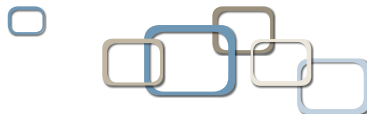


Studies & Research

2014/2015





- **Director of Publication**
Stéphane Pimbert
- **Chief Editor**
Didier Baptiste and Stéphane Vaxelaire
- **Editing and Coordination**
Patricia Bernard and Pascal Wild
- **Photo credits**
Patrick Delapierre for INRS, Gaël Kerbaol - INRS,
Grégoire Maisonneuve, Serge Morillon - INRS
- **“Studies and Research” Data Collection**
Nicole Renaut, Chantal Rolin
- **Translation**
Stephen Walsh
- **Co-ordination of the English version**
Michel Talarmin
- **Also contributed to the publication**
The INRS researchers
- **Graphic Design and Artwork**
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Professor Didier Baptiste
Scientific Director of INRS

Editorial by the scientific Director

To identify occupational risks, to analyse them in order to highlight the hazards related to exposures to different types of risk, and to develop solutions appropriate for keeping such risks under control, INRS conducts applied research, with a view to taking knowledge forwards so as to achieve quality prevention in a multitude of sectors of activity. In addressing the health and safety issues and in dealing with the continuously changing working situations encountered in industry, this work, which involves researchers, engineers, physicians, technicians, and PhD students, covers about twenty topics, from chemical risks to physical or psychosocial risks.

Knowledge acquisition is, once again, in the spotlight this year in this 2014-2015 edition of "Studies & Research", whose contents have been revamped to meet your expectations better. Section headings punctuated by visual markers identify the relevant work topics. A new presentation of the work in progress highlights the purpose of each study.

While 2014 was rich in scientific and technical output, with 92 studies, 153 publications, and 137 presentations at conferences, the year was also marked by a sharing of knowledge between experts, both nationally and internationally. Events that are not elaborated on in the following pages have contributed to the upsurge and enrichment in occupational safety and health knowledge. Four scientific and technical events organised by INRS in 2014 thus mobilised the research teams particularly in that year.

Without waiting for formaldehyde, which is a recognised carcinogenic, to be classified by the European Union, the French Directorate-General for Labour (DGT) and INRS organised an information day devoted to occupational exposure to the substance in the wood industries, and attended by 140 stakeholders from the sector in March 2014. It was an opportunity to present the prevention approaches to be implemented when faced with an occupational risk having deferred effects. The debates mainly focused on the dangers of the substance, the recommendations for exposure limit values, measurement techniques, and substitution.

From 15 to 19 June, the 8th Edition of the International Symposium Airmon on air quality monitoring and on biomonitoring for chemical risk prevention was held in Marseille, under the aegis of INRS. With 180 short talks, 68 plenary talks, and about one hundred poster presentations, the event enabled international specialists (researchers, decision-takers, and practitioners of environmental science and occupational health) to compare their experiences on the modern principles of air monitoring and of biomonitoring, and to promote the newly developed methods and strategies.

145 people also took part in the technical day on "Advantages and limits of virtual manikins for designing ergonomic work stations" that INRS organised with IFSTTAR (French Institute of Science and Technology for Transport, Development, and Networks) on 18 November, the design of work stations and of tools appropriate for operators and for their activities constituting an essential issue for occupational safety and health.

Not forgetting the seminar rounding up the second prospective exercise undertaken by INRS, and looking at the future for Nanos up to 2030, the conclusions of which will not fail to steer the work of our researchers for the coming years.

You can find the main information resulting from those exchanges on our website www.inrs.fr and in our journals *Hygiène et Sécurité du Travail* and *Références en Santé au Travail*.

I hope you will like exploring this new report.

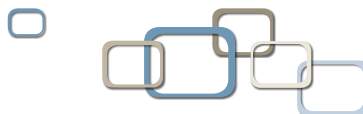
Enjoy the read.



The Scientific Executive

The Scientific Executive's remit is to lead and co-ordinate the study and research activities of INRS, and to analyse the trends and developments that might have impacts on the occupational health and safety environment. It develops European and international scientific partnerships.

Contact: ds@inrs.fr



Scientific commission of INRS

INRS has an independent scientific commission which appraises its scientific and technical work. This scientific commission is responsible for assessing the relevance and the validity of the studies and research the Institute conducts. It comprises individuals who are highly skilled and acknowledged experts in the disciplinary areas of INRS. The members of the scientific commission accompany each new operation and monitor its progress through to closure, in close collaboration with the Institute's specialists. Its members are voted in by the Board of Directors for a term of four years. The Chairperson and the Vice-Chairpersons of the scientific commission give their opinions to the Board.

Chairperson

Dominique CHOUDAT	Groupe hospitalier Cochin. Service de pathologie professionnelle Université Paris Descartes. Paris (75)
--------------------------	--

Vice-chairpersons

Denis BOULAUD	Institut de radioprotection et de sûreté nucléaire (IRSN). Direction environnement et intervention. Le Vésinet (78)
----------------------	--

Jean-Pierre LIBERT	Faculté de médecine. Laboratoire Péritox. Amiens (80)
---------------------------	---

Other members

Francis ALLARD	Université de La Rochelle. Laboratoire d'étude des phénomènes de transfert et de l'instantanéité : agro-industrie et bâtiment (LEPTIAB). La Rochelle (17)
-----------------------	--

Christine CHAUVIN-BLOTTIAUX	Université de Bretagne-Sud. Centre de recherche en psychologie, cognition et communication (CRPCC). Lorient (56)
------------------------------------	---

Daniel EILSTEIN	Institut de veille sanitaire (InVS). Saint-Maurice (94)
------------------------	---

Nadine GABAS	École nationale supérieure des ingénieurs en arts chimiques et technologiques (ENSIACET). Toulouse (31)
---------------------	--

Robert GARNIER	Hôpital Fernand-Widal. Centre antipoison. Paris (75)
-----------------------	--

Pascal GAUDUCHON	Groupe régional d'études sur le cancer (GRECAN). Centre F.-Baclesse, Caen (14)
-------------------------	--

Pascal GUENEL	Institut national de la santé et de la recherche médicale (INSERM). Centre de recherche en épidémiologie et santé des populations (CESP). Villejuif (94)
----------------------	---

Dominique HABAUT	Centre national de la recherche scientifique (CNRS). Laboratoire de mécanique et d'acoustique (LMA). Marseille (13)
-------------------------	--

Pascale LEVET	Agence nationale pour l'amélioration des conditions de travail (ANACT). Lyon (69)
----------------------	---

Benoît MAUNIT	Université d'Orléans. Institut de chimie organique et analytique (ICOA). Orléans (45)
----------------------	--

Alain PINEAU	Faculté de pharmacie. Laboratoire de toxicologie. Nantes (44)
---------------------	---

Jean-Claude SAGOT	Université de technologie de Belfort-Montbéliard. Laboratoire systèmes et transports. Belfort (90)
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Pascal UGHETTO	Université Paris-Est. Laboratoire territoires, techniques et sociétés (LATTTS). Marne-la-Vallée (77)
-----------------------	---

David VERNEZ	Institut universitaire romand de santé au travail. Lausanne (Switzerland)
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Elisabete WEIDERPASS VAINIO	Cancer registry of Norway. Institute of population based cancer research. Oslo (Norway)
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Follow-up groups

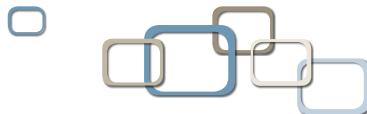
To cover the range of disciplines present at INRS, the scientific commission has recourse to subcommissions, termed follow-up groups. There are six of them, and each group is linked, by area of competence, to a particular scientific and technical division (see the following presentation) of the INRS Lorraine Centre. For each study, these groups examine the aims, the approach followed, the results, and the anticipated or achieved outcomes. Their members meet at INRS every year for two days to analyse the study files, to discuss them with the researchers, and to draft their assessment report.

Members of the occupational epidemiology follow-up group

Dominique CHOUDAT	Groupe hospitalier Cochin. Service de pathologie professionnelle Université Paris Descartes. Paris (75)
Pierre DUCIMETIÈRE	Institut national de la santé et de la recherche médicale (INSERM). Villejuif (94)
Daniel EILSTEIN	Institut de veille sanitaire (InVS). Saint-Maurice (94)
Pascal GUENEL	Institut national de la santé et de la recherche médicale (INSERM). Centre de recherche en épidémiologie et santé des populations (CESP). Villejuif (94)
Annette LECLERC	Institut national de la santé et de la recherche médicale (INSERM). Unité 687 hôpital Paul-Brousse. Villejuif (94)
Elisabete WEIDERPASS VAINIO	Cancer registry of Norway. Institute of population based cancer research. Oslo (Norway)

Members of the working life follow-up group

Emmanuel ABORD DE CHATILLON	Institut d'administration des entreprises de l'université Pierre-Mendès-France. Grenoble (38)
Christine CHAUVIN-BLOTTIAUX	Université de Bretagne-Sud. Centre de recherche en psychologie, cognition et communication (CRPCC). Lorient (56)
Laurence CHEZE	Institut national de recherche sur les transports et leur sécurité (INRETS). Laboratoire de biomécanique et mécanique des chocs. Université Lyon I. Villeurbanne (69)
Xavier CUNY	Professeur honoraire au CNAM. Paris (75)
Alexis D'ESCATHA	AP-HP. Unité de pathologie professionnelle, de santé au travail et d'insertion. Garches (92)
Alain GARRIGOU	Université de Bordeaux 1. Département hygiène, sécurité et environnement. Gradignan (33)
Benoît JOURNE	Faculté de sciences économiques et de gestion. Institut d'économie et de management de Nantes. Nantes (44)
Pascale LEVET	Agence nationale pour l'amélioration des conditions de travail (ANACT). Lyon (69)
Jean-Pierre LIBERT	Faculté de médecine. Laboratoire Péritox. Amiens (80)
Philippe MAIRIAUX	Université de Liège. Faculté de médecine. Département des sciences de la santé publique. Liège (Belgium)
James RICHARDSON	Université de Paris-Sud XI. Orsay (91)
Jean-Michel SCHWEITZER	Association régionale pour l'amélioration des conditions de travail (ARACT). Metz (57)
Pascal UGHETTO	Université Paris-Est. Laboratoire territoires, techniques et sociétés (LATTS). Marne-la-Vallée (77)



Members of the work equipment engineering follow-up group

Michel BERENGIER	Institut français des sciences et technologies des transports, de l'aménagement et des réseaux (IFSTTAR). Centre de Nantes. Bouguenais (44)
Bernard DEMOULIN	Professeur émérite. Groupe TELICE. Institut d'électronique et de microélectronique. Villeneuve-d'Ascq (59)
Élodie FALCONNET	Centre technique des industries mécaniques (CETIM). Senlis (60)
Christian GARNIER	CARSAT Auvergne. Centre interrégional de mesures physiques. Clermont-Ferrand (63)
Luc GAUDILLER	Laboratoire de mécanique des contacts et des structures. UMR CNRS/INSA 5259. Villeurbanne (69)
Dominique HABAUT	Centre national de la recherche scientifique (CNRS). Laboratoire de mécanique et d'acoustique (LMA). Marseille (13)
Louis JEZEQUEL	École centrale de Lyon. Écully (69)
Emmanuel MARTEAU	CRAM Île-de-France. Paris (75)
Patrick MARTIN	École nationale supérieure des Arts et Métiers (ENSAM). Laboratoire de conception, fabrication et commande. Metz (57)
Bernard ROUGIE	Institut national de métrologie du conservatoire des Arts et Métiers (CNAM). La Plaine-Saint-Denis (93)
Jean-Claude SAGOT	Université de technologie de Belfort-Montbéliard. Laboratoire systèmes et transports. Belfort (90)
Françoise SIMONOT-LION	Laboratoire lorrain de recherche en informatique et ses applications (LORIA). Villers-lès-Nancy (54)

Members of the process engineering follow-up group

Francis ALLARD	Université de La Rochelle. Laboratoire d'étude des phénomènes de transfert et de l'instantanéité : agro-industrie et bâtiment (LEPTIAB). La Rochelle (17)
Thierry BALANNEC	CARSAT Bretagne. Rennes (35)
Jean-Marie BUCHLIN	Institut von Karman. Rhode-Saint-Genèse (Belgium)
Jacques CATANI	CARSAT Sud-Est. Laboratoire risques chimiques. Métrologie. Marseille (13)
François DURIER	Centre technique des industries aérouliques et thermiques (CETIAT). Villeurbanne (69)
Nadine GABAS	École nationale supérieure des ingénieurs en arts chimiques et technologiques (ENSIACET). Toulouse (31)
Yves GONTHIER	Université de Savoie. Polytech' Annecy-Chambéry. Le Bourget-du-Lac (73)
Laurence LE COQ	École des mines. UMR/CNRS 6144. Nantes (44)
Michel LEBRUN	CARSAT Auvergne. Centre interrégional de mesures physiques. Clermont-Ferrand (63)
Jacques VENDEL	Ancien membre de l'Institut de radioprotection et de sûreté nucléaire (IRSN). Laboratoire de physique et de métrologie des aérosols et du confinement (LPMAC). Gif-sur-Yvette (91)

Members of the pollutants metrology follow-up group

Denis BOULAUD	Institut de radioprotection et de sûreté nucléaire (IRSN). Direction environnement et intervention. Le Vésinet (78)
Jacques CATANI	CARSAT Sud-Est. Laboratoire risques chimiques. Métrologie. Marseille (13)
Martine CHOUVET	Institut technique des gaz et de l'air (ITGA). Laboratoire PRYSM. Saint-Étienne (42)
Jérôme LAVOUE	Centre de recherche du centre hospitalier de l'université de Montréal (CHUM). Montréal (Canada)
Benoît MAUNIT	Université d'Orléans. Institut de chimie organique et analytique (ICOA). Orléans (45)
Valérie PICHON	École supérieure de physique et de chimie industrielles de la ville de Paris (ESPCI). UMR 8231 CNRS. Paris (75)
Enric ROBINE	Centre scientifique et technique du bâtiment. Département développement durable. Marne-la-Vallée (77)
Alain SOYEZ	CARSAT Nord-Picardie. Laboratoire d'évaluation des risques professionnels. Villeneuve-d'Ascq (59)
David VERNEZ	Institut universitaire romand de santé au travail. Lausanne (Switzerland)

Members of the toxicology and biomonitoring follow-up group

Jacques BOPP	Médecine du travail. FT Orange. Mulhouse (68)
Robert GARNIER	Hôpital Fernand-Widal. Centre antipoison. Paris (75)
Pascal GAUDUCHON	Groupe régional d'études sur le cancer (GRECAN). Centre F.-Baclesse. Caen (14)
Marie-Claude JAURAND	Institut national de la santé et de la recherche médicale (INSERM). CEPH/IUH. Paris (75)
Marc PALLARDY	Institut national de la santé et de la recherche médicale (INSERM). Laboratoire de toxicologie. Châtenay-Malabry (92)
Alain PINEAU	Faculté de pharmacie. Laboratoire de toxicologie. Nantes (44)
Guido RYCHEN	École nationale supérieure d'agronomie et des industries alimentaires (ENSAIA-INPL). Vandœuvre-lès-Nancy (54)



“Studies & Research” activities of INRS

In 2014, studies and research actions accounted for 44% of INRS activities.

In 6 divisions and 23 laboratories at the Lorraine Centre, these activities are conducted by researchers, engineers, physicians, technicians, chemists, toxicologists, ergonomists, etc. These divisions total 280 people.

Pollutants metrology

The pollutants metrology division develops methods for assessing and characterising occupational exposures that take place by inhalation and by contact with the skin. It proposes methods for sampling and analysing gaseous pollutants, particulate semi-volatile aerosols, including particles of nanometre size, and microbiological aerosols. It identifies the sectors of activity and/or the trades in which it is necessary to take actions for preventing chemical and biological risks. It makes advantageous use of the data collected in the databases COLCHIC and SCOLA.

Laboratories:

- Organic analytical chemistry
- Chemical risk characterisation
- Aerosol inorganic analysis and characterisation laboratory
- Aerosol metrology

Process engineering

This division seeks, studies and promotes prevention solutions in response to problems of exposure to chemical or biological pollutants, or to heat. It seeks the most appropriate solution by analysing the process causing the occupational exposure problem and by emphasising emission reduction at source.

Laboratories:

- Chemical risk assessment
- Technological applications for risk assessment
- Aerodynamics engineering
- Pollutant and air cleaning process

Toxicology and biomonitoring

This division does applied research in toxicology, in the field of assessment of risks related to exposure to pollutants in the occupational environment. The two focuses for the research work are firstly biological monitoring of exposure and of the consequences of exposure in humans in working situations, and secondly measurement of the toxic effects on experimental systems.

Laboratories:

- Biomonitoring
- Atmospheres generation and toxicological analytical chemistry
- Carcinogenesis, mutagenesis and reprotoxicity
- Awareness raising, allergies and clinical biology
- Cutaneous penetration, kinetics and metabolism
- Ototoxicity and neurotoxicity

Work equipment engineering

This division develops engineering for preventing the mechanical and physical risks related to work equipment. Stationary or mobile machinery, plant, vehicles, handheld machinery, tools, etc. all lie within the scope of actions by the division, as do safety components, premises (workshops, offices, etc.), and personal or collective protective equipment.

In addition to being a source of accident risks, work equipment can give off noise, vibration, and optical or electromagnetic radiation that can cause occupational diseases. The division aims to improve, if possible as of the design stage, all protective equipment and devices used in working life.

Laboratories:

- Technical prevention / Personal protective equipment
- Technical prevention for machinery
- Design engineering of safe systems
- Safety of automated systems
- Modelling of preventive mechanical systems
- Occupational noise reduction

Working life

This division conducts scientific activities aimed at improving working conditions by producing and transferring knowledge, approaches, methods, and tools resulting from research, and intended for stakeholders in occupational risk prevention. Focused on analysis of real working life activity, and of the practices actually used in industry, and on experimentation that simulates working situations, the division addresses the issues not only by assessing the risks in relation to the physical, physiological, psychosocial, organisational, technological, and demographic aspects, but also by using strategic and managerial risk prevention actions to manage health and safety at work.

Laboratories:

- Ergonomics and psychology applied to prevention
- Management and organisation for occupational safety and health
- Physiology - Movement - Work

Occupational epidemiology

This division conducts epidemiological studies aimed at highlighting deteriorations in health due to occupational exposures to substances, working environments, or psychosocial factors. The studies carried out examine respiratory and cardiovascular pathologies, allergies, cancers, musculoskeletal disorders, reproductive disorders, and disorders related to psychosocial factors. The division also conducts studies for assessing the impact on risk prevention of training, or of other interventions. The various studies can require appropriate statistics methods to be developed internally.





© DR

David Vernez
Director of the Institute
for Health and Work
(Switzerland)

Interview with

In Switzerland, your Institute is a centre of reference for occupational health. Could you tell us a little about some of the issues addressed by your research?

The Institute for Health and Work, or the Institut universitaire romand de Santé au Travail (IST), as it is called in French, is a skills centre that acts on various levels: teaching, and the importance of risk prevention training is a concept that is not unfamiliar to INRS; expertise and consulting, for assessing work situations out in the companies; promotion for raising awareness of good practice; and research, in order to take occupational health forwards. Our studies cover 7 flagship topics that are addressed in targeted manner, since our resources match the size our territory... This work is organised in relatively specific units. In the chemical field, biomarkers are a major focus for development for our teams. The idea is to design early effect markers, in particular at cell level (oxidative stress) or at skin level, making it possible, in particular, to limit the use of experimentation on animals. Another section of the research is focused on indoor pollutants – interior air quality is a concern shared with public health specialists – through measuring bioaerosols contained in buildings, such as moulds given off when renovating old buildings. Other work is conducted in conjunction with the occupational medicine services, in particular on the mechanisms of respiratory inflammation. And, of course, on identifying physical risk or psychosocial risk factors, such as musculoskeletal disorders, which we study in conjunction with new forms of work and of practices (e.g. numerical tools, etc.).

INRS had the privilege of having you among its speakers at the 4th Scientific Conference held in April on the topic of innovative methods and techniques in chemical risk prevention. Your talk was devoted to IT tools for performing chemical risk assessment; could you tell us a little more about that? And why, in your opinion, efforts on preventing exposure to chemicals should be maintained?

Even though massive exposure to chemicals has disappeared, every day new substances are created, and they can have combined effects or interact with each other to produce what we often call “cocktail effects”. A recent survey conducted at European level shows that use of chemicals has been stable for a few years now, but is no longer declining. Many sectors are concerned, in particular in small businesses that constitute a major challenge for prevention. I am thinking, for example, about the hairdressing or maintenance trades, for which exposure to chemicals is doubtless under-assessed.

At the recent conference organised by your Institute, I addressed the 340 participants about the scope and limits of IT modelling in chemical risk assessment. Although such tools are used to a considerable extent because of their limited costs and good reproducibility, their performance and validity are less well known. Exposure prediction, which is generally based on a small number of determinants, requires choices to be made, limits the fields of investigation and masks the subjective nature of human beings. These tools can enlighten decision-makers in their management of risks, alerting them and enabling them to understand an exposure context rapidly, but only intervention from a specialist makes it possible to take a critical look at such estimations, and their use should remain supplementary to metrology, and not an alternative to it.

You are specialised in occupational hygiene and in assessment of exposure to pollutants, in particular exposure of the skin. Some of your work has been to understand the link between exposure to ultraviolet sunlight and appearance of skin cancer. Can you share with us some of the knowledge you have acquired on this subject that is a public health concern?

10 years ago, work for occupational safety and health was more compartmented, with a distinction between occupational health issues and public health issues. But pollutants are not only generated at work, and their scientific and health issues are not limited to a single environment (private life or working life). Increasingly, work done by occupational hygienists feeds into debates on public health, in particular through epidemiology. Prevention messages distributed through public health channels should also be adapted and taken up for actions targeting employees. Exposure to UV solar radiation, which causes cataracts and skin cancer, is an excellent example of connection between a public health issue and the exposure context for trades in which work is done outdoors, that connection requiring the tools to be re-worked from the scientific and the regulatory points of view. By collating the data collected out in the field with climate and modelling information, we have been able to identify the sectors that are most exposed (Building and Civil Engineering, Tourism, Green Spaces, Agriculture, Armed Forces, Deliveries and Mail, Aerial Installation Services, etc.). Those sectors should be monitored particularly carefully, with recommendations in terms of skin and eye protection.

Our job is to strengthen the relationship between work and health in such a manner that it is beneficial to the worker, to the economy, and to society. In Switzerland, and in France, we look for compatibility between theory and practice, and between research and solutions, with a view to transposing our actions so that they are tuned in to the realities of the working world as finely as possible, and this is one of the reasons why our Institutes collaborate regularly in doing their respective studies.



IST's Identity Card

Affiliated to the Universities of Lausanne and of Geneva, the Institut Universitaire Romand de Santé au Travail (Institute for Health and Work) is a foundation governed by private law, whose missions are: teaching, research, expertise and consulting, and promotion in the field of occupational health. This overall approach and the expertise of its 70 specialists make IST a stakeholder who is recognised both nationally and internationally. It is a WHO Collaborating Centre. In order to make daily progress in occupational health, the Institute takes research forwards around the following focuses:

- chemical, physical, and biological exposure assessment;
- health effects and health effect markers;
- working conditions and organisation of work;
- psychophysiology of emotions and performance;
- prevention and preventive actions, intervention and workability;
- structural and development projects.

2014 “Studies & Research” annual report

In 2014, 92 studies (i.e. 248,763 hours) were conducted by the scientific and technical divisions of INRS, the activity represented by these studies accounting for 44% of the volume of work of INRS.
























The studies & research activities conducted in 2014 break down mainly into 17 topics from among the 22 topics identified in INRS’s strategic plan for 2013-2017.

These topics are defined on the basis of various entries: the type of risk in question (biological, chemical, etc.), the sector in which the risks appear (waste and recycling, road accident risks, etc.) or the type of effect in question (allergies, occupational cancers, musculoskeletal disorders, etc.). A special case is the topic “manufactured nanomaterials”, which, while being a subset of chemical risks, is the subject of specific developments.

In 2014, as in the preceding years, the topic “chemical risks” predominates (29% of the studies & research activity). Then come the themes of “manufactured nanomaterials” (10%), and “noise, vibration, electromagnetic fields, and optics” (11%).

The following pages offer detailed presentations of the 23 studies that were completed by the end of 2014, as well as short summaries of all of the 83 studies in progress in 2015. The studies are classified on the basis of the main topic to which they are related. Colour-coded visual markers indicate the home topic and the associated topics.

The 17 topics into which the studies conducted in 2014/2015 break down

- | | |
|---|--|
|  Accidentology, perception of risk, and acceptability of occupational risks |  Organisation, health and safety at work |
|  Care services |  Prevention of occupational cancers |
|  Occupational allergies |  Reproduction and work |
|  Biotechnologies |  Biological risks |
|  
Noise, vibration, electromagnetic fields, and optics |    Chemical risks |
|   |  Mechanical risks and new technologies for accident prevention |
|  Design of work equipment, workplaces, and working situations |  Psychosocial risks |
|  Waste and recycling |  Occupational road accident risk |
|  Multiple exposures: chemicals and noise |  Musculoskeletal disorders of the limbs and of the back |
|  Manufactured nanomaterials |  Ageing, staying in employment, and preventing occupational exclusion |



Accidentology, and perception & acceptability of occupational risks

One of the priorities of INRS in terms of accidentology is to incorporate safety as far upstream of working situations as possible, through systems for managing occupational safety and health, and through development of a prevention culture out in the companies.

The INRS studies & research activities on this topic follow two focuses:

- establishing new methods of understanding and of assessing accident risks;
- developing strategies for reducing the overly high accident rate of newly hired staff.



Assessment of the impact of initial occupational safety & health training on the occurrence of occupational accidents among the under-30s

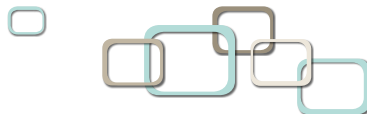
■ **Stéphanie BOINI-HERRMANN and Michel GRZEBYK**

Occupational epidemiology division

This study aims to determine the impact of initial occupational safety & health training on the occurrence of occupational accidents among young people aged 18 to 30 who are entering the working world. Identifying factors influencing accidentology is essential in order to propose prevention strategies appropriate to such employees.

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Occupational allergies

On this topic, the studies & research activities are attached to the following focuses:

- developing tools for measuring exposure and effects so as to identify the risk substances better;
- identifying the determining factors that contribute to exposures to the allergy risk.



Inflammation of the airways and microbiological exposure of composting plant workers: a longitudinal study

■ **Valérie DEMANGE and Michel GRZEBYK**

Occupational epidemiology division

Outline of reasons and objectives

Composting is based on considerable proliferation of microorganisms, which can then be found in the air due to the handling operations necessary for the process to take place properly. Such microorganisms and the ones that are present initially in the waste, be they alive or dead, then take part in forming bioaerosols in the atmosphere of the workplace. Occupational exposure during composting work would appear to generate relatively non-specific acute disorders in which the mucous membranes of the eyes and of the upper airways are irritated. Currently, in France, there is no official rule for good composting practice and nor are there any mandatory collective or personal prevention measures that are specific to composting. A survey has been conducted to determine whether the working conditions are associated with the existence or the intensity of chronic inflammation of the airways of the workers (symptoms, and functional respiratory exploration). The working conditions correspond to types of plant defined on the basis of type of waste treated, of whether or not they are in the open air (or confined), and of whether the composting process uses forced aeration or is constituted merely by mixing the waste by turning it over.

Approach

A repeated cross-sectional study of respiratory morbidity was conducted with, in all, 4 measurement times per subject, at intervals of about 6 months. The exposed group was made up of 90 employees working in the composting plants and who are exposed to waste and/or to compost. A group of 17 employees whose usual occupational activity does not involve exposure to bioaerosols, and who were comparable in terms of age and of socio-professional level, were also monitored.

Main results

Handling green waste is associated more with eye irritation, and handling shredded green waste is associated more with a higher level of lower airway inflammation marker. Doing cleaning tasks on foot at the plant is associated with greater bronchial reactivity, without going as far as bronchial hyperreactivity, which is present in cases of asthma, in particular. Use of vehicles that are less well equipped with air-conditioning is associated with more symptoms of irritation of the nose. Washing work clothes at home rather than them being cleaned by the company is associated with more symptoms of irritation of the lower airways.

Discussion

The study has highlighted the effect of absence of air-conditioning in the cabs of site vehicles, and the effect of absence of company cleaning of work clothes on symptoms of irritation of the airways. Equipping cabs with air-conditioning and having work clothes cleaned by the company could contribute to preventing risks for respiratory health. Translation, in terms of respiratory health, of the small effects observed on the pre-clinical markers remains to be clarified.



Nickel and its compounds: review and characterisation of exposure

■ **Barbara SAVARY**

Pollutants metrology division

Following listing of the sectors of activity in which nickel and its compounds are present, an industry survey is being conducted to identify the processes whereby nickel is used, and to assess the number of employees potentially exposed per sector, per process, and per nickel compound. It will make it possible to identify the working situations that are potentially of concern, and then to conduct epidemiological monitoring, biomonitoring, and atmospheric measurements.



Development of an *in vitro* co-culture model to assess the sensitising potential of industrial substances

■ **Fabrice BATAIS and Isabelle SPONNE**

Toxicology and biomonitoring division

■ **PhD thesis: Cécile HUPPERT**

University of Lorraine - Prof. Christophe PARIS

The sensitising potential of new chemical substances appearing in industry should be identified early in order to prevent occupational allergy risks. This study is seeking to develop a method of co-culture between epithelial cells and dendritic cells of mice in order to improve the sensitivity of a test developed previously and so as to discriminate between skin sensitizers and respiratory sensitizers.



Severity and control of work-related asthma

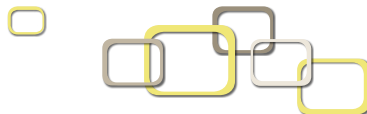
■ **Valérie DEMANGE and Anca RADAUCEANU**

Occupational epidemiology division

■ **PhD thesis: Hermine MEVEL**

University of Lorraine - Prof. Christophe PARIS

The distribution of work-related asthma according to severity and control is not known and could vary as a function of factors of exposure to allergens, in particular occupational allergens. A survey is being conducted on 400 subjects suffering from work-related asthma, and on 400 subjects suffering from non-work-related asthma. The knowledge gathered will make it possible to identify trades or sectors in which prevention of respiratory pathologies needs to be reinforced.



Biological risks

In the absence of Occupational Exposure Limit Values (OELVs), the INRS research work is focused in particular on:

- developing approaches for assessing the immunoallergic and toxic risks related to exposure to airborne agents of biological origin;
- developing methods and strategies for measuring (sampling and analysing) bioaerosols, such methods and strategies being transferable to stakeholders in prevention of such risks;
- acquiring methods for assessing the quality of interior air;
- studying means for reducing exposure to bioaerosols.



Comparative study of sampling methods for measuring exposure to bioaerosols constituted by stress-sensitive biological agents

■ **Xavier SIMON and Philippe DUQUENNE**

Pollutants metrology division

The objectives of the study are to assess and to compare sampling methods suitable for collecting sensitive microorganisms. The end purpose is to propose a biocollector that will supplement or replace the measurements taken by closed cassettes, in determining occupational exposure to bioaerosols. After doing work in the laboratory, tests will be conducted in working atmospheres (sanitation, food industry, maintenance, or tertiary sectors).



Development and assessment of a method of measuring (1,3)- β -D-glucans in workplace air

■ **Philippe DUQUENNE and Xavier SIMON**

Pollutants metrology division

The objectives of the study are to develop and to assess a method of measuring (1,3)- β -D-glucans (compounds of biological origin) contained in air, and to make the method available to the French Occupational Health and Pension Insurance Funds (CARSATs). In particular, the study plans to put in place an analysis setup and various assay tests with the main collection media, before organising exposure measurements in working environments.



Microbiological and physical characterisation of fungal aerosols emitted at the work station during sorting and recycling of waste

■ **Philippe DUQUENNE and Xavier SIMON**

Pollutants metrology division

■ **PhD thesis: Jodelle DEGOIS**

University of Lorraine - Prof. Pierre LEBLOND and Dr Cyril BONTEMPS

The study aims firstly to determine the composition (biodiversity) and the particle-size distribution of the fungal aerosols emitted during waste sorting and waste recycling activities, and secondly to look for one or more characteristic indicators of the bioaerosols emitted into the working atmosphere. The idea is to develop a measurement strategy making it possible to achieve in-depth characterisation of fungal aerosols at the work station, and to deploy it out in the companies.



Occupational exposure to mycotoxins: biomonitoring and atmospheric assessment

■ **Sophie NDAW and Alain ROBERT**

Toxicology and biomonitoring division

The objective of this work is to propose the tools for assessing exposure to mycotoxins. Methods of simultaneously assaying 5 mycotoxins and their metabolites in urine and in air will be developed. A characterisation campaign will be put in place in various sectors that are affected (stock farming, manufacture of animal feed, processing and transformation of food, harvesting of cereal, and handling of straw and fodder).



Processes for purifying workplace air that is contaminated with microorganisms: an investigative preparatory study on the technical solutions of separation and disinfection

■ **Denis BEMER**

Process engineering division

■ **Philippe DUQUENNE and Xavier SIMON**

Pollutants metrology division

Due to the very wide diversity of bioaerosols, of separation techniques that can be used in an industrial environment, and of disinfection techniques that are specific to microbiological agents, an in-depth preparatory investigation phase is necessary on this subject. It is proposed to identify the most appropriate process for treating aerosols of microbiological origin at workplaces.





Noise, vibration, electromagnetic fields, and optics

Noise

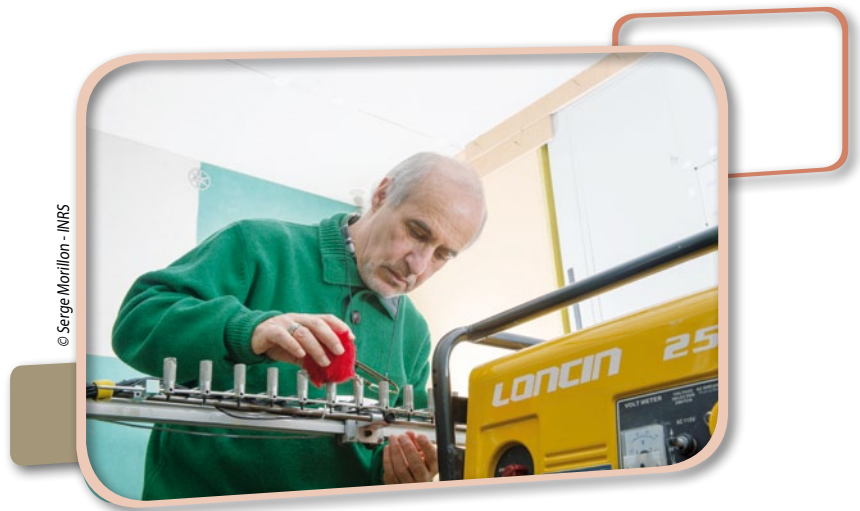
On this topic, the research work being conducted by INRS aims to improve methods of performing diagnostic surveys for and of locating sources of noise, and to study new acoustic materials and hearing protectors. Another focus for work is understanding and perception of messages in open-plan workplaces and the influence on worker hearing comfort or discomfort.

 Acoustic holography techniques for characterising noisy industrial machinery

■ **Armand NEJADE**
Work equipment engineering division

Outline of reasons and objectives

Acoustic holography is a technique that makes it possible to map the acoustic field at the surface of a noisy mechanical system on the basis of measurements taken in a parallel plane situated a small distance away. This mapping makes it possible to locate the sound sources and thus to define a strategy for reducing noise at source. Depending on the structure studied and on the type of sound signals emitted by the structure, various different holography methods can be implemented.



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Approach

Three methods were initially considered, namely: measuring sound pressure (which is the usual method); measuring particle velocities; and Broadband Acoustic Holography based on Intensity Measurements (BAHIM), which, unlike the others, does not require reference signals (which are chosen empirically). Furthermore, the first two methods can apply only when the noise sources in the structures under study are fully correlated, which is not generally the case. This limitation has led to a fourth method being developed and implemented, namely Multi-Reference Near-field Acoustic Holography (MRNAH). Finally, since the BAHIM holography method was unsatisfactory, a fifth and new method, called CIBNAH (Complex Intensity Based Near-field Acoustic Holography), was developed.

All of these methods were applied to:

- an academic structure having two well-known sources whose parameters are adjustable;
- a table saw with several sources (motor, blade, radiating plates, air turbulence, exhaust, etc.);
- an electricity generator set having several sources.

The results are presented in the form of maps of the sound pressure fields and of particle velocity. Application to the academic structure made it possible to adjust and assess each method and to compare them. Application to the machinery made it possible to test the accuracy of the results by comparison between measurements and calculations, in the presence of complex acoustic fields.

Main results

With the academic structure, the MRNAH multi-reference method was accurate in showing the sources, their positions, and their levels. The BAHIM method proved to be highly inaccurate. The CIBNAH method showed the same effectiveness as the MRNAH method. Comparison of the calculations for reconstructing the sound fields a small distance away from the surface of the saw by MRNAH and CIBNAH with direct measurements at the same distance away, showed that both approaches worked, CIBNAH offering greater accuracy at the high frequencies. Another positive point is that, when it is performed by measuring particle velocity, which decreases faster than sound pressure, holography allows the measurement plane and thus the measurement effort to be smaller than when measuring sound pressure.

Discussion

Among the holography methods developed and applied to an academic structure and then to machinery, two methods (MRNAH and CIBNAH) proved to be satisfactory. In addition, CIBNAH offers the advantage of being simple mathematically, and of not requiring reference signals.



Perception of useful acoustic signals in noise

■ **Jean-Pierre ARZ**

Work equipment engineering division

Outline of reasons and objectives

In a noisy industrial environment, perception of sound signals indicating danger is essential to keep workers safe from accident risks. When considering making it mandatory to wear personal hearing protectors to reduce exposure of workers to noise, it should be remembered that accident risks might become greater if wearing the protector degrades the perception of hazard warning signals. The challenge with wearing hearing protectors is thus twofold: to provide effective hearing protection and also to ensure that danger signals remain properly audible so as to keep workers safe. The aim of this study was to develop methods making it possible to assess the effect of wearing hearing protectors on the perception of warning signals for all protected workers, including those suffering from hearing loss.



Approach

Two complementary methods of assessing the effect of wearing hearing protectors on perception of danger signals were applied and compared: measuring masked thresholds and calculating masked thresholds. The masked threshold of a signal is the minimum level (the “threshold”) at which it is audible in a given ambient noise (the “masker”). Measurement of these thresholds is necessary, in particular, because of the potentially large differences between the real noise reduction of the hearing protectors and their theoretical reduction ratings given by the manufacturers, leading to erroneous calculation of the masked thresholds when such calculation is based on the theoretical noise reduction ratings. As regards calculating the masked thresholds, such calculation makes it easy to study the influence of various parameters (attenuation or reduction of the protectors, hearing losses, and hearing filters) independently or in combined manner.



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Main results

Through industrial collaboration involving about one hundred workers and two hearing protectors, the masked threshold measurements showed that wearing a protector improved perception or had no effect, except when the ambient noise was predominantly low-frequency. As regards hearing damage, the calculations of masked thresholds showed that, for high levels, the increase in the thresholds is due more to broadening of the hearing filters than to hearing losses. Finally, concerning the comparisons between measured thresholds and calculated thresholds, small differences were obtained for the tests without protectors. Conversely, calculation did not always reproduce the effect of the protector that was observed on the basis of the measurements.

Discussion

At the end of this survey, INRS had tested and validated methods of assessing, both by measurement and by calculation, the effect of wearing hearing protectors on the perception of hazard warning signals. These methods make it possible, henceforth, to respond to external requests and to assist companies in choosing protectors that are appropriate both to their sound situations and to the hearing statuses of their workers. Various prospects can also be explored for improving the robustness of the methods used: conducting other tests by also measuring the real attenuation or noise reduction of the hearing protector; estimating the repeatability of the threshold measurements; and, finally, proposing developments of the model for calculating masked thresholds so as to take better account of the hearing protection effect.



Calculating speech noise exposure indicators in the tertiary sector

■ Patrick CHEVRET

Work equipment engineering division

This study is looking at two focuses for reducing sound discomfort in open-plan offices. One of them relates to developing prediction tools making it possible to obtain indicators on the ambient sound. The second focus is related to the consequences on performance and fatigue of exposure to speech noise, which is the noise deemed to be the most annoying and disruptive in open-plan offices.



Characterising the acoustic properties of complex walls and panels and influence on noise in industrial premises

■ Nicolas TROMPETTE and Jacques CHATILLON

Work equipment engineering division

■ PhD thesis: Kevin RABISSE

University of Lorraine - Prof. Joël DUCOURNEAU

One aim of the study is to continue to examine the acoustic performance of industrial walls and panels. Another aim of the study is to develop an empirical model relating acoustic diffusion to apparent absorption and to deploy the system of measuring the characteristics of vertical walls and panels that is currently being developed at INRS.



Vibration

In order to contribute to preventing vibration, INRS is developing tools for assisting in measurement-free assessment (calculator, database, etc.). In the field of hand-arm vibration, actions are being conducted for modelling and for experimental characterising of propagation of vibration emitted by handheld machinery. As regards whole body vibration, work on taking account of co-factors (efforts, posture) is focusing on developing knowledge about this co-exposure at the driver stations of vibrating mobile plant or vehicles.



Experimental modelling and characterisation of mechanical vibration propagation in the upper limbs when using rotary handheld machinery

■ **Christophe NOËL**

Work equipment engineering division

In order to propose avenues for improving the standardised method of measuring vibration exposure of the hand-arm system, it is necessary to understand the phenomena of mechanical vibration propagation in the upper limbs and to master assessment of the forces at the hand-machine interface. This work involves analysing the reliability of the technique and developing a device making it possible to characterise the biodynamic response of the finger-hand-arm system.



Developing a tool for implementing the Vibration legislation for operators of handheld vibrating machinery

■ **Éric CARUEL and Patrice DONATI**

Work equipment engineering division

In order to help companies reduce exposure at the work stations, occupational safety & health stakeholders need a simple measurement-free assessment tool enabling them to consider whether the vibrating machinery exposes the operators to beyond the exposure limit values. After collecting data and conducting tests on the performance of anti-vibration systems, the study aims to develop an interactive calculator associated with a questionnaire on conditions of use and on exposure times.



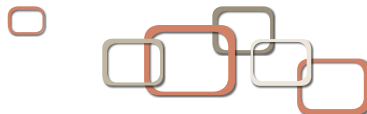
Mapping static and dynamic postures in seated operators of vibrating mobile plant or vehicles

■ **Maël AMARI**

Work equipment engineering division

The procedure for assessing vibration risks for operators of mobile plant or vehicles that is defined by the standard does not currently take account of the position of the body and of the movements related to doing a work task. The aim of this study is to map the static and dynamic postures in various vehicles or pieces of plant, and to identify the parameters relevant for discriminating between the various work stations.





Modelling the vascular remodelling phenomena that result from exposure of the hand-arm system to vibration

■ **Pierre LEMERLE**

Work equipment engineering division

■ **PhD thesis: Yue HUA**

University of Lorraine - Prof. Jean-François GANGHOFFER

This study proposes to contribute to improving understanding of the physiopathological mechanisms involved in “vibration syndrome” by attempting to adapt the techniques for modelling how soft tissue, and more particularly the peripheral arterial system, behaves when subjected to vibration-type stresses.



Simulation of vibration of handheld machinery

■ **G rard FLEURY**

Work equipment engineering division

In order to reduce the loss of objectivity in assessment of exposure to vibration to which users of handheld machinery are subjected, this study aims to use numerical simulation to predict the vibration level of a machine under real conditions, and to quantify the maximum error between the predicted value and the value actually emitted. This method should make it easy for occupational safety & health specialists to assess vibration exposure of employees who use handheld machinery.



Electromagnetic fields

As regards electromagnetic fields, we need to assess the real exposures, to characterise the sources, to identify the prevention means, to develop technical solutions for reducing the exposures, and to raise awareness in users.



Developing a tool for implementing the “Electromagnetic Fields” European Directive for operators of radiating machinery

■ **Philippe DEMARET and Patrice DONATI**

Work equipment engineering division

Outline of reasons and objectives

Industrial applications based on the physical properties of electromagnetic waves can expose operators to high levels. In 2011, INRS published the results of a study based on measurements at 600 work stations. They showed that seven families of machines could expose employees to field values greater than the action values set by European Directive 2004/40/EC. That directive was replaced in June 2013 by Directive 2013/35/EU. It sets new threshold values that are sometimes less stringent and makes it mandatory for companies to assess exposure. A new study has thus been conducted to supplement the preceding findings and to develop a tool designed to enable companies to make simplified assessments of this risk.

Approach

This study was conducted in collaboration with the 9 Physical Measurement Centres of the CARSATs/CRAMs (French Occupational Health and Pension Insurance Funds/French Regional Health Insurance Funds). The measurement protocols, drafted for the 7 families of machines studied in the previous study, were kept so as to continue to collect and analyse the data homogeneously and in a manner representative of the exposure conditions. One thousand



datasheets, each corresponding to a work station, were filled in. For each station, an exposure index equal to the ratio between the measured value and the Action Value (AV) defined by Directive 2013/35/EU was calculated. MRI and NMR equipment were not taken into account in this second study because the levels measured were low in the control booths where the operators work.

Main results

In spite of the less stringent thresholds for the new directive, the measurements taken gave exposure indices greater than 1 for 4 of the 7 families of equipment, sometimes on only some of the stations and sometimes on the majority of them. A value greater than 1 means that the AV is exceeded and the company must then improve the situation. For most of the equipment, the only prevention approach consisted in moving the work station as far as possible away from the emission source, even though other technical solutions existed. A parametric study made it possible to classify the machines into homogeneous sub-families based on the emitted field levels. This work made it possible to construct a simplified assessment tool making it possible, on the basis of the characteristics of the machinery, of the tasks performed, and of the position of the operator, to predict the probability of conformity or non-conformity of the exposure relative to the new directive.

Discussion

To the best of our knowledge, this study and the previous one were the first in France to have conducted an assessment of industrial exposure to electromagnetic radiation. These studies have enabled a good practice guide to be written to help companies identify the main risk equipment, assess the probabilities of exceeding the AV, and implement prevention means. The simplified assessment tool will be accessible from the “electromagnetic fields” file on the INRS website.



Optical radiation

As regards optical radiation, INRS studies are continuing with a view to defining a methodology for assessing risks *in situ* and for assessing protective means. Others aim to accompany implementation of the decree on protecting workers from the risks due to artificial optical radiation.



A system for accompanying implementation of French Decree 2010-750 of 2 July 2010 on protecting workers from risks due to artificial optical radiation

■ Annick BARLIER-SALSI

Work equipment engineering division

The study aims to set up an assistance system, based on the “CatRayon” software, making it possible, without measurement, to identify the sources of artificial optical radiation that are dangerous, and to assess, a priori, the risks of working situations and the means for preventing them. For cases where metrology is necessary, the aim is to make available to occupational safety and health specialists a method of measuring artificial incoherent optical radiation at the work station.



Prevention of occupational cancers

The research work on this topic is aimed at:

- improving prevention of all types of occupational cancer, and in particular assessing the opportuneness of using early-effect markers following exposure to carcinogens;
- initiating and accompanying companies in preventing the asbestos risk;
- studying the perception of carcinogenic risks.



Assigned Protection Factors of Respiratory Protective Devices used on asbestos removal worksites

■ **Sandrine CHAZELET and Éric SILVENTE**

Process engineering division

The change of method for characterising asbestos fibres and the changes in work equipment mean that it is necessary to reassess the protection factors of Respiratory Protective Devices (RPDs). An intervention protocol will be established in the laboratory and then implemented on asbestos removal worksites, in order to give the protection values of the RPDs, information on the actual exposure of workers, and ways of improvement for reducing the personal exposure to as low as possible.

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Multiple exposures: chemicals and noise

The work of INRS is aimed at:

- identifying the risks run by employees exposed to combinations of harmful/pollutant factors (association of noise and of chemicals), and assessing their potential effects;
- developing new tools capable of taking multiple exposures into account (databases, physiological and pharmacokinetic models, biomonitoring, protective equipment, screening, epidemiology, etc.);
- assessing the relevance of Occupational Exposure Limit Values OELVs, in particular when doses are small.



Compared harmfulness of impulse noise and of steady-state noise having the same acoustic energy during co-exposure to styrene

■ Pierre CAMPO

Toxicology and biomonitoring division

Outline of reasons and objectives

In its recommendations on protecting the hearing of employees exposed to noise of occupational origin, the Noise Directive 2003/10/EC does not take into account the nature of the noise, i.e. whether it is steady-state noise or impulse noise, and nor does it take into account whether or not it is associated with chemicals. And yet recent studies have shown that certain aromatic solvents, such as styrene, can disrupt auditory reflexes. From the prevention point of view, such information is significant, because the acoustic energy of impulse noise, with a shorter duration than the triggering latency of the stapedius reflex, will penetrate into the cochlea without being attenuated. Therefore, noise of short duration, such as impulse noise, could be more harmful than steady-state noise having the same energy. And the risk could be increased when the exposure to noise is concomitant with exposure to an aromatic solvent. In this study, the damaging effects of impulse noise were compared to those of steady-state noise, of the same spectrum, in the presence and in the absence of a styrene-rich atmosphere.

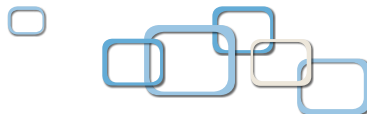
Approach

The hearing of brown Norway rats was assessed using a technique based on objective measurement of the otoacoustic emissions caused (acoustic distortion products). The selected noise was noise of octave band centred on 8 kHz. It was either continuous/steady-state noise, or impulse noise. The steady-state noise had an $L_{EX,d}^{(1)}$ of 85 dB, while the impulse noise's was 80 dB. For the impulse noise, the sequence of noise impulses was chosen in such a manner that the protection of the middle ear reflex was ineffective. The exposures to noise and to styrene (300 or 600 ppm) lasted 6 hours per day, 5 days a week, for 4 weeks. The toxicity of the exposures was illustrated by cochleograms, which are histograms in which the percentages of cell losses are shown for the hair cells of the organ of Corti.

Main results

In view of the difference in harmfulness observed, during the initial tests, between the two types of noise, the LEX,d of the impulse noise was lowered by 5 dB ($LEX,d = 80$ dB) relative to the LEX,d of the continuous noise ($LEX,d = 85$ dB). Despite this difference, the association of the impulse noise with the styrene caused a synergy of the damaging effects (25 dB) and of the cochleotoxic effects (doubling of the losses of hair cells from the first row). This did not apply with the continuous noise. Continuous noise triggers the middle ear muscle reflex, whereas impulse noise triggers it only once the acoustic energy has penetrated into the cochlea.

⁽¹⁾ Daily level of exposure constituted by the acoustic energy corresponding to steady-state noise for 8 hours.



Discussion

The study highlighted, in the rat, the exacerbated harmfulness of impulse noise compared with the harmfulness of continuous noise. This difference can be estimated at 5 dB over an LEX,d of 8 hours. In addition, the styrene potentiates the damaging effects of the impulse noise. The middle ear reflex thus constitutes a significant variable that, so far, has not been taken into account in the legislation on protection from the effects of noise. INRS will propose modifications of the action values (values at which action should be triggered) recommended by the Noise Directive 2003/10/EC or adaptations of the exposure time depending on the nature of the noise ("continuous versus impulse").



Interaction between toluene and butanone in rats: metabolic aspects and ototoxicity

■ **Frédéric COSNIER**

Toxicology and biomonitoring division

Outline of reasons and objectives

Multi-exposures, which are omnipresent in industrial environments, can lead to unsuspected interactions in a target organ or in the whole body. A preceding study entitled "Indicators of exposure to toluene: assessment in rats of the metabolic disruptions related to co-exposure", made it possible to identify an interaction between toluene (TOL) and butanone (MEK). Beyond the identification of the risks run by employees exposed to combinations of pollutant or harmful factors, the multiple exposures topic (MUEx) also aims to assess the potential effects associated with such combinations and to assess the relevance of Occupational Exposure Limit Values (OELVs).

In this context, the objectives of this study were:

- to identify the origin of the interaction between TOL and MEK;
- to assess its effect on biological exposure indicators;
- to assess the related ototoxic effects.

Approach

Eleven 28-day inhalation campaigns were conducted on adult brown Norway rats exposed to TOL vapours, MEK vapours, or to different binary mixtures of those compounds. During these exposures, urine samples and tissue samples (blood, liver, brain, kidney) were collected in order to assess the extent to which the animals were impregnated with TOL and with MEK and to analyse the metabolic alterations induced by the interaction of the two compounds. Exploration of the auditory function was achieved by measuring acoustic distortion products and by histological analyses (cochleograms and counting ganglion cells).

Main results

The metabolism of the MEK after inhalation is comparable in rats and in humans, the majority urinary metabolite being 2,3-butanediol.

The interaction between the TOL and the LEK is of a metabolic nature. The metabolism of the TOL is thus inhibited by the presence of MEK (and vice versa), which generates an increase that is sometimes considerable (depending on the relative proportions of each of the compounds in the mixture) in blood and brain concentrations. This interaction may have an effect on the excretion of the urinary metabolites of the two compounds, some of them being proposed as biological exposure indicators/indices (BEIs).

MEK did not prove to be ototoxic, even at high concentrations. The experimental conditions implemented in this study did not make it possible to highlight any potentiating of the ototoxic effects of TOL by MEK.

Discussion

The interaction between TOL and MEK can lead to a very large increase in the blood concentrations, and that increase is not necessarily retraced by the urinary BEIs. That can pose a problem for biomonitoring of employees; the level of exposure to the TOL/MEK mixture would then, at best, be under-assessed.

Evidence of the ototoxic effects of TOL being potentiated by MEK was not found. Metabolic saturation did not make it possible to obtain a blood concentration of TOL that was sufficiently high to measure its ototoxic effects after four weeks of exposure. Styrene, which is more ototoxic than TOL, would doubtless be more conclusive for illustrating the risks of potentiating of the ototoxic effects.

This study has made it possible to specify a strategy capable of determining the doses required to cause measurable hearing losses. Consideration is now being given to associating noise at a level allowed by the legislation with co-exposure with solvents at concentrations close to their OEL-8h values. In which case, the noise could catalyse the effects of the increase the blood concentrations induced by the co-exposure with two solvents, and might prove to be damaging.



Assessment of the use of measurements of exposure to chemicals in the French databanks COLCHIC and SCOLA for preventing occupational diseases

■ **Gautier MATER**

Pollutants metrology division

■ **PhD thesis: Gautier MATER**

University of Lorraine - Prof. Christophe PARIS

This project aims to evaluate the use of the COLCHIC and SCOLA data in preventing occupational diseases, including monitoring of exposure, development of risk analysis tools, and retrospective estimation of exposure for epidemiology purposes. Developing the comparison protocol could be of service to international collaborations, for pooling resources and objective information on occupational exposure levels.



Alteration in the amplitude of acoustic middle ear reflex after inhalation of solvent. Physiological consequences for exposure to noise

■ **Pierre CAMPO and Thomas VENET**

Toxicology and biomonitoring division

■ **PhD thesis: Ludivine WATHIER**

University of Lorraine - Prof. Cécile PARIETTI

This approach aims to gain a more in-depth understanding of the mechanisms explaining the synergy of the effects of noise and of chemicals on hearing, and to prioritise the risks run by workers co-exposed to substances whose ototoxic effects are little known (e.g. exposed to chlorinated solvents). The model established will make it possible to classify the "noise and ototoxic" associations depending on their dangerousness for hearing.



Alteration in the metabolism of styrene by co-exposure with 2-butanone (MEK)

■ **Benoît COSSEC**

Toxicology and biomonitoring division

Work has shown that styrene has toxic effects that can be accentuated in situations of multiple exposures. The influence of styrene/MEK co-exposure, and any interactions are being looked at in this study by measuring the variations in blood concentrations of the molecule, and the variations in concentrations of metabolites in urine. Various analytical tools will be developed in order to measure metabolites such as vinylphenols and mercapturic acids.



Effects on hearing and on balance of co-exposure to low-frequency-rich noise and to a solvent: the Carbon Disulphide (CS₂) model

■ **Monique CHALANSONNET and Pierre CAMPO**

Toxicology and biomonitoring division

■ **PhD thesis: Maria CARRERES-PONS**

University of Barcelone - Prof. Jordi LLORENS

The objectives of the study are to check whether the limit values recommended for noise and for Carbon Disulphide (CS₂) are sufficiently protective during exposure combining both solvent [(6 X 15 minutes)/day at 250 ppm] and continuous noise that is rich in low frequencies [85 dB, 6 hours/day]. Understanding the mechanisms leading to a hearing deficit at low frequencies will make it possible to distinguish between injuries caused by noise and injuries inherent to CS₂ intoxication.





Manufactured nanomaterials

INRS action on manufactured nanomaterials has three objectives:

- making knowledge on hazards available to the working world;
- designing tools for identifying, characterising, and measuring occupational exposures;
- proposing risk prevention approaches and tools for firms and laboratories who produce or handle these materials.



Studies of the *in vitro* genotoxic effects of nanostructured silica particles produced by different manufacturing processes

■ Yves GUICHARD and Christian DARNE

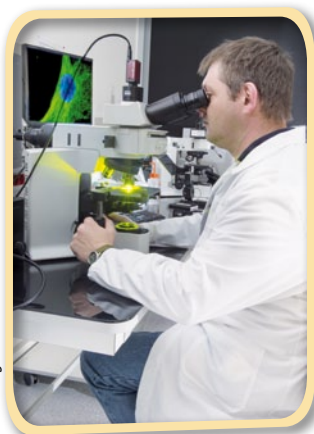
Toxicology and biomonitoring division

Outline of reasons and objectives

Nanoparticles of synthetic amorphous silica (SAS) are produced in large quantities worldwide (1 million metric tons/year) and they have numerous industrial uses. SASs can be broken down into two main types depending on the process of synthesising them: pyrogenic SASs (powders) and precipitated SASs (powders or colloids). The toxicity of such amorphous silicas as manufactured nanomaterials is currently being debated, and the genotoxicity data (genotoxicity referring to damage to the structural integrity of the genome) concerning industrial SASs remains limited. The objective of this study was, in two different cellular models, namely the V79 hamster lung cell line, and the A549 human bronchial epithelial cell line, to assess the cytotoxicity and the genotoxicity of representative samples of pyrogenic and precipitated SASs coming from industry.

Approach

Pyrogenic and precipitated SAS samples supplied by industry were physiochemically characterised at INRS. The V79 and A549 cells were exposed to the SASs at different concentrations and with different treatment periods. The genotoxic effects were assessed by measuring the damage to the DNA, the formation of micronuclei and the formation of mutations. Other cytotoxic effects (cell viability, apoptosis) and production of reactive species of oxygen were also studied in order to understand the observed effects better.



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Main results

The pyrogenic and precipitated SASs with a size of about 20 nanometres produced significant cytotoxic effects on the V79 cells, exposed for 24 hours. At this size, the colloidal precipitated and pyrogenic SASs also induced damage to the DNA on the V79 cells. Conversely, the SASs of slightly larger size, on average around 50 nm, did not produce any significant toxic effects regardless of their chemical nature or of the physical state (powder or colloid). In addition, no SAS induced any micronuclei or mutation of the hprt gene on the V79 cells. Finally, all of the toxicity tests conducted on the A549 cells proved to be negative, indicating that that line was significantly less sensitive than the V79 line for showing up the harmful effects of the tested SAS samples.

Discussion

This study confirms the data from the literature, such data being sparse, on the possibility of a cytotoxic and genotoxic activity of certain manufactured silica nanoparticles. The useful information that this study can bring as regards prevention is that it would appear that the toxicity of the SASs is related more to their size than to their chemical nature (pyrogenic or precipitated) or to their physical state (powder or colloidal). Our results thus highlight that SAS nanoparticles having a small difference in size, e.g. 20 and 25/70 nanometres, have genotoxic properties that are very different. Additional mechanistic studies would be necessary to explain these differences in effect, but these results already make it possible to alert nano-silica producers that a small variation in the primary size of the particles can influence their toxicity considerably.



Performance of real time exposure monitoring applied to nanoparticle aerosols

■ Sébastien BAU and Olivier WITSCHGER

Pollutants metrology division

This study follows on from the EXPONANO study (2008-2012), and links up with the NANOCEN, NanoREG, and EPINANO projects. The objective of the study is to assess real-time metrology performance for measuring particle-size distribution in terms of numbers of nanoparticle aerosols and for measuring their numerical concentration.



Assessment of exposure to nanometric titanium dioxide

■ Bertrand HONNERT

Pollutants metrology division

The aim of this study is to assess the chemical risk related to using nanometric titanium dioxide. It is based on an original method adapted to suit the nanometric nature of this chemical, using metrology conducted on the air inhaled by the operators during their activities at the workplace, and using a collection of prevention measures associated with the use of nanometric titanium dioxide.



Standardisation of activities concerning nanotechnologies and nanomaterials (NANOCEN)

■ Olivier WITSCHGER and Sébastien BAU

Pollutants metrology division

INRS is steering actions on 5 dustiness standards that will contribute to the process of understanding, managing, and disseminating information on the risks of occupational exposure to nanomaterials. As part of this study, testing of the reproducibility of measuring dustiness of "reference" powders is planned in various European institutes, including INRS. A test setup designed and validated by INRS will be reproduced and installed in the laboratories of a Danish institute.



EXPROPANO: Assessment of occupational exposure to nanometric particles (measurement strategy coupled with analysis of the activity)

■ **Olivier WITSCHGER**

Pollutants metrology division

■ **PhD thesis: Louis GALEY**

University of Bordeaux - Prof. Alain GARRIGOU

In this project, the idea is to develop a method of assessing occupational exposure by associating characterisation of the aerosols with a first level of activity analysis. The results will contribute to building the job-exposure matrix of the MatPUF program, that matrix showing jobs in relation to exposures to nanomaterials, and will also contribute both to the French system of monitoring of workers exposed to nanomaterials, and also to acquisition of knowledge for feeding, in particular, the European Nano-Exposure and Contextual Information Database (NECID).



Study of the effect of agglomeration on the respiratory toxicological properties and the toxicokinetics of inhaled titanium dioxide nanoparticles in rats

■ **Laurent GATE and Christian DARNE**

Toxicology and biomonitoring division

■ **PhD thesis: Laetitia CHEZEAU**

University of Lorraine - Prof. Bertrand RIHN

In order to study the toxicological properties of aerosols having distinct particle-size distributions, this study aims to develop an experimental system making it possible to expose laboratory animals to aerosols obtained from the same sample of manufactured nanopowder. The toxicological assessment will be preceded by a phase aiming to prepare samples of particles giving aerosols of predetermined particle-size distribution and to put in place tools for generating and characterising aerosols, and for exposing animals to them.



Study of neuro-inflammation and of potential disruptions of the blood-brain barrier in adult and old rats exposed to nanoparticulate TiO₂ by inhalation

■ **Monique CHALANSONNET and François GAGNAIRE**

Toxicology and biomonitoring division

The toxicity of Titanium dioxide (TiO₂) in the nanoparticulate state raises a number of questions. The impact on the central nervous system is, in particular, poorly understood. This research, which is bringing together teams from INRS, from the CEA (France's Alternative Energies and Atomic Energy Commission), and from the University of Orsay, is proposing to study, in rats, the effect on the physiological functions of the blood-brain barrier of subacute exposure to a TiO₂ aerosol by inhalation (a major route for occupational exposure).



A common European approach for regulatory assessment of nanomaterials (NANOREG)

■ **Laurent GATE**

Toxicology and biomonitoring division

■ **Olivier WITSCHGER**

Pollutants metrology division

■ **Emmanuel BELUT**

Process engineering division

INRS is a partner in the NANOREG project that aims to make available to the legislators relevant methods for improving assessment and management of the risks of nanomaterials for humans and for the environment. In this project, INRS is involved in the *in vivo* toxicology aspects (toxicity by reiterated administering of carbon nanotubes to rats by inhalation), occupational exposures, and collective protection.



Impact of sources and of the environment on confinement of nanoparticulate pollutants by collective protection equipment

■ **Emmanuel BELUT**

Process engineering division

The objectives pursued in this study are to develop numerical models for the conveying of nanometric aerosols (diagnostics, analysis, collection/capture design, and general ventilation), to improve knowledge on the sources of pollutant aerosols, and to conduct tests that can be used to assess the modification in the confinement induced by the pollution sources and the working environment.

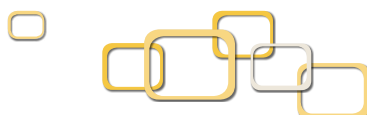


Performance of filtering or isolating respiratory protective devices (RPDs) in protecting from nanoparticles

■ **Sandrine CHAZELET**

Process engineering division

This study aims to better identify the performance of RPDs having high protection factors (full mask, with free or assisted ventilation, isolating equipment) with regard to nanoparticles of various types, sizes, and morphologies. The effect of the respiratory rate of the wearer of the RPD will also be simulated so as to take into account different working situations. This work should enrich the recommendations related to wearing RPDs when handling nanomaterials.





Organisation, health and safety at work

The INRS studies are focusing on three organisational dimensions that interact on health and safety: company organisation, production organisation, and prevention organisation. These dimensions of work organisation go from tool, system and work process design to human resources management and issues of occupational safety and health. Two lines of research are being taken:

- developing new organisation modes, new workforce management modes, and new information and communications systems, whether it be for Lean Management, for subcontracting, or for New Information and Communications Technologies in networked companies;
- changing roles and responsibilities in new trades, new sectors, and new forms of work design or of division of labour, including the work of designers and of the management on site.



Prevention in transport and logistics: technological and organisational changes in networked enterprises

■ **Virginie GOVAERE and Liën WIOLAND**

Working life division

■ **PhD thesis: Bérangère HITTINGER**

University of Toulouse - Prof. Julien CEGARRA

This study aims to propose an analysis framework that is suited to the networked organisational mode used in road haulage and logistics, and to develop a risk prevention strategy. About ten companies will be monitored to take account of the variety of the organisational setups (size, type of activity, status, etc.), and solutions for preventing technical, technological, and organisational risks will be proposed.



Prevention in design and co-operation between stakeholders from different working worlds. The case of a national project to extend treatment of recyclable waste

■ **Bertrand DELECROIX and Evelyne MORVAN**

Working life division

■ **PhD thesis: Leila BOUDRA**

Université Lumière de Lyon - Prof. Pascal BEGUIN

The study aims to develop methods of incorporating an occupational risk prevention approach as far upstream as possible in projects for transforming a branch of industry (e.g. for new regulations). The idea is to enable the various stakeholders to co-operate and to organise themselves to structure the operational work downstream and to consider the potential effects on health and safety. Prevention recommendations will be proposed.



Lean company practices and occupational health

■ **Evelyne MORVAN, Bertrand DELECROIX and Edwige QUILLEROU-GRIVOT**

Working life division

Interventions will be made through a multi-disciplinary approach (economics, ergonomics, psychology) in companies that use lean production rationalisation systems. The idea will be to gain a better understanding of the nature of the tensioning and regulating processes. Lessons will be learnt about the way in which lean organisation practices lead (or do not lead) to a deterioration in worker health.



Occupational exposures and the practice of outsourcing in the field of maintenance. Towards contextualised prevention

■ **Corinne GRUSENMEYER**

Working life division

The work is aimed at studying occupational exposures of maintenance staff (health, operator safety, facility safety); comprehending relations between the way maintenance work is organised and the risks for operators, in particular when it is outsourced, and developing understanding of such forms of outsourcing. The results should make it possible to propose appropriate avenues for prevention.





Chemical risks

Chemical risks have been studied at INRS since it was founded. The work is continuing through studies on new substances including substitute products, metrology, bio-indicators, influence on health, epidemiology, improving and developing processes, developing prevention techniques, etc.



Focus 1: making knowledge on hazards available

The works for highlighting and for quantifying the hazards related to exposure to chemicals, whether they be toxic, mutagenic, carcinogenic, reprotoxic, allergenic, or neurotoxic, are studied from two angles: experimental toxicology, on animals (*in vivo*) and on cells in culture (*in vitro*); and epidemiology. The studies for developing methods in these two disciplines appear under this sub-topic.



Ex vivo percutaneous absorption of solid lipophilic toxic substances: use of an artificial sebum type vehicle

■ **Dominique BEYDON**

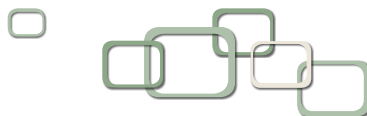
Toxicology and biomonitoring division

Outline of reasons and objectives

Measuring *ex vivo* percutaneous absorption of solid lipophilic toxic substances at ambient temperature, such as certain toxic substances already studied before (benzo[a]pyrene, pyrene, naphthalene, bisphenol A, 2,4-dichlorophenoxyacetic acid), is usually performed in solution in a volatile solvent such as acetone. This method, remote from the real conditions of exposure of the skin, frequently suffers from problems of instability of the percutaneous fluxes achieved with the *ex vivo* skin of human origin or of rat origin. The objective of the study was to find a formulation for artificial sebum whose composition is close to the physiological proportions in humans, and then to compare the *ex vivo* percutaneous absorption fluxes of the solid substances obtained with the sebum or acetone as a solubilisation vehicle. This study aimed to make it possible to define optimum experimental conditions for better assessing the risk related to exposure to solid lipophilic chemicals via the cutaneous route.

Methodology

In a first stage, bibliographic research made it possible to determine a standard formulation for artificial sebum that was tested by compared measurements of percutaneous absorption flux of a substance that had already been studied. The biocompatibility for the *ex vivo* skin of the selected formulation was then assessed by using validated methods. Comparison between acetone and the artificial sebum was then performed in humans and in rats by measuring the *ex vivo* percutaneous absorption fluxes of ten solid lipophilic substances at ambient temperature, with as wide a range of differential solubility ($\log(kow)$) as possible. The variation in *ex vivo* percutaneous fluxes as a function of skin thickness obtained in rats with sebum were extrapolated for a skin thickness of zero in order to estimate an *in vivo* percutaneous absorption flux. The results were compared with fluxes obtained with *in vivo* experimental data from the laboratory achieved with acetone as the vehicle.



Main results

The artificial sebum, made up of squalene (15%), Jojoba oil (25%), triolein (30%), and oleic acid (30%), was stable and non-toxic for the *ex vivo* skin, with good preservation of the activity of the enzymes of the viable skin. It allowed good solubilisation of all of the tested solid lipophilic substances. The profile of the percutaneous absorption fluxes of the substances as measured for 24 to 48 hours was always constant, without the problems of variation in fluxes encountered with acetone. The percutaneous flux measured with the sebum was greater than or equal to the flux measured with acetone for seven of the ten substances in humans. The *ex vivo* fluxes obtained with the sebum and extrapolated to a zero skin thickness were all significantly different from the *in vivo* percutaneous absorption fluxes obtained in rats with the acetone as the vehicle.

Discussion

The main advantages of the artificial sebum compared with the solvents usually used as vehicles for solid lipophilic substances are:

- a stable formulation composed of a mixture of four substances that are readily commercially available, and having a substitute close to human sebum;
- an absence of toxicity and of irritability of the skin for the artificial sebum, without significantly modifying the activity of the enzymes of the skin in humans and in rats;
- unlike with acetone, obtaining a flux profile at equilibrium makes it possible to estimate the equilibrium time of the fluxes and to have a mean flux that is constant for several hours in humans and in rats for the ten tested substances.

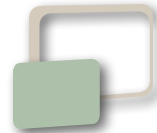
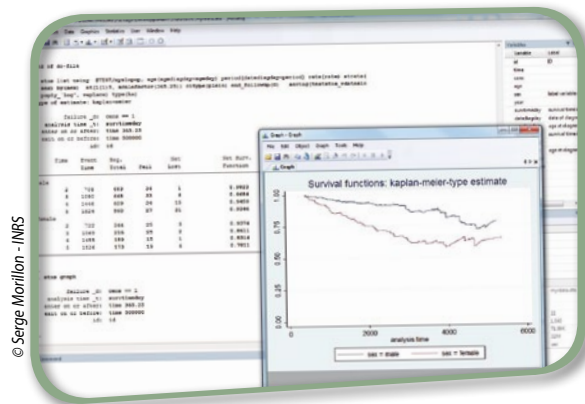
The risk of dilipidation of the skin by acetone precludes comparison between the *in vivo* percutaneous flux measured in rats with acetone and the *ex vivo* percutaneous flux at zero skin thickness measured with the sebum. This study shows that artificial sebum is an advantageous alternative to using organic volatile solvents as solubilisation vehicles for estimating the risk of exposure of the skin to solid lipophilic toxic substances at ambient temperature.



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MESuRE: Method of estimating relative survival

■ Michel GRZEBYK and Guy HEDELIN

Occupational epidemiology division

Outline of reasons and objectives

Relative survival methods make it possible to study the occurrence of events in a specific population relative to a reference population for which rate tables exist. They are mainly used in clinical and epidemiological studies on cancer. They are not used in occupational epidemiology but they are advantageous for studying the relationship between occupational exposures and health.

The object of this study is to transfer methodology to the field of occupational epidemiology and to develop computer tools for using those models.

This study represents the contribution from the division to two projects funded by the ANR (French National Research Agency), the first one, the MESuRE project, as part of the ANR's 2008 White Programme, and the second, the CENSUR project, as part of the ANR's 2012 White Programme.

Approach

Two computer tools were developed in consultation with the other partners for implementing the methodological developments of the MESuRE project. For each of them, a validation procedure was put in place. Adaptations for meeting needs more specific to occupational epidemiology were also implemented.

The concepts of analysis of relative survival were transposed to the field of occupational epidemiology. The methods were used in the short study "Mortality among Paris sewage workers", in parallel with the usual methodology that is based on calculating standardised mortality ratios (SMRs).

Main results

The two tools are operational and were used in the mortality study, making it possible to illustrate the advantage of such methods compared with the usual methodology. While the SMR is an overall measurement, relative survival analyses give dynamic indicators on the relationship between the studied risk and health.

Discussion

Relative survival methods can be used in occupational epidemiology in studies for improving prevention of occupational diseases. Like the calculation of the SMR, they use the rate tables of a reference population. The tables that are usually available correspond to the general population, and biases inherent to studies on populations of workers can ensue (healthy worker effect, profession). Looking for solutions is being addressed in the next stage of the CENSUR project which will continue until October 2017 and is the subject of a study scheduled to start in 2015.



Bladder cancer and oil mists: a prospective cohort study in populations of workers from the steel industry in the Nord-Pas-de-Calais region

■ **Eve BOURGKARD and Michel GRZEBYK**

Occupational epidemiology division

The aim of the study is to identify and to quantify the risk of bladder cancer that is associated with exposures to aerosols of cutting fluids, as they have been introduced since the 1960s. This risk will be studied in the steel industry since it is a sector that uses such fluids. This project includes a mortality study in steel industry cohorts and a case-control study of the incident cases of bladder cancer included in the cohorts.



CENSUR: Challenges in estimating relative survival

■ **Michel GRZEBYK and Guy HEDELIN**

Occupational epidemiology division

Relative survival methods make it possible to study the occurrence of events in a specific population relative to a reference population for which rate tables exist. The study proposes to develop approaches allowing rates to be non-linear and non-proportional, and to adapt these methodologies to suit the context of occupational health, by proposing solutions for the biases inherent to populations of workers (healthy worker bias). These approaches will undergo validations on the simulated and real data, applied in various sectors.



Development of a co-culture model to study the genotoxic properties of particles

■ **Laurent GATE and Christian DARNE**

Toxicology and biomonitoring division

This work aims to develop a co-culture model (macrophages, granulocytes, and alveolar epithelial cells) that is representative in the pulmonary inflammatory response. The aim is to assess whether such a model can mime the inflammatory response mechanism observed *in vivo* and improve detection of degradations in the genetic material of the pulmonary cells that might be induced by particles.



Taking into account the characteristics of skin samples for better estimating percutaneous absorption fluxes

■ **Fabrice MARQUET and Jean-Paul PAYAN**

Toxicology and biomonitoring division

This study proposes to correlate the percutaneous flux with the characteristics of the skin that are determined on the basis of histological sections, and, in particular, the thicknesses of the various cutaneous layers (stratum corneum, viable epidermis, and dermis). This should make it possible to reduce the variability observed in measuring the flux of certain molecules and thus to give a better estimation of the absorption fluxes measured *ex vivo*.



Determining the parameters making it possible to assay intra-erythrocytic chromium: I - *In vitro* study

■ Jérôme DEVOY

Toxicology and biomonitoring division

Hexavalent chromium is the most toxic form of chromium and no biological exposure marker currently exists. A bibliographic study has shown that Cr VI is incorporated into erythrocytes while the other species of chromium are not or are not to any significant extent. That assumption therefore needs to be verified before this assay is used as a marker specific to exposure to Cr VI, with the subsequent aim of establishing a biological exposure indicator value for exposure to hexavalent chromium.



Implementing the Bhas 42 *in vitro* cellular transformation assay. Application to assessing the carcinogenic potential of nanomaterials

■ Yves GUICHARD and Christian DARNE

Toxicology and biomonitoring division

The main objective of this study is to implement the Bhas 42 *in vitro* transformation assay. This assay will be validated using reference carcinogenic agents that will make it possible to establish historical data for future studies. The response of the assay to a particulate agent will be assessed with crystalline silica. If it is conclusive, it will be used to look for the carcinogenic potential of manufactured nanomaterials.



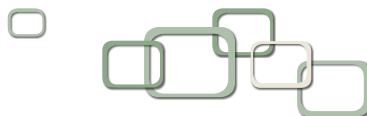
Percutaneous absorption of industrial esters: structure-activity relationship between absorption flux and substitution of the aromatic-type acid group

■ Catherine CHAMPMARTIN

Toxicology and biomonitoring division

For about ten esters, for which the acid group presents an aromatic nucleus that is substituted to a greater or lesser extent and a constant alcohol group (ethyl or methyl), their percutaneous absorption fluxes and their speeds of hydrolysis by two isozymes of esterases of human type will be measured. The results of this study should enable the percutaneous absorption flux of toxic industrial substances to be estimated better by basing the estimation on a semi-quantitative structure-activity relationship.





Focus 2: making knowledge available on the state of exposures and making tools available for evaluating exposures

Measuring occupational exposure to chemicals draws on two complementary disciplines: atmospheric metrology for the purpose of providing methods of sampling and analysing various chemical substances; and biomonitoring so as to measure exposure-revealing bioindicators in human fluids. For both of these approaches, studies for developing methods, and field studies are being conducted. The industry studies make it possible to estimate the extent of a particular type of exposure and the number of employees exposed. Then, by using exposure measurement databases (COLCHIC-SCOLA) and measurement campaigns, it is possible to appraise the levels of the exposures.



Decision assistance models for assessing occupational exposures

■ **Frédéric CLERC**

Pollutants metrology division

■ **Nicolas BERTRAND**

Technical expertise and consulting

Outline of reasons and objectives

The objective of this study is to give companies a method for:

- compiling various sources of information a priori making it possible to assess the levels of exposure to chemical pollutants, in particular statistical models and user expertise;
- incorporating measurements conducted in companies in order to obtain final exposure diagnostic surveys taking into account not only the measurements but also other sources of information.

The end purpose is to optimise the number of measurements necessary for producing quality final diagnostic surveys.

Methodology

The statistical models developed previously using data from the COLCHIC database (measurements of occupational exposures to chemicals) were extended to a larger number of substances (26 substances). These models make it possible to estimate the occupational exposure on the basis of exposure determinants that are simple for the occupational safety and health specialist to collect (task, trade, number of staff in the company, sector of activity, type of substance, and substance). Then, other a priori information sources were added: expertise of the occupational safety and health specialist and mathematical models. A method of incorporating these information sources with measurements based on Bayesian updating was improved. Finally, a software prototype called TEXAS, implementing the methodology, was developed and tested.

Main results

In addition to the extension of the methodology and to two scientific publications, the main result is the development and validation of the TEXAS software prototype that constitutes evidence of the feasibility of implementing the method and of the possibility of making a tool available to occupational safety and health specialists.

Discussion

The COLCHIC database constitutes a mine of information on exposures that is absolutely exceptional at world level. Making the knowledge contained in COLCHIC available offers major scientific added value that also enables occupational safety and health specialists to have indications about the levels of exposure commonly encountered in the situations facing them. Occupational safety and health specialists can thus, as early as possible, adapt the

metrological methods to be deployed and also adjust their decisions on the exposure diagnostic surveys (for non-regulatory purposes).

As a follow-on from this study, the “assessment by statistical models” part of TEXAS could be put on line in the form of a webpage on the INRS website. Subsequently, the other features of the TEXAS prototype could be gradually added, starting by the inputting of the exposure measurements and the possibility of conducting a regulatory diagnostic survey, which would lead to the current software, AltrexChimie, being replaced.



1,3-Butadiene: update of current knowledge and assessment of exposure in the working environment

■ Sarah BURZONI

Pollutants metrology division

Outline of reasons and objectives

Setting occupational exposure limit values for chemical pollutants is an essential tool in preventing chemical risks. Butadiene, the third most used Carcinogenic-Mutagenic-Reprotoxic (CMR) substance in France, is one of the substances for which the ANSES (French Agency for Food, Environmental and Occupational Health & Safety) has conducted expertise and appraisal work in order to propose a limit value. At national level in France, the data on exposure to butadiene lacks documentation and cannot be extended to all parties potentially concerned by the use and handling of butadiene. To mitigate this lack of information and to contribute to knowledge on this substance, this industry study was conducted with the aims of:

- identifying the sectors of activity in which butadiene is involved;
- taking an inventory of the modes of use of the substance;
- assessing the prevention practices implemented on the sites, in particular by appraising the exposure profiles relative to the limit value that could be proposed.

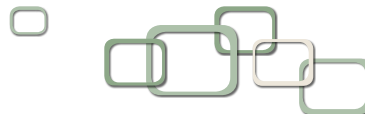
Approach

Three main steps were conducted to collect this information:

- identifying the various workers coming into contact with the substance while incorporating the various steps of the life cycle of butadiene; this approach consisted in compiling the available data, in interrogating the exposure databanks and in talking to the experts from the industrial fields and from occupational safety and health;
- collecting the information on how butadiene is used and on the prevention measures put in place on the sites; this step results from interventions in companies and from a survey by email;
- using and interpreting the collected data.

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Main results

Two types of potentially involved sectors appear: the main sectors of activity (production and use of butadiene, in particular in manufacturing polymers) and the secondary sectors (handling polymers manufactured with butadiene, use/handling of Liquefied Petroleum Gas (LPG) and use of butadiene for purposes other than polymer production).

After the interventions and the survey, it transpired that 305 sites from among the respondents were potentially involved in using or in working in the presence of butadiene, representing over 4 million metric tons of used/handled material. 12% of those sites implement chemical risk assessment approaches, and less than 50% of the ones that do such assessments record the results in the single document. After statistical adjustment of the results, it is estimated that 1,500 sites in France are concerned by the butadiene risk, representing 32,000 potentially exposed employees.

Discussion

This study emphasises that the risk factors related to use/handling of butadiene are taken into account to contrasting extents that depend on the players (primary and secondary sectors) and that are correlated with the potential levels of exposure of the employees:

- less than 10% of the sites belonging to the main sectors present the exposure levels that are, a priori, the highest; those sites account for 30% of the employees exposed, and all of them implement chemical risk assessment approaches;
- more than 90% of the sites in the secondary sectors have the levels of exposure that are, a priori, the lowest; those sites account for over 70% of the employees exposed, and 4% of them conduct chemical risk assessment approaches.

This study also bears witness to the importance of the form and of the content of the prevention messages to be put across, it being necessary for such messages to be appropriate to the activities of the players (main and secondary ones) and to their needs. Prospects such as conducting a national campaign of measurements of butadiene and developing new sampling/analysis methods should be considered in order to enrich the butadiene exposure profiles.



3-Hydroxybenzo[a]pyrene, a potential bio-indicator of exposure to polycyclic aromatic hydrocarbons: role of the enterohepatic cycle

■ Jean-Paul PAYAN

Toxicology and biomonitoring division

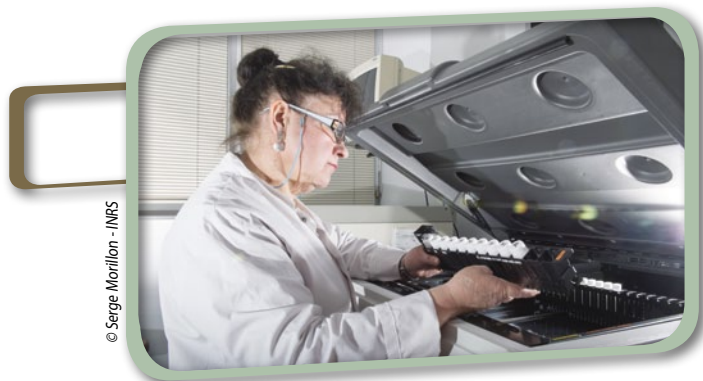
Outline of reasons and objectives

Numerous studies, including, more particularly those done by INRS, have shown the major advantage of assaying 3-hydroxybenzo[a]pyrene (3-OHBP(t)) in urine as a biomarker of exposure to carcinogenic polycyclic aromatic hydrocarbons (PAHs). Since in most workers exposed to PAHs, excretion of 3-OHBP(t) is very late compared with the end of the shift, it is recommended to collect the urine samples at the beginning of the shift on the day after a day of exposure. However, in more than 10% of the workers exposed to PAHs, the delayed urinary excretion of 3-OHBP(t) is at its maximum in the range 0 hours to 8 hours after the end of the shift. For such "premature excretors", collecting urine at the beginning of the shift on the day after exposure can lead to considerable underestimation of the real dose of BaP absorbed. Since the origin of the delay in the excretion of 3-OHBP(t) is unknown, the aim of this study was to determine whether the delay might be due to reabsorption of biliary metabolites of BaP.

Approach

In a first stage, methods of assaying unchanged BaP and its metabolite 3-OHBP(t) in urine and bile of rats by high-performance chromatography coupled with a fluorescence detector were developed and validated.

In a second stage, the urinary and biliary excretion kinetics of BaP and of 3-OHBP(t) were determined in rats with and without biliary diversion after intravenous administration of BaP.



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Main results

In rats without biliary diversions, the 3-OHBaP(t) excreted in the urine represented only a small fraction of the administered BaP. For low doses of BaP, the quantity of 3-OHBaP(t) in the urine increased proportionally to the dose of BaP. The urinary excretion of 3-OHBaP(t) was biphasic. The peak of maximum excretion of the metabolite appeared in the range 10 hours to 12 hours after administration of the BaP. For over 80% of the rats having biliary diversions ($n = 14/17$), the profiles of urinary excretion of 3-OHBaP(t) were very similar to those obtained in rats without biliary diversions.

Discussion

The results for urinary excretion of 3-OHBaP(t) in rats were very comparable to those obtained in workers exposed to PAHs. In particular, the peak of urinary excretion of 3-OHBaP(t) was delayed by from 10 to 12 hours after intravenous administration of BaP in the rats, and by 15 hours after the end of the shift in workers. This delay in the peak of urinary excretion of 3-OHBaP(t) could not be explained by reabsorption of biliary metabolites of BaP. According to the field data, the delay in the peak of excretion of 3-OHBaP(t) is fairly reproducible for the same worker. Thus, in the absence of explanation regarding the delay, which can be of various lengths, in the urinary excretion of 3-OHBaP(t), and in order to avoid considerably underestimating exposure in certain workers, identifying “premature excretors” could be a prerequisite to customised biomonitoring. This hypothesis remains to be backed up by taking urine samples from workers over several days of exposure.



Study of metal-plating processes: characterising the aerosols emitted and biological monitoring of operators

■ **Nadège JACOBY**

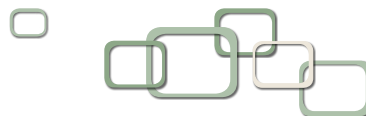
Toxicology and biomonitoring division

Outline of reasons and objectives

Thermal spraying is a process during which a coating is applied at high temperature and at high speed onto a metal object, for the purposes, for example, of producing a surface that is more resistant to corrosion, or of improving its conductivity. Various processes exist, including wire flame, powder flame, electric arc, HVOF⁽²⁾, and plasma spraying. Depending on their composition, their concentration, and on the duration of exposure, metal-plating fumes might cause adverse effects for health and cause occupational diseases.

The study is based on the observation that metal-plating workers might be exposed differently depending on the processes used. The particle-size distribution, and the number and the quantity of the aerosols produced might vary depending on the {processes/materials} matrix in question. This variability might have consequences on exposure of operators, and thus on the toxicity and the levels of urinary excretion. This cross-cutting study proposed to characterise the emissions and to assess the levels of exposure at the various thermal spraying stations in order to propose a biological monitoring strategy that was suitable for being used by the occupational safety and health specialists. Firstly, and in order to prioritise the prevention actions, an industry survey was taken and examined in order to deepen the knowledge of the sectors that use thermal spraying processes and in order to evaluate the number of potentially exposed employees.

⁽²⁾ HVOF: High Velocity Oxy-Fuel spraying, also known as “supersonic flame” spraying.



Approach

In the industry study, questionnaires were sent out to over 21,300 sites distributed across the 56 inventoried sectors of activity that included 61,000 sites.

Firstly, the aerosols were characterised on site, in collaboration with a company specialised in developing thermal spraying systems. An inventory of the various thermal spraying techniques was taken in order to determine the base configuration on the basis of which a certain number of experimental parameters were to be tested. The physical and chemical properties and the particle-size distribution of the aerosols of the {processes/materials} pairs that were thus selected were characterised, while specifying the distribution of the ultrafine particles (UFPs) and while, as far as possible, using a single metrology method.

In order to determine the relevance of the metals of interest as biological exposure indicators, sampling campaigns were conducted in the companies, by associating personal and atmospheric sampling with urine sampling.

Main results

The rate of return of the questionnaire was 43% and, after adjustment of the data, it appeared that in the range 1.3% to 1.6% of the companies had at least one thermal spraying facility, mainly located in the Rhône-Alpes Region of France. In general, the sites having integrated workshops were small structures (with fewer than 20 employees), and the number of operators working on or close to the processes was estimated at in the range 4,100 to 4,900. The most widely used process for anticorrosion treatment was electric arc spraying, with zinc-aluminium alloy as the feedstock material. Chromium (Cr) and nickel (Ni) were used in all of the processes.

Characterising the aerosols on site made it possible to describe aerosols in which UFPs were in a majority. The values for concentration in numbers of emitted particles were, in the context of thermal spraying operations, very considerably higher than the concentrations encountered in a "welding fumes" context. Thus, during this study, a number of particles emitted per second of about 1014 was highlighted, for a mean observed concentration in welding fumes of about 2 to 4. 1011 particles.s⁻¹. It is thus highly probable that the population of workers working in the thermal spraying sector are likely to be more exposed to high concentrations of UFPs than the population of welders are.

Prospecting of the companies was focused on the use of Cr and Ni as feedstock metals due to their recognised toxicity. The results of the urinary and atmospheric sampling campaigns, conducted on six sites with 29 volunteers, including 14 metal-plating workers, were processed in descriptive manner only, because of the small number of metal-plating workers monitored. The atmospheric sampling confirmed the majority presence of UFPs in the aerosols. The metal-plating workers spraying Cr oxide using plasma were exposed to Cr(VI). As regards the results of the biomonitoring, the levels of urinary excretion of Ni, for all processes together (11 µg/g creatinine), are relatively high compared to the levels in the controls, whose values were close to those in the general population, i.e. 3.8 µg/g creatinine. The urinary chromium levels measured remained relatively low, lower than 2 µg/g creatinine, remaining very remote from the French guide value applied to welders, that value being 30 µg/g creatinine.

A descriptive statistical analysis, process-by-process, would appear to show that the wire flame process exposes operators to a greater extent, but this result remains to be confirmed with additional data. For the same reason, it was not possible to find a relationship between the atmospheric data and the excreted urinary levels.

Discussion

The industry survey showed that thermal spraying processes are used in numerous sectors of activity but in scattered manner.

Characterisation of the aerosols made it possible to show the existence of a majority of particles of nanometric size (UFPs), and that the total mass concentrations recorded on emission and the mass distributions of the particles varied very considerably depending on the {processes/materials} matrix studied. The multiple information feedback from the experimentations conducted made it possible to assess the potential of certain methods and their limits for future use out in the field.

The Cr and Ni urinary excretion levels observed in the field attest to occupational exposure of metal-plating workers to aerosols emitted during use of thermal spraying processes. Occasional high urinary concentrations show that the exposure risk is not negligible, and recall the importance of wearing personal protective equipment appropriate to the activity.

These preliminary results would encourage us to continue the investigations undertaken in this sector of activity. Additional data should be collected, possibly with other biomarkers of exposure such as intra-erythrocytic Cr, specific to exposure to Cr VI.



Skin contact with bitumen in road surfacing work: analysis of the work activity and prevention

■ **Florence HELLA**

Working life division

■ **PhD thesis: Nathalie JUDON**

University of Bordeaux - Prof. Alain GARRIGOU

The study aims to produce knowledge on the conditions under which workers' skin is exposed to bitumen during road works, and on the practices implemented to prevent this chemical risk. Its aim is to lead and model the process that enables the relevant stakeholders to interact on the issues, by seeking to establish a consensus, both on the determinants of the exposure to bitumen and also on the prevention solutions.



Study of the performance of semi-volatile organic aerosol samplers

■ **Benjamin SUTTER and Eddy LANGLOIS**

Pollutants metrology division

This study proposes to assess the sampling effectiveness of the samplers in two stages: The first is constituted by designing and validating means for generating reference semi-volatile aerosols. The second will make it possible to determine the sampling effectiveness of the tested samplers, exposed to the reference aerosol. The results will be used for compiling a database to which occupational safety and health specialists can refer when choosing the sampler that corresponds to their needs.



Study of combining supercritical CO₂ desorption with chromatography analysis techniques

■ **Eddy LANGLOIS**

Pollutants metrology division

The objective of this study is to develop a technique for analysing atmospheric samples of volatile organic compounds that does not use solvent. This technique, based on combining extraction using carbon dioxide (CO₂) in a supercritical state with analysis using conventional gas or liquid chromatography, offers two advantages: laboratory handlers are not exposed to the chemical risk, and the analytical process is simplified.



Study of personal sampling devices for sampling thoracic fractions of sulphuric acid aerosols

■ **Peter GÖRNER**

Pollutants metrology division

The subject of the study will be to test personal sampling devices for sampling thoracic fractions of aerosols that are suitable for sampling sulphuric acid (a substance corrosive for the skin, the eyes, and the respiratory and digestive tracts) at the workplace. The end purpose will be to select or to develop a device, and to qualify it for measuring occupational exposure, before it is made available to the occupational safety and health network.



Developing the methodology for evaluating surface contaminations: metrological aspects and transfer by contact

■ **William ESTEVE**

Pollutants metrology division

The aim of this study is to address and to improve comprehension of evaluating the contamination of surfaces by deposition of atmospheric pollutants. The idea is to study the parameters influencing the effectiveness of surface samplers, to develop a metrological tool making it possible to obtain standardised information on the deposition kinetics, and to conduct exploratory experimentation to assess the transfer by contact from the contaminated surfaces to the employees.



Mapping of sectors and processes generating Polycyclic Aromatic Hydrocarbons (PAHs)

■ **Catherine CHAMPMARTIN**

Toxicology and biomonitoring division

■ **Hubert MONNIER**

Process engineering division

In order to identify, list, and prioritise the activities having PAH-related risks, both new (synthesis of nanoparticles, and carbon fibres) and old (aluminium industry, foundries, etc), it is proposed to study the generation and emission conditions (presence in raw materials and/or formation during manufacture, maintenance, or cleaning). The hypotheses will be verified by atmospheric samples, before being made available for assessing exposure and preventing the CMR risk.

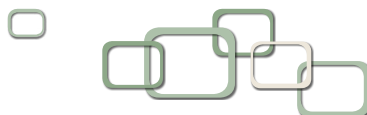


Biological monitoring of exposure to several volatile organic compounds by measuring their residual fractions in urine: feasibility study

■ **Amandine ERB and Alain ROBERT**

Toxicology and biomonitoring division

The study will consist in validating a technique for measuring the residual fractions of the VOCs in urine (analysis of the headspace) in order to monitor employees who are potentially and simultaneously exposed to several VOCs. The analytical method will be optimised on overloaded urines and then tested on the urines of employees who are actually exposed. This method of simultaneously analysing VOCs of different structures and chemical properties could be proposed to occupational hygienists as a tool for assessing multiple exposures, as an alternative and as a supplement to atmospheric monitoring.





Focus 3: making prevention solutions available

Other INRS studies focus on developing prevention solutions that give preference to reducing emissions at source, and on incorporating such solutions into the design of facilities and equipment. In addition, investigations are conducted to identify priority operations or activities for which technical solutions should be developed.



Reducing the chemical risks associated with treating automotive shredder residue

■ **Éric SILVENTE**

Process engineering division

Outline of reasons and objectives

Initially entitled “reducing the risks induced by shredding”, this study proposed to address that operation through three focuses: developing a ventilation solution suitable for channelling the flows of dust in a rotary shredder by using the centrifugal force; studying the shredding parameters suitable for limiting the emission of pollutants during treatment of fluorescent tubes and bulbs; and assessing the emissions during treatment of automotive shredder residue. Since the third focus is the only one that was addressed in this study, it was renamed “chemical risk associated with treating automotive shredder residue”.

European Directive 2000/53/EC aims to achieve a rate of recycling and reuse of End-of-Life Vehicles (ELVs) of 95%. Most ELVs are treated in automotive shredders, and are mixed with other flows of waste such as those coming from waste electrical and electronic equipment (WEEE). However recycling the residues resulting from the shredding still needs to be optimised. This work aimed to study the risks associated with the development of a new process for treating automotive shredder residue (ASR) under a project funded by the French National Research Agency (ANR).

Approach

The REFORBA (Recycling of the Organic Fraction of Automotive Shredder Residue) Project involves five partners comprising two other research institutes, an ELV recycler, a steelmaker, and INRS in order to develop a process for treating ASR making it possible to improve recycling of the light fraction or plastic fraction and the mineral fraction that is more rich in iron oxide. INRS's participation was aimed at taking prevention aspects into account as of the process design phase.

Each operation making up the process was assessed after having first characterised the various flows to be recycled.

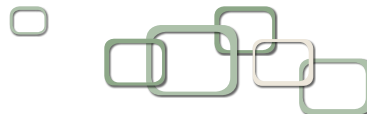
Main results

Apart from a prior sieving stage, the technological choice of liquid treatment for the plastic fractions made it possible to eliminate all of the sources of emission of dust that can contain toxic metal species or whose toxicity can be increased by the presence of wood dust.

The mineral fraction was treated during various stages in order to enrich it with iron oxide with the aim of reinjecting it into blast furnaces. The separation operations that were involved (screening, sieving, and magnetic separation) can all emit toxic dust, in particular dust having a high lead content. In order to limit dissemination of such dust around the workplace, it is necessary to keep the fractions at a high level of humidity within the limits of the operating conditions for the process.

Discussion

Initially intended to cover a broader spectrum, by looking at the consequences of shredding operations in general, the study had its original ambitions reduced. It re-focused essentially on participating in the REFORBA project,



centred on preventing the risks associated with the separation techniques implemented during treatment of ASR. The assessment made of them makes it possible to enrich the assessment of the risks in the companies who will implement the imagined process, so that they can anticipate them.



Technical-economic assessment of ventilation systems incorporating energy recovery units

■ **Roland RAPP**

Process engineering division

Outline of reasons and objectives

Collecting pollutants at source is very often the preferred recommended technique for reducing occupational exposure to hazardous substances. To ensure that the collection devices are effective and to secure thermal comfort for the employees, the extracted air must be made up for by an equivalent addition of air, that must be heated air in winter and cooled in summer. Unfortunately considerations regarding the energy costs associated with heating or cooling the new air often lead to solutions being adopted that are degraded from the occupational safety and health point of view. One way of reconciling the ventilation flow rates to be implemented with keeping running costs under control consists in adopting equipment that makes it possible to recover a fraction of the energy contained in the air removed by the ventilation systems.

The objective of this study was to make technico-economic assessments of existing facilities so as to show under what conditions it is possible to reconcile occupational risk prevention with keeping costs under control.

Approach

Three main recuperator systems making it possible to recover energy are used in industrial ventilation: plate heat exchangers; battery and water-circulation heat exchangers; and rotary heat exchangers. Four existing ventilation facilities equipped with such recuperator systems were monitored continuously over a minimum period of 50 days during the winter period. Each facility was equipped with sensors connected to acquisition units so that it was possible to monitor change over time in the ventilation flow rates extracted from and injected into the premises, change in the temperatures at various points of the facility, and change in electrical power consumptions. These measurements made it possible to assess the energy budget of the facility and to assess the cost-effectiveness of the recuperator system on the basis of the investment costs and of the operating costs.

Main results

During the measurements, the outside temperatures varied from -15°C to 23°C. The ventilation flow rates involved covered quite a wide range and varied, depending on the facilities, from 3,000 cubic metres per hour (m³/h) to 30,000 m³/h. Most of the time, the extracted air was polluted (with vapours, aerosols, dust, or chippings) and filtered before it went through the heat exchanger. In all of the observed situations, the energy recuperators were capable of preheating the new air with a maximum temperature increase close to or greater than 10°C. The efficiency of the devices varied on average in the range 50% to 90% depending on the climatic conditions of the facility. In spite of these results, only 10% to 55% of the energy needs for conditioning the new air were provided by the recuperators. However, for two installations, the energy recuperator system was advantageous, with the system paying for itself in a return-on-investment time lying in the range three to six years. That time was greater than ten years for the third facility, but would have been reduced to four years if the ventilation flow rates had been complied with. Finally, for the last case studied, the recuperator did not constitute a judicious investment because of its low rate of use, and because of the derisory cost of the fuel used (wood waste).

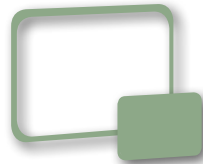
Discussion

The systems studied in this study are and remain high-performance in terms of thermal efficiency or effectiveness, even for processes that are highly emissive in pollutants.

Such performance levels are not sufficient to guarantee the cost-effectiveness of the investment made: two essential parameters need to be added: the rate of use of the energy recuperator system and the price of the energy/power.



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Joint assessment of the capture efficiency and the ergonomics of welding torches with extraction systems

■ Francis BONTHOUX

Process engineering division

Outline of reasons and objectives

Over 60,000 welders in France are exposed to welding fumes containing metals and metal oxides. The concentrations often exceed the occupational exposure limit value, even in the presence of a ventilation-type collective prevention system. For semi-automatic arc welding, the on-torch extraction system is often the only available prevention means. It offers the advantage of capture that is always close to the pollutant emission. Conversely, the extractor hose adds weight to the tool, and the closeness of the extraction can give rise to metallurgical defects. In the field, it is often observed that the capture efficiency of such systems is low and that they are discarded because of the ergonomic constraints they bring. The main objectives of the study were to identify the parameters influencing the capture efficiency. They had to make it possible to delimit the fields of applicability, to define guidelines for the air-flow characteristics, and to provide torch manufacturers with design information.

Approach

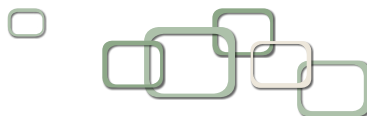
In order to test the parameters influencing capture efficiency, an automated welding test bench was created and fitted with instruments. To supplement the study, and in particular to address the issue of the metallurgical defects generated by the capture (porosities), modelling by numerical simulation of the flows was conducted. Interviews in the companies made it possible to define the situations to appraise and to obtain «trade» understanding of the intermediate results. A more detailed ergonomic analysis (video recordings and confrontation) was conducted for one of the companies in order to gain a better grasp of the reasons stopping workers from using torches with on-torch extraction systems.

Main results

The study of the various parameters that influence the capture efficiency highlighted the complexity of the problem. The discontinuity and the unsuspected significance of certain parameters explain the difficulties encountered in the past for establishing design/prevention rules on the basis of field measurements. The study confirmed that the current guidelines that set an extraction flow rate of 100 m³/h is not valid; the parameter to be considered is the speed induced at the point of emission of the fumes. In addition, the study on the extent to which capture interferes with the quality of the welding confirmed the reality of the problem for the welds in corners. From the extraction point of view, the equipment available on the market should be improved to enable satisfactory use to be made of it. As things stand, only welding configurations at moderate current (< 250A) can give full satisfaction. Replacing conventional torches with models equipped with extractor systems requires alterations to be made to the work stations, but the recommendations remain limited. At the margin of the work on the capture effectiveness, the study highlighted significant gains on the fume emission flow rates by modifying the parameters of the process.

Discussion

These results should be put into perspective with the characteristics of the equipment currently available on the market and with the technical possibilities for improving that equipment. A meeting with all of the torch manufacturers is scheduled in March 2015 in order to continue the exchanges and discussions begun in 2014 for improving the torches. In addition, definition of new guidelines for dimensioning/controlling torches with extractor systems is currently being discussed with the various stakeholders (occupational safety and health specialists, engineering research centres, and torch manufacturers).



Processes for removing traces of formaldehyde from indoor air

■ Fabien GERARDIN

Process engineering division

■ PhD thesis: Anaëlle CLOTEAUX

University of Lorraine - Prof. Dominique THOMAS

Outline of reasons and objectives

In France, the number of workers exposed to formaldehyde totals 190,000 spread across over one hundred professions. The need to provide prevention solutions for reducing the exposure of workers exposed to formaldehyde, in particular in the tertiary sector – due to the composition of materials present in the workspaces – has been declared to be a priority by the French health authorities. The main objective of the work done is to study stand-alone purification systems, mobile or otherwise, placed in the workspace, as alternatives to ventilation and that would make it possible to reduce the health risk induced by exposure to formaldehyde.

Approach

The first step in this work was devoted to determining the kinetic relationships of the photocatalytic degradation of formaldehyde and toluene, identified as another major pollutant in indoor air. The second part of the study was focused on determining the kinetics of transfer of the formaldehyde contained in the air to an aqueous solution flowing in a contactor of the packed absorption column type. The experimental approach was supplemented by a modelling stage that incorporated the pairing made up of absorption and of photocatalytic degradation of formaldehyde. The model was then compared with the experiment conducted with a laboratory demonstrator. Alongside this laboratory work, an approach based on numerical simulation was conducted to assess the impact of operation of such a purification system on the formaldehyde concentration in a working environment.

Main results

The degradation of formaldehyde was studied in two different reactors. The results corresponding to this work highlight the influence of parameters such as temperature, agitation, and oxygen content on the photocatalytic decomposition of formaldehyde in solution. The influence of the initial pollutant concentration and of the irradiance on the photocatalytic degradation of formaldehyde was modelled satisfactorily. In addition, the use of numerical simulation made it possible to confirm the advantage of using a stand-alone purification system in a room for the purpose of removing formaldehyde. On the basis of the simulations performed, it is recommended to position the purification system away from the ventilation inlets and outlets in order to avoid short-circuits and in order to increase the flow of air in the room and the entrainment of the formaldehyde.

Discussion

Although not providing any information about this mechanism, this kinetic study does give information essential to engineers for designing an industrial photocatalytic process for treating effluent containing formaldehyde.



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Modelling the process could be developed by considering more complex kinetic models incorporating, for example, the presence of co-pollutants, the influence of pH or dissolved oxygen concentration. Finally, if the tests conducted in real situations are as conclusive as the tests resulting from the experimentation, the technology proposed here will constitute an advantageous alternative to general ventilation of workspaces. Designing and producing a demonstrator is being considered.



Developing a prototype sensor for selectively sensing chemical exposure to monocyclic aromatics

■ **Bruno GALLAND and Patrick MARTIN**

Process engineering division

■ **PhD thesis: Khaoula HAMDJ**

University of Lorraine - Prof. Marc HEBRAND and Prof. Mathieu ÉTIENNE

Following development of a demonstrator, the study, conducted in collaboration with the CEA (France's Alternative Energies and Atomic Energy Commission) and with the CNRS (France's National Scientific Research Centre), aims to design and validate a miniaturised prototype for real time measurement that can be used to quantify monocyclic aromatic solvents during atmospheric exposure at worksites. Four steps are scheduled: simulation and optimisation of the measurement cell, laboratory qualification tests, design of the prototype, and validation tests out in the field.



Development of a methodology to measure dust emissions of electrical hand-held woodworking machines

■ **François-Xavier KELLER**

Process engineering division

■ **PhD thesis: Florent CHATA**

University of Lorraine - Prof. Anne TANIÈRE

The aim is to develop a methodology for measuring wood dust emissions and for characterising the systems for collecting them. A method of assessing the suction flow rate and the head-loss will be incorporated into this approach and will require test benches to be put in place. Ultimately, labelling for handheld tools could be put in place, specifying the diameter, the extraction flow rate, and the associated head-loss.



Impact of office space ventilation on interior air quality

■ **Laurence ROBERT**

Process engineering division

This study aims to gain better understanding of the chronic risk to which office employees are potentially exposed. The idea is to deepen knowledge of pollution in such workspaces, to study the impact of ventilation systems on the quality of the interior air, and to develop tools for occupational safety and health specialists, with a view to estimating the quality of air in the form of levels (excellent, satisfactory, or mediocre) and, if necessary, to conducting a more in-depth investigation.



Advantage and limitations of wet scrubbing in industrial hygiene

■ **Fabien GERARDIN and Emmanuel BELUT**

Process engineering division

■ **PhD thesis: Gaël CHERRIER**

University of Lorraine - Prof. Anne TANIÈRE

The study will consist in proposing the wet scrubber that is best suited to treating emissions of particles and of gas in the electrical and electronic waste recycling, composting, or wood processing industries, and to validate a numerical model dedicated to predicting the collection efficiency by drops of liquid. This study should make it possible to define the advantages and limitations of wet scrubbing, and to broaden the application to other working situations.



Developing tools for aiding skin protection

■ **François ZIMMERMANN**

Process engineering division

As regards preventing the risk of skin being exposed to chemicals, this study aims to continue to develop tools for assisting with choosing appropriate protections. The ProtecPo software will be implemented and apparatus for determining the resistance times of the protections will be developed and marketed (permeation kit). The apparatus will be complementary to the existing software and will make it possible to validate the performance of skin protections depending on the conditions of use.



Contribution to modelling the behaviour of respiratory protective device cartridges: exposure to complex atmospheres of organic vapours and effect of utilisation cycles

■ **Stéphanie MARSTEAU and Éric SILVENTE**

Process engineering division

■ **PhD thesis: François VUONG**

University of Lorraine - Prof. Cécile VALLIÈRES

With the objective of improving knowledge about the life span of the absorbent beds that equip respiratory protective devices (RPDs), the study aims to finalise modelling of the effect of humidity, and to investigate the effects of exposures to mixtures of solvents and the effects of operating cycles (human breathing, reutilisation, storage, etc.). The results will make it possible to enrich the PREMEDIA tool that was previously developed, by extending its field of application.



Separating out ultrafine particles generated by metal-working processes

■ **Denis BEMER**

Process engineering division

■ **PhD thesis: Loïc WINGERT and Maria Cristina CADAVID RODRIGUEZ**

University of Lorraine - Prof. Dominique THOMAS

Thermal metal spraying processes, metal cutting processes or arc welding processes generate large quantities of ultrafine particles (UFPs) which, in addition to being toxic, clog up the industrial filters that are used for removing them. In parallel to improving the unclogging techniques, provision is being made to study other processes: bubble columns, granular beds, and electrofilters. Their performance will be tested by using test benches, and the most appropriate solution will then be assessed *in situ*.



Three-dimensional simulation of aerosolization of powders when transferring materials in powder form

■ Emmanuel BELUT and Jean-Raymond FONTAINE

Process engineering division

■ PhD thesis: François AUDARD

University of Toulouse - Prof. Olivier SIMONIN

The objective of this study is to develop modelling methods for assessing dust emissions during operations of transferring powders, and for designing collective prevention means suitable for reducing the resulting occupational exposure.



Reduction at source of PAHs during pyrolysis operations

■ Hubert MONNIER

Process engineering division

■ Catherine CHAMPMARTIN

Toxicology and biomonitoring division

■ PhD thesis: Tsilla BENSABATH

*University of Lorraine
Prof. Pierre-Alexandre GLAUDE*

This study aims to limit exposure to PAHs for employees who do maintenance on facilities in which pyrolysis reactions take place. The aim is to change the core of the process by treating the pollutant "at source". A pyrolysis oven will be modelled and oven structures and the way they are fitted out will be studied. A methodology will be developed, which could be applied to other operations: atmosphere carburising; carbonitriding; and combustion.



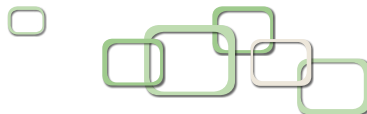
Reducing emissions of carbon particles, nitrogen oxides, and carbon monoxide for occupational health - Applications to diesel engine emissions in confined spaces

■ Hubert MONNIER, Marie-Thérèse LECLERC and Denis BEMER

Process engineering division

The objective is to study the feasibility and the viability of treating diesel engine exhaust fumes in confined workspaces of the garage type, when a central extractor system is inappropriate. The idea is to reduce emissions of soot particles charged with PAHs and with gases such as NOx and CO. The conclusions will make it possible to validate a diesel fume purifier that should be appropriate to the various specificities of the vehicles.





Waste and recycling

The studies & research activities are contributing to designing and organising the sectors (collection, sorting, dismantling, depolluting, treating, recycling & transforming) by including the health and safety component, in particular by analysing certain organisational processes, characterising the methods in emerging and/or existing sectors, and assessing levels of exposure of workers on the ground. INRS is also focusing on developing solutions for preventing risks for and effects on worker health, such solutions being adapted in particular to the specificities of the waste recycling & transformation sector, of the building & civil engineering trade, and of the polluted soil treatment sector.



Waste treatment and recycling sector for photovoltaic panels
An investigative preparatory study

■ **Ronan LEVILLY**

Process engineering division

Outline of reasons and objectives

The fact that photovoltaic panels have been included within the scope of application of the European Directive on WEEE (Waste Electrical and Electronic Equipment) means that questions need to be asked about managing such equipment when it comes to the end of its life. The treatment and recycling sector is taking shape, but the processes and players in the sector are little-known. It is necessary to shed more light on this activity in anticipation of the future increase in the stock of panels coming to the ends of their lives over the coming years.

Approach

To gain a better grasp of the issues and of the prevention needs in the sector, it was necessary to identify the various stakeholders in the field, to become better acquainted with the workings and composition of photovoltaic panels, and to analyse the various treatment techniques.

Resultats principaux

■ Identifying the players in the photovoltaic recycling sector in France

For two years now, the photovoltaic sector has been in recession in France and in the rest of the world. As a result there has been a major reshuffle among photovoltaic panel producers. However, the main French producers recently decided to come together through the "PV Cycle" Association to organise collection and treatment of the panels.

■ State of the art in terms of existing panel technologies

Three generations of photovoltaic panels will, in a few years, be cohabiting on the market: silicon panel technology, the most recent thin-layer panel technology (of the CdTe type or of the CIGS type), and innovative techniques (organic cell, Grätzel cell, or multijunction cell). Faced with such a range of technologies, the treatment and recycling processes need to be adapted.

■ Overview of techniques for treating photovoltaic panels

Two treatment approaches have been identified. The first one is based on non-destructive delamination of the photovoltaic panels so that the photovoltaic cells can be used again. The second approach consists in shredding the panel into fine fractions and then recycling or transforming the various fragments (glass, metal). These processes

are not without chemical risks and could need deeper investigation during the programmed development of the sector.

Discussion

In view of the lateness of the transposition of the new WEEE European Directive into French Law (19 August 2014), in view of the economic recession currently suffered by the photovoltaic sector, and in view of the smallness of the stock of waste from photovoltaic panels (only 10,000 metric tons collected throughout Europe in four years), it appeared that developing a lasting sector for collecting and reprocessing photovoltaic panels at the ends of their lives in France would not be conceivable for several years yet. However, the topic will continue to be watched so as to monitor any change in the treatment technique and in the positions of the stakeholders in the sector on the subject.



WEEE: reducing chemical risks in existing and emerging sectors

■ **Marie-Thérèse LECLERC and François ZIMMERMANN**

Process engineering division

The objectives of this study are to monitor the existing treatment sectors (cathode ray tube screens, used light bulbs, printed circuit boards, etc.), and to assist emerging sectors in industrialising processes while integrating occupational safety and health issues. Studying typical operations, followed by proposing improvements will constitute an approach to chemical risk prevention that can then be generalised to the trade as a whole.



Prevention of chemical and biological risks in anaerobic digester units

■ **Patricia DIRRENERBERGER**

Process engineering division

This work aims to reinforce knowledge of the chemical and biological pollution related to the influential parameters of anaerobic digestion processes. The sectors of activity and the processes implemented will be mapped. Metrology campaigns will be conducted for measuring the gaseous compounds, the dust, and bio-contaminants, and correlations between emissions and anaerobic digestion processes will be sought with a view to proposing solutions for reducing risks.



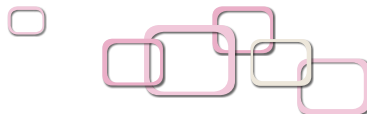
Overview of exposure of employees working to decontaminate contaminated soils

■ **Pascal POIROT**

Process engineering division

The objective of this study is to assess the chemical exposure levels and, in certain cases, the biological exposure levels of the operators working on polluted soil rehabilitation sites, by taking measurements to identify and quantify the pollutants. It will bring knowledge to the field and, if the exposure levels are high, will make it possible to study collective prevention systems.





Reproduction and work

The INRS research programmes are contributing to identifying certain hazards having potential impacts on pregnancy, by improving the state of experimentally acquired toxicological knowledge about chemicals, and in particular about phthalates. Other studies are focusing on identifying risk situations and on gathering data about relationships between occupational exposure of the mother and pathology in the child.



Occupational exposure to Bisphenol A when handling slips of thermal paper - Urinary biomonitoring

■ **Sophie NDAW, Alain ROBERT and Aurélie REMY**

Toxicology and biomonitoring division

■ **Danielle JARGOT**

Pollutants metrology division

Outline of reasons and objectives

Bisphenol A has been used for over 50 years in producing polycarbonate plastics and epoxy resins. BPA is also used as a developer in thermal papers, including cash register receipts, credit card receipts, and self-adhesive labels. Experimental data would suggest that BPA could represent a risk for human health because of its endocrine disruptor type effects that might occur at very low doses. In a report published in 2013, the ANSES (the French Agency for Food, Environmental and Occupational Health & Safety) concluded that there was a potential risk for unborn children of exposed pregnant women and drew attention to potential exposures related to handling thermal paper at work. It was in this context that INRS initiated a study on assessment of occupational exposures to BPA by urinary biomonitoring to determine whether handling thermal paper led to an increase in urinary excretion of BPA relative to a Control population. The targeted sectors were the retail trade, the restaurant trade, and industrial printing.

Approach

The urine sampling campaign was conducted in 11 companies from July 2013 to June 2014. Of those companies, 10 trade in direct contact with customers, requiring handling of cash register receipts and of credit card receipts. The potentially exposed employees on those sites, referred to by using the generic term "cashiers", handled in the range 10 to 1000 cash register receipts per day. A total of 134 volunteers were monitored, including 90 exposed cashiers and 44 employees who were controls. In the last company, which was a printing company, 30 exposed subjects including 21 operators of rotary machinery and 15 controls were monitored. The urine samples were accompanied by a questionnaire designed to give information on the occupational activities, diets, and extra-occupational activities. Samples of thermal paper were systematically taken and analysed for attesting to the presence of BPA. Free BPA and total BPA (sum of the free and conjugated forms) were quantified in the urine samples taken from the participants in the study.

Main results

In the population of Cashiers, the excretions of the Exposed group were significantly higher than those of the Control group. This increase, by a factor of approximately 2 to 3, is statistically significant for the total BPA (median concentration of 8.92 µg/l as against 3.94 µg/l) and not significant for the free BPA. The results from the printing company confirm the effect of handling thermal paper on the total BPA excretions but also on the free BPA excretions, unlike with the cashiers. It should be noted that, of the employees of the printing company, the operators assigned to rotary machinery with thermal paper containing BPA had excretion levels 10 times higher than those of the cashiers.



Discussion

This data indisputably shows that handling thermal paper caused an increase in urinary excretion of BPA in the monitored people. This exposure is of cutaneous origin, with a probable inhalation component in the printing company. This data should now enable the ANSES to confirm or to invalidate the internal exposures estimated from computations based on a probabilistic approach in its risk assessment file.



Biological assessment of occupational exposure to di(isononyl) phthalate (DiNP)

■ René GAUDIN

Toxicology and biomonitoring division

In France, no occupational exposure data is available regarding DiNP, a potential endocrine disruptor. The aim of the study is to conduct a biomonitoring assessment in the sector of flexible PVC, in particular companies who manufacture and/or use solid compounds in granulate form (compounds) or in solution form (plastisols). Urine samples will be taken, at the beginnings and at the ends of shifts, from exposed and unexposed employees.



Assessing the prenatal toxicity of pyrethroid insecticides in rats - Testicular effects

■ Anne-Marie SAILLEFAIT

Toxicology and biomonitoring division

The objective of this study is to evaluate the effects of pyrethroids on the foetal testicle in male rats exposed *in utero*. The production of testosterone, which is an element that is critical for development of the male genital system, will be particularly investigated. In the context of concerns about the effects of pesticides and of endocrine disruptors on the reproduction system, the study will contribute to reducing uncertainties on the hazards that might be constituted by occupational exposure to pyrethroids during pregnancy and will help to put in place protective measures.

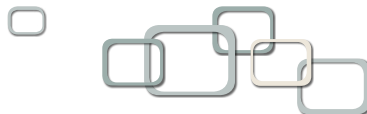


Research on endocrine disruptor type effects, when exposed to DiNP in an industrial environment

■ Jean-Bernard HENROTIN

Occupational epidemiology division

The main objective of this study is to evaluate the effect of DiNP on plasma concentrations of testosterone (hormone involved in male fertility), and the clinical consequences, in plastics industry workers. A longitudinal-type analytical study will be conducted in industry to measure a very short term effect on blood testosterone levels of exposure to phthalates (DiNP and DEHP), as measured on the basis of urine assays.



Mechanical risks and new technologies for accident prevention

INRS is playing a major part in preventing mechanical risks by:

- continuing the work aimed at making work equipment safer, contributing thus to developing safe control systems;
- making criteria available for choosing and using prevention systems based on new technologies;
- studying the real performance levels of PPE in order to improve use of such equipment.



Developing a method of specifying the requirements for an electro-sensitive device and a guide for choosing one

■ **David TIHAY**

Work equipment engineering division

Outline of reasons and objectives

Reducing the mechanical risks related to using fixed machinery can lead the user or the designer to put in place devices for detecting people, such as intangible barriers, for example. Although highly regulated by Directive 2006/42/EC, the choice of such a safety component remains difficult because of the diversity of the supply and of the potential offered by such equipment.

In response to this observation, this study proposes to develop a method aimed at helping users and designers of fixed machinery to specify their needs in terms of safety functions and to identify the most appropriate protective device for performing the function of detecting people. Particular attention is being paid to analysing the precautions to be taken when implementing such solutions, and in particular when they use specific operating modes or innovative technologies.

Approach

The approach proposed is based firstly on compiling a collection of information. The state of the art of existing solutions was drawn up and the potential suppliers were identified. Documentary analysis of such devices has made it possible to identify the characteristics that are determinant in their choices and to study the features proposed by each of them. Experimentations conducted on devices that are representative of the existing ranges on offer has made it possible to highlight the limitations of those devices and in particular those related to implementing the proposed features. On the basis of the information collected in this way, a choosing method has been developed with the aim of helping users choose the people detection device that is most appropriate to the mechanical risk related to their particular working situation.



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Main results

The study has led to the development of a method of choosing a people detection device. It is based on a questioning approach aimed at helping the user or the designer to specify their needs in terms of desired function while also taking into account the organisational and environmental constraints inherent to the conditions of use being considered for the machinery. On the basis of the resulting specifications, users find themselves guided towards the most appropriate solutions. A guide to choosing such a device has also been written to enable users or designers to identify the characteristics that are determinant in their choices of equipment. The limitations of the equipment are also indicated in the guide, as are recommendations for implementation and precautions for use resulting from knowledge acquired during experimentations conducted in the context of the study.

Discussion

It appears from this study that choosing sensitive protective equipment is a multi-criteria task and that the phase of specifying the needs remains essential for making the choice. Since each working situation is unique, and since there are sometimes multiple possible solutions, the method developed in the context of the study is not always deterministic, but it does propose to systematise the approach to specifying the needs and to guiding towards solutions whose characteristics are compatible with the needs. The information necessary for the final choice of the equipment and for implementing it is available in the INRS brochure to be published in 2015 for users, designers, and occupational safety and health specialists.



Safety of servomotor presses

■ James BAUDOIN and Jean-Paul BELLO

Work equipment engineering division

Outline of reasons and objectives

This study relates to a generation of innovative machinery, namely servomotor presses, distribution of which is going to increase because the features they offer are of interest to users. For example, the slide displacement and force characteristics, which are variable in real time, offer the possibility of performing complex work cycles. There are not yet any national or international safety guidelines that take account of the specificities of this type of press. This machinery, which is potentially dangerous and implements new technologies, should achieve a level of safety equivalent to that of conventional presses.

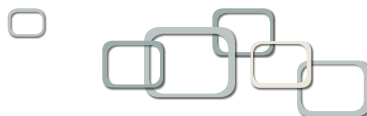
It was thus essential to study the techniques specific to these new presses, and to analyse their impact on the safety functions and on the validity of the protective means usually implemented for presses.



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Approach

This study was conducted in three main phases:

Phase 1: Inventory of the techniques specific to servomotor presses;

Phase 2: Detailed study of those specific techniques;

Phase 3: Validity of the conventional protective means on servomotor presses.

Main results

Unlike conventional presses, servomotor presses use a power drive system that does not merely supply the energy necessary for moving the slide. It becomes the core of a control system making new operating modes possible, while also offering a large number of safety functions that are necessary for protecting operators. Precautions need to be taken at the variable speed drive or the mechanical transmission so as to provide said safety functions, even in the event of failure. Similarly, a mechanical braking system needs to be provided, mainly for mitigating failures of the electronic control system. Despite these measures, the response time for the stop functions can be affected, which needs to be taken into account.

The protective means used previously remain effective for servo-motor presses. The use of guards with interlock systems would make it possible to overcome certain technical constraints such as controlling the stops (braking capacity and stop time), related to taking account of failures of the drive system.

Discussion

The servomotors make it possible to manage keeping the machinery stopped by energising. In such a situation, failure can generate untimely displacement of the slide, and the operator can then be in danger. It will remain to define, during standardisation work, whether the principle of tolerating an untimely displacement stroke is acceptable on the presses and within what limits it would not give rise to any risk.

The contributions from this study will serve directly for the standardisation work in progress on the presses, and will be usable as a reference for other machinery using servomotors.



Ageing of safety nets: understanding the phenomena and analysing the testing methods

■ Ghislaine GRAND

Work equipment engineering division

The study will concern safety nets having different characteristics, subjected to different types of natural and artificial ageing. The mechanical properties will be monitored in order to characterise changes in the phenomena involved. The results will make it possible to assess the relevance of the standardised methods of testing new nets, and possibly to propose improvements to such testing. In addition, a monitoring method enabling users to monitor ageing of nets while they are in use will be proposed.



Implementing safety functions for collaborative robotics

■ Adel SGHAIER

Work equipment engineering division

Two objectives are pursued by this study: firstly, to acquire more in-depth knowledge of the functions proposed by robotics manufacturers; and secondly to help integrators and users of collaborative robots to implement work cells with a view to reducing mechanical risks at source. Producing a collaborative robotics cell in the laboratory will make it possible to experiment with the difficulties or limits with which the future integrators and users might be faced.



Feasibility, in an integrated digital architecture, of detecting events that are precursors of dangerous situations, with a view to constructing return on experience

■ **Pascal LAMY**

Work equipment engineering division

The issue for this study is to assess the feasibility of constructing return on experience (detection of events) based on the capacities offered by communicating sensors. The approach consists in identifying dangerous situations outside predictable practice, either by using accounts of accidents, or by using experts who know the context, and to verify whether it is possible to link up with the observable data of the system, via sensors on work equipment.



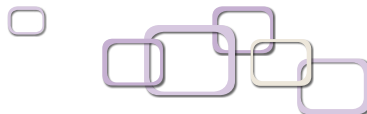
Human-robot coactivity: analysis of the needs and of the prevention means

■ **David TIHAY**

Work equipment engineering division

The study proposes to identify the real coactivity needs of industrial robotics users, and then to analyse the usability of prevention means for meeting those needs. The analysis of the needs will be made available to standardisation bodies and to research laboratories. The state of the art relating to the prevention means will give a more detailed review of the implementation constraints, giving the user points on which to be vigilant in preventing risks related to human-robot coactivity.





Psychosocial risks

The scientific work by INRS on this topic is aimed in particular at:

- giving companies and OSH specialists tools for diagnosing PSRs and new methods of preventing PSRs;
- studying the effects of new organisational factors and new constraints on physical and mental health, and mechanisms for regulating such effects;
- exploring work factors favourable to health construction;
- developing tools for objectifying factors in PSRs.



Work situations with high emotional loads, and organisational prevention practices

■ **Corinne VAN DE WEERDT**

Working life division

This psycho-ergonomic study follows on from the study on emotions at work and health. It aims to establish an inventory of theoretical results, methodologies, and practices, and to analyse the interventions made in various companies of the secondary and tertiary sectors, supplemented by new occupational contexts. It will provide some thoughts and foundations for preventive approaches that are accessible to OSH stakeholders.



Organisational intervention approaches: what appropriation for preventing PSRs?

■ **Mireille LAPOIRE-CHASSET**

Working life division

The objective of the study is to identify the various organisational approaches and to describe the conditions for them to be appropriated by OSH stakeholders. For each selected approach, the objective, the theoretical anchoring, and the presuppositions will be explained in a sociological perspective of the sciences and of the intervention. Educational documents could be designed to take training content forward, as could summary information media.



Assessment of PSR and MSD prevention interventions

■ **Christian TRONTIN**

Working life division

■ **Stéphanie BOINI-HERMANN**

Occupational epidemiology division

■ **Dominique CHOUANIERE**

General Management

In a constrained economic context, questions are focussed on the effectiveness, efficiency, and impact of PSR and MSD prevention actions. The issue is to have tools that make it possible, beyond subjective perception, to objectify the results related to practices. In collaboration with ANACT (the French National Agency for the Improvement of Working Conditions), the study thus aims to design and test an assessment approach, on the basis of a multi-disciplinary theoretical framework and of the needs of OSH specialists out in the field. This work will lead to a collective summary work and to recommendations.



Interactions between health and work: effect of occupational psychosocial conditions on changes in mental health

■ **Stéphanie BOINI-HERMANN and Michel GRZEBYK**

Occupational epidemiology division

Current knowledge indicates the existence of links between exposure to psychosocial risk factors and damage to health. The effects of age are less documented. On the basis of a longitudinal survey, the idea is to explain how mental health has changed as a function of the initial working conditions, of the changes in them, and of the career path. The effect of age will be studied more precisely. The results could be the subject of recommendations for managers and human resources players.





Occupational road accident risk

In addition to the prevention actions in collaboration with the French National Health Insurance Fund for Salaried Employees (CNAM-TS) and with the various Trades Associations, INRS is studying the effect of using a motor vehicle on the health (excluding accidents) of employees who drive for work reasons.

The results of prior research into the interior design of light commercial vehicles are enabling tests (industrial interior design in the event of emergency braking or of impacts) to be transformed into prevention solutions, for vehicle manufacturers and vehicle interior designers.

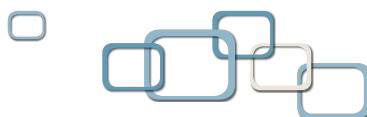


Driving light commercial vehicles, working conditions and musculoskeletal disorders in courier delivery operatives

■ **Anca RADAUCEANU and Stéphanie BOINI-HERMANN**

Occupational epidemiology division

Intensive driving of light commercial vehicles (LCVs) in courier/delivery activities is characterised by an accumulation of biomechanical, psychosocial, and organisational constraints, demands, stresses and strains. The effect of driving LCVs on MSDs of the lower back and of the upper limbs, and on perceived health, while taking account of working conditions and organisation, will be studied. Various types of data will be collected and analysed on the basis of the driving and delivery characteristics. Identifying the constraints, demands, stresses, and strains that can be changed in the work situation will open up avenues for finding prevention solutions.





Design of work equipment, workplaces, and working situations

Beyond compliance with regulatory requirements, the “integrated prevention” approach enables designers, company managers, and OSH players to anticipate occupational risks and to keep them better under control, while also reconciling the technical, organisational, and economic demands of their projects. The issue at stake is to apply safe design principles, upstream in equipment projects (for machines, tools, etc.) or for workplaces (buildings, workshops, etc.).

The INRS studies concern both the methodological approach and also the design tools. Other work is studying software tools or “digital manikins” for enabling designers to simulate various scenarios for a future working situation, and to check compliance with physical ergonomics principles (anthropometry, postures, efforts, stability, etc.).



Developing a methodology for safe detailed design of work equipment

■ Jacques MARSOT, Bruno DAILLE-LEFEVRE
and Aurélien LUX
Work equipment engineering division

■ PhD theses:
Nicholas de GALVEZ - *ENSAM ParisTech - Prof. Patrick MARTIN*
Ismaël El MOUAYNI - *ENSAM ParisTech - Prof. Jean-Yves DANTAN*

The objective of the study is to develop a structured and toolled approach that is applicable in the detailed design phase. It is in that phase that the technical solutions take shape and thus the level of risk of the future work equipment is set. The results will be validated with experts and through case studies.



Movement variability: characterisation during assembly work and capacity for integration into a computer aided design tool

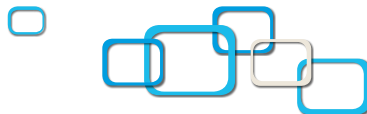
■ Jonathan SAVIN
Work equipment engineering division

■ Clarisse GAUDEZ and Martine GILLES
Working life division

■ PhD thesis: Jonathan SAVIN
Université Pierre and Marie Curie Paris VI
Prof. Philippe BIDAUD

The object of this study is to analyse motor variability and to describe various strategies for doing the same activity, in order to facilitate taking working situations into account at the design stage. The variability of the movement will be studied by biomechanical and physiological data for repetitive tasks, and a computer demonstrator of the features developed for virtual humans will be designed.





Musculoskeletal disorders of the limbs and of the back

The actions undertaken for MSDs and low back pain are conducted in synergy with numerous partners (institutional players or research organisations). They involve ergonomics, biomechanics, and design of work equipment and of workstations. As regards research, INRS proposes:

- to assess and to adapt the intervention strategies to various contexts (sociological approach by targeting more particularly small and medium-sized enterprises);
- to develop methods and tools incorporating the most recent knowledge on relationships between organisation, psychosocial factors, biomechanical factors, and MSDs, and to transfer them to OSH specialists and to managers on site;
- to introduce MSD prevention principles into the process of designing working situations (gestural variation, less demanding tools, etc.).



Effects of inclination of 3 types of mouse and of their positioning on the work surface on the biomechanical stresses on the upper limb, on performance, and on the perception of the subjects

■ François CAIL and Clarisse GAUZEZ

Working life division

Outline of reasons and objectives

The computer is in common use at work. In 2010, in France, 52% of workers used a computer at work and 23% of them remained in front of a screen for 20 hours or more per week. If the computer is in common use, then so is the mouse, an essential input peripheral for most tasks. Various studies have highlighted a link between using the mouse and the appearance of pain, or indeed musculoskeletal disorders (MSDs) in the neck and upper limb. For example, Atkinson et al. (2004) reported that 45% of mouse users complained of musculoskeletal pain and of discomfort in the hand and wrist. According to Standard ISO 9241-410, the neutral position or the most relaxed position of the forearm corresponds to the hand in pronation at 30° relative to the vertical (60° relative to the horizontal). The conventional mouse requires full pronation (with the palm of the hand facing towards the work surface). In order to reduce the pronation of the forearm, compared with the pronation required with the conventional mouse, vertical mice having inclinations of in the range 60° to 70° relative to the horizontal and mice inclined at in the range 30° to 40° relative to the horizontal are now on the market. These new mice are the subject of frequent queries and requests for information from OSH specialists who are seeking solutions for employees suffering from pain or MSDs. In addition, the mouse is usually placed next to the keyboard. Certain researchers recommend placing the conventional mouse in front of the operator if the keyboard is little used. Vertical and inclined mice have been the subjects of few studies so far, and no such studies concern their location on the work surface.

The objective of this study is to compare the muscular and postural stresses, the performance and the perception during use of 3 computer mice (a conventional mouse, a vertical mouse, and an inclined mouse) at 3 different locations on the work surface (next to the keyboard (i.e. on one side of it), in front of the keyboard, and in a free position without a keyboard).



Approach

Eighteen right-handers participated in this laboratory study. Each of them performed 7 tasks (pointing, clicking with the index finger, clicking with the middle finger, double clicking with the index finger, clicking with the index finger and then the middle finger, dragging a target, and taking hold of the mouse again after typing on the keyboard) under all 9 conditions (3 mice X 3 locations). The activity of 9 muscles of the upper limbs was recorded as was the articular amplitudes of the index finger, of the wrist, and of the shoulder of the right upper limb. The performance was assessed through the mean time for performing each of the tasks and through the minimum number of clicks required for the tasks requiring clicking. The perception of the people was assessed by means of self-assessment scales; the questions concerned the difficulty of performing the tasks, and the comfort and ease of use of each of three mice at each of the three locations.

Main results

It appears from this study that:

- The inclined mouse offers a good compromise between muscular and postural stresses, performance and perception of the people relative to the other two mice.
- Placing the mouse in front of the keyboard reduces the stresses compared with when it is placed on one side of the keyboard. The performance and comfort are improved when the mouse is placed freely relative to the other two locations. Unfortunately such free placement requires the keyboard to be absent, which occurs rarely in everyday practice.
- The action of taking hold of the mouse again after typing on the keyboard is the most demanding of the 7 tasks. It is therefore to be avoided whenever possible during the work activity.

Dissemination and added value

These results have made it possible to update the INRS documents relating to computer screen work, the contents of the 3 INRS training courses, and the courses for higher education run in two universities. They are being disseminated in a peer-reviewed international journal, in a journal for OSH specialists, and in an open-archive technical scientific note.



Identification of emerging determinants linked to the risk of MSDs:
ergonomic and biomechanical analysis of the activity of meat cutting

■ **Adriana SAVESCU**

Working life division

The objectives of this study are to provide new prevention responses, by identifying emerging determinants of MSD risks in the activity of cutting meat, on the basis of analysis of the interactions between the cutting operators and sharpeners (knife grinders), including when those employees have different statuses, and by analysing the impact of these emerging determinants on the health of employees with regard to MSDs.



On-site management and MSD prevention: representations and actions

■ Aude CUNY

Working life division

■ PhD thesis: Aude CUNY

University of Grenoble - Prof. Sandrine CAROLY

This study aims to produce knowledge on the activity of management, and on its potential role in organisational management, and in so doing, to improve prevention of MSDs. The reference methodology will be research and intervention in the ergonomics of the activity. Analysis of the management activity will use multiple tools (observations, interviews, self-confrontations, etc.) whose results should provide useful focuses for the OSH specialists.



Developing and validating an ambulatory system for evaluating postures and upper limb movements under real working conditions

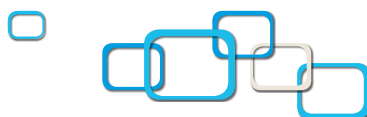
■ Adriana SAVESCU

Working life division

■ PhD thesis: Brice BOUVIER

University of Lyon - Prof. Raphaël DUMAS

The general objective of this study is to develop an ambulatory system making it possible to have a realistic representation of postures and movements of the upper limb and to approach gestural variability in a research context, including under real working conditions. The system will ultimately make it possible to characterise specific work tasks, or to provide applications such as validating hand tools with regard to the biomechanical stresses related to use of them.





Ageing, staying in employment, and preventing occupational exclusion

INRS studies and research in this field have three focuses:

- putting together strategies for raising the awareness of companies about the issue of ageing at work;
- acting on constraints responsible for premature ageing (approach for assessing risk factors, and adapting working situations for older workers);
- establishing positive and negative determinants between career and health on the basis of various parameters: socio-professional category, sector of activity, working conditions, career changes or interruptions, unfitness for work, changes in physical functional capacities, etc.).



Exploratory study for an overall assessment of past and current constraints at work

■ **Kevin DESBROSSES, Jean-Pierre MEYER and Emmanuelle TURPIN-LEGENDRE**

Working life division

Outline of reasons and objectives

Repeated and/or prolonged exposure to physical, organisational, psychosocial, and environmental constraints at work can lead to a degradation in health. Various tools make it possible to assess such constraints. However, they are only rarely used simultaneously and they do not therefore make it possible to assess the various dimensions of such constraints jointly. And yet an overall approach to the constraints is necessary to take prevention action. In addition, collecting data on the career path and the related past constraints should make it possible to understand better the relationship between prior exposure to constraints and current state of health. The objectives of this exploratory study were to propose a data collection approach making it possible to implement an overall approach to constraints, so as to describe:

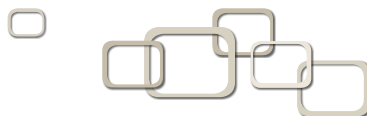
- what dimensions of the work were perceived by the employees as constraints;
- what were the links between the past and present constraints and the current state of health;
- what relationships could be established between observed constraints and perceived constraints. This overall exploratory approach was experimented on a limited sample of employees from two companies in order to appraise its feasibility.

Approach

The health of 54 employees was assessed by means of measurements of functional capacities and of questionnaires. Questionnaires also made it possible to analyse the constraints perceived by the employees in their current jobs. These collections of data were supplemented by measurements and observations of constraints at the work station. A tool (made up of a bibliographic table and of a questionnaire) has also been developed to assess the perceived constraints of the jobs previously held.

Main results

For the sample in question, health was related not only to the perceived constraints of the previous jobs, but also to the observed constraints of the currently held job. The perceived constraints concerned various dimensions of the work (physical, organisational, environmental, and psychosocial) and varied with age. Thus, for the younger group (< 40 years), the psychosocial dimension appeared preeminent in the perception of constraints. For the older group (≥ 40 years), in addition to the psychosocial dimension there are constraints related to the physical demands of the work.



Discussion

Assessing work constraints and their relationship with state of health is complex. Firstly, it is to consider a degradation in the state of health as a possible consequence of exposure to current and past constraints, generating more or less long-term damage. Conversely, a reduction in functional capacities and/or a degradation in health, in particular with advancing age, could induce and/or increase the constraints. In addition, the constraints perceived by the employees of our sample covered various dimensions of the work and seemed to be expressed differently depending on age. From the point of view of occupational health, it is thus essential to consider all of these constraints through an overall approach in order to grasp their complexity and in order to associate lasting prevention actions with them. From a methodological point of view, the tools used in this study appear to be pertinent for exploring the various components of work constraints. However, this overall approach can be difficult, in particular because of the time required to implement all of the tools. A study based on a larger number of employees could make it possible to reinforce these preliminary results and to optimise the choice of tools to be used.



Age-related impact of varied time constraints in an assembly task on biomechanical and physiological exertions

■ **Martine GILLES, Laurent CLAUDON and Anne PICHENE-HOUARD**

Working life division

This study proposes to measure, in terms of physiological and biomechanical exertions, for two different age groups, the effects related to a turn of events involving an acceleration in the pace of work, and the effects related to the presence of an intermediate stock of parts when performing a task on an assembly line. The effects of doing muscular exercises will also be studied. The results should make it possible to define certain design choices.



How can companies be helped to incorporate the issue of health and prevention better into age management policy?

■ **Isabelle SALMON**

Working life division

■ **PhD thesis: Isabelle SALMON**

University of Grenoble - Prof. Émmanuel ABORD de CHATILLON

The objective of the study is to help companies to consider age management, by targeting HR managers, who are key players in the process. It aims firstly to develop an approach enabling the HR Manager to mobilise all of the stakeholders, within the company and outside the company, who are concerned by age management, and secondly to propose recommendations (on the existing HR tools and methods) for incorporating health and prevention into career management policies.



Evaluation of physical functional capacities as a function both of the physical demands encountered in the course of a career, and also of psychosocial factors

■ **Emmanuelle TURPIN-LEGENDRE**

Working life division

The objective of the study is to analyse the effects of physical and psychosocial demands on functional capacities and their repercussion on perceived health. Screening for premature deterioration would make it possible to identify wear phenomena (osteoarticular and cardiovascular damage) and to put in place actions for limiting them. The survey and a set of tests will be conducted on 200 employees from the building and civil engineering sector, with the collaboration of the occupational health service.



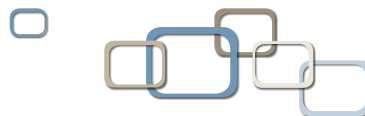
Factors of success and of failure in the process of returning to work after surgery for a work-related degenerative shoulder injury

■ **Anne PICHENE-HOUARD**

Working life division

In order to improve the conditions for returning to work, it would appear important to describe the prognostic factors contributing to a favourable outcome and to an unfavourable outcome for this process. Longitudinal monitoring will be conducted on 120 employees and will include five stages of collection of objective and subjective data relating to the numerous aspects involved along the road to return to work for employees who have suffered injuries, and from a perspective of preventing occupational exclusion.





Partnerships

The INRS strategic plan identifies as an objective for studies & research to “Associate INRS with the best national and/or international teams”. In practice, scientific partnerships frequently constitute working frameworks for INRS research teams. A majority of the studies currently being conducted are being run in partnership not only with French universities or organisations (ANACT, ANSES, CEA, CNRS, InVS, INERIS, IRSN, etc.) and with foreign universities or organisations, but also with the French networks of health insurance, occupational health insurance, and pensions insurance bodies (CRAMs/CARSATs), and with the European or international networks (PEROSH, ISSA).

The Project Teams represent a particularly close form of collaboration in which skills and facilities are pooled to achieve common goals.

INRS-CNRS / University of Lorraine Project Teams:

- 1. Filtration and Adsorption (LFA, Laboratoire Filtration et Adsorption):** between CNRS's Process Engineering and Reactions Laboratory (LRGP, Laboratoire de Réactions et de Génie des Procédés), and INRS's Pollutant and Air Cleaning Process (PROCEP, Procédé et Epuraton des polluants) Laboratory: the work conducted in 2014 concerned removal of formaldehyde, reduction of PAHs at source during pyrolysis operations, modelling of the behaviour of respiratory protective device (RPD) cartridges, separating out of ultrafine particles, and performance of filtering and isolating RPDs in protecting from nanoparticles.
- 2. Pollution Prevention (LMPP, Laboratoire Mixte de Prévention de la Pollution):** between the Energetics, Theoretical and Applied Energetics and Mechanics Laboratory (LEMTA, Laboratoire d'Énergétique et de Mécanique Théorique et Appliquée), a CNRS-University of Lorraine joint research unit, and INRS's Aerodynamics Engineering (Ingénierie Aéronautique) Laboratory: studying the impact of sources and of the environment on confinement of nanoparticulate pollutants by collective protective equipment.
- 3. Acoustics of Surfaces in Industrial Workplaces (APLI, Acoustique des Parois dans les Locaux Industriels):** between the LEMTA and INRS's Occupational Noise Reduction (Réduction du Bruit au Travail) Laboratory: characterising the acoustic properties of complex walls and panels and influence on noise in industrial premises.
- 4. Safe Design of Working Situations Laboratory (LC2S, Conception Sûre des Situations de Travail):** between the Design-Manufacture-Control (Conception-Fabrication-Commande) Laboratory of ENSAM Paris Tech in Metz, and INRS's Safe Systems Design Engineering (Ingénierie de Conception des systèmes sûrs) Laboratory: developing a methodology for safe detailed design of work equipment.
- 5. Oncological Diseases, Statistics, and Work-Related Allergies (MOSART, Maladies Oncologiques, Statistiques et Allergies en Relation avec le Travail):** between the “Equipe d'Accueil” (a type of research unit that receives PhD students) known as the “Interactions between Genes and Environment Risks and Effects on Health” (INGRES, Interactions Gènes-Risques environnementaux et Effets sur la Santé) unit and various INRS laboratories; this Project Team is focused on occupational cancer and allergy issues, and joint work is in progress concerning work-related asthmas (occupational asthmas and asthmas made worse by work).

International partnerships are initiated through institutional networks such as PEROSH, through the European OSH Agency of Bilbao, or on the basis of bilateral relations.

International partnerships through PEROSH

In order to reinforce European scientific knowledge sharing, INRS is involved in the PEROSH (Partnership for European Research in Occupational Safety and Health) network that brings together, at European level, the main occupational safety and health research bodies (12 bodies and 11 countries). INRS has chaired PEROSH since 2011, and its teams are taking part in various actions conducted through it.

- **The “Well-being at work” group** was involved in 2014 in organising a conference on the topic of “Promoting health and sustainable work-lives” that was held in May in Copenhagen. In 2014, the exchanges within the group were

focused on producing recommendations for physical activity at the workplace, on analysing national intervention cases and seeking common points in interventions conducted under the “well-being” label, and on employment accessibility for all, in particular for people suffering from health inequalities.

- **“Recommendations for procedures to measure occupational physical activity and workload” Group** was set up in 2014. A first meeting in Copenhagen made it possible to identify the needs on this topic. In particular, the idea is to propose standardised methods for measuring physical activity and to develop joint research projects run jointly by various counterpart institutes.
- **The NECID (Nano Exposure and Contextual Information Database) Project** (<http://www.perosh.eu/research-projects/perosh-projects/exposure-measurements-and-risk-assessment-of-manufactured-materials-nanoparticles-devices/>) aims to take advantage of data on exposure to nanomaterials by enabling that data to be used for research and risk assessment purposes. In 2014, the work involved defining data input modules, presenting and statistically processing results, and harmonising the exposure measurement strategy. A first version of the database was tested.
- **“Determination of Workplace Protection Factors for Respiratory Protective Devices”**. This action aims to propose effective protection factors that are recognised at European level for various items of Personal Protective Equipment (PPE) rather than nominal protection factors determined in the laboratory.
- **Health Impact Assessment for Occupational Respiratory Diseases**. This project proposes to estimate the number of employees suffering from certain respiratory diseases attributable to occupational exposure on the basis of modelling of present and past exposure measurement data, from registers and other sources in various countries covered by PEROSH. The ultimate aim would be to assess the benefit and the costs related to the various scenarios for prevention action.
- **Concept of integration of ambient intelligence solutions for safety and health towards smart factories**. The aim of this project is to identify artificial intelligence technologies that can be used for the safety of employees working in “smart factories”. The results of this action should help to submit a tender for the European Union’s “HORIZON 2020” research and innovation call for projects.
- Finally, INRS is taking part in the joint thinking by all of the institutes federated through PEROSH on the direction to be given to future occupational health research: **Futures project**.

Bilateral international relations

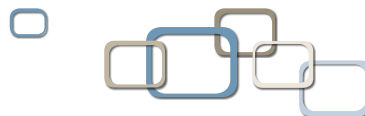
INRS is working in various fields with IRSTT, its counterpart in Quebec, with whom a 5-year framework partnership agreement has just been renewed for the second time. Three amendments have been signed relating respectively to biomonitoring, to ProtecPo, a piece of interactive software for preselecting polymer materials used in personal protective equipment, and to MIXIE, a database containing toxicological data for assisting with decision-taking on exposures to mixtures of chemicals at the workplace. Partnership framework agreements have also been signed with NIOSH (United States), IFA (Germany), and IST (Switzerland). Finally, agreements have been signed with AIHA (American Industrial Hygiene Association) for using, developing, and translating two pieces of exposure assessment software, IHMOD and IH SKinPerm.

Furthermore, INRS submits joint bids with its partners in response to both national and international calls for research projects

Projects with external funding

Two European projects

- **NANoREG**: as part of the European project NANoREG, initiated through PEROSH, INRS committed itself in 2013 to conduct a study of exposure by inhalation on carbon nanotubes, in partnership with the Danish Institute NRCWE, and with the British Agency PHE. The system for generating a first type of carbon nanotube had been developed and validated by the end of 2014. It is planned to expose animals to those nanotubes in 2015. Furthermore, a critical review was initiated in 2014 for reviewing the methods of generating test aerosols used for toxicological studies on exposure by inhalation, and the associated measurement strategies.



■ **NanoCEN:** under Mandate 461, the European Commission has commissioned the European standards organisations CEN, CENELEC, and ETSI to standardise activities relating to nanotechnologies and nanomaterials. INRS is taking part in several projects including pre-standardisation research actions and preparing 8 standards, and it is steering the actions relating to the dustiness of nanomaterials. The year 2014 was devoted to the experimental stage. The work is continuing, with the next stages being processing and interpretation of the data, and then writing of draft standards.

Five projects for the French National Agency for Food, Environmental and Occupational Health & Safety (ANSES)

■ **GABO (Gène Acoustique dans les Bureaux Ouverts) Acoustic Discomfort in Open-Plan Offices:** in partnership with INSA (France's National Institute for Applied Sciences), INRS has contributed to identifying the effect of multiple conversations on discomfort or disturbance, and has proposed exposure indicators that take account of this specificity of background noise.

■ **MEPAS (Méthode de Prévision de l'Ambiance Sonore dans les bureaux ouverts) Method of Predicting the Soundscape in Open-Plan Offices:** in partnership with CSTB (the French Scientific and Technical Centre for Building), the idea is to provide a simplified method of estimating the sound exposure to which workers are subjected in an open-plan office on the basis of layout/fitting-out plans that are supplied, without it being necessary to perform measurements *in situ*. In 2014, the work consisted in comparing the subjective assessments of perceived discomfort with objective measurements of sound emissions in open-plan offices.

■ **DICER (Définition d'Indicateurs pour la Caractérisation des Expositions aux Radio-fréquences) Defining Indicators for Characterising Exposure to Radiofrequency fields:** in collaboration with CSTB, INERIS (French National Institute for the Industrial Environment and Risks), France Telecom Orange, and Telecom Bretagne, we sought to characterise the variation in indicators that might be used for determining any risks presented by radiating equipment. In particular, spatial variation in exposure to electrical field was measured around a welding press by dielectric losses.

■ **NANOTRANSBRAIN:** selected in September 2014, this new project aims to assess, *in vivo* and *in vitro*, the effects of exposure to nanoparticles on the physiology of the blood-brain barrier in adult and old rats, in collaboration with CEA Saclay (Life Sciences Division).

■ **EXPROPANO started at the end of 2014.** On the basis of the various recommendations formulated at national and international level, this project, which involves other partners such as the University of Bordeaux (Laboratoire santé travail environnement, LSTE, Health, Work, Environment Laboratory), INERIS, the University of Montreal and the Aquitaine Regional Occupational Health and Pension Insurance Fund (CARSAT Aquitaine), aims to develop and validate a method making it possible to assess occupational exposure to nanomaterials by associating characterisation of aerosols with a first level of activity analysis. The innovative nature of this action is based on this association, and on stabilisation of a method that should be operational for a large number of different scenarios and accessible to all of the OSH specialists out in the field. The results of this project will also feed into the job-exposure matrix of the MatPUF programme, and into the French system for monitoring workers potentially exposed to nanomaterials, that system being put in place by InVS (French Institute for Public Health Surveillance).

One ANR (French National Research Agency) project

■ **The project CENSUR aims to propose a method of estimating relative survival:** INRS is associated with 3 French teams and with 4 international research teams, and it is involved in developing the methods specific to the issue of occupational health studies. In 2014, the development of statistical programmes continued, and they were implemented in the course of an epidemiological study on sewer workers. Thinking was begun on reference mortality tables specific to workers, enabling the healthy worker bias to be removed.

Two ADEME (French National Environment and Energy Management Agency) projects

■ **REFORBA:** the work aimed to study the risks associated with the development of a new process for treating automotive shredder residue (ASR) under a project co-ordinated by the Bureau de Recherches Géologiques et Minières (BRGM, French Geological Survey Bureau). An a priori risk assessment was conducted, showing that the process for recycling the plastic fraction of ASR by wet treatment makes it possible to limit emissions of toxic

substances considerably. That does not apply to the process for recycling the mineral fractions in which the presence of compounds containing lead, barium, or chromium was detected.

- **The objective of the project ATENA** is to optimise conventional methods of dust removal when dealing with fine particles such as particles emitted by metal coating processes. It also aims to develop alternative solutions such as bubble columns or spray columns. INRS is partnered in this project with a CNRS laboratory in Nancy, the LRGP. In 2014, the work on bubble columns was continued with the study of parameters such as bubble residence time, air flow rate, bubble size, and presence of packing.

Finally, INRS has put in place a policy for receiving PhD students.

Hosting PhD theses

This policy for receiving PhD students co-supervised by senior researchers at INRS and at the universities – INRS always has over twenty PhD students (23 in 2014), for whom it provides some of the funding – is also conducive to forging ties with the partner universities, enabling mutual scientific enrichment and pooling of resources for the greater improvement of knowledge.

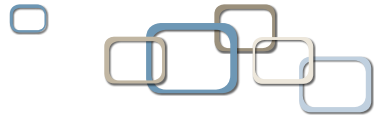
In this context, INRS encourages its experienced senior researchers – who have at least five years experience in post-PhD research, experience of co-supervising theses, and publications in peer-reviewed international scientific journals – to obtain authorisation to direct research. Currently, nine people at INRS have such authorisations, two of whom obtained them in 2014.

In 2014, the following three theses were defended:

- **Thibaut DURAND**: développement d'outils de caractérisation physico-chimique des particules ultrafines (Development of tools for physically and chemically characterising ultrafine particles). Université de Pau et des Pays de l'Adour.
- **Romain CHAUVEAU**: modélisation multi-paramètre du phénomène d'adsorption pour la détermination du temps de percée des cartouches de masques à gaz (Multi-parameter modelling of the adsorption phenomenon for determining the breakthrough time of gas mask cartridges). University of Lorraine.
- **Assad MOHAMMED**: les nanomatériaux manufacturés, un enjeu pour la protection de la société. Le cas de la protection juridique des travailleurs (Manufactured nanomaterials, an issue for societal protection. The case of legal protection for workers). University of Aix-en-Provence.

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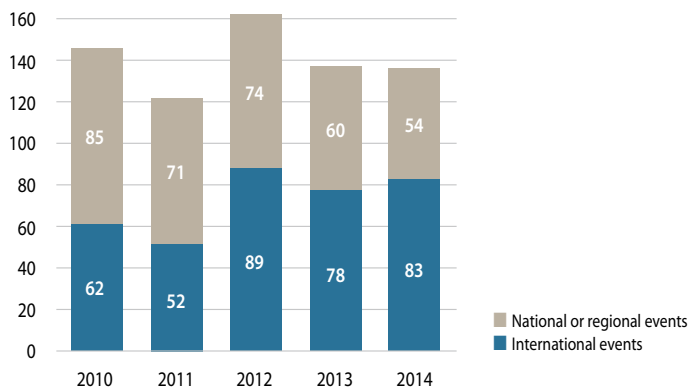
Presentations and Publications in 2014

Presentations in 2014

Every year, INRS researchers and experts take part in numerous national and international congresses: 137 presentations were given at various events in 2014, including 83 at international congresses, and, in particular:

- 19 presentations by INRS at the AIRMON International Symposium in Marseille;
- 10 presentations by INRS at the 12th French Acoustics Congress in Poitiers;
- 6 presentations by INRS at the 29th French Aerosol Congress in Paris.

Numbers of presentations presented at scientific events.



In parallel with the symposia in which it took part, INRS co-organised one international scientific conference and organised various theme days in 2014:

- **On 27 March in Paris:** occupational exposure to formaldehyde in the woodworking industry – risks and issues.
- **From 15 to 19 June 2014 in Marseille, the AIRMON symposium:** 8th International Symposium on Modern Principles of Air Monitoring and Biomonitoring.
- **On 27 and 28 November in Paris:** occupational cancer days.
- **On 18 November in Paris:** advantages and limits of virtual manikins for designing ergonomic work stations.

Publications 2014

The findings of the “studies & research” are published in scientific and technical journals.

97 articles were published in 2014, including:

- 46 in international peer-reviewed journals
- 51 in national journals, including:
 - 26 in the INRS journal “*Hygiène et Sécurité du Travail*”
 - 13 in the INRS journal “*Références en Santé au Travail*”

As well as:

- 12 chapters in works, 30 conference proceedings, 14 technical and scientific notes, published.

The list of publications for the year 2014 is given below.

List of publications 2014



Accidentology, and perception & acceptability of occupational risks

- **ABDAT F., LECLERCQ S., CUNY X., TISSOT C.**
Extracting recurrent scenarios from narrative texts using a Bayesian network: Application to serious occupational accidents with movement disturbance. (Extraction de scénarios récurrents à partir de récits en utilisant les réseaux bayésiens : application à un ensemble d'accidents avec perturbation du mouvement particulièrement graves). *Accident Analysis and Prevention*, 70 (2014), 155-166.
- **CHAU N., DEHAENE D., BENAMGHAR L., BOURGKARD E., MUR J., TOURON C., WILD P.**
Roles of age, length of service et job in work-related injury: a prospective study of 63,620 person-years in railway female workers. *American Journal of Industrial Medicine*, 2014, vol. 57, No.2, pp. 172-183.
- **LECLERCQ S., SAUREL D., CUNY X., MONTEAU M.**
Research into cases of slips, collisions et other movement disturbances occurring in work situations in a hospital environment (une recherche sur les glissades, heurts et autres perturbations du mouvement en situation de travail en milieu hospitalier). *Safety Science*, 68 (2014), 204-211.
- **LECLERCQ S.**
Organisational factors of occupational accidents with movement disturbances (OAMD) et prevention. (Facteurs organisationnels d'accidents avec perturbation du mouvement et prévention). *Industrial Health*, 2014, Vol. 52, pp. 393-398.
- **TRONTIN C.**
Stress au travail : évaluation économique. In: Zawieja P. & Guarnieri F. (dir.). *Dictionnaire des risques psychosociaux, éditions du Seuil*, 2014, pp. 738-741.
- **LASSAGNE M., TRONTIN C.**
Risques psychosociaux : évaluation économique. In: Zawieja P. & Guarnieri F. (dir.). *Dictionnaire des risques psychosociaux, éditions du Seuil*, 2014, pp. 659-662.



Occupational allergies

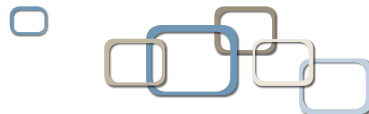
- **GONZALEZ M., JEGU J., KOPFERSCHMITT M.-C., DONNAY C., HEDELIN G., MATZINGER F., VELTEN M., GUILLOUX L., CANTINEAU A., DE BLAY F.**
Asthma among workers in healthcare settings: role of disinfection with quaternary ammonium compounds (l'asthme chez les personnels de santé : rôle de la désinfection par des composés d'ammonium quaternaire). *Clinical & Experimental Allergy* 2014.
- **FRANCUZ B., DEMANGE V., MOUSEL M.-L., GRZEBYK M., NICAISE P., CHOLLET-MARTIN S., CHOUDAT D.**
Manifestations allergiques ou irritatives chez le personnel des laboratoires de préparation et des animaleries d'un Institut de recherche. *Archives des maladies professionnelles et de l'environnement* 2014.
- **BOURGKARD E., BOINI S., GRZEBYK M., HEDELIN G., HENROTIN J.-B., RADAUCEANU A.**
15^e colloque de l'Association pour le développement des études et recherches épidémiologiques sur la santé et le travail (ADEREST), Paris, 7 et 8 novembre 2013. *Références en santé au travail*, 2014, n° 138, TD 209, pp 83-92.



Noise, vibration, electromagnetic fields, optics

- **PIERRETTE M., PARIZET E., CHEVRET P., CHATILLON J.**
Noise effect on comfort in open-space offices: development of an assessment questionnaire (évaluation sonore des open-spaces : le point de vue des salariés). *Ergonomics*, October 2014, 11p.
- **NEJADE A.**
Reference-less acoustic holography techniques based on sound intensity (techniques de l'holographie acoustique sans référence basées sur l'intensité sonore). *Journal of Sound et Vibration* 333 (2014), pp. 3598-3608.





- **NEJADE A.**
Investigation des performances d'une méthode hybride (intensimétrie- MISO) pour l'identification et la localisation des sources de bruit d'un centre d'usinage bois. *Acoustique & Techniques*, 2014, n° 76, pp. 34-39.
- **CHEVRET P., LEMUET Y., ASSELINEAU M.**
Acoustique des bureaux ouverts : vers une nouvelle norme française. *Acoustique & Techniques*, 2014, n° 76, pp. 27-33.
- **NEJADE A.**
Détecter et hiérarchiser les sources pour réduire le bruit des machines à bois. *Le Bois International. L'Officiel du bois*, n° 38, 8 novembre 2014, pp. 10-12.
- **CHATILLON J., KUSY A., TROMPETTE N.**
Efficacité des protecteurs auditifs : que valent les méthodes d'évaluation personnelle et *in situ* proposées aujourd'hui ? *Références en Santé au Travail*, juin 2014, n° 138, TP 19, pp. 103-107.
- **TROMPETTE N., CHATILLON J., KUSY A.**
Des systèmes commerciaux pour évaluer individuellement l'efficacité des protecteurs contre le bruit. *Hygiène et Sécurité du Travail*, n° 235, juin 2014, pp. 32-35.
- **TROMPETTE N.**
Comment choisir une machine portative peu bruyante ? *Hygiène et sécurité du travail*, n° 237, décembre 2014, pp. 31-33.
- **CARNIEL X., TROMPETTE N., VAUQUELIN E., HUBERT D.**
Determination of acoustic characteristics of pneumatic exhaust silencers: proposal for a new standard (détermination des caractéristiques acoustiques des silencieux d'échappement : proposition pour une nouvelle norme). *Proceedings 9th IFK Conference, Aachen, Germany*, 24-26 March 2014, 11 p.
- **KUSY A., TROMPETTE N.**
Évaluation des systèmes commerciaux pour le test individuel de l'efficacité des protecteurs auditifs. *Proceedings cfa2014, Poitiers, France*, 22-25 avril 2014, pp. 255-261.
- **FAIZ A., DUCOURNEAU J., KHANFIR A., CHATILLON J.**
Nouveau dispositif de mesure du coefficient de diffusion acoustique de parois à relief verticales présentes dans les locaux industriels. *Proceedings cfa2014, Poitiers, France*, 22-25 avril 2014, pp. 1283-1289.
- **KHANFIR A., DUCOURNEAU J., FAIZ A., CHATILLON J.**
Détermination du champ de pression acoustique réfléchi au-dessus d'une paroi à relief aperiodique contenant des cavités non parallèles. *Proceedings cfa2014, Poitiers, France*, 22-25 avril 2014, pp. 1277-1282.
- **CHATILLON J., CHEVRET P.**
Gêne acoustique des salariés dans le tertiaire : évaluations et solutions de prévention. *Proceedings cfa2014, Poitiers, France*, 22-25 avril 2014, pp. 2287-2293.
- **ARZ J.-P., GETTLIFE J., GRIMAULT N.**
Méthodes d'évaluation de la perception des signaux de danger : influence des atteintes auditives et du port de protecteur auditif. *Proceedings cfa2014, Poitiers, France*, 22-25 avril 2014, pp. 945-951.
- **ROUCH J., CHEVRET P.**
Identification de paramètres physiques du signal pour l'évaluation de la gêne en bureaux ouverts. *Proceedings cfa2014, Poitiers, France*, 22-25 avril 2014, pp. 2325-2331.
- **LE MUET Y., CHEVRET P.**
Acoustique des bureaux ouverts : vers une nouvelle norme française. *Proceedings cfa2014, Poitiers, France*, 22-25 avril 2014, pp. 2301-2308.
- **JAGLA J., SCHMICH I., JEAN P., CHEVRET P., CHATILLON J.**
Prédiction de l'ambiance acoustique des bureaux ouverts. *Proceedings cfa2014, Poitiers, France*, 22-25 avril 2014, pp. 2317-2323.
- **CHEVRET P., CHATILLON J.**
Etude du démasquage par la modulation du bruit ambiant en bureau ouvert. *Proceedings cfa2014, Poitiers, France*, 22-25 avril 2014, pp. 2295-2300.
- **BROCOLINI L., PARIZET E., CHEVRET P., CHATILLON J.**
Influence du type de source sonore sur l'évaluation de la gêne et de la performance dans les bureaux ouverts. *Proceedings cfa2014, Poitiers, France*, 22-25 avril 2014, pp. 2309-2315.

■ **SCHMICH I., JAGLA J., JEAN P., CHEVRET P., CHATILLON J.**

Prediction of open plan office acoustics (modélisation de l'acoustique des open-spaces). *Actes du congrès Forum Acusticum, 7-12 septembre 2014, Cracovie (Pologne), 6p.*

■ **AMARI M., DONATI P.**

Inter-individual postural variability of off-road machine drivers exposed to WBV (variabilité inter-individuelle de la posture de conducteurs d'engins de chantiers exposés à des vibrations de l'ensemble du corps). *Proceedings of the 5th International Conference on Whole Body Vibration Injuries, Academic Medical Center (Amsterdam), Netherlands, 5-7 June 2013, 2 p.*

■ **EBISSOU A.**

Gêne sonore en bureaux ouverts : impact de la présence de plusieurs voix intelligibles. *Note Scientifique et Technique, NS 322, mars 2014, 144 pages.*

 **Design of work equipment, workplaces, and working situations**

■ **PIERRET B., DESBROSSES K., PAYSANT J., MEYER J.-P.**

Cardio-respiratory et subjective strains sustained by paraplegic subjects, when travelling on a cross slope in a manual wheelchair (MWC) (astreintes cardio-respiratoires et subjectives de sujets paraplégiques en fauteuil roulant manuel lors du déplacement en dévers). *Applied Ergonomics, Volume 45, Issue 4, July 2014, Pages 1056-1062.*

■ **CANETTO P., MARSOT J.**

MAVImplant, une aide à la conception des lieux de travail pour les TPE. *Hygiène et sécurité du travail, mars 2014, n° 234, pp. 33-35.*

■ **SAVIN J., GAUDEZ C., DE MAGISTRIS G.**

A human-like dynamic Digital Human Model controller for ergonomic assessment of workstations (un humain virtuel animé par des techniques robotiques bio-inspirées pour l'évaluation ergonomique en conception de postes de travail). *Actes de la 10^e Conférence Francophone de Modélisation, Optimisation et Simulation MOSIM'14 - 5 au 7 novembre 2014, Nancy, France "de l'économie linéaire à l'économie circulaire", 10 p.*

■ **MARSOT J., DAILLE-LEFEVRE B., LUX A., ETIENNE A., SIADAT A.**

Safe design of work equipment: proposal of two approaches for taking practices into account (conception sûre des équipements de travail : proposition de deux approches pour la prise en compte des usages). *Actes de la 10^e Conférence Francophone de Modélisation, Optimisation et Simulation MOSIM'14 - 5 au 7 novembre 2014, Nancy, France "de l'économie linéaire à l'économie circulaire", 7 p.*

■ **DEGALVEZ N., AMARA M., MARSOT J., MARTIN P., BAUDOUIIN C.**

Caractérisation en conception générale et détaillée du niveau de risque d'un équipement de travail. *Actes du 19^e Congrès de Maîtrise des Risques et Sécurité de Fonctionnement, Dijon, France, 21-23 octobre 2014, 8 p.*

■ **MARSOT J., FADIER E., DAILLE-LEFEVRE B., ROIGNOT R., FALCONNET E.**

Méthodologie d'aide à la rédaction d'un cahier des charges basée sur l'usage. *Actes du 19^e Congrès de Maîtrise des Risques et Sécurité de Fonctionnement, Dijon, France, 21-23 octobre 2014, 8 p.*

■ **DE MAGISTRIS G.**

Étude et conception de la commande de mannequins virtuels dynamiques pour l'évaluation ergonomique des postes de travail. *Note Scientifique et Technique de l'INRS, 2014, NS 321, 171 p.*

■ **MARCHAL P., JACQUES M.**

LabINRS - Mesures en laboratoire du coefficient de frottement dynamique de revêtements de sol. *Note Scientifique et Technique de l'INRS, 2014, NS 316, 11 p.*

■ **MARCHAL P., JACQUES M.**

Portable Tester Friction (PFT) - Mesures du coefficient de frottement dynamique de revêtements de sol. *Note Scientifique et Technique de l'INRS, 2014, NS 317, 12 p.*

 **Waste and recycling**

■ **ZIMMERMANN F., LECLER M.-T., CLERC F., CHOLLOT A., SILVENTE E., GROSJEAN J.**

Occupational exposure in the fluorescent lamp recycling sector in France (exposition professionnelle dans la filière des lampes usagées en France). *Waste Management, 2014, 34, pp. 1257-1263.*

■ **LEVILLY R.**

Panneaux photovoltaïques, les déchets du futur. *Hygiène et sécurité du travail*, n° 237, décembre 2014, pp. 92-95.

■ **LEVILLY R.**

Exposition aux substances chimiques et aux bioaérosols dans les centres de traitement thermique des déchets non dangereux. *Hygiène et sécurité du travail*, n° 237, décembre 2014, pp. 68-71.



**Multiple exposures:
chemicals and noises**

■ **MEIER R., CASCIO W., GIO A., WILD P., DANUSER B., RIEDIKER M.**

Associations of short-term particle et noise exposures with markers of cardiovascular et respiratory health among highway maintenance workers (associations entre exposition à court terme au bruit et aux particules et des marqueurs de la santé cardiovasculaire et respiratoire parmi des travailleurs de la maintenance autoroutière). *Environmental Health Perspectives*, 2014, Vol. 122, Issue 7, pp. 726-732.

■ **CAMPO P., VENET T., THOMAS A., COUR C., BROCHARD C., COSNIER F.**

Neuropharmacological et Cochleotoxic Effects of Styrene. Consequences on noise exposures (effets neuropharmacologiques et cochléotoxiques du styrène. Conséquences sur les co-expositions avec le bruit.). *Neurotoxicology et Teratology*, 2014, Vol. 44, pp. 113-120.

■ **VENET T., CAMPO P., RUMEAU C., THOMAS A., PARIETTI-WINKLER C.**

One-day measurement to assess the auditory risks encountered by noise-exposed workers (mesures quotidiennes pour mettre en évidence les risques auditifs encourus par les travailleurs exposés au bruit). *International Journal of Audiology* 2014; *Early Online*: 1-8.

■ **CAMPO P., VENET T.**

EchoScan: a new preventive tool for hearing loss prevention (EchoScan : un nouvel outil pour la prévention des atteintes auditives). *Brisbane Convention & Exhibition 2014 pp 3- 151*.

■ **CAMPO P., VENET T., PARIETTI-WINKLER C.**

L'EchoScan : une alternative à l'audiométrie tonale en médecine du travail. *Le Concours Médical*, 2014, Tome 136, n°1, pp. 59-61.

■ **CAMPO P.**

Les multi-expositions rendent sourds. *Le Concours Médical Tome 136 N°2 février 2014*.

■ **SAVARY B.**

Conteneurs maritimes : attention aux vapeurs et gaz dangereux. *Hygiène et sécurité du travail*, n° 234, mars 2014, DC 4, pp. 6-9.

■ **VENET T., CAMPO P.**

Évaluation de la fatigue auditive au terme d'une journée de travail. *Références en Santé au Travail*, 2014, n°137, AC 63, pp. 8-10.

■ **VENET T., CAMPO P., RUMEAU C., THOMAS A., PARIETTI-WINKLER C.**

La mesure de la fatigue auditive périphérique par EchoScan. *Références en santé au travail*, 2014, n°140, pp 55-63.

■ **VENET T., CAMPO P.**

Comment évaluer la fatigue auditive ? *Hygiène et Sécurité du Travail - n°234 - Mars 2014*.



Manufactured nanomaterials

■ **DARNE C., TERZETTI F., COULAIS C., FONTANA C., BINET S., GATE L., GUICHARD Y.**

Cytotoxicity et genotoxicity of panel of single- et multi-walled carbon nanotubes: *in vitro* effects on normal Syrian Hamster Embryo (SHE) et immortalized V79 hamster lung cells (cytotoxicité et génotoxicité d'un panel de nanotubes de carbone simple et multi-parois : effets *in vitro* sur les cellules normales d'embryons de hamster syrien et sur les cellules immortalisées de poumon V79.). *Journal of Toxicology Volume 2014 (2014)*, 15 pages.

■ **WITSCHGER O.**

Aerosol emissions during sanding et sawing of composites, with presence or absence of embedded nanomaterials. (Emission d'aérosols lors du ponçage et du sciage de composites incluant ou non des nanomatériaux). *Environmental, Health et Safety Impacts of Nanoparticles No.16, December 2014*.

■ **CHARVERT A., BAU S., PAEZ COY N., BEMER D., THOMAS D.**

Characterizing the effective density et primary particle diameter of airborne nanoparticles produced by spark discharge using mobility et mass measurements (tandem DMA/APM) (détermination de la densité effective et le diamètre des particules primaires de nanoparticules produites par décharge électrique via la mesure simultanée de leur mobilité et masse). *Journal of Nanoparticle Research*, (2014), April 2014.

■ **BAU S., BEMER D., GRIPPARI F., APPERT J.-C., THOMAS D.**

A new approach for the determination of airborne nanoparticle effective density with the tandem DMA/ELPI based on multiple charging correction. (Une nouvelle approche pour la détermination de la densité effective des nanoparticules par couplage DMA/ELPI basée sur la correction de charges multiples). *Journal of Nanoparticle Research*, 2014, Vol. 16, 13 p.

■ **GUICHARD R., BELUT E., RIMBERT N., TANIÈRE A.**

Evaluation of a Moments-based Formulation for the Transport et Deposition of Small Inertia Aerosols (évaluation d'une formulation en moments d'un modèle de transport et de dépôt d'aérosols faiblement inertiels). *Journal of Computational Multiphase Flows*, vol. 6, 4, 2014, pp. 407-418.

■ **GUICHARD R., TANIÈRE A., BELUT E., RIMBERT N.**

Simulation of nanoparticle coagulation under Brownian motion et turbulence in a differential-algebraic framework: developments et applications. (Simulation de la coagulation de nanoparticules sous l'effet du mouvement brownien et de la turbulence par une approche algébrique-différentielle : développement et applications). *International Journal of Multiphase Flow*, 2014, Vol. 64, pp. 73-84.

■ **CHAZELET S.**

Adapter la protection respiratoire à l'homme et à son exposition. *Actes 29^e Congrès Français sur les Aérosols, CFA 2014, CD-ROM, 7 p., Paris, 22-23 janvier 2014.*

■ **GUICHARD R., TANIÈRE A., BELUT E., RIMBERT N.**

Évaluation d'un modèle d'agrégation, de transport et de dépôt de particules faiblement inertiels dans une enceinte ventilée. *Actes 29^e Congrès Français sur les Aérosols, CFA 2014, CD-ROM, 6 p., Paris, 22-23 janvier 2014.*



Organisation, health and safety at work

■ **GRUSENMEYER C.**

Maintenance organizational modes, activities et health & safety. Exploitation of a French National Survey et *in situ* analyses. (Modes d'organisation, activités de maintenance et santé-sécurité. Exploitation d'une enquête nationale française et analyses *in situ*). *Accident Analysis et Prevention*, 2014, vol. 73, pp. 187-199.

■ **WIOLAND L., GOVAERE V.**

Comparative study of two organizations using information et communication technology: effects on the health of operators in the road haulage (étude comparative de deux organisations utilisant une technologie de l'information et de la Communication : effets sur la santé des opérateurs dans le transport routier de marchandises). *Journal of Traffic et Logistics Engineering*, March 2014, Vol. 2, n°1, pp. 66-70.

■ **LUX A., QUILLEROU E.**

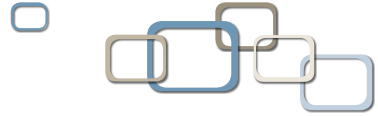
Production activity analysed by an engineer et a psychologist: what contributions for taking health into account when designing production systems? (un ingénieur et une psychologue pour une analyse d'activité de production : quels apports pour la prise en compte de la santé au travail lors de la conception des systèmes de production ?). *Actes de la 10^e Conférence Francophone de Modélisation, Optimisation et Simulation MOSIM'14 -5 au 7 novembre 2014, Nancy, France "de l'économie linéaire à l'économie circulaire"*, 9 p.

■ **WIOLAND L., GOVAERE V.**

Comparative Study of Two Organisations implementing Information et Communication Technology: effects on the Health of Goods Transport Operators (étude comparative de deux organisations utilisant une technologie de l'information et de la Communication : effets sur la santé des opérateurs dans le transport routier de marchandises). *Proceedings of the 3rd International Conference on Traffic et Transportation Engineering*, 17-18 April 2014.

■ **GOVAERE V., WIOLAND L.**

Pourquoi s'intéresser aux TIC pour la prévention des risques professionnels ? Spécificités de ces outils et difficultés. *Actes COMMON 14 "Communication multimodale et collaboration instrumentée"*, septembre 2014, Bruxelles, pp 103-115.



■ **BOUDRA L., BÉGUIN P.**

Analyzing territorial governance to prevent occupational risks in the sector of waste management (analyser la gouvernance territoriale pour la prévention des risques professionnels dans le secteur de la gestion des déchets). *Human Factors in Organizational Design et Management - XI, Nordic Ergonomics Society Annual Conference - 46*, p. 115-120.

■ **GRUSENMEYER C.**

Externalisation et sécurité des activités de maintenance. Analyses cliniques et ergonomiques dans un réseau d'entreprises. *Actes SELF 2014, La Rochelle, France 01-03 octobre 2014*, pp 429-438.

■ **GOVAERE V.**

Stress et messagerie électronique. Quelle prévention peut être mise en place ? *Références en Santé au Travail*, n° 139, septembre 2014, QR 92, pp 182-185.

■ **GRUSENMEYER C., WILD P.**

Les expositions professionnelles des personnels de maintenance aux contraintes organisationnelles, physiques et d'ambiance. Exploitation de l'enquête SUMER 2003. *Références en Santé au Travail*, septembre 2014, n° 139, TF 223, pp 83-98.

■ **GRUSENMEYER C.**

Organisation et activités de maintenance : analyse ergonomique dans une entreprise de transport en commun de passagers. *Hygiène & Sécurité du Travail*, septembre 2014, n° 236, Étude de cas 6, pp 60-63.

■ **MARC J.**

Le recours aux formations à distance (e.learning) dans la formation professionnelle des salariés : présentation, influence sur les acteurs et éléments de vigilance. *Note Scientifique et Technique de l'INRS*, novembre 2014, NS 327, 72 p.

■ **MARC J.**

Formation professionnelle des salariés : recours aux formations en ligne (e.learning). *Formation professionnelle des salariés : recours aux formations en ligne (e.learning)*.



Reproduction and work

■ **SABATE J.-P., SAILLENFAIT A.-M.**

Developmental toxicity of phthalates. Read across approach (toxicité du développement des phthalates. Approche par "read across"). *Toxicology Letters* 229s(2014) S40-S-252.

■ **HOPF N., BERTHET A., VERNEZ D., LANGARD E., SPRING P., GAUDIN R.**

Skin permeation and metabolism of di(2-ethylhexyl) phthalate (DEHP) (pénétration cutanée et métabolisme du phthalate du di(2-éthylhexyle) (DEHP). *Toxicology Letters* 224(2014) 47-53.

■ **LAFON D., BOUSLAMA M., PICOT C., COLLOT-FERTEY D., LABRO M.-T., LARROQUE B., ROUDOT A.-C., SATER N., RADAUCEANU A., HENROTIN J.-B., OULD ELHKIM M.**

Etat des connaissances sur les liens entre les troubles de la reproduction et l'exposition aux produits cosmétiques chez les professionnels de la coiffure et des soins de beauté : Approche épidémiologique et méta-analytique. *Note Scientifique et Technique de l'INRS*, juillet 2014, NS 307, 93 p.

■ **HENROTIN J.-B.**

Besoins d'études épidémiologiques sur les effets de l'exposition à de(s) perturbateur(s) endocrinien(s) en Entreprises. *Note Scientifique et Technique de l'INRS*, mars 2014, NS 323, 196 p.



Biological risks

■ **FORTHOMME A., JOUBERT A., ANDRES Y., SIMON X., DUQUENNE P., BEMER D., LE COQ L.**

Microbial aerosol filtration: Growth et release of a bacteria-fungi consortium collected by fibrous filters in different operating conditions (filtration des aérosols microbiens : croissance et relargage d'un consortium bactéries - champignon collecté par des filtres à fibres dans différentes conditions opératoires). *Journal of Aerosol Science*, 2014, 72, pp. 32-46.

■ **DUQUENNE P., AMBROISE D., GORNER P., CLERC F., GREFF-MIRGUET G.**

Exposure to airborne endotoxins among sewer workers: an exploratory study (exposition des travailleurs égoutiers aux endotoxines : une étude pilote). *Annals of Occupational Hygiene*, 2014, vol. 58, No.3, pp. 283-293.

■ **SIMON X., DUQUENNE P.**

Assessment of workers' exposure to bioaerosols in a French cheese factory (évaluation de l'exposition des salariés aux bioaérosols dans une cave d'affinage de fromages en France). *Annals of Occupational Hygiene*, 2014, Vol. 58, No.6, pp. 677–692.

■ **SIMON X., DUQUENNE P.**

Fabrication de saucissons : mesures et prévention des expositions aux bioaérosols. *Hygiène et sécurité du travail*, juin 2014, n° 235, EC 5, pp. 58-62.



Chemical risks

■ **ROUSSET D., VINCENT R., GOUTET P., GILLET M., GUICHARD C., HEDOUIN-LANGLLET C., FROCAUT A.-M., LAMBERT P., LERAY F., MARDELLE P., DOROTTE M.**

Occupational Exposure to Chrome VI Compounds in French Companies: Results of a National Campaign to Measure Exposure (2010–2013) (exposition professionnelle aux composés du chrome VI dans les entreprises françaises : résultats d'une campagne nationale de mesures d'exposition (2010-2013)). *Annals of Occupational Hygiene* (2015) 59 (1): 41-51.

■ **BEYDON D., PAYAN J.-P., FERRARI E., GRANDCLAUDE M.-C.**

Structure-activity relationships for percutaneous absorption of herbicides derived from 2,4-dichlorophenoxy acid (absorption percutanée d'herbicides dérivés du 2,4-dichlorophénoxyacide: relation structure-activité). *Toxicology in vitro* 28 (2014) 1066–1074.

■ **GAGNAIRE F., BOUCARD S.**

Olfactory mucosal necrosis in rats following acute intraperitoneal administration of 1,2-diethylbenzene et 1,2-diacetylbenzene: possible role of regional bioactivation (nécrose de la muqueuse olfactive chez le rat après administration intrapéritonéale de 1,2-diéthylbenzène et de 1,2-diacétylbenzène : rôle possible d'une bioactivation locale). *Neurotoxicology* 41C (2014), pp. 9-19.

■ **COSNIER F., NUNGE H., BROCHARD C., BURGART M., REMY A., DECRET M.-J., COSSEC B., CAMPO P.**

Impact of co-exposure on toluene biomarkers in rats (impact d'une co-exposition sur les biomarqueurs du toluène chez le rat). *Xenobiotica*, (2014) 44(3), 217-228.

■ **URMES I., GRZEBYK M., HEDELIN G.**

Net survival estimation with stns (estimation de la survie nette avec stns). *The stata journal*, 14, number 1, 2014, pp 87-102.

■ **CLERC F., BERTRAND N., VINCENT R.**

TEXAS: a Tool for EXposure ASsessment. Modèles statistiques pour l'estimation de l'exposition professionnelle aux agents chimiques (TEXAS: a Tool for EXposure ASsessment. Statistical models for estimating occupational exposure to chemical substances). *Annals of Occupational Hygiene*, 2014, 1–15.

■ **GERSTER F., VERNEZ D., WILD P., HOPF N.**

Hazardous substances in frequently used professional cleaning products (exposition des personnels de nettoyage à des produits sensibilisants et/ou irritants respiratoires). *International Journal of Occupational and Environmental Health*, 2014, vol. 20, No.1, pp. 46-60.

■ **CHAMPMARTIN C., CLERC F.**

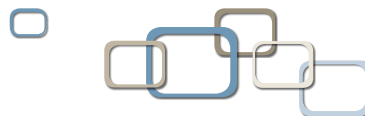
Inhalable Dust Measurements as a First Approach to Assessing Occupational Exposure in the Pharmaceutical Industry (mesures d'empoussièrement (fraction inhalable) : première étape pour évaluer l'exposition professionnelle dans l'industrie pharmaceutique). *Journal of Occupational and Environmental Hygiene*, 2014, 11: 85–92.

■ **ROUSSELLE C., PERNELET-JOLY V., MOURTON-GILLES C., LEPOITTEVIN J., VINCENT R., LEFRANC A., GARNIER R.**

Risk assessment of DMFu residues in dwellings following contamination by treated furniture (évaluation des risques présentés par des résidus de diméthylfumarate dans les habitations après contamination par les meubles traités). *Risk Analysis*, 2014, 10 p.

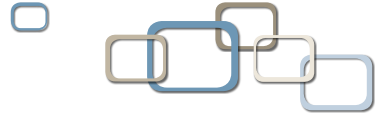
■ **SIMON X., BEMER D., CHAZELET S., THOMAS D.**

Downstream particle puffs emitted during pulse-jet cleaning of a baghouse wood dust collector: influence of operating conditions et filter surface treatment. (Bouffées de particules émises à l'aval des dépoussiéreurs à manches avec décolmatage pneumatique : influence des conditions opératoires et du type de médias dans le cas de la filtration de poussières de bois). *Powder Technology* 261 (2014) 61-70.



- **GERARDIN F., GENTRIC C., MIDOUX N.**
Particle dispersion in the near-wake of an isolated rotating wheel: experimental et CFD study (dispersion de particules fines dans le champ proche d'une roue isolée en rotation : étude expérimentale et numétique). *Journal of Aerosol Science, 2014, Vol. 76, pp. 56-71.*
- **KELLER F.-X.**
Field investigations applied to wood dust emissions around vertical panel saws (mesures de terrain des émissions de poussières de bois autour des scies à panneaux verticales). *Gefahrstoffe Reinhaltung der Luft, 2014, Jan./Febr., pp.021-26.*
- **CLOTEAUX A., GERARDIN F., THOMAS D., MIDOUX N., ANDRE J.**
Fixed bed photocatalytic reactor for formaldehyde degradation: experimental et modeling study (réacteur photocatalytique à lit fixe pour la dégradation du formaldéhyde : étude expérimentale et modélisation). *Chemical Engineering Journal 249 (2014) 121-129.*
- **CADAVID RODRIGUEZ M.-C., CHARVET A., BEMER D., THOMAS D.**
Optimization of bubble column performance for nanoparticle collection (optimisation des performances de collecte des nanoparticules par une colonne à bulles). *Journal of Hazardous Materials, 2014, n° 271, pp. 24-32.*
- **BRUSCHWEILER E., HOPF N., WILD P., HUYNH C.-K., FENECH M., THOMAS P., HOR M., CHARRIERE N., SAVORA-BIANCHI D., DANUSER B.**
Workers exposed to wood dust have an increased micronucleus frequency in nasal et buccal cells: results from a pilot study (des travailleurs exposés aux poussières de bois ont une fréquence de micronoyaux augmentée dans les cellules nasales et buccales : résultats d'une étude pilote). *Mutagenesis, 2014, Vol. 29, Issue 3, pp. 201-207.*
- **CARE I., BONTHOUX F., FONTAINE J.-R.**
Measurement of air flow in duct by velocity measurements (mesure de débit d'air en conduit par des mesures de vitesse). *European Physical Journal - Web of Conferences 77, 00010 (2014).*
- **FALCY M., NDAW S., PILLIERE F.**
Cytotoxiques : évaluation des risques professionnels. EMC. *Pathologie professionnelle et de l'environnement 2014 ; 0(0): 11p. - Article 16-545-A-05.*
- **PILLIERE F.**
Surveillance biologique des expositions à des produits chimiques, environnementale et professionnelle. EMC. *Pathologie professionnelle et de l'environnement 2014 ; 0(0):1-7 (Article 16-001-J-30).*
- **CLOTEAUX A., GERARDIN F., THOMAS D., ANDRE J.-C., MIDOUX N.**
Dégradation du méthanal en solution par photocatalyse TiO₂/UV. *L'actualité chimique, novembre 2014, n° 390, pp. 60-62.*
- **BEMER D., MORELE Y., DRESCHER C., CHARVET A., THOMAS D.**
Séparation de particules ultrafines métalliques par lit granulaire. *Actes 29^e Congrès Français sur les Aérosols, CFA 2014, 8 p., Paris, 22-23 janvier 2014.*
- **BELUT E.**
Simulation numérique de l'abattage humide des particules ultrafines. *Actes 29^e Congrès Français sur les Aérosols, CFA 2014, CD-ROM, 6 p., Paris, 22-23 janvier 2014.*
- **SAVARY B., MATER G.**
Projection thermique : état des lieux en 2012. *Hygiène et sécurité du travail, septembre 2014, n° 236, NT 18, pp. 54-58.*
- **EYPERT-BLAISON C., FREVILLE L., VEISSIERE S., STARCK M.-C., CLERC F., ROMERO-HARIOT A., WILD P., LAINE P.**
Amiante : un badge pour améliorer la perception du risque. *Hygiène et sécurité du travail, mars 2014, n° 234, NT 9, pp. 46-50.*
- **GUILLEMOT M., OURY B., MELIN S.**
Identifier les composés libérés lors de la dégradation thermique des plastiques. *Hygiène et sécurité du travail, 2014, n° 237, NT, pp. 54-60.*
- **GORNER P.**
Surveillance de l'air et surveillance biologique : états des lieux des connaissances. *Hygiène et sécurité du travail, n°237, oct/nov/déc 2014, pp 74-76.*

- **RAPP R.**
Récupération d'énergie : évaluation d'un échangeur à plaques. *Hygiène et sécurité du travail*, n° 235, juin 2014, note technique, pp. 40-42.
- **RAPP R.**
Récupération d'énergie : évaluation d'un échangeur rotatif. *Hygiène et sécurité du travail*, 2014, n° 236, NT 17, pp. 50-53.
- **RAPP R.**
Récupération d'énergie : évaluation d'un échangeur à batteries et à circulation d'un mélange eau-glycol. *Hygiène et sécurité du travail*, 2014, 234, Note technique 11, pp. 54-56.
- **CHOLLOT A., ZIMMERMANN F.**
ProtecPo, un outil de pré-sélection de matériaux de protection cutanée. *Hygiène et sécurité du travail*, n° 235, juin 2014, pp. 25-27.
- **SAVARY B.**
Panorama de la projection thermique en France Résultats de l'enquête 2012. *Note Scientifique et Technique de l'INRS*, septembre 2014, NS 326, 78 p.
-  **Mechanical Risks and New Technologies for Accident Prevention**
- **BLAISE J.-C., LEVRAT E., IUNG B.**
Process approach-based methodology for safe maintenance operation: from concepts to SPRIMI software prototype (méthodologie basée sur une approche processus pour des interventions de maintenance sûres : des concepts au prototypage informatique SPRIMI). *Safety Science*, 2014, vol. 70, pp. 99-113.
- **BAUDOIN J., BELLO J.-P.**
Sécurité des machines. Presses à servomoteur : la sécurité en question. *Hygiène et sécurité du travail*, mars 2014, n° 234, Veille & Prospective, VP 4, pp. 88-92.
- **REBELLE J.**
Aide au choix d'un système de retenue pour cariste : approche technique et analyse des contraintes liées à leur utilisation. *Hygiène et sécurité du travail*, n° 237, décembre 2014, pp. 46-52.
- **JACQUES M., GRAND G.**
Recommandations pour évaluer la résistance des semelles anti-perforation textiles. *Hygiène et sécurité du travail*, n° 235, juin 2014, pp. 28-31.
- **PERRIN N., LUX A., WILD P.**
Évaluation des systèmes caméra-écran pour la détection des piétons. *Hygiène et sécurité du travail*, septembre 2014, n° 236, DO 6, pp. 36-38.
- **HELLA F., ZORE F.**
Prévenir les collisions engins-piétons : ce que révèlent les observations de terrain. *Hygiène & Sécurité du Travail*, septembre 2014, n° 236, DO 6, pp. 26-28.
- **LAMY P., BURY M.**
Collisions engins-piétons : pour une Approach globale de prévention. *Hygiène et sécurité du travail*, septembre 2014, n° 236, DO 6, pp. 24-25.
- **LAMY P., BUCHWEILLER J.-P.**
Recommandations pour mettre en œuvre un système de détection. *Hygiène et sécurité du travail*, septembre 2014, n° 236, DO 6, pp. 32-35.
- **JACQUES M., DUVAL C.**
Des équipements plus intelligents. *Hygiène et sécurité du travail*, juin 2014, n° 235, pp. 36-37.
- **MARCHAL P., JACQUES M.**
Bearing force distribution over knee protectors (répartition de la force d'appui sur les protecteurs des genoux). *Note Scientifique et Technique*, NS 318, April 2014, 19 pages.
- **MARCHAL P., JACQUES M.**
Étude de la répartition de la force d'appui sur les protecteurs des genoux. *Note Scientifique et Technique*, NS 319, février 2014, 60 p.
- **REBELLE J.**
Risk of ejection - Efficiency of restraint systems for counterweight forklift trucks. Requirements et test method. (Risque d'éjection - Efficacité des systèmes de retenue pour chariot élévateur à contrepoids. Exigences et méthode d'essai.). *Note Scientifique et Technique*, NS 324, mars 2014, 30 pages.
- **BAUDOIN J., BELLO J.-P.**
Approaching standard EN ISO 13849-1 by designing a basic safety function (approaching standard EN ISO 13849-1 by designing a basic safety function). Aborder la norme NF EN ISO 13849-1 via la conception d'une fonction de sécurité basique). *Note Scientifique et Technique de l'INRS*, janvier 2014, NS 315, 56 p.



Psychosocial risks

- **STUDER R., DANUSER B., HILDEBRANDT H., ARIAL M., WILD P., GOMEZ P.**
Psychophysiological activation during preparation, performance, et recovery in high- et low-anxious music students. *Applied Psychophysiology et Biofeedback*, 2014, vol. 39, No.1, pp. 45-47.
- **DE PUY J., ROMAIN-GLASSEY N., GUT M., WILD P., MANGIN P., DANUSER B.**
Clinically assessed consequences of workplace physical violence: risk factors for severity (conséquences cliniques de la violence physique au travail). *International Archives of Occupational et Environmental Health*.
- **BOINI S., CHOUANIERE D., LANGEVIN V.**
La mesure de l'environnement psychosocial au travail : oui, mais comment ?
Archives des Maladies Professionnelles et de l'Environnement, 2014, vol. 75, pp. 3-5.
- **GROSJEAN V.**
Le concept de bien-être au travail.
Soins, novembre 2014, n° 790, pp 24-26.
- **VAN DE WEERDT C., GOVAERE V., MARC J.**
Activités humaines, technologies et bien-être.
Compte-rendu de la 7^e Conférence de Psychologie Ergonomique (EPIQUE) à Bruxelles (Belgique) du 10 au 12 juillet 2013. *Références en santé au travail*, mars 2014, n° 137, TD 206, p. 127-132.
- **GROSJEAN V., FORMET N., ALTHAUS V., KOP J.-L., BRANGIER E.**
Recherche et développement conceptuels autour du bien-être au travail : entre mesure et action.
Références en Santé au Travail, septembre 2014, n°139, TC 148, pp 29-39.
- **MOUZE AMADY M.**
Stress chronique : panorama et focus sur de nouveaux indicateurs biologiques et biomécaniques.
Références en Santé au Travail, 2014, 137, TC146, pp. 31-46.
- **BARLET B.**
Faire de la santé au travail en équipe pluridisciplinaire ? In: Bernard S. et al. (coord.). Les dispositifs publics en action vers une sécurisation des parcours professionnels et personnels. *Liaisons Sociales, Centre d'Études de l'Emploi, Éditions LIAISONS*, juin 2014, chap. 1, pp. 23-38.
- **CHOUANIERE D.**
Institut National de Recherche et de Sécurité (INRS). In: Zawieja P. & Guarnieri F. (dir.). *Dictionnaire des risques psychosociaux*, éditions du Seuil, 2014, pp. 399-400.
- **MARC J., LADREYT S.**
Isolement au travail. In: Zawieja P. & Guarnieri F. (dir.). *Dictionnaire des risques psychosociaux*, éditions du Seuil, 2014, pp. 421-422.
- **MARC J., LADREYT S.**
Solitude professionnelle. In: Zawieja P. & Guarnieri F. (dir.). *Dictionnaire des risques psychosociaux*, éditions du Seuil, 2014, pp. 711-712.
- **FAVARO M.**
Recension d'ouvrage. @ctivités, 2014, 11(2), pp.201-204. *Recension de l'ouvrage de Damien Cru "Le risque et la règle"*, Toulouse, Erès, 2014.
- **FAVARO M.**
Violences internes. In: Zawieja P. & Guarnieri F. (dir.), *Dictionnaire des risques psychosociaux*, éditions du Seuil, 2014, pp. 822-825.
- **GROSJEAN V.**
Bien-être au travail. In: Zawieja P. & Guarnieri F. (dir.). *Dictionnaire des risques psychosociaux*, éditions du Seuil, 2014, pp. 66-69.
- **ALTHAUS V., BRANGIER E.**
Intervention systémique. In: Zawieja P. & Guarnieri F. (dir.). *Dictionnaire des risques psychosociaux*, éditions du Seuil, 2014, pp. 416-419.
- **FAVARO M.**
Mécanismes organisationnels de formation des violences au travail : proposition d'un modèle pour comprendre et intervenir. *Note Scientifique et Technique de l'INRS*, février 2014, NS 320, 71 p.
- **LADREYT S., LHUILIER D., MARC J., FAVARO M.**
Rapport subjectif à l'isolement au travail : régulation, résistance, dégageant. *Note Scientifique et Technique de l'INRS*, septembre 2014, NS 325, 55 p.

**Musculoskeletal disorders
of the limbs and of the back****■ ARIAL M., BENOIT D., WILD P.**

Exploring implicit preventive strategies in prehospital emergency workers: a novel approach for preventing back problems (explorer des stratégies de prévention implicites chez les urgentistes : une nouvelle approche pour la prévention des lombalgies). *Applied Ergonomics*, 2014, Vol. 45, Issue 4, pp. 1003-1009.

■ BOUVIER B., SAVESCU A., DUPREY S., DUMAS R.

Benefits of functional calibration for estimating elbow joint angles using magneto-inertial sensors: preliminary results (apports d'une calibration fonctionnelle pour l'estimation des angles articulaires du coude à partir de capteurs inertiels : résultats préliminaires). *Computer Methods in Biomechanics et Biomedical Engineering*, 2014, vol 17, n° S1, 108-109.

■ MEYER J.-P.

Biomécanique rachidienne. Support pour la prévention et les traitements des lombalgies. In: Descatha A., Fouquet B., Roulet A., Hérisson C., Collections Pathologies professionnelles et médecine de réadaptation, EMPRE 2014, Manutention et Appareil Moteur. 42^e entretiens de médecine physique et de réadaptation, 03-05 mars 2014, Montpellier, pp. 24-35.

■ SAVESCU A.

8^e conférence scientifique internationale sur la prévention des troubles musculosquettiques, PREMUS 2013. *Références en Santé au Travail*, 2014, 137, TD205, pp. 121-125.

■ CLAUDON L., MARSOT J., ZORE F.

Conseils pour la conception et le choix de machines portatives. *Hygiène et Sécurité au Travail*, décembre 2014, n°237, DO 4, pp. 34-38.

**Ageing, staying in employment,
and preventing occupational exclusion****■ HENROTIN J.-B., BEJOT Y., GIROUD M.**

Accidents vasculaires cérébraux et travail posté : données épidémiologiques. *Cardiologie, Cardinale - Février 2014*, vol. 8, n°61, p 36-40.

■ PRAZ-CHRISTINAZ S.-M., PASCUAL M., PILON N., SIMCOX A., WILD P., DANUSER B.

Facteurs influençant le retour au travail après transplantation chez 61 patients rénaux ou hépatiques. *Revue Médicale Suisse*, 2014, Vol. 10, pp. 1148-1152.

■ MEYER J.-P., GINGEMBRE L., TURPIN-LEGENDRE E., HORVAT F., DIDRY G.

Évaluations des astreintes thermiques à l'aide de la fréquence cardiaque : les extrapulsations cardiaques thermiques (EPCT). *Références en Santé au Travail*, décembre 2014, n°140, TM34, pp. 83-94.

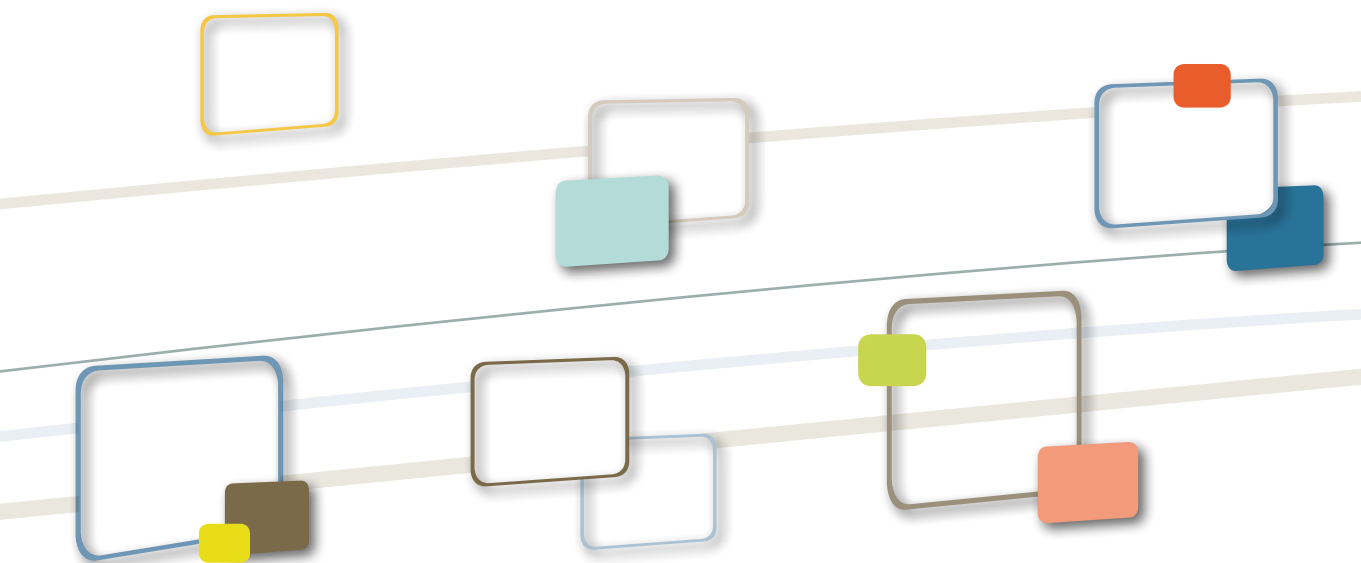
■ MEYER J.-P.

Évaluation subjective de la charge de travail. Utilisations des échelles de Borg. *Références en Santé au Travail*, septembre 2014, n°139, TM 33, pp 105-122.

■ PICHENE-HOUARD A.

Regards croisés France - Belgique - Québec sur la prévention de la désinsertion professionnelle liée à l'incapacité de travail. Séminaire de recherche action dans le cadre du congrès Santé Travail de Lille, 2 et 3 juin 2014. *Références en Santé au Travail*, décembre 2014, n° 140, TD214, pp. 95-102.





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Head office

65, boulevard Richard Lenoir - 75011 Paris - France
Tel.: +33 (0)1 40 44 30 00 - Fax: +33 (0)1 40 44 30 99

Lorraine centre

1, rue du Morvan - CS 60027 - 54519 Vandœuvre-lès-Nancy cedex - France
Tel.: +33 (0)3 83 50 20 00 - Fax: +33 (0)3 83 50 20 97

E-mail: info@inrs.fr
www.inrs.fr