.

[20] Based on definitions in ISO IEC Guide 51 (1999), Safety aspects - Guidelines for their inclusion in standards

[21] Based on definitions in ISO IEC Guide 73 (2002), Risk Management Vocabulary - Guidelines for use in standards

[22] From Dictionary of Public Health, Oxford Reference Online Premium (Accessed through on-line link of Danish Royal Library, May 2011) and Freeman, R.E., 'The stakeholder approach revisited' Zeitschrift für Wirtschafts- und Unternehmensethik, Vol. 5, No 3, 2004 pp. 228–241

The European Agency for Safety and Health at Work (EU-OSHA) contributes to making Europe a safer, healthier and more productive place to work. The Agency researches, develops, and distributes reliable, balanced, and impartial safety and health information and organises pan-European awareness raising campaigns. Set up by the European Union in 1996 and based in Bilbao, Spain, the Agency brings together representatives from the European Commission, Member State governments and employers' and workers' organisations, as well as leading experts in each of the EU-27 Member States and beyond.

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