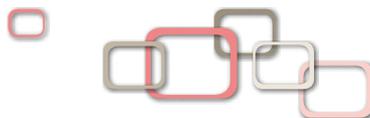


Studies & Research

2015/2016





Identity card

1947: Social partners found the French national OSH institute (INS), a non-profit organisation under the aegis of the National Health Insurance Fund for Salaried Employees (CNAMTS), and is managed by a joint Board of Directors (9 representatives of employers and 9 of employee trade unions).

1968: INS becomes the French National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases (INRS) with research activities being added, and becomes part of the Occupational Accidents and Diseases branch of the Social insurance.

INRS's missions

- To identify occupational risks and highlight hazards
- To analyse their impact on human safety and health at work
- To develop and promote the means to control these risks out in the companies

The articles of association and the code of ethics guarantee the impartiality of INRS. Its scientific and technical independence is ensured by an external experts committee that assesses its work. Its focuses are in line with the agreement on objectives and management of the occupational accident and disease commission.

Four complementary modes of action

From acquiring knowledge to disseminating it and transforming it into solutions, INRS uses its cross-disciplinary resources to spread OSH culture as widely as possible and to offer methodological and practical tools.

INRS's goal is to contribute to the prevention of occupational accidents and diseases through a set of complementary actions that break down as follows in 2015:

- studies and research 43%
- assistance 25%
- training 11%
- information 14%

(International activities and external communication account for 7%)

Some figures

Staff

- 586 employees including
- 210 people based in the Paris headquarters and
- 376 people in INRS's Lorraine centre in Vandœuvre-lès-Nancy

Budget

- €82.5 million including 98% from the National Fund for the Prevention of Occupational Accidents and Diseases

Target Audience

- 18.6 million employees and
- 1.7 million companies that fall under the general Social Security scheme

Contents

■ Foreword

Editorial by the Scientific Director of INRS	4
Scientific Commission of INRS	6
Follow-up Groups	7
“Studies and Research” Activities of INRS Divisions	10
Interview with the Chairperson of the Scientific Commission of INRS	12
2015 Studies & Research Annual Report	14

■ 2015/2016 Studies & Research Programme

Overview of the studies conducted in 2015/2016 by topic:

Accidentology and Prevention Culture	15
Occupational Allergies	16
Noise, Vibration, Electromagnetic Fields, and Optics	18
Design of Work Equipment, Workplaces, and Working Situations	25
Waste and Recycling	26
Multiple Exposures: Chemicals and Noise	30
Manufactured Nanomaterials	32
Organisation, Health and Safety at Work	35
Prevention of Occupational Cancers	37
Reproduction and Work	39
Biological Risks	41
Chemical Risks	44
Mechanical Risks and New Technologies for Accident Prevention	58
Risques psychosociaux	60
Occupational Road Accident Risk	63
Musculoskeletal Disorders of the Limbs and of the Back	64
Ageing, Staying in Employment, and Preventing Occupational Exclusion	67

■ Partnerships

■ Presentations and Publications in 2015

■ List of Publications 2015





Professor Didier Baptiste
Scientific Director of INRS

Editorial by the Scientific Director

With its distinctive feature of having 4 modes of action (studies and research, assistance, training and information) at disposal, INRS provides practical and concrete knowledge in the field of occupational safety and health. The end purpose of the Studies and research activity is to act in the sphere of occupational risk prevention, which is a multifarious and changing domain, in order to anticipate and correct working situations that are potentially dangerous. Understanding generates innovation; and acquiring such knowledge leads to new methods or techniques that can then be transferred to industry. In 2015, this approach was illustrated particularly in the field of chemical risks.

Although exposures to substances has decreased in recent years, and levels of pollution are lower – thanks to unprecedented scientific and regulatory contributions – the risk for health remains a major concern for stakeholders in occupational safety and health. Over 100 million substances were identified at the end of 2015 in the Registry of the Chemical Abstracts Service.

INRS's researchers are mobilised to understand the impact of the use of chemicals on the working environment and to contribute to lowering the concentrations to the lowest possible levels. They are continuing their work on determining hazards (toxicology) and effects on health (cancers, allergies, etc.), on new substances (nanomaterials, etc.), on characterising exposures (characterisation methods), and on biomonitoring (measurement and monitoring). Other aspects related to the real activity on the ground are being studied, such as multiple exposures or co-exposures (combined effects, and synergic effects), ergonomics (analysis of work stations), epidemiology (highlighting health damage related to exposures), type of protection (filters, collective and personal protective equipment), and treating emissions at source (collection, etc.).

INRS also attaches importance to transfer and appropriation of knowledge. An international scientific conference organised in April by the INRS research teams thus made it possible to take stock of the latest innovations for assessing and reducing chemical exposures. 360 participants were able to discover the methods available or in the pipeline, the summaries of which were published in the journal *Hygiène et Sécurité du Travail*. A technical day devoted to exposure to welding fumes also facilitated sharing of information, in particular on innovative welding stations. New assessment tools produced through the studies & research work have also been made available to companies (tools such as Metropol, Seirich, etc.).

To understand and to innovate in studies & research is also to act so that prevention is integrated as far upstream of the working situations as possible. With its work on designing future equipment, organising how work is done, and protecting the youngest members of the working population, or ageing workers, and workers exposed to physical or psychological risks, INRS is furthering the progress of the risk prevention culture out in the companies.

We hope that this edition will enable you to better identify the scientific and technical contributions from INRS and that you will like the content of them that is illustrated in it.

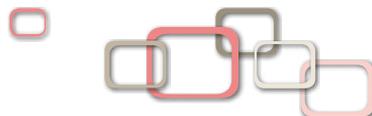
I hope you enjoy the read.



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

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

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

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

Jean-Claude SAGOT	Université de technologie de Belfort-Montbéliard. Laboratoire systèmes et transports. Belfort (90)
--------------------------	--

Other members

Paul AVAN	Institut national de la santé et de la recherche médicale (INSERM) – Université d'Auvergne. Faculté de Médecine. Équipe Biophysique et Neurosensorielle. Clermont-Ferrand (63)
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Raphaël DUMAS	Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux (IFSTTAR). Laboratoire de biomécanique et mécanique des chocs. Villeurbanne (69)
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Daniel EILSTEIN	Institut de veille sanitaire (InVS). Saint-Maurice (94)
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Alexandre GARCIA	Conservatoire National des Arts et Métiers. Laboratoire de Mécanique des Structures et des Systèmes Couplés/Laboratoire d'acoustique (LMSSC). Paris (75)
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Alain GARRIGOU	Université de Bordeaux 1. Département Hygiène, Sécurité et Environnement. Gradignan (33)
-----------------------	--

Yves GONTHIER	Université de Savoie. Polytech/Annecy-Chambery. Le Bourget du Lac (73)
----------------------	--

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)
----------------------	--

Benoit IUNG	Université de Lorraine. Centre de Recherche en Automatique de Nancy (CRAN). Vandœuvre les Nancy (54)
--------------------	--

Annie JOLIVET	Centre d'Études de l'Emploi. Noisy le Grand (93)
----------------------	--

Laurence LE COQ	Ecole des mines. Département systèmes énergétiques et environnement. Nantes (44)
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Benoît MAUNIT	Université d'Orléans. Institut de chimie organique et analytique (ICOA). Orléans (45)
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Alain PINEAU	Faculté de pharmacie. Laboratoire de toxicologie. Nantes (44)
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Nicolas TRICOT	Institut National de Recherche en Sciences et Technologies pour l'Environnement et l'Agriculture (IRSTEA). Unité de recherche Technologies et systèmes d'information pour les agrosystèmes. Aubieres (63)
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David VERNEZ	Institut universitaire romand de santé au travail. Lausanne (Switzerland)
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Christophe VIAL	Institut Pascal. Axe Génie des Procédés, Énergétique et Biosystèmes (GePEB). Aubiere (63)
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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

Amélie ADAM	Association Lorraine de Santé en Milieu de Travail. Ludres (54)
Dominique CHOUDAT	Groupe hospitalier Cochin. Service de pathologie professionnelle Université Paris Descartes. Paris (75)
Alexis D'ESCATHA	AP-HP. Unité de Pathologie Professionnelle, de Santé au Travail et d'Insertion. Garches (92)
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)
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Members of the Working Life Follow-up Group

Christophe BONNAUD	CARSAT Auvergne. Département Risques Professionnels. Clermont-Ferrand (63)
Sandrine CAROLY	Université de Grenoble-Alpes. UMR PACTE. Grenoble (38)
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Raphaël DUMAS	Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux (IFSTTAR). Laboratoire de biomécanique et mécanique des chocs. Villeurbanne (69)
Alain GARRIGOU	Université de Bordeaux 1. Département hygiène, sécurité et environnement. Gradignan (33)
Catherine HELLEMANS	Université libre de Bruxelles. Faculté des Sciences Psychologiques et de l'Éducation. Brussels (Belgium)
Annie JOLIVET	Centre d'Études de l'Emploi. Noisy le Grand (93)
Annette LECLERC	Institut national de la santé et de la recherche médicale (INSERM). Unité 687- hôpital Paul Brousse. Villejuif (94)
Jean-Pierre LIBERT	Université de Picardie Jules Verne. Laboratoire Peritox. Amiens (80)
Pascal MADELEINE	Aalborg University. Department of Health, Science and Technology. Aalborg East (Denmark)
Philippe MAIRIAUX	Université de Liège. Faculté de médecine. Département des sciences de la santé publique. Liège (Belgium)
Arnaud MIAS	Université Paris-Dauphine. Institut de Recherche Interdisciplinaire en Sciences Sociales (IRISSO). Paris (75)
Michel NIEZBORALA	Association de Santé au Travail Interentreprises et de l'Artisanat. Toulouse (31)
Jean-Michel SCHWEITZER	Association régionale pour l'amélioration des conditions de travail (ARACT). Metz (57)

Members of the Work Equipment Engineering Follow-up Group

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Emmanuel FOLTETE	École Nationale Supérieure de Mécanique et de Microtechniques (ENSMM). Département Mécanique appliquée. Besançon (25)
Alexandre GARCIA	Conservatoire National des Arts et Métiers (CNAM). Laboratoire de mécanique des structures et des systèmes couplés (LMSSC). Laboratoire acoustique. Paris (75)
Benoît IUNG	Centre de Recherche en Automatique de Nancy (CRAN). Vandœuvre les Nancy (54)
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Emmanuel MARTEAU	CRAM Ile-de-France. Paris (75)
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Philippe GÉRARDIN	Université de Lorraine. Faculté des sciences et technologie. Laboratoire d'études et de Recherche sur le Matériau Bois. Vandœuvre les Nancy (54)
Yves GONTHIER	Université de Savoie. Polytech' Annecy-Chambéry. Le Bourget-du-Lac (73)
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Michel LEBRUN	CARSAT Auvergne. Centre interrégional de mesures physiques. Clermont-Ferrand (63)
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Christophe VIAL	Institut Pascal. Axe Génie des Procédés, Énergétique et Biosystèmes (GePEB). Aubiere (63)

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)
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Caroline DUCHAINE	Centre de Recherche Hôpital de Laval. Département de Biochimie et de Microbiologie. Sainte-Foy (Quebec)
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Pierre LE CANN	École des hautes études en santé publique. Rennes (35)
Benoît MAUNIT	Université d'Orléans. Institut de chimie organique et analytique (ICOA). Orléans (45)
Valérie PICHON	Ecole supérieure de physique et de chimie industrielles de la ville de Paris (ESPCI). Paris (75)
David VERNEZ	Institut universitaire romand de santé au travail. Lausanne (Switzerland)

Members of the Toxicology and Biomonitoring Follow-up Group

Brice APPENZELLER	Institut de Santé du Luxembourg. Laboratoire de Biomonitoring. Esch-sur- Alzette (Luxembourg)
Paul AVAN	Institut national de la santé et de la recherche médicale (INSERM) – Université d'Auvergne. Faculté de Médecine. Équipe Biophysique et Neurosensorielle. Clermont-Ferrand (63)
Jacques BOPP	ORANGE. Service de Santé au Travail. Mulhouse (68)
Robert GARNIER	Hôpital FernandWidal. Centre antipoison. Paris (75)
Marie-Claude JAURAND	Institut national de la santé et de la recherche médicale (INSERM). CEPH/IUH. Paris (75)
Saadia Kerdine-Römer	Université Paris-Sud – Faculté de pharmacie – Laboratoire d'excellence en recherche sur le médicament et l'innovation thérapeutique (LabEX LERMIT). Chatenay-Malabry (92)
Pierre LeBailly	Centre François Baclesse. UMR INSERM Cancers et Prévention. Caen (14)
Alain Pineau	Faculté de pharmacie. Laboratoire de toxicologie. Nantes (44)



“Studies and Research” activities of INRS

In 2015, studies and research actions accounted for 43 % of INRS activities.

In 6 divisions and 21 laboratories at the Lorraine Centre, these activities are conducted by researchers, engineers, physicians, technicians, chemists, toxicologists, ergonomists, etc. These divisions total 255 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 with particles of nanoscale 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:

- Occupational Acoustics
- Electromagnetism – Vibration - Optics
- Design – Protective Equipment – Human-Machine Interfaces
- Safety of Work Equipment and Automated Systems

Working Life

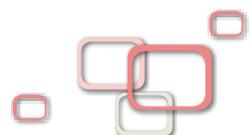
This division conducts scientific activities aimed at improving working conditions by producing and transferring knowledge, approaches, methods, and tools resulting from research, and intended for stakeholders in occupational risk prevention. Focused on analysis of real working life activity, and of 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

Denis Boulaud
Chairperson of the Scientific
Commission

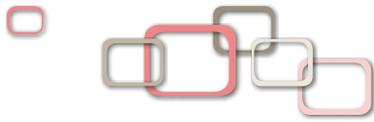
3 questions for Denis Boulaud

You have just been appointed Chairperson of INRS's Scientific Commission, on which you have been contributing your expertise for the last 14 years. What is your view of the «studies & research» activity at INRS and of how it has changed in recent years?

I have indeed been contributing to the work of INRS's Scientific Commission since 2002. I was Vice-Chairperson from 2008 to 2015 and then agreed to be Chairperson at the beginning of 2016. I have also been leading the Pollutants Metrology Division's Follow-up Group since 2008. Over the last 14 years, I have seen a significant change in INRS's studies & research with them opening up, with increasing assertion, to external collaborations, in particular through contributing to European projects and to projects funded by ANR (the French National Research Agency). The number of PhD students has also increased considerably over the last 10 years, showing how dynamic and attractive research at INRS is. This change has, in particular, been apparent in terms of scientific dissemination of the findings of the studies & research, with a remarkable increase in the numbers of publications in peer-reviewed international journals.

The Scientific Commission and the Follow-up Groups have just been appointed for a new term. How do you see the role of this body in charge of assessing the studies & research work at INRS?

The discussions and decisions of the Scientific Commission are based primarily on the Follow-up Groups who painstakingly assess and monitor the studies & research with external experts having specialities that are well in tune with the scientific disciplines of the various divisions. Those opinions, with their associated recommendations, are then consolidated on the Scientific Committee, whose members debate collegially on how well founded they are. In this process, the link-up between the Follow-up Groups and the Scientific Commission is essential and we should be watchful to ensure that the richness of this process is preserved at all levels as we move forward. This dual system (Scientific Commission & Follow-up Groups) thus enables the work of INRS to be supported usefully as regards not only assessment but also monitoring & follow-up, with the Scientific Committee requiring changes of direction for the work whenever it deems necessary.



In your opinion, what are the future needs as regards research dedicated to occupational safety and health? At national level, what role does INRS play upstream from these issues for the benefit of occupational risk prevention?

Naturally, the research conducted at INRS should meet the needs of the working world, which has to cope not only with risks that have been identified for many years, but also with emerging risks. INRS's topics for studies & research are well rooted in the current issues with prevention of chemical & biological risks, physical & mechanical risks, and risks related to how work is organised. Within these three major topics, new concerns are appearing, the following list of which is not exhaustive, such as nanoparticles, bioaerosols, multiple exposures, sound disturbance, which is a source of discomfort and fatigue, human-robot coactivity, well-being at work, and the increase in the age of employees in the working world. In taking up these challenges, INRS plays a leading role in preventing such occupational risks in France, by anticipating problems through continuous science watch and continuous analysis of needs, in order to ensure that the work conducted is relevant and applicable.



Career path

"After my PhD in Physics at the University of Paris VI, I held various posts at CEA (France's Alternative Energies and Atomic Energy Commission), and then at IRSN (French Institute for Radiological Protection and Nuclear Safety): head of laboratory, head of department, deputy director of operations for studies & research on transfer of contaminants in facilities and in the environment. This path led me to develop specific skills in the fields of air management, aerosol physics, and aerosol metrology, in particular for nanoparticles. "

IRSN's Identity Card

The French Institute for Radiological Protection and Nuclear Safety (IRSN) has 1,748 employees, including many specialists, engineers, physicians, agronomists, veterinary surgeons, technicians, experts, and researchers. IRSN is a state-funded industrial and commercial establishment governed jointly by the French Ministries for Ecology, Research, Energy, Health, and Defence.

IRSN provides expertise and research in the following fields:

- nuclear safety;
- safety in transporting radioactive and fissile materials;
- protecting humans and the environment from ionising radiation;
- protecting and monitoring nuclear materials; and
- protecting nuclear facilities.

2015 “Studies & Research” Annual Report

89 studies (totalling 240,837 hours) were conducted in 2015 by the scientific and technical divisions of INRS, the activity represented by these studies accounting for 43% of the volume of work of INRS.

These studies & research activities come mainly under 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 2015, as in the preceding years, the topic “chemical risks” predominates (28% of the studies & research activity). Then come the themes of “manufactured nanomaterials” (10%), and “noise, vibration, electromagnetic fields, and optics” (10%). Topics related to organization at work, ageing, psychosocial risks and musculoskeletal disorders represent altogether 16%.

The following pages offer detailed presentations of the 18 studies that were completed by the end of 2015 (status given after the title), as well as short summaries of all of the 85 studies in progress in 2016. 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 under which the studies conducted in 2014/2015 come

 Accidentology, and Perception & Acceptability of Occupational Risks

 Occupational Allergies

  Noise, Vibration, Electromagnetic Fields, and Optics

 Design of Work Equipment, Workplaces, and Working Situations

 Waste and Recycling

 Multiple Exposures: Chemicals and Noise

 Manufactured Nanomaterials

 Organisation, Health and Safety at Work

 Prevention of Occupational Cancers

 Reproduction and Work

 Biological Risks

   Chemical Risks

 Mechanical Risks and New Technologies for Accident Prevention

 Psychosocial Risks

 Occupational Road Accident Risk

 Musculoskeletal Disorders of the Limbs and of the Back

 Ageing, Staying in Employment, and Preventing Occupational Exclusion



Accidentology and Prevention Culture (ACC)

One of the objectives 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 have two focuses:

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

2009 > 2016



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.

2016 > 2019



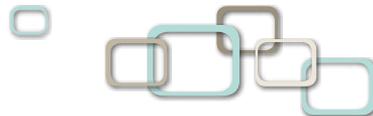
Developing and testing a method of analysing Accidents with Movement Disturbance (AMDs) intended for corporate prevention specialists

■ **Sylvie LECLERCQ**

Working Life Division

The aim of this study is to develop an AMD analysis method for corporate prevention specialists. The ultimate goal is to change the way such accidents are taken into consideration so that they are better prevented, by identifying the factors (in particular the environmental and organisational factors) that combine to cause a movement disturbance in a working situation. The resulting method, which will include identification of appropriate prevention measures, will be implemented in practice in ten companies with the aim of then incorporating the feedback from that practical testing.





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; and
- identifying the determining factors that contribute to exposures to allergy risks.

2013 > 2018



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.

2014 > 2016



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 – 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.

2013 > 2017



Severity and control of work-related asthma

■ **Valérie DEMANGE and Anca RADAUCEANU**

Occupational Epidemiology Division

■ **PhD thesis: Hermine MEVEL**

University of Lorraine – 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 (professions) or sectors in which prevention of respiratory pathologies needs to be reinforced.

2016 ▶ 2019



Developing standardised analytical protocols for searching for allergens in protective gloves

■ **Danielle JARGOT**

Pollutants Metrology Division

The aim of the study is to define and validate analytical protocols that are effective in detecting allergens in protective gloves. The most frequently offending sensitizers, the emerging allergens, and those raising diagnosis difficulties will be prioritized. The aim of these analyses is to develop an investigation tool supplementary to the skin allergist's assessment for preventing the risks of allergic skin conditions, for checking the efficacy of the protective gloves used by the diagnosed employees, and, ultimately, for enabling them to stay in their jobs.

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Noise, Vibration, Electromagnetic Fields, and Optics

Noise

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.

2015 > 2018



Calculating speech noise exposure indicators in the tertiary sector

■ Patrick CHEVRET

Work Equipment Engineering Division

■ PhD thesis: Krist KOSTALLARI

INSA - Etienne PARIZET

This study pursues two directions in the framework of reducing noise nuisances in open-space offices. One focuses on the development of prediction tools to obtain sound ambiance indicators. The second is linked to the consequences on performances and fatigue of exposure to speech noise, judged to be of the greatest nuisance in open-space offices

2016 > 2019



Perception of audible alarms by hearing-impaired employees wearing hearing protectors

■ Jean-Pierre ARZ

Work Equipment Engineering Division

The aim of this study is to develop methods of assessing the parameters guaranteeing that sound signals are perceived in noisy surroundings, in particular in the presence of hearing deficiencies and when protectors for protecting their wearers from noise are being worn. The first method will be based on sound simulations in order to reproduce what is heard by hearing-impaired people and what is heard by hearing-normal people, and the second method will be based on a psychoacoustic model for calculating the sound level necessary for an alarm to be audible in ambient noise. At the end of the study, the two tools will be made available to risk prevention specialists.

2016 > 2017



Acoustic holography, by scanning, for noisy machinery

■ **Armand NÉJADE**

Work Equipment Engineering Division

This investigation aims at developing an approach in acoustic holography technique that uses a novel data acquisition technique. Two methods are implemented, namely the “Equivalent Source Method (ESM)” and “Statistically Optimized Near-Field Acoustic Holography (SONAH)”. The idea is to devise a practical tool for the industry to locate noise sources and to identify the radiation mechanisms in machinery or other structures.

2013 > 2017



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



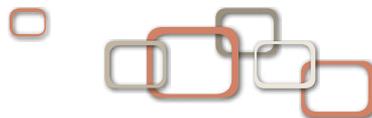
Modelling and experimental characterisation of mechanical vibration propagation in the upper limb when using rotary handheld machinery *(completed in 2015)*

■ **Christophe NOËL**

Work Equipment Engineering Division

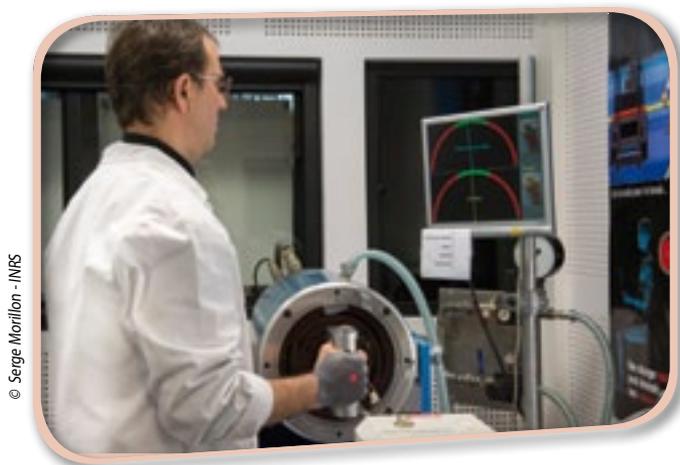
Outline of reasons and objectives

Today, in France, approximately 11% of salaried workers are exposed to vibration transmitted to the upper limb. Prolonged exposure to high levels of vibration can lead to a certain number of pathologies. To try and protect workers, daily exposure to vibration is governed by regulations and is assessed in compliance with a measurement standard that currently does not guarantee sufficient protection for workers if we consider vascular disorders such as Raynaud's phenomenon. Our ultimate aim is to provide knowledge enabling certain physiopathological effects of vibration on the digital vascular system to be better taken into account in the standardised method for assessing exposure to vibration. This study therefore aims to measure and to predict the mechanical effects of the vibration transmitted to the hand-finger system and to assess the influence of certain factors on vibration propagation (gripping force, pushing force, amplitude of the vibration, etc.).



Approach

At the scale of the hand, an experimental setup was implemented using a scanning laser vibrometer, which made it possible to estimate the local biomechanical characteristics at the surface of the dorsal face of a hand gripping a vibrating handle. At the scale of the phalange, a test setup was built to measure the biodynamic response of the vibrated pre-stressed phalange. In addition, an appropriate numerical mathematical model was developed for simulating the same experimental conditions, and for calculating the thermo-mechanical magnitudes inside the biological tissues of the finger, such data being difficult to access by experimentation. All of the measurements were taken on a group of 20 volunteers, under a biological research protocol.



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Main results

The local biomechanical responses at the surface of the hand were spatially heterogeneous. They highlighted zones of high vibration absorption (soft tissues) and zones of low vibration absorption (metacarpals). Compared with the pushing forces or thrust forces, the gripping forces were of predominant significance in vibration transfer between the wrist and the hand. The measurements showed that the phalanges had mechanical behaviour similar to that of certain elastomers with a flexibility that varied little, up to 125 Hz, and then high stiffening above that frequency. For the numerical model, a new mechanical behaviour relationship, based on physiological considerations, was devised. The associated parameters were then identified (test/calculation error less than 8%).

Discussion

As regards prevention, the measurement methodologies developed can be used to characterise the vibration attenuation performance of anti-vibration solutions (gloves, and handles). Charts giving contours for dissipated power as a function of acceleration level and frequency of vibration have been established. They offer a potential avenue to explore for changing the standard for measuring exposure to vibration. From a scientific viewpoint, the numerical model designed and validated in this study constitutes the first stage in a multi-scale strategy whose ultimate objective is to predict certain effects of vibration on deregulation of basal arterial vasoconstriction by taking into account the coupling between mechanics, biology, and physiology.



Developing a tool for implementing the “Vibration” Decree for operatives of handheld vibrating machinery *(completed in 2015)*

■ **Éric CARUEL and Patrice DONATI**

Work Equipment Engineering Division

Outline of reasons and objectives

Over 2 million salaried workers use handheld vibrating machinery. Regular exposure to such vibration can give rise to disorders that are recognised as occupational diseases giving entitlement to compensation. With the aim of prevention, French Decree No. 2005/746 requires companies to assess exposure to vibration, which can be complicated to achieve in practice.

The objective of this study was to develop a digital application for easy and measurement-free estimation of exposure of operatives to hand-arm vibration. For this purpose, it was necessary to:

- collect a considerable amount of hand-arm vibration data in order to quantify the distribution of the vibration emission values per family of commonly used machines;
- determine the parameters of the machinery and the tasks influencing the vibration levels; and
- develop a method of building the application.

Approach

The vibration measurements were taken in compliance with Standards NF ISO 5349-1 and 2 on the zones at which the operative takes hold of the vibrating machinery as used in real situations. The work was done firstly by the nine physical measurement centres of the French Regional Health Insurance Funds and by INRS, with them all having previously harmonised their mode of operation and their measurement datasheets, and secondly by the Health and Safety Laboratory (HSL), the British counterpart of INRS. In all, more than 122 families of machines grouped together into four categories were listed, the four categories being construction, green spaces, woodworking, and metalworking. All the measurement datasheets were collected and completed by INRS via the Internet for the physical characteristics of the machines. On the basis of the data collected in the database and for each family of machines grouping together at least 30 measurements, a detailed analysis was done that aimed to highlight the main parameters affecting the measured vibration values for each family. Building the application for assessing the vibration risk will be based on the conclusions of that analysis and also on the practical experience acquired in the field.



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Main results

In all, 1875 measurement datasheets (including 600 from HSL) were collected and distributed over a set of 122 families of machines. The analyses were performed on the 18 families including at least thirty datasheets, some of those families including more than 200. The large quantity of vibration acceleration data together with knowledge of the characteristics of the machinery and of the environment made it possible to determine 37 sub-families of homogeneous machines that were defined on the basis of parameters easily accessible by users

(tasks done or machine characteristics). Checks were made to ensure these sub-families gave acceleration values that were different (at least by 30%). For each sub-family, a specific questionnaire on the conditions of use was written. A prototype application was built and, for each sub-family, it gives an estimated daily exposure for the operative, a comparison with the regulatory exposure limit values, and appropriate prevention advice. For this purpose, the user should identify the sub-family, answer the questionnaire and indicate the length of exposure.

Discussion

The vibration datasheets will continue to be collected so as to cover more families, in particular tamping rammers, jackhammers, sanders, hedge trimmers, etc. Before it is made available on the INRS website, the application should operate in a user-friendly and reliable manner. It should be validated by the specialists from the French Regional Health Insurance Funds and be tested by prevention specialists in companies.



Mapping static and dynamic postures in seated operatives of vibrating mobile plant or vehicles *(completed in 2015)*

■ Maël AMARI

Work Equipment Engineering Division

Outline of reasons and objectives

Prolonged exposure to whole-body vibration increases the risk of low-back pain problems. In France, 3 million mobile plant operatives who work in the sitting position may be exposed to this type of stress (drivers of tractors, bulldozers, excavators, forklift trucks, ride-on lawnmowers, etc.). The procedure for assessing vibration risks does not take account of the position of the body and of the movements related to doing a work task, even though those parameters are considered to be significant cofactors in the risk. To improve prevention in the field of vibration, INRS aims to incorporate postural constraints into the next revision of Standard ISO 2631-1:1997, and, in the longer term, aims to develop a combined posture and vibration assessment method.

In this context, the objectives of the study were to take vibration and posture measurements simultaneously at the driver stations of vibrating mobile plant for (1) identifying postural indicators relevant for distinguishing between types of plant, (2) estimating inter-individual differences in posture between operatives doing identical work tasks, and (3) assessing, under real conditions, the differences in posture between operatives for the main families of machines.

Approach

Vibration measurements were taken in compliance with Standard ISO 2631-1:1997. A seat pad accelerometer was placed on the seat of each of the vehicles. Posture measurements were taken in compliance with the recommendations of the standardised technical report ISO/TR 10687:2012 by means of the CUELA¹ system developed by IFA². The angular differences of the segments of the body were compared with limit values derived from Standard EN 1005:2005 for evaluating working postures and movements.

The inter-individual posture variations were estimated by comparing measurements taken with 12 drivers on 3 construction vehicles (loader, dumper, and excavator) under controlled conditions.

125 measurements representative of the real exposure of the operatives were taken in companies for 13 families of plant.

Main results

This study made it possible to identify two distinguishing indicators for the static positions and for the movements. Significant differences were observed between drivers doing identical work tasks. It was possible to attribute some of

¹ CUELA: Computer-Unterstützte Erfassung und Langzeit-Analyse von Belastungen des Muskel-Skelett-Systems

² IFA : Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung, German counterpart of INRS

the differences to driving strategies that were common to several different vehicles. Differences between the postures taken up by the drivers were observed depending on the vehicles both in the static positions and during the movements. Some of the differences were significant from the point of view of the procedure for evaluating the risk defined by Standard EN 1005:2005.

Discussion

The segments of the body and the movements that had the most significant differences relative to the reference positions were identified. The list of descriptive quantities for postures that is recommended by Standardised Technical Report ISO/TR 10687:2012 has thus been reduced for the families of vehicles measured.

The mapping of postures and of vibration will be continued as and when companies ask for assistance. Certain vehicles will be studied as priorities (tractors, lawnmowers, forklift trucks, etc.). The research efforts should now focus on developing a severity criterion that takes posture and vibration into account simultaneously. For that purpose testing will be done in the laboratory under controlled conditions.

2014

2017



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 - 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.

2015

2017



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.

2015

2017

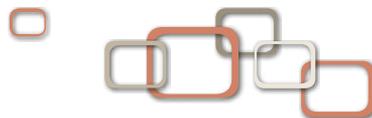


Seeking solutions for attenuating vibration on travelling goods-handling vehicles by implementing floor treatment

■ **J r me REBELLE**

D partement ing nierie des  quipements de travail

This work aims to study implementing floor treatment and limiting any obstacles or breaks in slope that the floor might include in order to reduce generation of vibration and of shocks. It is planned to develop operational dock leveller and adjustable ramp prototypes. The experimental approach will lead to a critical analysis of the solutions available on the market, whether they involve implementing “anti-vibration” treatment or installing new devices, so as to make it possible to guide the choices made by buyers and users.



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.

2016 > 2018



EXTI: Exposure of workers to industrial electromagnetic fields

■ **Mélina BOULDI**

Work Equipment Engineering Division

This study aims to develop numerical and experimental tools making it possible to obtain a parametric assessment and relevant predictions for worker exposure to electromagnetic fields in industrial environments. Various different approaches will be combined: numerical simulations based on models of human bodies and of sources; in situ mapping of the fields radiated around a press; in vitro measurements of the internal field in an instrumented gel manikin.



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.

2011 > 2017



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 measurements are necessary, the aim is to make available to occupational safety and health specialists a method of measuring such radiation at the work station.



Design of Work Equipment, Workplaces, and Working Situations

Beyond compliance with regulatory requirements, the “integrated prevention” approach enables designers, company managers, and OSH player 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.).

2012 > 2017



Developing a methodology for safe detailed design of work equipment

■ Jacques MARSOT, Bruno DAILLE-LEFEVRE
and Aurélien LUX
Work Equipment Engineering Division

■ PhD thesis:
Nicholas de GALVEZ - *ENSAM ParisTech - Pr Patrick MARTIN*
Ismaël EL MOUAYNI - *ENSAM ParisTech - Pr Jean-Yves DANTAN*

The objective of the study is to develop a structured and tooled approach that is applicable in the detailed design phase. It is during 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.

2014 > 2017



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

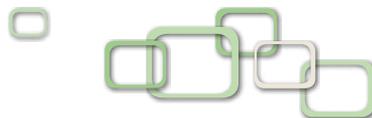
■ Jonathan SAVIN
*Work Equipment
Engineering Division*

■ Clarisse GAUDEZ and Martine GILLES
Working Life Division

■ PhD thesis: Jonathan SAVIN
*Université Pierre et Marie Curie Paris VI
Pr 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.





Waste and Recycling

The studies & research activities are contributing to designing and organising the sectors (collection, sorting, dismantling, depolluting, treating, recycling & recovering or 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 the levels of exposure of the workers. 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 & recovery or transformation sector, of the building & civil engineering trade, and of the polluted soil treatment sector.



WEEE: reducing chemical risks in existing and emerging sectors
(completed in 2015)

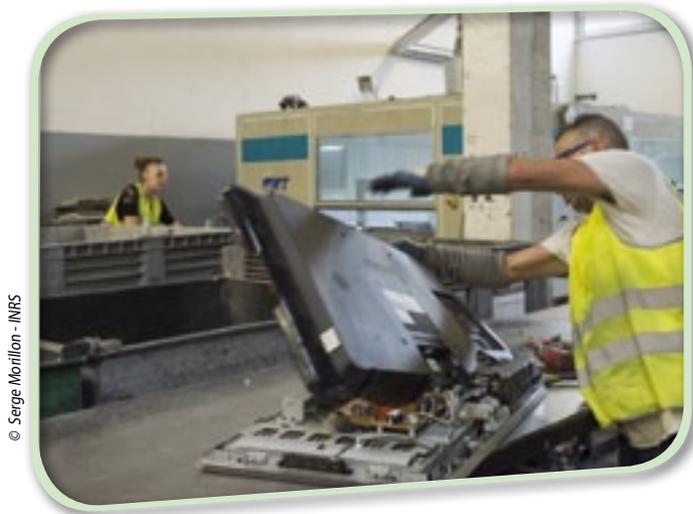
■ **Marie-Thérèse LECLERC and François ZIMMERMANN**
Process Engineering Division

Outline of reasons and objectives

The sectors and channels for treating Waste Electrical and Electronic Equipment (WEEE) have changed considerably in recent years due to the regulatory context and to the development of new technologies. In the existing and mature sectors, the means for action on occupational risk prevention are limited. Conversely, risk prevention actions conducted during the emergence phase of new sectors are more efficient for preserving worker health. The objectives of this study are to monitor the existing treatment sectors, to assist companies in industrialising their processes in the emerging sectors, and to optimise the treatment processes so as to reduce exposure to pollutants at source.

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Approach

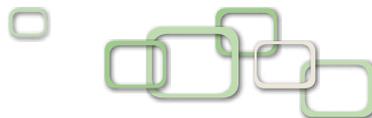
Assessments of chemical risks were conducted in the existing treatment sectors (cathode ray tube (CRT) screens, used light bulbs, and small household electrical appliances) and in the emerging sectors (flat screens) for each process and per unitary operation. The monitoring of the emerging sectors was conducted from the design phase of the processes onwards and continued up to industrialisation of them.

In view of the issues related to the presence of mercury in the treatment sectors, mercury material balances and a parametric study were conducted to determine the influential factors making it possible to optimise the processes for treating mercury waste.

Main results

All of the treatment sectors are affected by chemical risks. The sector most contaminated by pollution is the used light bulb treatment sector, in which the main pollutant is mercury. In the CRT screen treatment sector, the high levels of exposure remain a concern, with the exposure limit value for lead being exceeded. In the flat screen treatment sector, an initial phase of assessment of the pilot processes showed that the chemical risk would appear to lie mainly in the levels of exposure to lead. The pilot processes having the highest exposure levels were not selected during the call for bids, whereas the prototypes offering the lowest exposure levels were awarded the treatment contracts. A second phase of assessment on the new processes as industrialised showed relatively low exposure levels.

The mercury material balances in used light bulb treatment showed considerable variability in the distribution of the mercury in the various output fractions. The parametric study made it possible to determine the parameters that are influential in optimising treatment of mercury. All of this laboratory work on used light bulbs was used advantageously to assess the mercury treatment performance of an industrial process in the liquid crystal display (LCD) screen treatment sector.



Discussion

In this context of the development of new sectors, the proposed prevention approach satisfied the pragmatic requirements of recycling and of environment-friendliness. It enabled decision-takers and eco-organisations to be assisted in including a health and safety part in the specifications for the treatment companies. This had three benefits for occupational safety and health, namely:

- making recommendations to process designers and to treatment companies;
- seeking technical solutions for optimising processes in which emissions were too high;
- selecting for industrialisation those processes that had the lowest exposure levels.

Ultimately, when the sector becomes mature, this initial approach will steer it “naturally” towards the “best available technologies”.



Overview of exposure of employees working to decontaminate contaminated soils (*completed in 2015*)

■ **Pascal POIROT**

Process Engineering Division

Outline of reasons and objectives

Rehabilitating polluted sites and soil is a sector of activity that is booming in France, due to an industrial context that is leading to an increase in industrial wasteland, and to the action of the French Ministry of Ecology who made it a priority at the “Grenelle de l’Environnement” talks. Beyond the risks that such sites can have for health and the environment, depollution of soil, which is still a recent activity, raises chemical risk issues. The objective of this study was to produce an overview of the sector so as to identify the decontamination techniques used and the risky jobs involved in decontaminating soil, and so as to assess and measure worker exposure to chemicals and, in certain cases, biological agents during the various treatment operations. If high levels are brought to light, the reasons for them will need to be analysed, and collective prevention measures will need to be studied.



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Approach

The methodology for identifying depollution sites used the database Basol developed by the French Ministry for Ecology, Sustainable Development, and Energy (MEDDE), but, above all, it was based on cooperation with the Union des Professionnels de la Dépollution des Sites (UPDS, the French Association of Site Decontamination Professionals) for collecting the necessary information from the decontamination sites before conducting measurement campaigns on them. Seven campaigns of measurements were conducted on building sites or other sites polluted with hydrocarbons, the main pollutant, and they made it possible to assess the chemical exposure of the workers during the decontamination work.

Main results

On the outdoor worksites, the study highlighted total particulate matter (TPM) concentration levels that were low, and showed that the various operatives, be they ground workers or excavator drivers, were exposed only to very low levels. As regards the total hydrocarbons potentially present in the soil, the analyses of the samples generally indicated low content for aromatic hydrocarbons of the BTEX (benzene, toluene, ethylbenzene and xylenes) type present in the working atmosphere, except on one worksite, where the content was higher (50% of the occupational exposure limit (OEL) value for benzene).

Conversely, on a worksite enclosed under a tent, the study showed TPM and BTEX concentrations that were high, but that did not exceed the OEL values. The use of direct-read photoionisation detectors (PIDs) also showed that the operatives could be subjected to large exposure peaks in spite of the suction/extractor devices. It should be noted that other pollutants, such as polycyclic aromatic hydrocarbons (PAHs) and chlorinated solvents that were potentially present in soil (diagnostic survey stage), were measured on certain worksites as traces in the ambient air.

Discussion

Due to the considerable diversity of the parameters governing the activity, the study enabled only a partial approach to be taken, by targeting the work sites proposed by the French Association of Site Decontamination Professionals (UPDS). However, most of those building sites or other sites having soil polluted with hydrocarbons and using biological decontamination techniques account for 60% of the quantities, excluding confinement. On those sites, the TPM concentrations and the volatile organic compound (VOC) concentrations are generally low when the worksites are outdoors and not enclosed or covered. The study also shows that, despite the suction and extractor devices and systems put in place, a covered excavation worksite can be (very) polluting.

The results will be the subject of a publication in the journal *Hygiène et Sécurité du Travail* (HST), that will be intended for the professionals of the sector, and for OSH specialists.

2013 > 2018



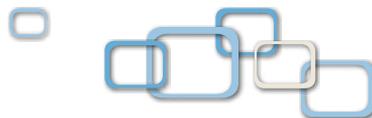
Prevention of chemical and biological risks in anaerobic digester units

■ Patricia DIRRENERGER

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.





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.); and
- assessing the relevance of Occupational Exposure Limit Values OELVs, in particular when doses are small.

2013 > 2016



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 – 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.

2013 > 2016



Alterations 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 - 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. to chlorinated solvents). The model established will make it possible to classify the “noise and ototoxic” associations depending on their dangerousness for hearing.

2014 > 2016



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.

2015 > 2017



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**

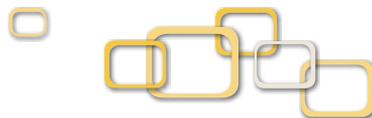
Toxicology and Biomonitoring Division

■ **PhD thesis: Maria CARRERES-PONS**

University of Barcelona – 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 loss 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; and
- proposing risk prevention approaches and tools for firms and laboratories who produce or handle these materials.

2013 > 2017



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

■ **Laurent GATÉ and Christian DARNE**

Toxicology and Biomonitoring Division

■ **PhD thesis: Laetitia CHEZEAU**

University of Lorraine - 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.

2014 > 2017



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).

2013 > 2016



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

■ **Laurent GATÉ**

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.

2014 > 2018



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 measuring performance of determining particle-size distribution and concentration in terms of particle counts of nanoparticle aerosols

2014 > 2017



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 nanoscale nature of this chemical, using metrology conducted on the air inhaled by the operatives during their activities at the workplace, and using a collection of prevention measures associated with the use of nanometric titanium dioxide.

2013 > 2018



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.

2015 > 2017



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 - 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).



2016 > 2019



Nanomaterials and occupational exposure during operations implementing powders: study of the relationships between the physico-chemical properties of the powders and the characteristics of the aerosols emitted at workplaces

■ **Olivier WITSCHGER and Sébastien BAU**

Pollutants Metrology Division

■ **PhD thesis: Claire DAZON**

Université Aix-Marseille –Philippe Llewellyn

In view of the diversity of nanopowders and of occupational exposure scenarios, the objectives of the study are to develop an approach for characterising the powders so that their categories can be determined, to develop methods for studying emission of nanopowder aerosols, and to establish relationships between particle size of the aerosols obtained in the laboratory and particle size of the aerosols to which workers are potentially exposed, through studies of relevant jobs in companies. This work will feed into the French recommendations on assessment of occupational exposure through the methods that will be developed.

2013 > 2016



Impact of sources and of the environment on confinement of nanoparticulate pollutants by collective protective 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.

2013 > 2016



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 unpowered or powered 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 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 roles of designers and of the management on site.

2011 > 2016



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

■ **Virginie GOVARE and Liën WIOLAND**

Working Life Division

■ **PhD thesis: Bérangère Hittinger**

University of Toulouse - 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.

2013 > 2016



“Lean management” company practices and occupational health

■ **Évelyne 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.



2015 > 2019  Occupational exposures and outsourcing practices 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, operative safety, facility safety); comprehending relations between the way maintenance work is organised and the risks for operatives, 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.

2013 > 2016   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 Évelyne MORVAN** ■ **PhD thesis: Leila BOUDRA**
Working Life Division *Université Lumière de Lyon – 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.

2016 > 2019   Analysis of the profession of production system designer: contributions from occupational psychology and from engineering for transforming design practices favouring the health and safety of operatives

■ **Edwige QUILLEROU-GRIVO** ■ **Aurélien LUX**
Working Life Division *Work Equipment Engineering Division*

This study aims to improve the health and safety of operatives by examining the way their working situations are designed. It will include three parts: acquiring knowledge about the real activity of the designers of industrial production systems; identifying the design processes and adapting them to favour occupational risk prevention; and developing an intervention methodology for working with designers to facilitate integrating health and safety into their projects.

2016 > 2018  Analysis of organisational changes associated with use of the Grilles de Positionnement en Santé et Sécurité au Travail (GPS&ST: positioning grids enabling companies to see how they stand with respect to OSH)

■ **Karen ROSSIGNOL**
Working Life Division

This study will be conducted with users of the GPS&ST (OSH positioning grid) tools that were designed ten years ago by the French Prevention Network (Réseau Prévention) to help companies study, report, and objectify their prevention practices. The details collected will make it possible to examine how the tools are used, to understand how the focuses for progress are defined, and how a prevention action plan is developed and then put into application. The results will then be useful for developing recommendations for the prevention specialists so that the GPS&ST grids have organisational effects aimed at improving how well OSH is taken into account.



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 (*completed in 2015*)

■ **Sandrine CHAZELET and Éric SILVENTE**

Process Engineering Division

Outline of reasons and objectives

Following the expert appraisal work published in 2009 by the French Agency for Environmental and Occupational Health & Safety (Agence Française de Sécurité Sanitaire de l'Environnement et du Travail) on asbestos fibre toxicology and metrology, this study, which is part of the INRS "Amiante-META " project, aimed to re-assess the assigned protection factors of the Respiratory Protective Devices (RPDs) that, in theory, offer the highest performance and that are used during the process of removing asbestos-containing materials, by using Transmission Electron Microscopy (TEM) analysis of the samples.

Approach

The first stage was, working in collaboration with the manufacturers, to develop a modified mask prototype integrating an asbestos fibre sampling system in compliance with Standard XP X 43-269 (2002) inside the RPD. The second stage was to have the modified RPDs certified in compliance with the PPE Directive. In parallel with this work, two modes of operation were developed for taking samples on asbestos removal worksites of levels 2 and 3. The protocols were then applied during nine campaigns conducted on six level-3 worksites and on three level-2 worksites. After analysing the samples collected by analytical TEM, statistical exploitation led to determining the assigned protection factors of the two types of RPD targeted: supplied-air devices, and powered air-purifying devices.



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¹ Asbestos – Analytical Transmission Electron Scanning

Main results

Firstly, the study monitored operatives wearing positive-pressure supplied-air devices and performing removal or maintenance tasks, during the following processes performed under level-3 conditions: removal of sprayed-on coatings by scraping; removal of Progypsol® by chipping, very high pressure or tool-holder removal, removal of heat insulation by scraping, removal of Insonastic® by sand-blasting, and removal of Caourep® by chipping. Out of 132 dustiness measurements, 23% exceeded the maximum threshold of 25,000 fibres per litre.

Secondly, operatives equipped with powered air-purifying devices were monitored during processes of removing floor-tile or wall-tile adhesive by chipping or sanding, and during processes of dismantling asbestos-cement pipes. The measurements showed that the threshold value of 6 000 fibres per litre was exceeded very rarely, caused, in part, by poor control of the suction/negative pressure in the zone, and to poor control of the suction/extraction at the source.

The statistical exploitation of the counts gave two protection factor distributions whose 5th percentiles were respectively equal to 250 for the positive-pressure supplied-air RPDs and 100 for the powered air-purifying RPDs.

The data obtained on the INRS samplers in the zone showed that an observer a few metres away from the point of removal was much less exposed than the asbestos-removal operatives.

Discussion

Due to the levels of individual exposure obtained during the study, numerous recommendations for improving task organisation and collective protection have been made and distributed to the companies.

The new assigned protection factor values proposed are strongly related to the specificities of the asbestos removal worksites (other PPE, operative training, adjustment tests, and constraints related to postures, and to confinement).

Furthermore, the results obtained for both types of device cannot be compared because they were assessed on types of worksite and under environmental conditions (humidity, general dustiness, etc.) that were very different.





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.



Biological assessment of occupational exposure to di(isononyl) phthalate (DiNP) (completed in 2015)

■ René GAUDIN

Toxicology and Biomonitoring Division

Outline of reasons and objectives

Di(isononyl) phthalate (DINP) is mainly used as a plasticizer in the flexible PVC industry, as a substitute for di(2-ethylhexyl) phthalate (DEHP). The industrial process is based on extrusion, and then gelling, in order to obtain a solid compound (compounding). It is also possible to obtain solutions referred to as “plastisols”. Unlike DEHP, DINP is not classified as reprotoxic (toxic for reproduction) by the European Union, but new information has been provided by recent publications that highlight the endocrine-disrupting activity of DINP. Three main objectives were set for this study: to assess occupational exposure to DINP in the flexible PVC industry, to estimate the daily internal dose for employees exposed to DINP, and to assess any co-exposure both to DINP and to DEHP.

Approach

With the help of the CARSATs (the French Regional Occupational Health and Pension Insurance Funds) and of the Services de Santé au Travail (company or inter-company occupational health services), we approached several companies from the industrial sectors of flexible PVC who manufactured and/or used solid granulated compounds obtained by mixing PVC, DINP and various additives. Three companies from the compounding sector took part in the study. Urine samples were taken daily, at the beginnings and ends of the shifts, for 5 consecutive days, from 47 volunteers who were employees potentially exposed to DINP. Other samples were taken from 27 employees considered as controls not occupationally exposed and mainly working in administrative departments. The methodology used was based on urine assays for three metabolites of DINP, namely mono-(4-methyl-7-hydroxyoctyl) phthalate (7-OH-MINP), mono-(4-methyl-7-oxooctyl) phthalate (7-oxo-MINP), and mono-(4-methyl-7-carboxyheptyl) phthalate (7-cx-MINP), using a high-performance liquid chromatography technique coupled with tandem mass spectrometry (HPLC-MS/MS). To determine whether there was co-exposure to DEHP, the urinary metabolites of that phthalate were also assayed.

Main results

Analysis of the 358 urine samples from the 47 employees using DINP and of the 216 samples collected from the 27 controls did not show occupational exposure to DINP that was higher in the exposed employees than in the controls, with daily internal doses (median at 3.3 µg/kg of bodyweight per day) very much lower than the acceptable daily doses (European and US ADDs). Only one internal dose measured at 137.3 µg/kg/day exceeded the ADD advocated by the United States. Conversely, the concentrations of metabolites of DEHP that were measured in the collected urine samples bear witness to occupational exposure to that phthalate and confirm that it is still used.

2014 > 2017



Assessing the prenatal toxicity of pyrethroid insecticides in rats

■ **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 reproductive system, the study will contribute to reducing uncertainties about the hazards that might be constituted by occupational exposure to pyrethroids during pregnancy and will help to put in place protective measures.

2015 > 2017



Experimental study of urinary excretion and of toxicity of N-ethyl-2-pyrrolidone

■ **Anne-Marie SAILLEFAIT**

Toxicology and Biomonitoring Division

The aim of this study is to provide new information on the metabolism and the toxicity of NEP after repeated oral administration. It will be conducted in collaboration with the Toxicology Laboratory of the Institut für Prävention und Arbeitsmedizin (IPA), which has expertise in assaying urinary metabolites of NEP. This data will contribute to improved assessment of the health risk of occupational exposure to NEP. It will be possible for the data to be used in a regulatory context for establishing toxicological and/or biological reference values, and when choosing a substitute substance for NMP.

2014 > 2017



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.



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.



Processes for purifying workplace air that is contaminated with microorganisms: an investigative preparatory study on the technical solutions of separation and disinfection (*completed in 2015*)

■ Denis BEMER

Process Engineering Division

■ Philippe DUQUENNE and Xavier SIMON

Pollutants Metrology Division

Outline of reasons and objectives

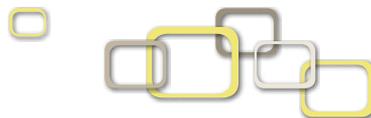
Exposure to bioaerosols (bacteria, moulds, and sub-products or fragments of micro-organisms) present in the air at workstations has been established in numerous occupational sectors. In certain employees, inhaling airborne biological agents has been associated with occurrence of respiratory disorders. Technical solutions have been proposed for preventing such biological risks, in particular air treatment systems designed to reduce the levels of bioaerosol concentration in the workshops or at the workstations. And yet, knowledge about the efficacy of such systems, their harmlessness and their consistency with biological risk prevention is not yet stabilised and does not make it possible to put forward specific recommendations. Such expertise is however necessary in order to be efficient in answering questions from companies or CARSATs (Regional Occupational Health and Pension Insurance Funds) who are faced with significant exposures. In order to study the air treatment solutions that are most appropriate for the bioaerosols that can be generated in workplace air, an preliminary study was launched. The objectives were to acquire the necessary knowledge and a critical assessment of the conceivable treatment processes for treating atmospheres contaminated by bioaerosols, and to determine the test means for supplementing that knowledge.

Approach

The study comprised two parts conducted in parallel:

- a bibliographic study aiming to document the separation/inactivation techniques and to identify the most appropriate processes;
- a pre-study conducted on the basis of two purification processes deemed relevant during the bibliographic search: filtration using a granular bed, and filtration using a metal fibre filter media, the filtration being coupled with thermal inactivation.





Main results

The bibliographic search (> 300 articles) made it possible to identify and to document all of the air treatment processes that aim to remove micro-organisms, all activities considered together. A distinction was made between processes based on direct inactivation of bioaerosols in the air without prior collection, and processes leading to prior separation and collection of the biological particles and to their inactivation by means of different modes of treatment. The step consisting in separating the particles out, when such a step exists, takes place exclusively by means of fibre filter media. Thermal inactivation offers numerous advantages compared with the other techniques due to it being easy to implement and to it guaranteeing that the micro-organisms are completely destroyed. It does not generate any toxic sub-products, which can conversely be generated by oxidation processes and certain chemical treatments.

Discussion

The summarised results of the bibliographic search on the processes for separating/inactivating the microbiological agents constitute an initial foundation of knowledge on the treatment processes conceivable for treating atmospheres contaminated with bioaerosols. It also makes it possible to answer questions from companies or CARSATs, and, where applicable, to give elements of expert appraisal of commercially available processes that some manufacturers propose. However, the data collected do not make it possible to propose a technical prevention solution capable of reducing, with known efficacy, the bioaerosol concentration levels in workshops or at workstations.

The experimental phase made it possible to show that both technologies were capable of presenting high separation efficacies and of allowing a sufficient thermal load to destroy the most resistant micro-organisms, such as fungal entities, for example. These solutions look promising. Additional work will be necessary to validate these techniques with biological particles, and to enable them to be dimensioned for possible industrial application.

Finally, an inventory was taken of the action and prevention means currently available to the French Prevention Network (Réseau Prévention) for improving working conditions and for reducing biological risks in companies. The INRS guides and brochures, and the feedback from the CARSATs may contribute to actions for improving working situations when it is established that employees are exposed to bioaerosols.

2013 > 2017



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 real working settings (sanitation, food industry, maintenance, or tertiary sectors).

2013 > 2017



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.

2015 > 2018



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 - Pierre LEBLOND and 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 emitted bioaerosols in these occupations. 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.

2014 > 2017



Occupational exposure to mycotoxins: biomonitoring and atmospheric assessment

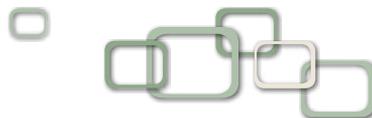
■ **Sophie NDAW and Alain ROBERT**

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 relevant sectors (stock farming, manufacture of animal feed, processing and transformation of food, harvesting of cereal, and handling of straw and fodder).

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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 research for highlighting and for quantifying the hazards related to exposure to chemicals, whether they be toxic, mutagenic, carcinogenic, reprotoxic, allergenic, or neurotoxic, approaches the work from two different 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.



Bladder cancer and oil mists: a prospective cohort study in populations of workers from the steel industry in the Nord-Pas de Calais Region (*completed in 2015*)

■ Ève BOURGKARD and Michel GRZEBYK
Occupational Epidemiology Division

Outline of reasons and objectives

Oil mists are aerosols of cutting fluids comprising straight oils or aqueous fluids (soluble oils or synthetic fluids). Certain chemicals can be present in such fluids or can form while they are being used: in particular polycyclic aromatic hydrocarbons (PAHs) (straight oils and soluble fluids), and nitrosamines (aqueous fluids). The concentration of these pollutants has changed over time due to improvements made in the composition and in the nature of the cutting fluids. Past epidemiological studies have suggested that bladder cancers are more frequent in populations who use cutting oils that are unrefined or relatively unrefined. However, studies per type of fluid show discordant results.

The objective of this study was to seek to determine whether a risk of bladder cancer is associated with occupational exposure to oil mist, resulting from the more recent use of straight oils or of aqueous fluids, while taking into account other occupational and extra-occupational carcinogens. This risk was studied in the steel industry.

Approach

A case-control study was put in place in a cohort constituted by all of the employees hired from 1960 to 1997 in 6 steel works in the Nord-Pas-de-Calais Region. The cases of bladder cancers occurring in the subjects of the cohort, during the period 2006-2012, were identified based on data from the French National Health Insurance scheme, and on information from 21 public and private hospitals in the Nord-Pas-de-Calais Region. The controls were selected from the subjects of the cohort using the counter-matching method. The medical information, tobacco consumption, job history (job titles, dates, tasks performed, exposures) was gathered by questionnaires filled

in face-to-face at the subjects' homes. The occupational exposures from 1960 to 2012 were assessed by experts from INRS and from the Laboratoire Interrégional de Chimie de l'Est (LICE, the Eastern Interregional Chemistry Laboratory).

Main results

This study showed a relationship between occurrence of bladder cancer and occupational exposures to cutting fluid mists of all types, as well as to straight-oil cutting fluid mists. The relationship observed for straight-oil cutting fluids results from exposures dating back over the last 30 years. This study did not show any relationship between bladder cancer and exposures to aqueous fluids (soluble oils or synthetic fluids).

Discussion

Since the straight oils were mainly constituted by mineral oils, this result would appear to argue in favour of the presence of carcinogens contained in mineral oils, whether they be new or used. This study shows that prevention remains necessary in the sectors in which cutting fluids are used. However, effective prevention presupposes improved knowledge of the composition of cutting fluids, be they new or in the process of being used.

Multi-disciplinary studies designed to determine the composition of cutting fluids (new and used), the current atmospheric levels, and their relationships with early-effect biomarkers, would make it possible to improve the targeting of the prevention actions and thus to reduce the frequency of bladder cancers related to exposures to cutting fluids.



Development of a co-culture model to study the genotoxic properties of particles (completed in 2015)

■ Laurent GATÉ and Christian DARNE

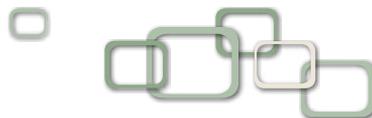
Toxicology and Biomonitoring Division

Outline of reasons and objectives

To meet the expectations of the international bodies in terms of reducing the use of laboratory animals, it is necessary to develop methods that are alternatives to animal experimentation for studying the toxicological properties of manufactured particles to which employees are potentially exposed by inhalation. The majority of the in vitro assessments of the toxicity of such chemicals are performed on monocultures of target cells such as epithelial cells from the lung. However, that experimental approach does not take into account the complexity of the pulmonary tissue or the fact that several different factors are involved in the inflammatory reaction that can result from exposure to particles. The objective of this study was therefore to develop a co-culture model that would take better account of this complexity and of the interactions that take place in vivo in the lungs between the various types of cell.

Approach

A co-culture model was developed. It included epithelial cells (A549 cells), macrophages (differentiated THP1 cells), and granulocytes (differentiated HL60 cells). The system response was assessed by means of a crystalline silica (DQ12) whose inflammatory and genotoxic properties were known, and of its homologous counterpart in an "inactivated" form (covered with polyvinylpyridine-N-oxide) (DDQ12-PVNO). The study of the DNA damage was determined by the comet assay and an inflammatory response was determined by analysis of the expression of the tumour necrosis factor α and of interleukin-8.



Main results

DQ12 but not DQ12-PVNO induced a significant increase in DNA damage in A549 cells grown on their own. The presence of the macrophages and/or of the granulocytes reduced the genotoxic effects of the silica sample. The DQ12 but not the DQ12-PVNO stimulated the expression of interleukin-8 by the A549 cells grown on their own. The presence of the macrophages and/or of the granulocytes increased this production. The phenomena were correlated with the production of reactive species of intracellular oxygen in the A549 cells.



Discussion

This study is one of the first to have assessed in vitro the interaction between the major cellular players in pulmonary inflammatory response. It contributes to showing significant communication between these cells, and to providing additional information on the toxic action mechanism of silicas. However, it does not make it possible to validate the hypothesis that granulocytes can increase the genotoxicity of particles. Although this model needs to be understood in more depth, it could ultimately help assess the toxicity of fibres and particles and thus limit the use of laboratory animals. Due to availability of resources and to the nanotoxicology laboratory being used for in vivo work, such in vitro work cannot be undertaken for the time being. However, technical developments resulting from this study could be used in the laboratory.

This work will be the subject of at least one publication in a peer-reviewed international scientific journal.

■ 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.

2013 > 2016



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.

2014 > 2016



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.

2014 > 2017



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 particulate agents will be assessed with crystalline silica. If it is conclusive, it will be used to screen the carcinogenic potential of manufactured nanomaterials.

2015 > 2018



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

■ **Catherine CHAMPMARTIN and Jean-Paul PAYAN**

Toxicology and Biomonitoring Division

The percutaneous absorption fluxes and the speeds of hydrolysis by two isozymes of esterases of human type will be measured in about ten esters, for which the acid group presents a more or less substituted aromatic nucleus and a constant alcohol group (ethyl or methyl). 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.



Mapping of sectors and processes generating Polycyclic Aromatic Hydrocarbons (PAHs) (*completed in 2015*)

■ Catherine CHAMPARTIN and Hubert MONNIER

Process Engineering Division

Outline of reasons and objectives

Recent work has highlighted new activities such as carbon densification and repairing facilities covered with pitch-based coatings, and during which occupational exposure to Polycyclic Aromatic Hydrocarbons (PAHs) was unsuspected or little-known since the literature does not address or hardly addresses PAH generation during such activities. This shows how difficult it is for hygienists and companies to identify the potential presence of a PAH risk. The objective of this study was to develop and to make available a typological tool for identifying the sectors and the processes that might be likely to generate PAHs, to which 111,000 employees in France are potentially exposed according to the SUMER 2010 survey.

Approach

The study consisted firstly in identifying the sectors of activity in which PAHs were emitted and operatives were exposed. Using benzo[a]pyrene (BaP) as a carcinogenic risk tracer, the risk sectors were prioritised. Six sampling campaigns (atmospheric, urinary, surface, and material or residue samples) were then performed in the activities of gas carburising, carbon densification, and coking to supplement that data. These campaigns made it possible to enrich the knowledge on the PAH generation conditions specific to each of the processes. In a third stage, work was done to check the influence of parameters such as temperature, pressure, and gas reagent flow rate on generation of benzene, of PAHs, and of soot in a process such as low-pressure gas carburising.

Main results

Low-pressure carburising, carbon densification, and coking generated BaP at levels significantly greater than the level recommended by the French National Health Insurance Fund, that recommended level being 150 ng/m³ of air inhaled over an eight-hour shift. During a pyrolysis operation, the gas-phase cracking operating conditions are such that PAHs or PAH precursors are generated. On exiting from the furnaces, the PAHs form deposits on coming into contact with cold surfaces, giving rise to exposures during maintenance and cleaning operations. However, if the furnaces are not completely sealed (leaks or doors open), the exposures can take place during production, in particular for coking. Exposure routes are both by inhalation and via the skin. In addition, the theoretical studies

conducted using a simplified reaction mechanism for acetylene pyrolysis showed that by using low pressure and by reducing the residence time, it is possible to reduce the concentrations of carcinogenic substances and PAH initiators such as benzene.

Discussion

After having monitored exposure of employees in the activities of low-pressure carburising and of carbon densification, over several years and in various different companies, it was observed that implementing prevention solutions made it possible to reduce the high levels of exposure measured during the initial campaigns. However, in the coking sector, they remained very high, or indeed excessive, for certain jobs/workstations. In that sector, there is room for progress and efforts should be made to limit exposure by inhalation and exposure by contact with the skin. A theoretical study on low-pressure carburising showed that a change in the operating conditions of the pyrolysis made it possible to reduce the PAHs at source. Application to industrial processes is complex and, in any event, will require the parts and the process to be qualified.

2013 > 2016



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 - 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.

2011 > 2017



Study of the performance of semi-volatile organic aerosol samplers

■ Benjamin SUTTER and Eddy LANGLOIS

Département métrologie des polluants

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.

2013 > 2017

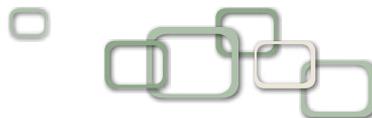


Study of combining supercritical CO₂ desorption with chromatography analysis techniques

■ 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 staff are not exposed to the chemical risk, and the analytical process is simplified.



2014 > 2016



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 French Prevention Network (Réseau Prévention).

2014 > 2017



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 better assess 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.

2011 > 2016



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.

2015 > 2018



Chemical characterisation of bitumen fumes

■ **Eddy LANGLOIS**

Pollutants Metrology Division

■ **PhD thesis: Marie-Astrid DUTOIT**

Géoressources - Raymond Michels and LIEC - Pierre Faure

The method MetroPol 123 recently developed by INRS has been validated for measuring exposure of workers on roadwork sites. This method needs to be extended not only to higher but also to lower exposure levels. The aim of this study is to characterise emissions from various bitumens produced in the laboratory, by using a system for generating and for condensing fumes, in order to select the detection conditions that are appropriate for all types of exposure.

2015 > 2018



Updating good practices for developing a sampling strategy

■ **Frédéric CLERC**

Pollutants Metrology Division

This study aims to propose an update of good practices for developing a sampling strategy, following various regulatory changes. Current practices for bioaerosols and nanoaerosols will be identified, the differences and similarities will be highlighted, and reference data on exposure will be collected in order to simulate the impact of various strategies on exposure diagnostic assessment. A methodology for forming homogeneous exposure groups will be proposed and tested on the data contained in the COLCHIC database. Experiments on the impact of taking multi-exposures into consideration will also be conducted by applying the MiXie algorithms.

2016 > 2019



Improving the statistical analysis of biomonitors data: application to beryllium and to chromium

■ **Aurélié REMY**

Toxicology and Biomonitoring Division

■ **Thèse de doctorat : Aurélié REMY**

Université de Lorraine – Pascal WILD

It is common to measure atmospheric and biological exposure levels that are below limits of quantification. Such data, said to be "censored", cannot be ignored and require special processing. The study will concern optimising a statistical processing method for addressing the issue of censored data. It will be applied for exploiting the measurement data of inorganic compounds that it had not yet been possible to analyse, particularly data on occupational exposure to beryllium and to chromium. The biological exposure data collected (organic and inorganic substances) will feed into compiling a biomonitors database.

2015 > 2018



Developing a new method of assessing exposure to diesel engine particulate matter emissions

■ **Benoît OURY**

Pollutants Metrology Division

■ **Denis BEMER**

Process Engineering Division

This study aims to develop a new method of assessing protection of employees from carcinogenic diesel particles. The approach will be to take the thermo-optical method of assaying elemental carbon that is used for the environment and to adapt it to suit occupational exposure assessment. Once validated in various situations, the method will then be transferred, in particular to the CARSATs (French Occupational Health and Pension Insurance Funds) in the form of a MétroPol datasheet and possibly in the form of training. This development will also make it possible to assess the relevance and pertinence of other methods such as the portable aethalometer, soot counters, etc.

2015 > 2019

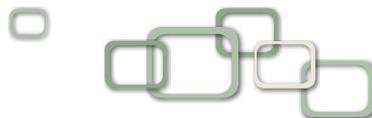


Development of gas chemical sensors for real-time measurement of occupational exposures to organic chemicals

■ **Marianne GUILLEMOT**

Pollutants Metrology Division

Various avenues will be explored with a view to developing a method of assessing the concentration of ozone in the air, based on the interaction between a gas chemical sensor and the target compound. This system of measurement will make it possible to identify the exposure phases during a conventional exposure measurement over a period of 8 hours. Vinyl chloride monomer and 1,3-butadiene are also molecules that are potentially advantageous for this study, and they will be studied if the results are not conclusive with ozone. This study could lead to a prototype for real-time measurement of occupational exposures to ozone.



2016 > 2017



Validation, in occupational situations, of the use of passive sampling in extreme conditions: short durations and low air speeds

■ **Eddy LANGLOIS**

Pollutants Metrology Division

The objective of this study is to validate the use of badges in two types of extreme-use conditions: short durations and low air speeds. For this purpose, interventions will be performed in companies in which such situations have been identified. Conducting active and passive sampling simultaneously at the work station will make it possible to validate the technique of passive sampling statistically, regardless of the substance and of the type of activity. The results will be disseminated to the potential users of this technique so as to consolidate their confidence and so as to enable use of badges for assessing occupational exposure to be developed.



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.



Developing a prototype sensor for selectively sensing chemical exposure to monocyclic aromatics *(completed in 2015)*

■ **Bruno GALLAND and Patrick MARTIN**

Process Engineering Division

■ **PhD thesis: Khaoula HAMDJ**

University of Lorraine – Marc HEBRAND and Mathieu ÉTIENNE

Outline of reasons and objectives

Volatile Organic Compounds (VOCs) are among the most common pollutants. Industrial production and use of motor cars has led to an increased supply of these organic chemical substances in the atmosphere. Benzene derivatives (i.e. benzene, toluene, p-, m-, and o-xylene, and BTX, i.e. mixtures of benzene, toluene, and xylenes) are a very specific category of VOCs because of their particular hazards for the environment and for human health (CMR). The main objective of this study was to design a transportable real-time analyser prototype for analysing BTX that was usable for taking measurements in the workplace atmosphere. The general principle was to develop a sensitive material, or sensor, for sensing the concentration of BTX and for taking a UV spectroscopy measurement.

Approach

Initiated in 2009 with the Laboratoire Francis Perrin (LFP) of the CEA (France's Alternative Energies and Atomic Energy Commission), the project did not produce the expected results, mainly due to difficulties with the reproducibility of the dimensions of the sensors. Reoriented in 2012, the study continued with a new partner, the Laboratoire de Chimie Physique et Microbiologie pour l'Environnement (LCPME), a research unit run jointly by CNRS and Université de Lorraine. A PhD thesis was attached to this work whose core was to develop a material having porosity and functionality that were controlled for BTX concentration.

Numerous tests were performed and they led to silicated sensors being produced that were of geometrical configurations of the monolithic type (thickness of about one millimetre; sol-gel technique) and of the thin film type (a few microns thick; technique of deposition by dip coating with a solution of silica nanoparticles). Functionalisation tests were conducted to improve the hydrophobicity of the material and to increase the BTX detection sensitivity. In parallel, a testing facility was designed, validated, and used for characterising the various sensors that were manufactured.

Main results

The performance levels achieved with the thin films made it possible to validate the feasibility of the principle of the analyser, in particular for detecting toluene and xylenes over a range from 1 ppmv to 100 ppmv. But the effect of the humidity of the air on adsorption of BTX was significant and the presence of other solvent vapours, such as ketone vapours, prevented quantification of BTX. The benzene detection threshold is not yet satisfactory (it was approximately a few tens of ppmv), compared with the limit value of 1 ppmv for benzene. Initial tests showed drift of about 40% for the same sensor during one hour of testing, and a reproducibility of about 40% over about forty sensors produced. Conversely, the experience acquired during this work made it possible, on the basis of a different film structure, to envisage making an improvement in reproducibility (about 10%).

Discussion

While the work was taking place, it was observed that the design of the sensor (type of the material and dimensions) and its functionalisation raised technical and scientific problems, which had repercussions on keeping to schedule. That difficulty prevented the metrological performance of the sensors from being evaluated and therefore prevented a prototype from being finalised. The avenues for improving the new film should be confirmed before considering resuming testing on a generation setup. The experience acquired during the work also made it possible to acquire new skills (UV detection, Nafion tubing, thin-film microcell, etc.) that could be developed in future studies.



Development of a methodology to measure dust emissions of electric handheld woodworking machines *(completed in 2015)*

■ **François-Xavier KELLER**
Process Engineering Division

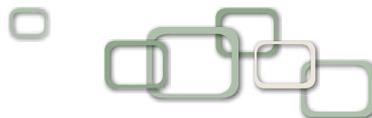
■ **PhD thesis: Florent CHATA**
University of Lorraine - Anne TANIÈRE

Outline of reasons and objectives

In France, wood dust is classified on the national list of carcinogenic processes and the decree of 23 December 2003 sets a stringent occupational exposure limit value for wood dust of 1 mg.m⁻³ that has been applicable since 1st July 2005. On average, over 120 cases of occupational diseases related to wood dust, including 70-80 cancers are recorded every year by the general health insurance scheme. The objective of this study is to put in place a methodology for characterising emissions of wood dust from electric handheld machinery. Such machinery is in widespread use in the woodworking industry and it has particularly high levels of emissions.

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Approach

A test method was chosen on the basis of the existing European Standard EN1093-3 and was applied to electric handheld woodworking machines. For that purpose, a ventilated booth was used during the work. The tests were made via a robot so as to optimise the repeatability of the measurements and so as to avoid subjecting an operative to exposure. Various sensors were selected to measure the concentration of dust emitted during the tests. Specific machining cycles were determined for assessing five sanders and nine circular saws. The work focused mainly on characterising emissions from random orbit sanders and from circular saws. The head-loss related to the extractor network for extracting the dust and to the various machines was measured in order to determine the relative fan power and the suction flow rates for each machine.

Main results

The results of this method made it possible to establish a level of concentration of dust emitted by the sanders and circular saws that were tested. These measurements showed the possibility of developing a classification for the machines. A statistical analysis was conducted and made it possible to confirm the distinctions made between the machines. For sanders, one machine emitted more dust than the others. As regards the circular saws, we can conclude that three of the nine machines had lower concentration values (factor of 7 between the most emissive and the least emissive).

Discussion

This study made it possible to put in place a test procedure for characterising the emissions of woodworking machines. It can be used for studying other machines and other types of particulate pollutant. The manufacturers and designers of machines, and also the professional associations can appropriate it and use it to establish a criterion for choosing between various machines as regards dust emission. In parallel with this study, standardisation work is in progress through CENELEC with a view to publishing dust measurement methods with the manufacturers of handheld machinery. Furthermore, in 2016, a new version of the machinery directive is to be discussed. Adding information about dust emission would be useful for prevention. An indication regarding the emission of a machine would enable company managers and users to steer their choices towards equipment having the lowest levels of emissions.



Impact of office space ventilation on interior air quality *(completed in 2015)*

■ **Laurence ROBERT**

Process Engineering Division

Outline of reasons and objectives

With service-based employment becoming increasingly prominent, and nearly 10 million employees working in offices in France, Indoor Air Quality (IAQ) has become an issue for occupational health. However, the nature of the chemical compounds, their concentration, the part played by ventilation and the parts played by the various emission sources remain little known components, and the chronic risk run by the workers is relatively ignored. It is in this context that INRS initiated a study on IAQ in buildings of the office type. The study aims to deepen the knowledge about the pollution risks to which such employees might be exposed, to study the impact of the ventilation systems, and to propose a diagnostic prevention approach for the employees.

Approach

Fourteen air monitoring campaigns in offices were conducted, thirteen of which in collaboration with the Observatoire de la Qualité de l'Air Intérieur. For each campaign, five offices and an outdoor point (more than 70 measurements) were instrumented with a view to qualifying the working environments, as regard both comfort parameters and also exposure to volatile organic compounds (VOCs) and aldehydes present in these environments. In parallel, an experimental method was developed to assess the impact of ventilation on IAQ in a space of the office type by monitoring the TVOC (total VOC) indicator in real time. For this purpose, a network of metal oxide mini-sensors and an experimental booth reproducing operation of an office were implemented.

Main results

As regards comfort, offices are spaces that tend to be overheated and to have very dry air, as confirmed by the majority of the complaints passed on by the French Prevention Network (Réseau Prévention) on the subject of IAQ. As regards exposure, formaldehyde is a ubiquitous compound present in all of the instrumented office environments; 66% of them had concentrations above the guide value of 10 µg/m³ proposed by ANSES (the French Agency for Food, Environmental, and Occupational Health & Safety). Numerous volatile organic compounds, reflecting specific pollution, were also present in these environments. Conversely, exposure to fine particles does not seem to be a major concern in this type of premises.

The original experimental method, developed to understand the impact of ventilation on the IAQ in a space representing an office, made it possible to show the significance of certain little-studied characteristics of ventilation on the distribution of pollutants, in the plane of the respiratory tracts, for the same rate of renewal of the air. It then appeared to be a priority to change the ventilation flow rates to take into account no longer only the occupants as pollution sources (CO₂ and humidity), but also the sources of emissions of chemical compounds present in these environments.

Finally, a diagnostic approach was established. This approach proposes, through a set of actions, to predict whether or not a suspected building presents an air quality defect. An INRS guide will make it possible to transfer this approach to the French Prevention Network (Réseau Prévention).

Discussion

The issue of IAQ covers a multitude of aspects that all deserve to be studied in order to estimate, understand, improve, reduce, and prevent exposure of employees in this type of premises.

Two particular aspects are worth discussing: the choice of reference values appropriate to the IAQ issue, and the revision of the ventilation flow rates to take into account the chemical pollution coming from sources other than humans.

A study relating to tertiary premises in which the workers are in contact with new manufactured products is being considered to supplement this work.

An INRS technical day on the issues of IAQ is scheduled in 2017, and publications are being written.



2014 > 2017



Advantage and limitations of wet scrubbing in industrial hygiene

■ **Fabien GÉRARDIN and Emmanuel BELUT**

Process Engineering Division

■ **PhD thesis: Gaël CHERRIER**

University of Lorraine - 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 efficiency of collection 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.

2015 > 2018



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.

2013 > 2017



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 - 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.

2013 > 2016



Separating out ultrafine particles generated by metal-working processes

■ **Denis BEMER**

Process Engineering Divisions

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

University of Lorraine - 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.

2013 > 2016



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 - 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.

2014 > 2018



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
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.

2015 > 2018



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

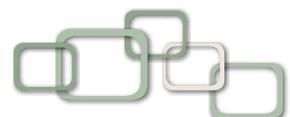
■ Hubert MONNIER, Marie-Thérèse LECLERC and Denis BEMER

Process Engineering Division

■ PhD thesis: Florine DELACHAUX

University of Lorraine - Cécile VALLIERES

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.





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

2013 > 2016



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. A monitoring method for monitoring ageing of nets during their lives will be proposed to users.

2014 > 2016



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.

2015 > 2017



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.

2016 > 2018



Safety of Smart Personal Protective Systems (SPPSs) - Developing general design principles - Appraising the risk and reducing the risk

■ **Patrice MARCHAL**

Work Equipment Engineering Division

With the appearance of new smart personal protective systems (SPPSs), prevention specialists would like to estimate the level of safety so as to choose the system that is most appropriate, and manufacturers need general design principles for SPPSs. This study proposes to establish a state of the art of SPPSs, to define categorisation and to develop design principles, on the basis of a risk analysis process. In addition to raising the awareness of the prevention specialists through publication of a brochure, and to raising the awareness of the manufacturers through a design guide, it is planned to pass on the results to the European Committee for Standardization, in order to integrate the concept of operating safety into standards for SPPSs.

2015 > 2017



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

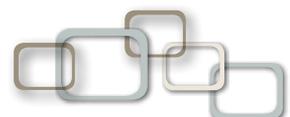
■ **David TIHAY**

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.



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Psychosocial Risks

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

- giving companies and OSH specialists tools for diagnosing psychosocial risks (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.



Interactions between health and work: effect of occupational psychosocial conditions on changes in mental health (*completed in 2015*)

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

Occupational Epidemiology Division

Outline of reasons and objectives

Current knowledge makes it possible to assert the existence of links between exposure to certain psychosocial risk factors (PRFs) and short-term and long-term damage to health. Exposure to PRFs is generally defined using the Karasek and Siegrist models. Other concepts have emerged (e.g. violence at work, and job insecurity), but, so far, they remain little explored, in particular through longitudinal studies.

The objective of this study was to examine the effect of changes in exposures to a wide variety of PRFs on changes in mental health (depression or anxiety) from 2006 to 2010, as well as on changes in the perceived state of health, and on changes in the limitations on daily activity due to health problems.

Approach

The “Santé et Itinéraire Professionnel” (“Health and Career Path”) survey is a longitudinal study on the general population organised jointly by the French Ministries for Health and for Labour, and concerning 14,000 subjects in 2006, 11,000 of whom were able to be questioned again in 2010. This study concerned the 5 684 subjects in jobs both in 2006 and in 2010.

Four exposure situations (subjects exposed both in 2006 and in 2010; subjects exposed in 2006 only; subjects exposed in 2010 only; subjects not exposed either in 2006 or in 2010) for 17 PRFs were analysed to see how they linked up respectively with degradation in mental health, occurrence of limitations on activity, and degradation in perceived state of health in 2010 relative to 2006. These changes were analysed separately in the men and in the women, while taking account of the past career path, of major events (in their personal or professional lives), of the job characteristics, and of the individual characteristics, collected in 2006 or in 2010.

Main results

For the men and the women alike, high complexity of the work and lack of recognition were the exposures that were declared most in 2006 and in 2010. The changes in exposure between 2006 and 2010, although moderate, tended to be deteriorations, in particular in terms of pressure at work and of lack of recognition.

The associations observed with the PRFs were more numerous for mental health and perceived state of health than for limitations on activity. Degradation in health is, overall, more frequent in cases of exposure to PRFs in 2010 only or in cases of exposure both in 2010 and in 2006, compared with exposure in 2006 only. In particular, perception of job insecurity is associated with degradation in all three health indicators both in the men and in the women. The exposures to a feeling of fear during work (own safety/security or safety/security of others) or to a poor work-life balance were significant in the women, and exposures to high quantities of work or to low use of current skills were significant factors in men. Having more “autonomy” in 2010 in the men and more recognition or resources for doing quality work in 2010 in the women reduces the risk of deterioration of health in 2010.

Discussion

The results observed argue in favour of PRFs having an immediate effect on deterioration of health and the question of whether these effects are reversible remains to be answered. The results also highlight that it is necessary to have a standardised and validated measurement tool that covers all of the PRFs, and such a tool is currently lacking. Studies on changes in the health of ill subjects or intervention studies focused specifically on the changes in working conditions could usefully feed into addressing the issue of characterising the effects of PRFs. An article for prevention specialists and scientific presentations and articles are planned.

2012 > 2016



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 production and service sectors, supplemented by new occupational contexts. It will provide some thoughts and foundations for preventive approaches that are accessible to OSH stakeholders.

2014 > 2017

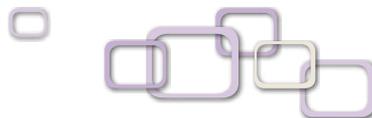


Organisational intervention approaches: what appropriation for preventing PSRs?

■ **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.



2013 > 2016



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.

2016 > 2019



Well-being and use of ICT: launching a debate about collective practices

■ **Vincent GROSJEAN**
Working Life Division

Information and Communications Technology (ICT) is the subject of multiple questions about its psychosocial impacts and the parts it plays in defining the activities of tertiary management and staff. This study proposes to launch a debate about the practices and customs of the broad range of modes of communication currently available in companies. The study will monitor implementation of solutions in companies for assessing the impacts of ICT within a broader perspective of opening up spaces for dialogue on work and on the conditions under which it is done.

2016 > 2018



Developing a model for intervention on violence at work (MIVT)

■ **Marc FAVARO**
Working Life Division

This study aims to continue the investigations, for testing the modes of practice, in a context of interventions to be conducted with a company (or more than one company) faced with situations of internal or external violence and to move towards a model for intervention on violence at work (or "MIVT" in French). This work will be based on data from observations specific to each company, and on a structured dynamic exchange, which, starting from real problems or from virtual scenarios introduced in working sessions, will gradually lead to stabilisation of the "MIVT" model dedicated to preventing violence in occupational contexts.



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.

2014 > 2017

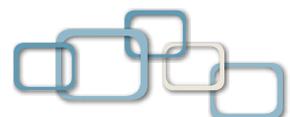


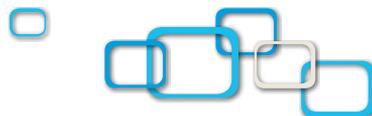
Driving light commercial vehicles, working conditions and musculoskeletal disorders in courier delivery operatives

■ **Anca RADAUCEANU et 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.





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; and
- to introduce MSD prevention principles into the process of designing working situations (gestural variation, less demanding tools, etc.).



Identification of emerging determinants linked to the risk of MSDs: ergonomic and biomechanical analysis of the activity of meat cutting
(completed in 2015)

■ **Adriana SAVESCU**

Working Life Division

Outline of reasons and objectives

The meat-cutting sector is one of the sectors that is most affected by musculoskeletal disorders (MSDs). Organisational changes, in particular when subcontracting is used, can mean that employees from a variety of enterprises (user enterprises (UEs) and external enterprises (EEs)) can work on the same production site, in particular for performing certain knife maintenance operations, such as sharpening or grinding. Divergences of viewpoint on the cutting quality of the knives have been observed, particularly when subcontractors are used. The objective of this study is to propose new prevention responses by identifying new MSD risk determinants in the activity of meat cutting. To this end, various criteria for assessing knife cutting power (KCP) that were indicated by cutting operatives and knife sharpeners or grinders were analysed in varied organisational and contractual contexts.

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Approach

An ergonomics and biomechanics approach was implemented by combining quantitative and qualitative assessments of the cutting power of the knife before and after the sharpening and grinding operations. Sharpening activities were analysed and operatives were interviewed alone and in pairs (intra-profession, between cutting operatives or between sharpeners/grinders; and inter-profession, between cutting operatives and sharpeners/grinders). The methodology was implemented on four meat cutting sites (29 cutting operatives and 7 sharpeners/grinders), including three different modes of organising the sharpening/grinding.

Main results

The study made it possible: to identify KCP assessment criteria specific to each profession (cutting operative and sharpener/grinder): physical, visual, auditory, and productivity criteria; and to compare them. Among those criteria, auditory and productivity criteria appeared as being new. In addition, new physical and visual criteria came to supplement the ones that already existed in the literature, in particular: the "sensation" experienced when the knife comes into contact with the sharpening/grinding tool or in contact with the test paper; twist in the blade of the knife; colouring of the knife as a sign of quality or of a defect in the cutting edge of the knife; or meat-cutting quality indices. As regards the determinants of the cutting power of the knife, differences in opinion were identified depending on the profession (cutting operative or sharpener/grinder). Other determinants, such as lack of exchange between the cutting operatives and the sharpeners/grinders, organisational dependence, or lack of training or inappropriate training were also identified.

Discussion and conclusion

These results will enable enterprises and professionals in this sector to act on organisation of knife maintenance in a context of subcontracting involving user enterprises and external enterprises, while taking into account the ties between sharpener and cutting operative. To this end, depending on the mode of organisation of the sharpening/grinding, thought needs to be given on creating intra- and inter-profession discussion spaces. Working on these issues will enable progress to be made in optimising knife maintenance and, in doing so, in controlling the MSD risk, while taking account of the organisational contexts of the enterprises. These results may also bring about changes in the training aids made available by INRS for meat-cutting enterprises and in the contents of training in knife maintenance (sharpening and grinding). Such changes will emphasise the close ties between these two tasks (cutting and sharpening) and the operatives that perform them. Those operatives need to incorporate to the same extent knowledge common to both professions and knowledge that is specific to each profession. The results of this study have already been the subject of various presentations at international conferences, and will be incorporated into INRS training aids.

2016 > 2018



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 - Raphaël DUMAS

Outline of reasons and objectives

The objective of this study was to develop and validate an ambulatory system for evaluating postures and movement of the upper limb, on the basis of inertial sensors. The use of such systems requires kinematic modelling of the upper limb, associated with such sensors (the modelling depending on the selected calibration method), and validation of the kinematic output data (angles of the joints and positions of the segments), in order to develop a reliable system.



Approach

An experimental protocol was conducted in the laboratory. 10 subjects were equipped with 5 inertial sensors (hand, forearm, arm, shoulder blade, thorax) and they performed a calibration session aimed at building the correspondence between the segment axes and the technical axes of the inertial sensors, and a test session making it possible to validate the best calibration procedure. The calibration session was made up of 7 posture holds/functional movements and the test session was made up of 8 different posture holds/functional movements. For each subject, all of these sessions were repeated with 3 different experimenters. Kinematic modelling of the upper limb made it possible to compare the angular data (wrist, elbow, and shoulder) and the position of the hand in space, as calculated from the inertial sensors, with the values obtained by means of an optoelectronics system, considered as a reference system. The angular value comparison criteria concerned accuracy (relative to the reference), fidelity (reproducibility), and interpretability (compliance with physiological limits of the joints). Positioning error of the hand was characterised by calculating the accuracy.

Main results

The results showed that a calibration combining a static posture and a functional flexion/extension movement of the elbow was more appropriate in view of the various comparison criteria chosen. The following were observed, in particular: a joint angle fidelity of about 5-10°, and a positioning error of the hand in space of 7-15 cm depending on the various test conditions considered. These results are consistent with the existing scientific literature on the subject. In addition, it was shown that, by following the experimental procedure rigorously (using written instructions), it was possible to limit the experimenter effect (observer-expectancy effect). Finally, a graphical interface was developed, offering viewing of the joint angles of the wrist, of the elbow, and of the shoulder, and a realistic 3D representation of the movement of the upper limb.

Discussion

This study, which was the subject of a PhD thesis defended on 8 December 2015, contributed to making available an ambulatory system for evaluating postures and upper limb movements with a view to assessing upper limb MSD risks in working environments. Based on the use of inertial sensors, this system will ultimately make it possible to avoid having to implement an optoelectronic system and having to cope with the lack of accuracy of conventionally used goniometers. Recommendations on the anatomic calibration procedure were formulated on the basis of the criteria of accuracy, fidelity, and interpretability. The limits of current kinematic modelling were identified and prospects for improvement were proposed. Those prospects concern taking account of an inertial sensor placed on the shoulder blade, and characterising the system in a magnetically disturbed environment. The results of this study have been the subject of several presentations at national and international conferences, and were published in the peer-reviewed international journal "Sensors" published in July 2015.



■ Aude CUNY

Working Life Division

■ PhD thesis: Aude CUNY

University of Grenoble - 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.



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, unfit for work, changes in physical functional capacities, etc.).



Age-related impact of varied time constraints in an assembly task on biomechanical and physiological exertions *(completed in 2015)*

■ **Martine GILLES, Kévin DESBROSSES and Laurent CLAUDON**

Working Life Division

Outline of reasons and objectives

Working under time constraints is particularly difficult for ageing workers. "Leeway" or "room for manoeuvre" may enable regulation strategies to be put in place or production contingencies to be coped with more easily. The objective of this study was to compare, depending on age, the physiological strains recorded during a repetitive assembly task, and to characterise the effects of leeway in time related to a feed system having higher or lower degrees of constraint during assembly cycles that could have contingencies.

Approach

14 junior subjects (25-35 year-olds) and 14 senior subjects (55-65 year-olds) performed an assembly task of the industrial type (cycle time of 22 seconds) under two different workpaces and under two information conditions: the pace could either be forced, with a production penalty if the task was not performed within an imposed cycle time, or allow leeway in time, with a production penalty if 3 consecutive cycle times were longer than 3 theoretical cycle times (66 seconds). Prior information on the occurrence of an assembly cycle with contingencies could be given to or withheld from the subjects. For each of the 4 conditions (for a total length of time of 50 minutes), the subjects performed 136 assembly cycles, 15% of which included contingencies requiring additional operations to be made within the same cycle time. The number of production penalties, the electromyographic activity of 12 muscles, and biomechanical parameters of the movement were analysed. The operatives worked standing up and the parts to be assembled were fed automatically to their work stations.

Main results

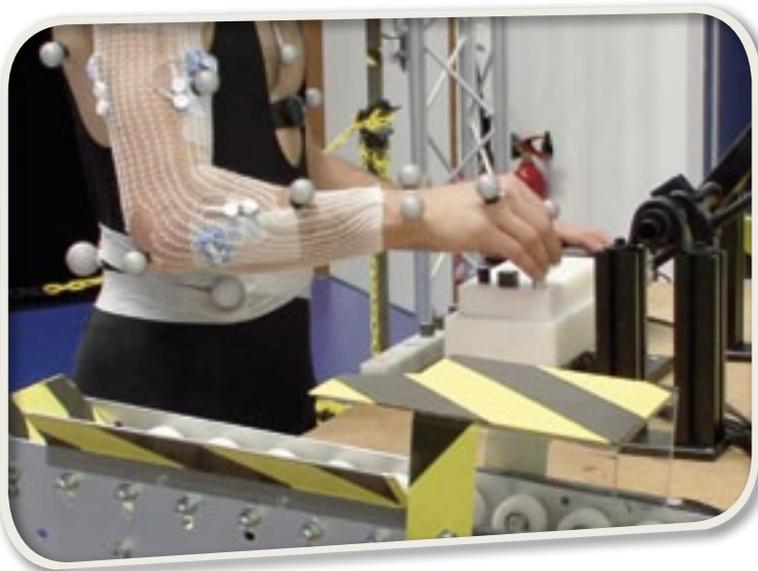
The main effects observed concerned age and rate conditions. Thus, the number of production penalties was higher at the forced pace than at the rate with leeway, and this applied more particularly for the senior subjects during the assembly cycles with contingencies. The assembly cycles with contingencies also generated muscular strain that was higher at the forced pace for both classes of age, and at the pace with leeway for the senior subjects only. For all of the assembly cycles, the pace with leeway made it possible to reduce the muscular strain relative to the strain at the forced pace, and this was more pronounced in the junior subjects. The speeds of movement of the wrist were higher during the assembly cycles with contingencies relative to the speeds during the assembly cycles without contingencies, in particular for the senior subjects and at the forced pace. For the assembly cycles without

contingencies, the speeds of the wrist were lower at the pace with leeway than at the forced rate in the junior subjects only. For the assembly cycles with contingencies, the speeds of the wrist were lower at the rate with leeway than at the forced rate for both classes of age. Finally, the condition with prior information about the occurrence of an assembly cycle with contingencies, coupled with the pace with leeway, was accompanied by a slight reduction in the muscular strain, essentially in the senior subjects.

Discussion

The pace allowing leeway in time made it possible to limit the production penalties, the biomechanical stresses and the muscular strains, both for junior and senior subjects, and in more marked manner during assembly cycles with contingencies. Furthermore, although the possibility of leeway in time enabled the junior subjects to perform all of the assembly cycles (with or without contingencies) with the same level of muscular strain, the level of muscular strain in the senior subjects remained slightly higher for assembly cycles with contingencies. Finally, having prior information about the occurrence of contingencies, coupled with the possibilities of leeway in time, made it possible to reduce the strain, in particular for senior subjects. Even though generalisation from a laboratory study should be considered with caution, preferring production systems allowing leeway could have protective effects for operatives, both junior and senior.

These results can enrich INRS training, and will be published in a peer-reviewed journal.



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2013 > 2016



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 – Emmanuel 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 HR management of ageing workers.

2014 > 2017



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 consequences 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 an occupational health service.

2015 > 2020



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 after a shoulder surgery, 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. It will include five data collection times of objective and subjective data relating to the numerous aspects involved in return to work for employees who have suffered injuries, and from a perspective of preventing occupational exclusion.

2016 > 2022

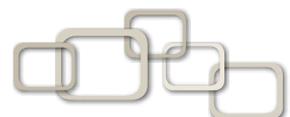


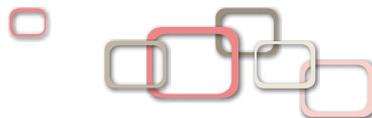
Effect of night work on occurrence of ischemic cardiovascular diseases

■ **Jean-Bernard HENROTIN and Stéphanie BOINI-HERMANN**

Occupational Epidemiology Division

Ischemic cardiovascular diseases are a frequent cause of premature death or disablement. The "classic" risk factors explain only some of these diseases. Other occupational factors, such as night work, have been mentioned in recent years. This epidemiological study proposes to examine the link between night work, which concerns about 15% of employees, and the occurrence of ischemic cardiovascular diseases. It is expected that the results will facilitate dissemination and implementation of specific prevention measures in companies on the theme of ischemic cardiovascular diseases.





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 Épuration 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 and Theoretical & Applied 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 Aérialique) 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.

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’s teams take part in various actions conducted through it.

- In 2015, the “Well-being at work” Group contributed to organising the conference scheduled for May 2016 in Amsterdam on the topic of “Combining knowledge to support well-being of workers in the changing world of work (Associer les connaissances au service du bien-être des travailleurs dans un monde du travail évolutif)”. In addition, recommendations aimed at combating sedentarity at work were produced. The group also took part in the first scientific meeting of the network in October 2015 in Warsaw on 3 topics including ageing at work, and prevention in the face of major technological changes.
- In 2015, INRS continued to participate in the NECID (Nano Exposure and Contextual Information Database) Project which is being led by TNO (Netherlands Organisation for Applied Scientific Research) and IFA (Institut

für Arbeitsschutz). The objective of that database is to take advantage of data on exposure to nanomaterials by enabling that data to be used for research and risk assessment purposes. The work undertaken since 2014 has involved defining data input modules, presenting and statistically processing results, and harmonising the exposure measurement strategy. A first version of the database has also been tested.

- **The participation in the “Recommendations for procedures to measure occupational physical activity and workload”** Group continued in 2015 with three meetings and training in the software Acti4 developed by the Danish Institute (NRCWE). This participation enables us to discuss with our European counterparts new tools and techniques for measuring occupational physical activity and workload with a view to compiling a common document containing recommendations for European OSH specialists and researchers.
- **INRS has committed to the “indIR-UV”** Project on exposure to UV and IR radiation in people working in arc welding environments. This project, scheduled to last two and a half years, began in June 2015. Inter-laboratory measurements on welding arcs with the six European partner institutes took place for one week at the GLIWICE Institute of Welding (Poland) in November 2015.
- 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 IRSST, its counterpart in Quebec, with whom a 5-year framework partnership agreement has just been renewed for the second time. Partnership framework agreements have also been signed with NIOSH (National Institute of Occupational Safety and Health – United States), IFA (Institut für Arbeitsschutz – Germany), and IST (Institut Universitaire Romand de Santé au Travail or “Institute for Work and Health”, Switzerland) covering various medium-term collaboration actions.

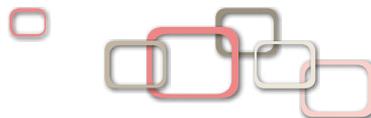
Finally, collaborations are currently in progress with the Florida Institute of Technology (FIT, United States), the Massachusetts Institute of Technology (MIT, United States), the Centre Hospitalier Universitaire de Montréal (Canada), the Berufsgenossenschaften für Handel und Warenlogistik (BGHW - Germany), the Institut für Prävention und Arbeitsmedizin (IPA- Germany) and INRS's Korean counterpart KOSHA.

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

Projects with external funding

Three European projects

- **NANoREG** : INRS is a partner in the NANoREG European project that is co-funded by the European Commission and co-ordinated by the Dutch Ministry for the Environment. About sixty partners from 16 Member States are taking part in the four-year project (2013-2017). In 2015, tests aimed at determining the performance of various systems for generating aerosols from powder nanomaterials were conducted. The study of toxicity by repeated administering of carbon nanotubes to rats by inhalation involved generating, characterising and choosing the carbon nanotubes to be tested. INRS was also involved in monitoring the overall progress of the project and in taking part in the joint meetings.
- **NanoCEN** : Under Mandate 461, the European Commission has commissioned 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. In 2015, the initial versions of the documents were proposed. The experimental actions are continuing for the work on the dustiness of nanomaterials with, in particular, the continued experimental work on the intercomparison of ELPI+, dustiness testing on two systems that INRS possesses, analysis of the data, and writing of the final report.



- **SMARTNANOTOX** : a new European project accepted in 2015 and relating to the toxicology of nanoparticles, submitted under the Horizon 2020 Framework Programme for Research and Innovation with 12 partners from 8 Member States.

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

- **MEPAS (Méthode de prévision de l'ambiance sonore dans les bureaux ouverts)** : a 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 2015, the work was finished. A simple new indicator that is objective and easily measurable has been established for the discomfort perceived by people in the presence of noise in open-plan offices. Recommendations for laying out/fitting out open-plan offices for optimising the soundscape have been published in a new standard (NF S 31 199 – Standardisation Commission AFNOR S30D, under publication).
- **EXTI (a French acronym for "Exposure of Workers to Industrial Electromagnetic Fields)** aims to develop numerical and experimental tools making it possible to obtain a parametric assessment of worker exposure to electromagnetic fields. The case of a high-frequency press has been chosen for this study being conducted by INRS in collaboration with the Ampère Laboratory of the University of Lyon, with the IMEP (microelectronics, magnetism, and photonics) Laboratory of the Joseph Fourier University of Grenoble, and with the CSTB of Grenoble. This project began at the end of 2015.
- **NANOTRANSBRAIN** : this project aims to assess in vivo the effects of inhalation exposure to titanium dioxide nanoparticles on the physiology of the blood-brain barrier in adult and old rats, in collaboration with the neurovascular pharmacology team from CEA Saclay and the University of Orsay. The phase of exposure of the adult and old rats took place in 2015. The bio-distribution of titanium in the various organs and the disturbance to the blood-brain barrier were studied. Neuro-inflammation was also analysed by immune-enzymatic techniques, and other techniques will be implemented in 2016.
- **EXPROPANO** : 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, and 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 the twin approach of metrology and ergonomics, and on the avowed objective of developing an operational method for a large number of different scenarios, that method being accessible to all of the OSH specialists out in the field. 2015 was devoted to training the various people involved in the action and then to selecting the companies.
- **MAMBO (a French acronym for «Control of Ammonia Emissions in Anaerobic Digestion & Composting Waste Treatment Plants, Biowaste, and Organic Effluent)**, accepted by ANSES through the APR-EST 2015 call for research projects. Its content is incorporated into the field of a study that is already in progress on chemical and biological risk prevention in anaerobic digestion plants: the idea is to identify the risky jobs/work stations by trying to correlate them to the process parameters. It will enable pilot tests to be conducted by one of the partners of the consortium.

One ANR (French National Research Agency) project

- **The project CENSUR** aims to propose a method of estimating relative survival: INRS is associated with 5 French teams and with 4 international research teams, and it is involved in developing the methods specific to the issue of occupational health studies. The statistical methods developed in this project were implemented in the software R and Stata.

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 (28 in 2015), 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 2015, the following theses were defended:

- **Anaëlle CLOTEAUX** : Conception, modélisation et réalisation d'un procédé d'élimination du formaldéhyde dans l'air intérieur (Designing, modelling and producing a process for removing formaldehyde from indoor air). University of Lorraine
- **Bérangère HITTINGER** : Le travail collectif à travers les actions collectives, les processus de coordination et les manifestations de soutien social : le cas de binômes d'opérateurs du transport routier de marchandises (Collective work through collective actions, the processes of coordination and manifestations of social support: the case of road haulage operatives working in pairs). University of Toulouse.
- **Maria-Cristina CADAVID RODRIGUEZ** : Les laveurs: une alternative aux médias fibreux pour le traitement des nanoparticules issues des fumées de métallisation (Scrubbers: an alternative to fibre filter medias for treating nanoparticles from metal-plating fumes). University of Lorraine.
- **Blandine BARLET** : De la médecine du travail à la santé au travail. Les groupes professionnels à l'épreuve de la « pluridisciplinarité » (From occupational medicine to occupational health. Professional groups put to the "multidisciplinarity" test). University of Paris-Ouest
- **Florent CHATA** : Estimation numérique et expérimentale des profils d'émission en poussières des machines électroportatives (Numerical and experimental estimation of dust emission profiles of electric handheld machinery). University of Lorraine
- **Brice BOUVIER** : Développement et validation d'un système ambulatoire pour l'évaluation des postures et des mouvements du membre sup. en conditions réelles de travail (Developing and validating an ambulatory system for evaluating postures and upper limb movements under real working conditions). University of Lyon



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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 apply for the university post-PhD diploma necessary to to officially supervise PhD students. Currently, nine people at INRS have this diploma.

Presentations and publications in 2015

Presentations in 2015

Every year, INRS researchers and experts take part in numerous national and international conferences.

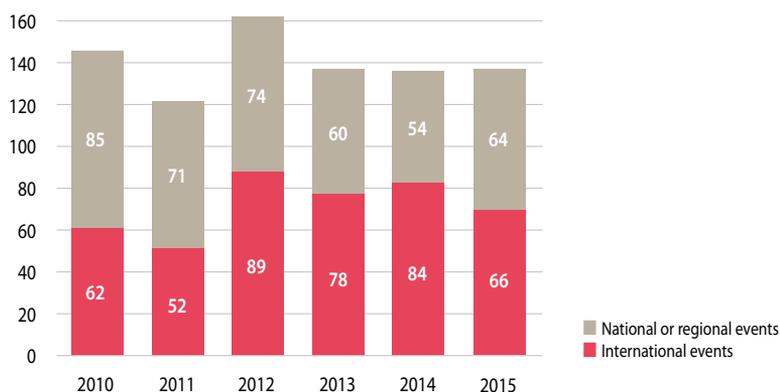
130 presentations were given at various events in 2015, including 66 at international conferences, and, in particular:

- 19 presentations by INRS at the “Chemical Risks” Conference in Nancy
- 9 presentations by INRS at the Optical and Electromagnetic Radiation Symposium in Paris
- 8 presentations by INRS at the 50th Congress of the French-Speaking Ergonomics Society (SELF) in Paris
- 7 presentations by INRS at the 30th French Aerosol Congress in Paris

In parallel with the symposia in which it took part, INRS organised one international scientific conference and various theme days in 2015:

- **Chemical risks** : innovative methods and techniques, Nancy on 8, 9, 10 April 2015
- **Optical and electromagnetic radiation at work** : from exposure to prevention, Paris, 21-22 October
- **Occupational exposures to welding fumes** : solutions for risk prevention, in Paris on 16 June, in partnership with the CNAM-TS (French National Health Insurance Fund for Salaried Employees), the CETIM (Centre technique des industries mécaniques or “Technical Centre for Mechanical Industry”).

Numbers of presentations presented at scientific events :



Publications in 2015

The findings of the “studies & research” are published in scientific and technical journals. **136 were published in 2015.**

Of these publications, 79 articles were published as follows:

- 44 in international peer-reviewed journals
- 32 in national journals, including:
 - 21 in the INRS journal “Hygiène et Sécurité du Travail”
 - 3 in the INRS journal “Références en Santé au Travail”

In addition,

- 8 chapters in works, 38 conference proceedings, and 11 scientific and technical notes were published.

The list of publications for the year 2015 is given below.

List of publications 2015



Accidentology and Prevention Culture

■ Ergonomics (IF: 1,409)

LECLERCQ S., CUNY X., GAUDEZ C., AUBLET-CUVELIER A.

Similarities between work related musculoskeletal disorders and slips, trips and falls. (Similitudes entre troubles musculo-squelettiques et glissades, trébuchements et chutes. *Accident Analysis and Prevention*. 2015, vol 58, n° 10, pp. 1624-1636.

■ Encyclopédie Médico Chirurgicale - Pathologie professionnelle et de l'environnement

FAVARO M.

Accidentologie : concepts, modèles et méthodes. 2015, vol. 10, n°1, pp. 16-793.

■ Hygiène et Sécurité du Travail

LECLERCQ S.

Enjeux pour la sécurité au travail et freins à la prévention. *Juin 2015, n° 239, DO 9, pp. 24-27.*

LECLERCQ S., JACQUES M.

Prévenir les accidents avec perturbation du mouvement au travail. *Juin 2015, n° 239, DO 9, pp. 28-31.*

■ 19th Triennial Congress of the IEA, 9-14 August 2015, Melbourne, Australia

LECLERCQ S.

Should prevention take an all-round view of occupational accidents triggered by movement disturbance? (La prévention doit-elle considérer, ensemble, les accidents occasionnés par une perturbation du mouvement ?). *Proceedings, 2 p.*



Occupational Allergies

■ Annals of Agricultural and Environmental Medicine (IF: 3,06)

DORRIBO V., WILD P., PRALONG J., DANUSER B., REBOUX G., KRIEF P., NICULITA-HIRZEL H.

Respiratory health effects of fifteen years of improved collective protection in a wheat-processing worker population. (Effets de quinze ans de protection collective améliorée sur la santé respiratoire d'une population de salariés exposés à la poussière de blé). 2015, Vol. 22, n° 4, pp. 683-690.

■ Revue des Maladies Respiratoires (IF: 0,62)

DINH-XUAN A.T., ANNESI-MAESANO I., BERGER P., CHAMBELLAN A., CHANEZ P., CHINET T., DEGANO B., DELCLAUX C., DEMANGE V., DIDIER A., GARCIA G., MAGNAN A., MAHUT B., ROCHE N.

Place de la mesure du NO expiré dans l'évaluation de l'inflammation bronchique dans l'asthme. Mise au point et position de la Société de Pneumologie de Langue Française. 2015, Vol. 32, Issue, pp. 193-215.

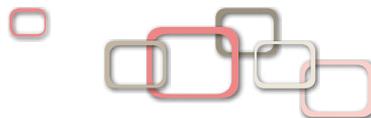


Noise, Vibration, Electromagnetic Fields, and Optics

■ Journal of the Acoustical Society of America (IF: 1,55)

CHEVRET P.

Advantages of the incoherent uniform theory of diffraction for acoustic calculations in open-plan offices. (Avantages de la théorie uniforme de la diffraction incohérente pour la modélisation acoustique dans les bureaux ouverts). 2015, 137(1), pp. 94-104.



■ **Journal of Radiological Protection (IF: 1,386)**

BARLIER-SALSI A.

Stray light correction on array spectroradiometers for optical radiation risk assessment in the workplace. (Correction de la lumière parasite sur des spectroradiomètres CCD pour l'évaluation, au poste de travail, des risques dus aux rayonnements optiques). 2015, Vol. 34, pp. 915-930.

■ **Applied Acoustics (IF: 1,068)**

DUCOURNEAU J., FAIZ A., CHATILLON J.

New device for measuring sound scattering coefficients of vertical uneven surfaces in a reverberant workplace. (Nouveau dispositif pour la mesure des coefficients de diffusion de surfaces verticales à relief dans les ateliers réverbérants). 2015, Vol. 90, pp. 21-30.

CHEVRET P.

Release from masking of speech intelligibility due to fluctuating ambient noise in open-plan offices.. (Etude du démasquage de l'intelligibilité de la parole par les fluctuations du bruit ambiant en open-space). 2016, Vol. 101, pp. 156-167.

JEAN P., SCHMICH-YAMANE I., JAGLA J., CHEVRET P.

The modelling of desk screens by a combined BEM – Source image approach. (Modélisation des cloisons de bureaux par une méthode combinée BEM-sources images.). 2015, Vol. 101, pp. 91-97

■ **Acoustics in Practice**

CHEVRET P., CHATILLON J.

Acoustic discomfort for tertiary-sector employees: issues and means of action for prevention. (Inconfort acoustique des employés du secteur tertiaire : enjeux et moyens d'action pour la prévention.). 2015, Vol. 5, pp. 53-59.

■ **Hygiène et Sécurité du Travail**

TROMPETTE N., DONATI P., FONTAINE J.R., KELLER F.X., CLAUDON L.

Panorama des risques liés à l'utilisation de machines portatives. Janvier 2015, n° 237, DO 7, pp. 22-24.

■ **Internoise 2015, 9-12 August 2015, San Francisco, États-Unis**

CHEVRET P., ZIMPFER V.

Study of factors governing intelligibility in multi-speaker environments from an experiment with a large panel of listeners. (Etude des facteurs contribuant à l'intelligibilité multi-locuteur à partir d'une expérience faite avec un large panel d'auditeurs). *Proceedings*, 13 p.

■ **Euronoise 2015, 31 May - 3 June 2015, Maastricht, The Netherlands**

JAGLA J., NOE N., SCHMICH-YAMANE I., CHEVRET P.

A hybrid method for open-plan offices acoustics prediction using beam and particle tracing. (Méthode hybride de simulation pour la prédiction de l'acoustique des opens-spaces, utilisant des tracés de faisceaux et de particules.). *Proceedings*, 6 p.

LE MUET Y., CHEVRET P.

Acoustic of open spaces - toward a new French standard. (Acoustique des bureaux ouverts – vers une nouvelle norme française). *Proceedings*, 6 p.

■ **NOVEM 2015, Noise and vibration – emerging technologies, 13-15 April 2015, Dubrovnik, Croatia**

NEJADE A.

CIBNAH: a new Near-field Acoustic Holography method with no requirement for reference signals. (CIBNAH : une nouvelle méthode d'holographie acoustique de champ proche qui n'exige pas de signaux de référence.). *Proceedings*, 7 p.

■ **50th UK conference on Human responses to Vibration, 9-10 September 2015, Southampton, The United Kingdom**

FLEURY G.

Sensitivity analysis of the spinal load model used in the draft standard ISO 2631-5. (Étude paramétrique du modèle de colonne vertébrale utilisé dans le projet de norme ISO 2631-5). *Proceedings*, 11 p.



Design of Work Equipment, Workplaces, and Working Situations

■ Applied Ergonomics (IF: 1,332)

GAUDEZ C., GILLES M., SAVIN J.

Intrinsic movement variability at work. How long is the path from motor control to design engineering?. (La variabilité intrinsèque du mouvement : des théories du contrôle moteur jusqu'à son intégration dans les outils de conception de postes de travail, un long chemin à parcourir.). 2016, Volume 53, pp. 71-78.

■ The Visual Computer (IF: 0,909)

DE MAGISTRIS G., MICAELLI A., EVRARD P., SAVIN J.

A human-like learning control for digital human models in a physics-based virtual environment. (Présentation d'un système de contrôle biomimétique d'humains virtuels par apprentissage). 2015, Volume 31, pp. 423-440.

■ International Journal of the Digital Human

DE MAGISTRIS G., MICAELLI A., SAVIN J., GAUDEZ C., MARSOT J.

Dynamic digital human models for ergonomic analysis based on humanoid robotics techniques. (Contrôleur de mannequin numérique dynamique basé sur des techniques robotiques et le comportement humain pour les analyses ergonomiques). 2015, Volume 1, n° 1, pp. 81-109.

■ Bibliothèque virtuelle de l'AFNOR

DAILLE-LEFEVRE B., FADIER E., MARSOT J., DEQUAIRE E., ROIGNOT R.

Prévention en phase de conception (cahier des charges basé sur l'usage d'une machine). Novembre 2015, MAR-A-III-20-20, 13 p.

■ Hygiène et sécurité du travail

DAILLE-LEFEVRE B., DEQUAIRE E., ROIGNOT R., FADIER E.

Acheter une machine : comment décrire les usages attendus ? *Hygiène et sécurité du travail*, juin 2015, n° 239, EC 10, pp. 70-73.

MARSOT J.

Prévention intégrée : quelles sont les pratiques des concepteurs de machines ? *Hygiène et sécurité du travail*, juin 2015, n° 239, NT 26, pp. 52-58.

MARSOT J.

Apports et limites des mannequins «virtuels» pour la conception des postes de travail. *Hygiène et sécurité du travail*, juin 2015, n° 239, CC 9, pp. 76-79.

■ Référence en santé au travail

CANETTO P., MARSOT J.

MAVImplant : un outil pour prendre en compte la santé-sécurité lors de la création ou du réaménagement d'un lieu de travail. *Septembre 2015*, n° 143, AC81, pp. 5-7.

■ XIXth Triennial Congress of the International Ergonomics Association, 9-14 August 2015, Melbourne, Australia

QUILLEROU E., LUX A.

New perspectives in intervention for health at work: analyzing design work to transform design practices. (De nouvelles perspectives d'intervention et de transformation des pratiques de conception, analyse de travail d'un concepteur par une psychologue du travail et un ingénieur). *Proceedings*, 3 p.

■ CPI 2015 - Xth International Conference on Integrated Design and Production, 2-4 December 2015, Tanger, Maroc

SAADI Y., ETIENNE A., SIADAT A., DAILLE-LEFEVRE B.

Vers l'utilisation des ontologies pour la formalisation des exigences de sécurité fondées sur la notion de situation de travail. *Actes*, 5 p.

■ USE 2015 - Understanding Small Enterprises Conference 2015, 21-23 October, Groningen, The Netherlands

CANETTO P., MARSOT J.

MAVImplant, an online tool to build workplace 3D mockup. (MAVImplant, un outil en ligne pour construire des maquettes 3D de locaux de travail). *Proceedings*, 8 p.

■ **14^{ème} colloque national AIP-Priméca, 31 mars - 02 avril 2015, La Plagne, France**

DEGALVEZ N., MARSOT J., MARTIN P., GODOT X.
Détection et retour d'information sur les phénomènes dangereux durant le processus de conception. *Actes*, 6 p.

■ **Note Scientifique et Technique de l'INRS 2015**

MANSOUR D.
Contrôle de l'équilibre de mannequins virtuels dans un environnement perturbé. *Note Scientifique et Technique*, NS 335, 180 p.



Waste and Recycling

■ **Waste Management (IF: 2,485)**

LECLER M.T., ZIMMERMANN F., SILVENTE E., CLERC F., CHOLLOT A., GROSJEAN J.
Exposure to hazardous substances in cathode ray tube (CRT) recycling sites in France. (Évaluation du risque chimique dans le secteur du recyclage des tubes cathodiques (TCR) en France). 2015, 39, pp. 226-235.



Multiple Exposures: Chemicals and Noise

■ **Neurotoxicology and Teratology (IF: 3,181)**

VENETT., CAMPO P., THOMAS A., COUR C., RIEGER B., COSNIER F.
The tonotopicity of styrene-induced hearing loss depends on the spectrum of the noise associated with. (La tonotopie des pertes auditives induites par le styrène dépend de la fréquence du bruit avec lequel il est associé). 2014, Volume 48, pp. 56-63.

■ **Journal of Pharmacological and Toxicological Methods (IF: 2,15)**

BONFANTI E., COSNIER F., WATHIER L., CAMPO P.
Determination of ketamine and xylazine in rat brain by liquid-liquid extraction and gas chromatography-mass spectrometry. (Dosage de la kétamine et de la xylazine cérébrale chez le rat après extraction liquide-liquide et chromatographie en phase gazeuse couplée à la détection de masse). 2015, Volume 77, pp. 6-9.

■ **Environnement Risques & Santé**

CAMPO P.
Les ototoxiques exacerbent les surdités induites par le bruit. 2015, vol. 14, n° 2, pp. 125-134.

■ **Hygiène et sécurité du travail**

VENET T., THOMAS A.
Bruit et substances ototoxiques : cocktail à risque pour l'audition. *Mars 2015*, n°238, DC 8, pp. 6-9.



Manufactured nanomaterials

■ **Particle and Fibre Toxicology (IF: 7,11)**

DISDIER C., DEVOY J., COSNEFROY A., CHALANSONNET M., HERLIN N., BRUN E., LUND A., MABONDZO A.
Tissue Biodistribution Revealed Blood-Brain Barrier Clearance of Intravenously Administered Titanium Dioxide Nanoparticles and Brain Inflammation in Rat. (La biodistribution tissulaire révélant une clairance de la barrière hémato-encéphalique de nanoparticules de dioxyde de titane administrées par voie intraveineuse et une inflammation du cerveau chez le rat). 2015, Volume 12, Issue 27.

■ **Aerosol Science and Technology (IF: 3,155)**

CHARVET A., BAU S., BEMER D., THOMAS D.
Density in ELPI data post-treatment: the importance of being earnest. (De l'importance du choix de la densité de particule dans le post- traitement des données de l'ELPI). 2015, Volume 49, pp. 1263-1270.

■ **Environmental and Molecular Mutagenesis**
(IF: 2,553)

GUICHARD Y., MAIRE M.A., SEBILLAUD S., FONTANA C., LANGLAIS C., MICILLINO J.C., DARNE C., ROSZAK J., STEPNIK M., FESSARD V., BINET S., GATÉ L.

Genotoxicity of synthetic amorphous silica nanoparticles in rats following short-term exposure.

Part 2: intratracheal instillation and intravenous injection.. (Génotoxicité de nanoparticules de silices synthétiques amorphes chez le rat après une exposition court-terme. Partie 2 : instillation intratrachéale et injection intraveineuse.). *Mars 2015, Volume 56, Issue 2, pp. 228-244.*

■ **Environmental Science: Processes & Impacts**
(IF: 1,991)

BAU S., ZIMMERMANN B., PAYET R., WITSCHGER O.

Laboratory study of the performances of the miniature Diffusion Size Classifier (DiSCmini) for various aerosols in the range 15-400 nm. (Étude en laboratoire des performances du DiSCmini pour différents aérosols dans une gamme de 15 à 400 nm). *2015, Volume 17, pp. 261-269.*

■ **Toxicology and Industrial Health (IF: 1,859)**

GUICHARD Y., DARNE C., FONTANA C., CHAVIGNIER E., GATÉ L., BINET S.

Cytotoxic and genotoxic evaluation of different synthetic amorphous silica nanomaterials in the V79 cell line. (Évaluation de la cytotoxicité et de la génotoxicité de différents nanomatériaux de silices synthétiques amorphes sur la lignée cellulaire V79).

Online 10 Mars 2015, DOI: 10.1177/0748233715572562, 1- 12.

■ **Archives des maladies professionnelles et de l'environnement (IF: 0,222)**

GUSEVA CANU I., DUCAMP S., DELABRE L., AUDIGNON-DURAND S., DUCROS C., DURAND C., IWATSUBO Y., JEZEWSKI-SERRA D., LE BIHAN O., MALARD S., RADAUCEANU A., REYNIER M., RICAUD M., WITSCHGER O.

Proposition d'une méthode de repérage des postes de travail potentiellement exposant aux nano-objets, leurs agrégats ou agglomérats dans les entreprises mettant en œuvre des nanomatériaux manufacturés. *2015, Volume 76, pp. 329-336.*

■ **Journal of Physics: Conference Series**

GUSEVA CANU I., DUCAMP S., DELABRE L., AUDIGNON-DURAND S., DUCROS C., DURAND C., IWATSUBO Y., JEZEWSKI-SERRA D., LE BIHAN O., MALARD S., RADAUCEANU A., REYNIER M., RICAUD M., WITSCHGER O.

A standardized non-instrumental tool for characterizing workstations concerned with exposure to engineered nanomaterials. (Une méthode standardisée non instrumentale pour le repérage des postes de travail exposant aux nano objets et leurs agrégats et agglomérats dans des entreprises avec manipulation de nanomatériaux intentionnellement produits). *2015, 617, 012036 doi:10.1088/1742-6596/617/1/012036.*

■ **Pistes**

L'ALLAIN C., CAROLY S., DRAIS E., WITSCHGER O.

Concevoir la prévention d'un risque émergent : une démarche fondée sur les représentations et les activités. *2015, <http://pistes.revues.org/4421>*

■ **Nanomaterial Characterization: An Introduction, John Wiley & Sons Inc. Editions, 2015.**

WITSCHGER O.

Methods for Testing Dustiness. (Méthodes d'essais de dustiness).

■ **Référence en santé au travail**

GUSEVA CANU I., DUCAMP S., DELABRE L., AUDIGNON-DURAND S., DRUCROS C., DURAND C., IWATSUBO Y., JEZEWSKI-SERRA D., LE BIHAN O., MALARD S., RADAUCEANU A., REYNIER M., RICAUD M., WITSCHGER O.

Proposition de méthode d'identification et d'observation des postes de travail potentiellement exposant aux nanomatériaux. *Septembre 2015, n° 143, TM 35, pp 33-62.*

■ **Hygiène et sécurité au travail**

SAVARY B.

Nano-argents : de la production à l'utilisation, quels sont les risques. *Mars 2015, n°238, NT 24, pp. 58-62.*

BAU S., WITSCHGER O., GALLAND B., MARTIN P.
Métrologie en temps réel de substances chimiques au poste de travail: intérêts et limites. *Juin 2015, n°239, DC 9, pp. 6-10.*

■ **CFA 2015, 30ème Congrès Français sur les Aérosols, 27-28 janvier 2015, Paris, France**

WITSCHGER O., BROUWER D., TUINMAN I., JENSEN K., JANKOWSKA E., DAHMAN D., BURDETT G., BARD D. DUSTINANO: a pre-normative research project towards a harmonized approach to evaluate the nanomaterials dustiness. (DUSTINANO: un projet européen de recherche pré-normative pour harmoniser l'évaluation de la « dustiness » des nanomatériaux en poudre). *Actes, 6 p.*

BAU S., ZIMMERMANN B., PAYET R., WITSCHGER O.
Laboratory study of the performances of the DiSCmini for various mono and polydisperse aerosols in a range from 15 to 400 nm. (Étude en laboratoire des performances du DiSCmini pour différents aérosols mono- et polydispersés dans une gamme de 15 à 400 nm). *Actes, 6 p.*

■ **SELF 2015 - 50ème congrès international de la Société d'Ergonomie de Langue Française, 23-25 septembre 2015, Paris, France**

L'ALLAIN C., CAROLY S., DRAIS E.
Les espaces de débat sur le travail : des ressources pour la prévention des risques dans un contexte d'innovations et d'incertitudes. *Actes, 7 p.*

■ **Note Scientifique et Technique de l'INRS 2015**

BAU S., WITSCHGER O.
Étude en laboratoire des performances de l'appareil DiSCmini pour la mesure des aérosols submicroniques. *NS 337, Août 2015, 39 p.*



Organisation, Health and Safety at Work

■ **Work (IF: 0,521)**

KLOETZER L., QUILLEROU E., SIMONET P.
Engaging practitioners in WRMSD prevention: interdisciplinary experiences in Activity Clinic. (L'engagement des professionnels dans la prévention des TMS : expériences interdisciplinaires en clinique de l'activité). *2015, n°51, pp 161-173.*

■ **Le Travail Humain (IF: 0,469)**

MORVAN E., DELECROIX B., QUILLEROU E.
Dynamiques des marges de manœuvre et santé au travail. le cas d'un projet d'organisation en «opérateurs tournants». *2015, vol. 78, n° 1, pp. 53-65.*

■ **Francophone Perspectives of Learning Through Work. Conceptions, Traditions and Practices. Filliettaz L., Billett S., Springer Editions, 2015**

KLOETZER L., CLOT Y., QUILLEROU E.
Stimulating Dialogue at Work: the Activity Clinic Approach to Learning and Development. (Stimuler le dialogue au travail : l'approche de la clinique de l'activité pour l'apprentissage et le développement), *pp. 49-70.*

■ **XIXth Triennial Congress of the International Ergonomics Association, 9-14 August 2015, Melbourne, Australia**

BOUDRA L., DELECROIX B., BUÉGUIN P.
Taking into account the territorial dimension of work for sustainable work system. The case of waste sorting centers. (Prendre en compte la dimension territoriale du travail pour des systèmes durables. Le cas des centres de tri des déchets d'emballages ménagers.). *Proceedings, 3 p.*

■ **SELF 2015 - 50ème congrès international de la Société d'Ergonomie de Langue Française, 23-25 septembre 2015, Paris, France**

MORVAN E., DELECROIX B.
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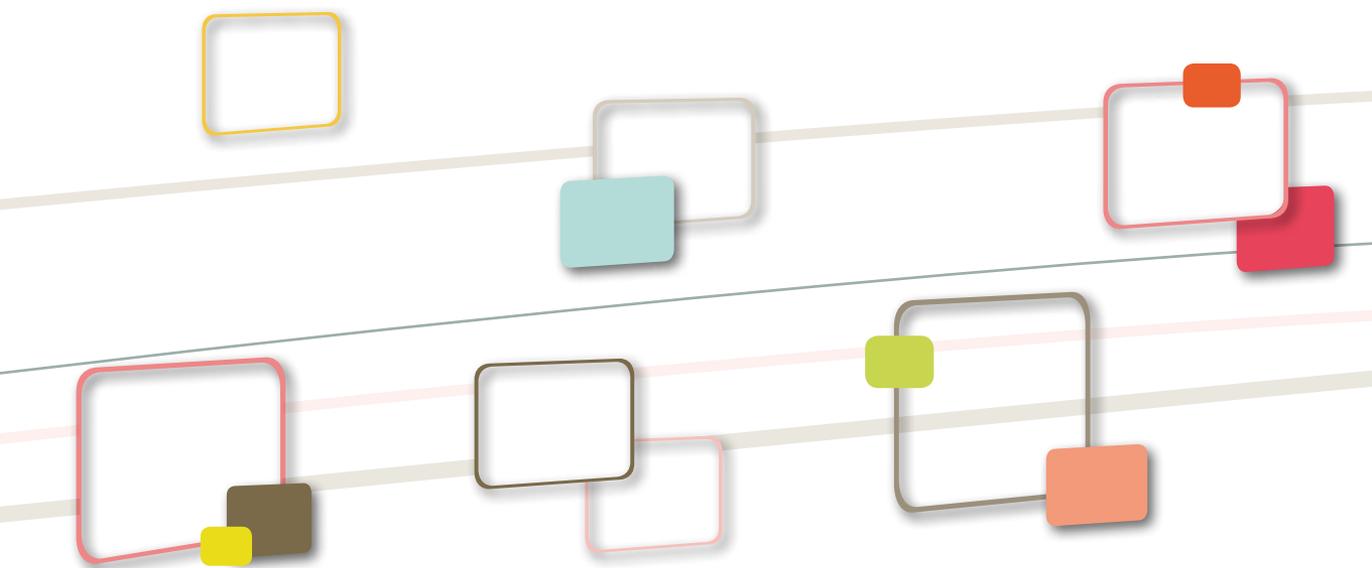
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