Institut National de Recherche et de Sécurité

Studies & Research

2016/2017

Institut national de recherche et de sécurité
pour la prévention des accidents du travail
et des maladies professionnelles

www.inrs.fr

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 2016:

- studies and research 42%
- assistance 25%
- training 11%
- information 15%

(International activities and external communication account for 7%)

Some figures

Staff
- 580 employees including
- 209 people based in the Paris headquarters and
- 371 people in INRS's Lorraine centre in Vandœuvre-lès-Nancy

Budget
- €81,15 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 Professor Yves Roquelaure ... 12
2016 Studies & Research Annual Report ... 14

2016 / 2017 Studies & Research Programme

Overview of the studies conducted in 2016/2017 by topic:

Accidentology and Prevention Culture ... 15
Occupational Allergies ... 17
Noise, Vibration, Electromagnetic Fields, and Optics ... 19
Design of Work Equipment, Workplaces, and Working Situation ... 25
Waste and Recycling ... 26
Multiple Exposures: Chemicals and Noise ... 27
Manufactured Nanomaterials ... 31
Organisation, Health and Safety at Work ... 35
Reproduction and Work ... 42
Biological Risks ... 43
Chemical Risks ... 45
Mechanical Risks and New Technologies for Accident Prevention ... 60
Psychosocial Risks ... 62
Occupational Road Accident Risk ... 66
Musculoskeletal Disorders of the Limbs and of the Back ... 67
Ageing, Staying in Employment, and Preventing Occupational Exclusion ... 69

Partnerships ... 71

Presentations and Publications in 2016 ... 75

List of Publications 2016 ... 77

© S. Morillon - INRS

Professor Didier Baptiste
Scientific Director of INRS

Editorial by the Scientific Director

For me this year once again, the edition of the "2016-2017 Studies and Research" Brochure, is an opportunity to highlight the wealth of the contributions from the scientific and technical teams to the debate on occupational risk prevention.

Firstly, through the 16 finished studies presented in this report, some of which lie within the field of multiple exposures, or within the field of work organisation, with invaluable knowledge being acquired in transport and logistics and on "lean management" company practices. The researchers have also been mobilised on psychosocial risks, with, in particular, a study on situations having high emotional loads, and the results of an assessment of PSR and MSD prevention interventions conducted in companies. That assessment will, in the coming weeks, be the subject of a publication of a reference work. Not forgetting the constant need to enrich knowledge on chemical risks, to which one third of French workers declare they are exposed in the course of their work, and not forgetting work on MSD prevention with, for example, an analysis of the role of first-line supervisors. Naturally, I am not forgetting the studies in progress with prospects in the short term in the fields of collaborative robotics, exoskeletons, nanomaterials, the impact of night work on health…

This density of topics is the fruit of continuous adaptation of INRS's activities to take on board the latest developments in occupational risk prevention. The various skills of INRS interact, engaged in the reality of what is happening on the ground, so as to build knowledge, disseminate it, and cascade implementation of it. Thus, 2016 was marked by an intensification of the events activity. All of the events were privileged moments for increasing dissemination and sharing of knowledge, with, in particular an international conference on endocrine disruptors, a technology day on passive sampling, and the assessment of the "asbestos-analytical TEM" project.

Finally, following on from the topics and changes that I mentioned above, the 5th international conference "Innovorg", held in March 2017, was devoted to the health and safety issues of technological innovations and of the associated organisational changes. In a socio-economic context of intensification of work, use of robotisation, omnipresence of digital technology, longer career paths, and of ageing of the working population, the idea was for INRS - in collaboration with the PEROSH network - to reflect on the impact of such profound changes on health and safety, in their productive, organisational, managerial, and relational dimensions. The "factory of the future", or more exactly the services and industry of the future require us to be vigilant with respect to a future that we, as occupational risk prevention stakeholders, need to comprehend. At the core of this determination to apply foresight and prospective analysis, occupational risk prevention can no longer be seen as an obstacle to performance in companies, but rather as a genuine aid to the development and vitality of companies, and to the well-being of their employees.

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. Fontenay-aux-Roses (92)

Vice-Chairpersons

Annie JOLIVET	Centre d'Études de l'Emploi. Noisy-le-Grand (93)
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)
Christine CHAUVIN-BLOTTIAUX	Université de Bretagne-Sud. Centre de recherche en psychologie, cognition et communication (CRPCC). Lorient (56)
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)
Daniel EILSTEIN	Santé Publique France. Cellule Inégalités sociales et territoriales de santé, Direction de la prévention et de la promotion de la santé. Saint-Maurice (94)
Alexandre GARCIA	Conservatoire national des arts et métiers. Laboratoire de mécanique des structures et des systèmes couplés/Laboratoire d'acoustique (LMSSC). Paris (75)
Alain GARRIGOU	Université de Bordeaux 1. Département hygiène, sécurité et environnement. Gradignan (33)
Yves GONTHIER	Université de Savoie. Polytech Annecy-Chambéry. Le Bourget-du-Lac (73)
Pascal GUÉNEL	Institut national de la santé et de la recherche médicale (INSERM). Centre de recherche en épidémiologie et santé des populations (CESP). Villejuif (94)
Benoît IUNG	Université de Lorraine. Centre de recherche en automatique de Nancy (CRAN). Vandœuvre-lès-Nancy (54)
Laurence LE COQ	IMT Atlantique Bretagne-Pays de Loire, École Mines-Télécom. Département Systèmes Énergétiques et Environnement. Nantes (44)
Benoît MAUNIT	Université d'Orléans. Institut de chimie organique et analytique (ICOA). Orléans (45)
Alain PINEAU	Faculté de pharmacie. Laboratoire de toxicologie. Nantes (44)
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. Aubière (63)
David VERNEZ	Institut universitaire romand de santé au travail. Lausanne (Suisse)
Christophe VIAL	Institut Pascal. Axe génie des procédés, énergétique et biosystèmes (GePEB). Aubière (63)
Elisabete WEIDERPASS VAINIO	Cancer registry of Norway. Institute of population based cancer research. Oslo (Norvège)

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	Erdf-grdf, Médecine du Travail, service de santé au travail. Villers-lès-Nancy (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). Vitry-sur-Seine (94)
Daniel EILSTEIN	Santé Publique France, Cellule inégalités sociales et territoires de santé. Saint-Maurice (94)
Pascal GUÉNEL	Institut national de la santé et de la recherche médicale (INSERM). Centre de recherche en épidémiologie et santé des populations (CESP). Villejuif (94)
Elisabete WEIDERPASS VAINIO	Cancer registry of Norway. Institute of population based cancer research. Oslo (Norvège)

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)
Christine CHAUVIN-BLOTTIAUX	Université de Bretagne-Sud. Centre de recherches en psychologie, cognition et communication (CRPCC). Lorient (56)
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. Bruxelles (Belgique)
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 (Danemark)
Philippe MAIRIAUX	Université de Liège. Faculté de médecine. Département des sciences de la santé publique. Liège (Belgique)
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)

Members of the Work Equipment Engineering Follow-up Group

Michel BERENGIER	Institut français des sciences et technologies des transports, de l'aménagement et des réseaux (IFSTTAR). Centre de Nantes. Bouguenais (44)
Élodie DEQUAIRE	Centre technique des industries mécaniques (CETIM). Senlis (60)
Jacques FELBLINGER	Institut national de la santé et de la recherche médicale (INSERM). CHU Nancy-Brabois. Imagerie adaptative, diagnostique et interventionnelle. Vandœuvre-lès-Nancy (54)
Emmanuel FOLTETE	École nationale supérieure de mécanique et des 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-lès-Nancy (54)
Guy LE BERRE	CARSAT Bretagne. Direction des risques professionnels. Rennes (35)
Emmanuel MARTEAU	CRAM Île-de-France. Paris (75)
Fodil MERAGHNI	École nationale supérieure d'arts et métiers. Laboratoire d'étude des microstructures et de mécanique des matériaux (LEM3). Metz (57)
Bernard ROUGIE	Institut national de métrologie du Conservatoire national des arts et métiers (CNAM). La Plaine-Saint-Denis (93)
Jean-Claude SAGOT	Université de technologie de Belfort-Montbéliard. Laboratoire systèmes et transports. Belfort (90)
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. Aubière (63)

Members of the Process Engineering Follow-up Group

Jacques BORÉE	École nationale supérieure de mécanique et d'aérotechnique. Futuroscope. Chasseneuil (86)
Jacques CATANI	CARSAT Sud-Est. Laboratoire risques chimiques - Métrologie. Marseille (13)
Frédéric DURAND	Laboratoire interrégional de chimie de l'est. Vandœuvre-lès-Nancy (54)
François DURIER	Centre technique des industries aérauliques et thermiques (CETIAT). Villeurbanne (69)
Philippe GÉRARDIN	Université de Lorraine. Faculté des sciences et technologie. Laboratoire d'études et de recherche sur le matériau bois. Vandœuvre-lès-Nancy (54)
Yves GONTHIER	Université de Savoie. Polytech Annecy-Chambéry. Le Bourget-du-Lac (73)
Laurence LE COQ	IMT Atlantique Bretagne-Pays de Loire, École Mines-Télécom. Département Systèmes Énergétiques et Environnement. Nantes (44)
Michel LEBRUN	CARSAT Auvergne. Centre interrégional de mesures physiques. Clermont-Ferrand (63)
Michel SARDIN	Université de Lorraine. École nationale supérieure des industries chimiques (ENSIC). Nancy (54)
Christophe VIAL	Institut Pascal. Axe Génie des procédés, énergétique et biosystèmes (GePEB). Aubière (63)

Members of the Pollutants Metrology Follow-up Group

Denis BOULAUD	Institut de radioprotection et de sûreté nucléaire (IRSN). Direction environnement et intervention. Fontenay-aux-Roses (92)
Jacques CATANI	CARSAT Sud-Est. Laboratoire risques chimiques. Métrologie. Marseille (13)
Martine CHOUVET	Institut technique des gaz et de l'air (ITGA). Laboratoire PRYSM. Saint-Étienne (42)
Caroline DUCHAINE	Centre de recherche Hôpital de Laval. Département de biochimie et de microbiologie. Sainte-Foy (Québec)
Catherine HEDOUIN-LANGLET	CRAM Île-de-France. Laboratoire de toxicologie industrielle. Paris (75)
Jérôme LAVOUE	Centre de recherche du centre hospitalier de l'université de Montréal (CHUM). Montréal (Canada)
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	École 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 (Suisse)

Members of the Toxicology and Biological Monitoring 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)
Robert GARNIER	Hôpital Fernand Widal. 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). Châtenay-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 2016, studies and research actions accounted for 42% 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
- Inorganic analysis and aerosol characterisation
- 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:
- Temporal and spatial analysis of chemical exposure
- Aerodynamics Engineering
- Processes and air cleaning treatment

Toxicology and Biological Monitoring

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:
- Biological Monitoring
- Atmospheres Generation and Toxicological Analytical Chemistry
- Carcinogenesis, Mutagenesis and Reprotoxicity
- Sensitisation, 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.

© S. Morillon - INRS

Yves Roquelaure
Chief Medical Officer,
Head of the Department of Occupational Health and Occupational Diseases at the Teaching Hospital of Angers
Director of the Epidemiology in Occupational Health and Ergonomics (Ester) Laboratory

Interview with Professor Yves Roquelaure

Your Department treats occupational diseases and deals with occupational health issues at the Teaching Hospital of Angers. What prevention efforts have you identified in the light of the problems that you encounter?

At the occupational health department that I manage, we are mainly confronted with three occupational pathologies. Firstly, we see a lot of cancer cases. Clearly, the efforts for taking carcinogenic risk into account in enterprises, in particular the smallest ones, need to be kept up, and even reinforced. The difficulties involved in tracing career paths, the complexity of the exposures, and all the different types of worker status today make the need for prevention even greater, at all levels. Secondly, our patients suffer from musculoskeletal disorders, in particular disabling chronic low back pain. The particularity of our unit is that not only does it offer medical expertise to such patients, it also gives them support through a comprehensive treatment, care, and assistance pathway. Thirdly, we are experiencing a rise in psychosocial risks, with cases of depression, burnout, or post-traumatic stress disorder… that require all our attention.

INRS had the privilege of having you among its speakers at the 5th Scientific Conference on the topic of organisational changes and their potential impacts on prevention. You raised the issue of sustainability of occupational health actions for preserving health in a changing working world. Can you shed some light for us on the impact of such changes in terms of how prevention is organised?

The multiplicity of forms of employment (precarious or insecure contracts, temporary work, self-employment) that I was talking about earlier, the major transformation of modes of organisation and of production in companies - that INRS proposed to focus on during three days of discussions in March – are not without consequences on occupational health. In a working world that is more flexible, and more individualistic, healthcare professionals are warning about the impact of this socio-economic upheaval. The challenges for occupational risk prevention are to focus on a constructive dimension of healthcare with prevention and intervention strategies being combined, so as to give better support and care for companies and for their employees. Today, a general practitioner encounters at least one occupational pathology case during any one day. Exchange networks therefore need to develop, to improve medical monitoring, and keeping people in their jobs and in good health (e.g. in our Department with exposure monitoring being shared between the French Occupational Health and Insurance Fund, the teaching hospital, and a group of cancer specialists). Co-operation between public health and occupational health policies could be accentuated, and the will to do so exists on the ground.
The idea is also to mobilise companies and their managers, who are faced with market uncertainty, so as to support their prevention policies. In the specific case of MSDs, co-ordinating the treatment and prevention aspects through concerted actions between healthcare staff and representatives in the company generates participative synergy

with, for example, more room for manoeuvre or latitude being left for operatives on a production line. The occupational healthcare system has, for a long time now, been organised and adapted to cope with the occupational risks that it has even often anticipated. We now need to build bridges and gateways in order to co-ordinate this action with all healthcare players.

Your research work, in particular on musculoskeletal disorders, has led to long-standing collaboration with INRS. What actions bring you closer to the teams in charge of studies and research at INRS, in particular at the "Working Life" Division?

As an occupational physiologist, I became acquainted with INRS and with the current "Working Life" Division in the nineteen nineties, when I was doing a thesis on design approaches related to MSD prevention. Although the concept of "room for manoeuvre" or "latitude" or "leeway" was not yet talked about at the time, INRS was already proposing to combine ergonomics and organisational logic for acting on the working conditions of operatives. These "watch and expertise" dynamics are unique in France, and I have always been receptive to the originality of INRS's work that brings together skills in all occupational risks (chemical, physical, psychological, etc.). Few teams have such an approach and the means for transferring it, through training and guides intended for companies. Currently, the INRS teams are co-operating in a large-scale project that is devoted to night work and that is being conducted on a cohort of 200,000 people, in order to estimate the potential impact of such atypical working hours on health; an occupational situation that is not so atypical in the working world with its great diversity.

Identity Card: Presentation of the ESTER Team / INSER UMR 1085

As at 1 January 2017, the Epidemiology in Occupational Health and Ergonomics (Ester) Team led by Yves Roquelaure became the 10th team of the French Research Institute for Environmental and Occupational Health (Irset), co-labelled with Inserm (French National Institute of Health and Medical Research) as the joint research unit UMR 1085. Ester groups together researchers in the field of occupational health, in particular the members of the former Laboratory of Ergonomics and Epidemiology in Occupational Health (Leest) in the field of musculoskeletal disorders (MSDs), and researchers working on the topics of mental health (psychosocial risks) and occupational cancers.

The research focuses are as follows:

- Etiological research on occupational determinants;
- Assessment of their contribution to social inequalities in health;
- Assessment of occupational exposures;
- Prevention interventions and assessment of the interventions

Website: www.ester.univ-angers.fr/

2016 "Studies & Research" Annual Report

In 2016, 92 studies (totalling 235,551 hours) were conducted by the scientific divisions of INRS, the activity represented by these studies accounting for 42% of the volume of work of INRS.
The studies & research activities conducted in 2016 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 2016, as in the preceding years, the topic "chemical risks" predominates (31% of the studies & research activity). Topics related to organization at work, ageing, psychosocial risks and musculoskeletal disorders represent altogether 17% .Then come the themes of "manufactured nanomaterials" (12%) and "noise, vibration, electromagnetic fields, and optics" (10%).

The following pages offer detailed presentations of the 16 studies that were completed by the end of 2016, as well as short summaries of all of the 94 studies in progress in 2017. 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 2016/2017 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

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.**

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

(completed in 2016)

- **Stéphanie BOINI-HERRMANN and Michel GRZEBYK**
  Occupational Epidemiology Division

Outline of reasons and objectives

In the period of transition from school to work, under-25s are more vulnerable to occupational accident risks due to them being both young and new to their jobs. In view of this overly high accident rate, prevention for this population has been focused on teaching occupational safety and health (OSH). In France, OSH teaching has been the subject of a partnership between the French Ministry of National Education and the French National Health Insurance Fund for Salaried Workers (CNAM-TS) since 1993. INRS takes part in defining the OSH skills on Consultative Occupational Committees of the Ministry of National Education. However, so far, the impact of such teaching on the occurrence of occupational accidents has not been assessed. The main objective of this study was to determine the effect of OSH teaching received during schooling on the occurrence of occupational accidents in young people entering the working world. The secondary objectives of this study were focused on the potential effects of other items contributing to an OSH environment: "occupational first aider" training received during schooling and conditions of arrival and induction in the company (information on occupational risks, safety training, and job training given by a more senior colleague, etc.).

Approach

A prospective cohort study was put in place with apprentices and students from seven education districts, enrolled in the final year of their studies for their vocational diplomas (CAP/BEP), vocational certificates (brevet professionnel), vocational baccalaureates, or higher vocational diplomas (BTS), in production or service specialities (inclusions from 2009 to 2012, and end of monitoring of the last one in 2014).
The inclusion questionnaire, filled in by the participants just before they graduated, questioned them about their schooling paths, and in particular on the OSH teaching received. The monitoring or follow-up questionnaire, filled in every six months for two years, questioned them, among other things, about the characteristics of the job, the working conditions, and the conditions of arrival and induction in the company, and about any occurrence of accidents at work.

Main results

Of the 755 participants eligible for the study, 90% declared they had received OSH teaching. During the monitoring, the participants declared 1290 jobs (1.7 jobs per participant on average). In 70% of cases, the job corresponded to the initial training. Also during the monitoring, 158 occupational accidents were reported by the participants or

identified through the databases of the Occupational Health and Pension Insurance Funds (CARSATs), corresponding to an incidence rate of 0.12 [0.10-0.14] occupational accidents per participant-year. Half as high a risk of occupational accident was observed for participants who stated they had received OSH teaching during their schooling. A lower risk of occupational accident for the participants who had done the "occupational first aider" training was also observed. The conditions of induction on arrival in the company were not statistically associated with the occurrence of occupational accidents.

Discussion

This longitudinal study made it possible to highlight a lower risk of occupational accident among young people who had received OSH teaching, and among young people who had done "occupational first aider" training. OSH teaching is given widely during studies for occupational qualifications, with an approach that is often broader than merely concentrating on the specific risks of the trade being learnt. Our results emphasise the utility of pursuing and of generalising this approach.

With the aim of providing continuation in OSH education (initial and further training throughout working life) it would be advantageous to pursue the assessment of overall OSH teaching strategies (developing prevention culture, facilitating ties between schools and companies), and the modes of inducting young people, or indeed newly hired people, that are put in place as of arrival in the company.

A summary of the main results will be produced for the participants in the study. Scientific presentations and articles are also planned.

© P. Delapierre for INRS

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 and Andréa EMILI**
  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, biological monitoring, and atmospheric measurements.

2014 > 2017

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

- **Fabrice BATTAIS and Isabelle SPONNE**
  Toxicology and Biological Monitoring 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.

2017 > 2020

Measuring the performance levels of the BMDC *in vitro* model for assessing the sensitisation potential of chemical substances

- **Fabrice BATTAIS and Isabelle SPONNE**
  Toxicology and Biological Monitoring Division

Occupational allergies caused by exposure of workers to chemical substances are a major occupational health problem. This study is seeking to assess the performance levels of the Bone Marrow derived Dendritic Cell (BMDC) model on a large panel of chemical substances. If the BMDC model is shown to give good performance in terms of accuracy, sensitivity, and specificity, it will be proposed to the European Centre for the Validation of Alternative Methods (ECVAM), who validates alternative methods dedicated to detecting new substances that are potentially sensitising.

2017 > 2019

Developing a test for assessing the sensitising potential of industrial chemical substances: contribution of knowledge of the intracellular mechanisms involved

■ **Isabelle SPONNE and Fabrice BATTAIS**
Toxicology and Biological Monitoring Division

The objective of this study is to determine the involvement of various signalling pathways in the cellular response to skin and respiratory sensitisers. This work will be conducted initially on a model using dendritic cells, the central role of which in the physiopathology of skin or respiratory allergies is recognised, and then on other cell types of interest. The ultimate aim of this work is to supply biomarkers that could be incorporated into a test that is being developed for predicting sensitising potential.

2013 > 2017

Severity and control of work-related asthma

■ **Valérie DEMANGE and Anca RADAUCEANU**
Occupational Epidemiology Division

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.

© C. Almodovar for INRS

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 - Étienne PARIZET

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

2016 > 2019

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

- **Jean-Pierre ARZ**
  Work Equipment Engineering Division
- **PhD Thesis: Ossen EL SAWAF**
  University of Lyon 1 (Ecole doctorale MEGA) - Nicolas GRIMAULT

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.

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.

2017 > 2020

Developing protocols for assessing the comfort of earplugs at the workplace and in the laboratory, and proposing a comfort index

■ **Jonathan TERROIR**
Work Equipment Engineering Division

Currently, earplugs are exclusively characterised by the acoustic attenuation they procure. This study aims to assess the comfort of earplugs through an overall approach including the four identified types of comfort: physiological, auditory, psychological, and functional. The findings will facilitate choosing an appropriate protector and thus improving the protection for people who are exposed to noise, as regards both attenuation and comfort.

© P. Delapierre for 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.

2014 > 2017

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

■ **Pierre LEMERLE**
Working Life 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

■ **Gérard 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

■ **Jérôme REBELLE**
Work Equipment Engineering Division

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.

2017 > 2019

Study of the dynamic response of the body of a mobile plant driver exposed to vibration. Effects of position and of movements related to the work task

Maël AMARI
Work Equipment Engineering Division

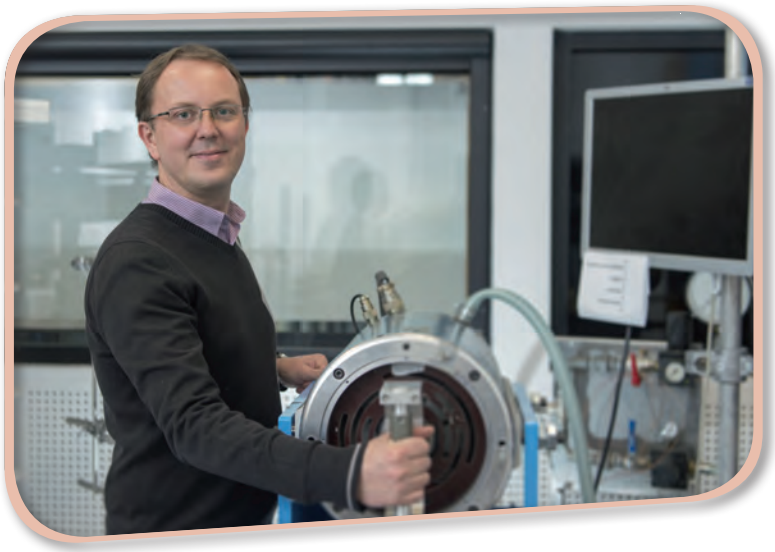
Regulations require employers to assess vibration risks. For whole-body vibration, the procedure defined by the relevant standard does not take into account the postural constraints (static position held, and movements). The aim of this laboratory study is to improve the standard, by characterising the dynamic response of the body of a plant driver exposed to vibration, while taking into account the diversity of the postures and of the movements made while accomplishing the work tasks.

2017 > 2020

A multi-scale approach for predicting certain effects of mechanical vibration on finger blood vessels

Christophe NOËL
Work Equipment Engineering Division

Of the employees who work with handheld machinery, the majority use rotary machinery that generates vibration that is potentially responsible for angioneurotic disorders such as secondary Raynaud's syndrome. The aim of this study is to improve the standardised measurement method by gathering knowledge that will make it possible better to understand, analyse, and predict the relationship between mechanical vibration and some of its acute physiological and chronic pathological consequences on digital microcirculation.



© S. Morillon - INRS

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.

2016 > 2019

Assessment of interactions between low-frequency electromagnetic fields and operatives in industrial environments: numerical and experimental approach

Mélina BOULDI
Work Equipment Engineering Division

The objective of this study is to develop an assessment method that is based on numerical simulations, and whose validity will be verified by comparison with *in vitro* measurements. An experimental test bench will be designed that is made up of a radiation source (low-frequency spot welder or high-frequency press), and of a manikin made of a material having dielectric properties close to those of human tissues. Ultimately, this simulation work will make it possible to determine, parametrically, the internal exposure limit values for workers for various industrial sources and various work stations.

Optical Radiation

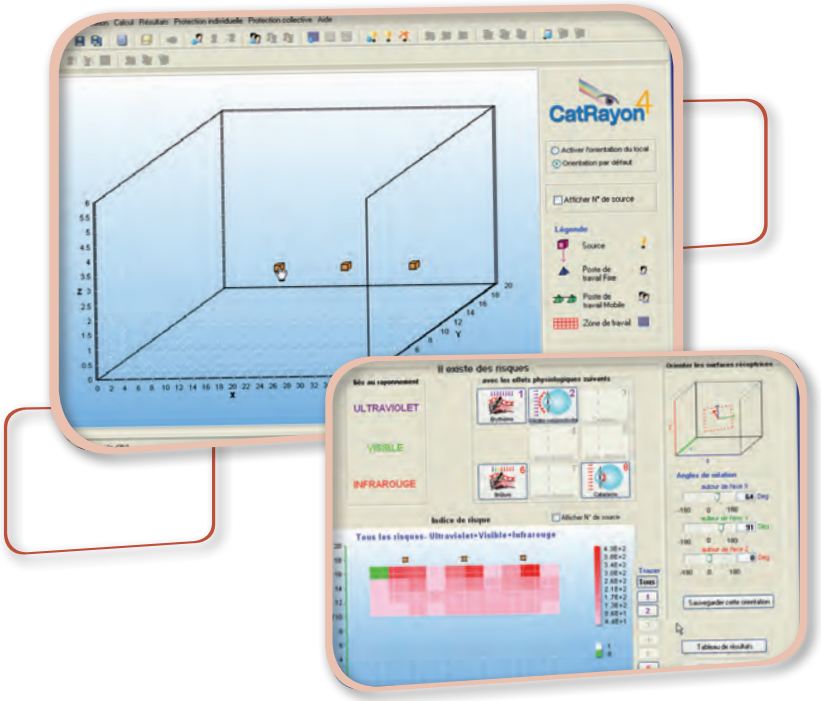
As regards optical radiation, INRS studies are continuing with a view to defining a methodology for assessing risks in situ and for assessing protective means.
Others aim to accompany implementation of the decree on protecting workers from the risks due to artificial optical radiation.

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 players to anticipate occupational risks and to keep them better under control, while also reconciling the technical, organisational, and economic demands of their projects. The issue at stake is to apply safe design principles, upstream in equipment projects (for machines, tools, etc.) or for workplaces (buildings, workshops, etc.).
The INRS studies concern both the methodological approach and also the design tools.
Other work is studying software tools or "digital manikins" for enabling designers to simulate various scenarios for a future working situation, and to check compliance with physical ergonomics principles (anthropometry, postures, efforts, stability, etc.).

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: Ismaël El MOUAYNI**
ENSAM ParisTech - 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
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.

2013 ▷ 2018

Prevention of chemical and biological risks in anaerobic digester units

■ **Patricia DIRRENBERGER**
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.

© G. Kerbaol - INRS

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, biological monitoring, protective equipment, screening, epidemiology, etc.); and**
- **assessing the relevance of Occupational Exposure Limit Values OELVs, in particular when doses are small.**

Assessment of the use of measurements of exposure to chemicals in the French databanks COLCHIC and SCOLA for preventing occupational diseases *(completed in 2016)*

- **Gautier MATER**
  Pollutants Metrology Division
- **PhD Thesis: Gautier MATER**
  University of Lorraine - Christophe PARIS

Outline of reasons and objectives

In France, two occupational exposure to chemicals databases, COLCHIC and SCOLA, coexist with different objectives (respectively prevention and regulation). COLCHIC and SCOLA, owned by the French National Health Insurance Fund for Salaried Workers (CNAM-TS) and by the French Directorate-General for Labour (DGT), are managed by INRS, who also handle use of them. Through three applications, SOLVEX and FIBREX available on www.inrs.fr and Scolamiante, http://scolamiante.inrs.fr/, INRS makes available to users tools enabling them to interrogate the data recorded in the two databases by sector of activity, trade or task, or by substance, so as to find out the levels of exposure a priori. COLCHIC and SCOLA contain respectively 929,700 items of data (670 chemical agents) and 429,104 items of data (105 chemical agents). Their representativeness relative to the general public is, however, unknown and is the subject of this work.

Approach

After conducting a comparative descriptive analysis, the association between the levels of exposure and the contextual elements was studied by statistical modelling for each agent, separately for COLCHIC and for SCOLA, and then in a common set of data. The summary across the agents was achieved by meta-analysis. The graphical representation in the form of a forest plot made it possible to illustrate the inter-chemical-agent variability.

Main results

Three strong predictors, "Sampling Duration", "Personal Protective Equipment", and "Year", are systematically associated with the levels in both databases, and three others are specific to each of them. With levels twice as a high in COLCHIC as in SCOLA in 2007, their concentrations become substantially comparable from 2012 to 2015 for 15 chemical agents common to both occupational exposure databases.

Discussion

After having identified the predictors in the separate analyses of COLCHIC and SCOLA, this work made it possible to compare the two occupational exposure databases for which the origin of the measurements is the same industrial fabric, but that each have their own specificity in terms of objectives. Consistent associations between variables of

interest and the measured levels were highlighted through the chemical agents, and they could cause biases when establishing exposure portraits. They should thus be taken into account to enable the estimations to be as close as possible to the real exposure levels in the working environment in France. The moderate amplitude of these associations, and the similarity between the levels for recent years in both of the databases remain reassuring in this respect, despite the absence of a "gold standard" with which to compare them. The convergence of the levels of COLCHIC and SCOLA opens up prospects for joint future uses, thereby reinforcing a priori knowledge of exposures for the substances common to the two databases.
This work opens up avenues for possible changes in the applications SOLVEX and FIBREX by combining the COLCHIC and SCOLA data if the trends are confirmed in the coming years, which would improve the statistical power. The models proposed could thus be used to predict exposures in situations to be described by the user, including, for example, determinants such as volatility of the substances, characteristics related to emission potential, etc.
This work was disseminated through: a presentation to the EPICOH Conference (Utrecht 2013); a scientific article published in the American Journal of Industrial Medicine; and a PhD thesis. Two other articles are currently being written to finalise this dissemination.

© S. Morillon - INRS

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

(completed in 2016)

■ **Pierre CAMPO et Thomas VENET**
Toxicology and Biological Monitoring Division

■ **PhD Thesis: Ludivine WATHIER**
University of Lorraine - Cécile PARIETTI

Outline of reasons ans objectives

Industrial environments can be noisy, and that noise can sometimes be combined with atmospheres polluted by volatile chemical substances. Although the damaging effects of noise on the sensory cells situated in the cochlea are well known, the toxic effects of solvents on those cells are less so. And yet certain solvents, such as toluene, can potentiate the cochleo-traumatic effects of noise in co-exposed employees. Preceding results have shown that toluene can disrupt middle ear reflex (MER). This study aimed to use this sensitivity of MER to aromatic solvents to develop a screening test capable of identifying the volatile substances likely to modify this reflex. In addition, the choice of the solvents made it possible to study their mode of action on the neurons involved in the reflex arc.

Approach

The solvents tested were chosen on the basis of their lipophilia (log Kow); benzene (2.13) is the most hydrophilic, whereas m-xylene (3.2) is the most lipophilic. The experimental protocol consisted in having adult male brown Norway rats inhale solvents. For this purpose, the animals were anaesthetised so as to adjust the amplitude of the MER to a value close to 1.5 dB. The amplitude of the MER was determined by measuring the amplitude of the acoustic

distortion product (ADP). When the MER was triggered by an acoustic stimulation of 95 dB at 4400 Hz, the amplitude of the ADP decreased. The variation in the amplitudes as measured before and during triggering of the MER made it possible to calculate the amplitude of the MER. After stabilisation of the MER, the animal was exposed to 3000 ppm of solvent via the intratracheal route, for 15 minutes.

Main results

The model developed made it possible to discriminate between the effects of the solvents on the MER: benzene had the maximum effect, and it was followed by chlorobenzene and then by toluene, styrene, p-xylene and m-xylene; as for ethylbenzene and o-xylene, they had no effect on the anaesthetised MER. The three isomers of xylene had different actions depending on the arrangement of the methyl groups around the benzene nucleus. Finally, nuclear magnetic resonance analysis of the brain microsomes of rats exposed to toluene showed that realistic concentrations of toluene did not disturb the fluidity of the biological membranes.

Discussion and dissemination

Solvents disrupt the neurons involved in the loop of the middle ear reflex in a mode of action that is modulated by the structure of the molecule. By means of this model, the study of the action mechanisms of solvents will be continued by testing other volatile substances, such as chlorinated solvents. This screening test can already be used for identifying volatile substances capable of modifying the MER and of potentiating the cochleo-traumatic effects of noise.

This work was disseminated at international conferences (INA 2015, Risques chimiques 2015, ARET 2015, GERM 2016) and was the subject of a publication in the journal Neurotoxicology.

Alteration in the metabolism of styrene by co-exposure with 2-butanone (MEK) *(completed in 2016)*

■ **Benoît COSSEC**

Toxicology and Biological Monitoring Division

Outline of reasons and objectives

Exposure to a single chemical substance is not the general rule in working environments. And yet Occupational Exposure Limit (OEL) values are often established on the basis of biological monitoring data: blood concentration of the substance of interest or urine concentrations of the metabolites, which do not take account of the multifactor atmospheric exposure conditions.

The objective of this study was to assess, in rats, the metabolic impact of an atmospheric exposure to a molecule known for its toxicity, styrene, with a molecule used in large quantities, because it is supposed to be harmless, methyl-ethyl–ketone (MEK), or 2-butanone.

Approach

Three operations were implemented. Firstly, the internal standards and the metabolites not commercially available were synthesised and then characterised. Then groups of rats were exposed to styrene on its own, to MEK on its own, or to both of the solvents jointly. The blood and urines were collected at the beginning and at the end of the week of exposure. The blood and urine samples were analysed by gas or liquid chromatography.

Main results

Combined exposure to 50 ppm (~ 2 x OEL8h) of styrene and to 200 ppm of MEK (OEL8h) increased the concentration of styrene in the blood relative to exposure to styrene on its own. Therefore, MEK shifts the hepatic metabolism of styrene, and increases its blood concentration and therefore its toxicity. Such an effect is more marked at the beginning than at the end of the week, suggesting that occasional exposures are more harmful than routine exposures during which the enzymes involved in the metabolisation can adapt (induction, inhibition, for example). The disruption of

the metabolism of styrene by MEK also has repercussions on the biological exposure indicators, or, in other words, on urinary metabolites. The concentrations of mandelic and phenylglyoxalic acids, indicators of exposure in humans, were also increased after co-exposure to styrene and to MEK.

Discussion

Today, mandelic and phenylglyoxalic acids are the biological indicators of exposure to styrene. However, co-exposure to styrene and to MEK disrupts firstly the metabolism of the molecule of interest, and secondly the kinetics of excretion of the metabolites. The question then arises of how relevant the biological exposure indicators are in the event of multiple exposures. This study emphasises the importance of multiple exposures in managing chemical risks for employees. It should be supplemented by studies of removal kinetics in order to propose collection periods that are better suited to atmospheric exposure conditions.

A publication will be submitted to an international journal at the end of the 1st quarter of 2017. In addition, the data obtained in this study will make it possible to enrich the database MiXie France for raising occupational physicians' awareness of the risks run by employees exposed to more than one solvent.

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 Biological Monitoring 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.

2017 ▷ 2018

Volatile chemical substances and middle ear reflex

■ **Ludivine WATHIER and Pierre CAMPO**
Toxicology and Biological Monitoring Division

This study proposes to test chlorinated solvents and non-aromatic molecules so as to establish rules making it possible to predict the action of volatile chemical substances on protective middle ear reflex (MER). These investigations aim to shed more light on the relationship that exists between the changes in the amplitude of the MER and certain structural characteristics of the solvents.

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.**

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

(completed in 2016)

Emmanuel BELUT
Process Engineering Division

Outline of reasons and objectives

The objective of this study was to develop tools necessary for assessing the effectiveness of collective protection systems, based on ventilation, for protecting people from nanoparticle aerosols. To investigate this subject, three focuses for action were identified: characterising the sources of nanoparticle aerosols, studying the airflow factors in degradation of the confinement of ventilated enclosures, and developing models for numerically simulating the dispersion of nanoaerosols at workplaces (predictive ventilation).

Approach

In order to characterise the nanostructured aerosol sources that are most commonly placed in airflow confinement enclosures, these sources were, in a first stage, identified and classified on the basis of a detailed bibliographical analysis. The analysis showed that credible mapping of the quantities of pollutant emitted by the processes could be achieved only experimentally, after developing a specific method. Such a method was thus developed and standardised so as to be applied to the nanoaerosol sources placed in ventilated enclosures.

In order to develop a predictive ventilation model adapted to the specificities of the nanoparticle aerosols (deposition, aggregation), collaboration with a university laboratory was initiated and PhD thesis work was undertaken. The work was underpinned by an experimental base and there was a strong requirement for the applicability of the developed method to be good.

Main results

The results made it possible to identify the main nanomaterial aerosol sources present in ventilated enclosures. An experimental method of characterising the generation flow rates of these sources that is applicable out in the field was then developed and validated. A realistic predictive model for the variation in pollutant nanoaerosols in work atmospheres was designed. This model is usable for assistance purposes and a simplified version, in the form of a two-zone exposure model, was developed. The simplified model is designed to guide prevention specialists in estimating the approximate order of magnitude of the concentrations expected in a given working situation, and the state of aggregation of the aerosol.

Discussion

The method of characterising the sources will be proposed to the technical units of the CARSATs. The predictive ventilation model that has been developed is operational for actions out in the field. Finally, the work conducted for this study has been disseminated in the form of scientific publications and national and international presentations, and will be disseminated through microsoftware that is in the process of being finalised.

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 Biological Monitoring 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 Biological Monitoring 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 > 2017

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

■ **Laurent GATÉ**
Toxicology and Biological Monitoring 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.

2016 > 2020

Development of a smart experimental approach for assessing the hazard related to nanomaterials (European project SMARTNANOTOX)

■ **Laurent GATÉ**
Toxicology and Biological Monitoring Division

Under the European project SmartNanotox, funded by the European Commission, INRS will take charge of the work related to *in vitro* assessment of the toxicological properties of nanomaterials (subacute toxicity in rats). INRS will also perform transcriptome analyses in order to identify the initiating molecular mechanisms and the key mechanistic events leading to adverse outcomes. Finally, INRS will take part in developing a "smart" screening method for *in vitro* and in silico predictive assessment of the toxicity of nanomaterials.

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.

2016 ▷ 2019

Multiparametric characterisation of metal ultrafine particles

■ **Davy ROUSSET**
Pollutants Metrology Division

■ **PhD Thesis: Massimissa BELHADJ**
Institut Mines Télécom Lille Douai – Patrice CODDEVILLE

The small size of nanoparticles gives them high reactivity that is related to them having increased specific surface area and increased solubility. This chemical reactivity results in a greater capacity to cause oxidative stress at cellular level, which is the main mechanism responsible for the toxicity of this type of particle. This study will make it possible to have a methodology for characterising more specifically the exposures to ultrafine particles, and to assess the utility of such characterisation for interpreting the effects observed on worker's systems.

2016 ▷ 2020

Optimising methods of sampling ultrafine particles of metal aerosols using cascade impactors

■ **Virginie MATERA and Élodie PARDIEU**
Pollutants Metrology Divisionnts

This study aims to assess the performance of various impactors, and to propose an efficient and reproducible method for sampling ultrafine particles, in a context of exposure to metal particles. The purpose of this work is to give prevention specialists access to the resulting method of measuring the particle size of aerosols and of chemically analysing them.

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

EXPROPNANO: 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**
University of 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 ▷ 2017

Performance of filtering and 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.**

Prevention in transport and logistics: technological and organisational changes in networked enterprises *(completed in 2016)*

- **Virginie GOVAERE and Liên WIOLAND**
  Working Life Division
- **PhD Thesis: Bérangère HITTINGER**
  University of Toulouse - Julien CEGARRA

Outline of reasons and objectives

Road Haulage and Logistics companies form a sector that is essential for the economy. This sector concerns 1.8 million employees who, in terms of accident rate, are two to three times more often victims of accidents than workers in the other sectors of activity. The companies of the sector are organised into logistics chains that can be likened to networks of interconnected companies. In 2011, INRS studies brought to light the phenomenon of "propagation" (spread of disruptive or protective factors) from one working situation to another, and its counterpart in terms of risk prevention "acting elsewhere". The objective of the current study was to conduct thinking about putting together a prevention strategy intended for these networked companies by incorporating the phenomena of "propagation and acting elsewhere" through analysis of the effects of introducing Information and Communications Technologies (ICTs) and of the organisational changes in the sector.

© S. Morillon - INRS

Approach

An ergonomics analysis was conducted in 5 companies. One of the companies was monitored longitudinally (for 6 years) in order to consider the various phases of the deployment of ICTs and the company's organisational changes related to that deployment. For all of the companies, data was collected by means of interviews and observations with the various players (from managers to operatives). The data were then formalised into 4 levels: the network, the company, the team, and the players.

Main results

The strategy of the company, the way it is managed, and the way it is organised define the conditions of the activity and of the use of ICTs, and how the constraints are handled by the operatives. Regardless of the company, the phenomenon of propagation is observed both within the company (between departments) and between networked companies. The origin of the disruptive and protective factors is thus to be sought at the scale of the working situation and also at the scale of all of the interconnected situations.

In addition, all of the employees of the companies must take into account the co-existence of a plurality of ICTs for performing any one task. The use of an ICT changes the core trades and results in an intensification of the work of the various players in the company. This intensification has potential consequences on the health and safety of the employees and also on the way in which occupational risk prevention is managed in the company.

Discussion

The diagnostics and prevention solutions led to findings for each company. A prevention approach intended for the networked companies was developed. It includes a diagnostic part and a prevention solutions deployment part. In this approach, the idea is to identify and then to implement solutions aimed at keeping disruptive factors under control at source rather than at the level of the situation in which they express themselves.

This study was disseminated through publications (21) and presentations (24) for various audiences (scientists, prevention specialists, and professionals). As part of the ANR (French National Research Agency) projects, the "smart planning" project was selected and constitutes one of the follow-ons from this study.

A technical day is also scheduled for October 2017.

© S. Morillon - INRS

"Lean management" company practices and occupational health

(completed in 2016)

Évelyne MORVAN, Bertrand DELECROIX and Edwige QUILLEROU-GRIVOT
Working Life Division

Objectives

Risk factors for health or opportunities for improving working conditions? Studies on the "lean management" organisation mode do not always converge. The scope of the analyses in terms of causes-and-effects is limited by the lack of clarity of the concept, changes in it, and the heterogeneity of practices. Since the realities of how lean management has been introduced into companies are ill-known, this study of the processes and of their determinants aimed to identify spaces for linking up with occupational risk prevention. Faced with the current spread of the concept, in particular to sectors that are new to it like the building trade or care services, the objectives of the study were to document the diversity of lean management, with a view to finding levers for preventing occupational risks.

Methodology

The work took place in four parts: construction of a framework for analysing the introduction of a change related to lean management; assessment of the literature in the building trade and the hospital sector; putting together a set of case companies for conducting interviews and site visits, making a detailed analysis of the implementation process (2 cases from industry and 1 case from the building trade) and putting all of the cases into perspective (3 cases from industry, 6 from the building trade, and 9 from care services); and exchanges with prevention specialists and researchers.

Main results

At the end of the study, an analysis framework was proposed for exploring the diversity of lean management through the characteristics of the pathways along which this organisational concept is implemented, is spreading, and is transferred. Resulting from work on management tools and on managerial trends, this framework makes it possible to take a step back from the lean management references (true/false, partial/full, etc.). The pretention that lean management is universal conceals a multitude of processes for interpreting and translating it, depending on the context. Economic, historic, and social factors, health & safety, and other projects could play parts that are more important than the content of the change itself. A table recapitulating change factors (content, implementation process, internal and external context) likely to have an impact on the results of the change was proposed. More generally, this work made it possible to identify the roles of players who influence the pathways for implementation, spread and transfer from one sector to another. A map of the players involved (promoters, external and internal "implementers", first-line supervisors who are "integrators", and users) made it possible to realise how diverse the roles are. An analysis of the interactions between the internal "implementers" and the "integrators" was conducted on 2 building sites, making it possible to identify tensions and learning in the practical implementation of tools. More general knowledge about transfer of lean management to the building trade and to hospitals was procured through looking at the literature from that perspective. Beyond the interest in lean management shown by these two sectors,

© G. Kerbaol - INRS

the case studies show the variety of pathways (each "implementer" translates lean management as they see fit), a variety of names and approaches developed locally, with concern for making progress in a manner that is incremental and adapted to suit the constraints of the sector, without rushing.

Conclusion

By observing the lean management pathways in these various contexts, it was observed that the managerial concept and the management tools that make it operational continue to be modified after they have been implemented. Realising the full extent of the fluctuating nature of lean management and the importance of contextual and implementation factors can help prevention specialists to better anchor their actions sustainably and to position themselves on the "performance and health & safety" line, during exchanges with promoters, consultants, and "implementers" of lean management. This work was the subject of 2 scientific publications, various training actions (sessions) for the CARSATs, an INRS web file, an article in "Travail et Sécurité", and various forms of presentations to prevention specialists and researchers.

Prevention in branch design and co-operation between local stakeholders. The case of a national project to extend treatment of recyclable waste *(completed in 2016)*

■ **Bertrand DELECROIX and Évelyne MORVAN**
Working Life Division

■ **PhD Thesis: Leila BOUDRA**
Université Lumière de Lyon - Pascal BÉGUIN

Outline of reasons and objectives

This study aimed to improve the way worker health and safety is taken into account in the waste sorting sector. It was based on a national experiment that was conducted by Eco-Emballages and that, from 2010 to 2013, related to the extension of recyclable waste sorting instructions in 32 sorting centres. With the aim of improving occupational risk prevention before possibly generalising the extension of the instructions to all sorting centres in France, the idea was for INRS to study the influence of the decision processes of the various stakeholders on the actual work of the sorting operatives, in order to propose avenues for improving the working situations in the centres, thereby reducing the risks of adversely affecting the health and safety of the operatives.

Approach

The approach comprised two parts. Firstly, an ergonomics intervention was conducted in 4 of the 32 sorting centres concerned by the experiment. More precisely, the interventions analysed the effects, on the real work and risks for the health & safety of the operatives, of the change in the sorting instructions given to residents. The results were given to

© P. Delapierre for INRS

the decision takers in the companies and in the local authorities, with the aim of comparing the logics of the various players and of designing the working situations in such a manner as to facilitate risk prevention. Then, the results of these analyses were given at national level (Ademe (the French Environment and Energy Management Agency) and Eco-Emballages), who assessed the results of the experiment.

Main results

The main results of this study made it possible to reveal the disconnection existing between the technical and organisational characteristics of the sorting centre and the local specificities (modes of consumption, economic activity, tourist attractiveness, etc.) that heavily influence the characteristics of the waste to be treated. The extension of the sorting instructions accentuates the gap between the characteristics of the waste to be recycled and the technical and organisational characteristics of the sorting centre that are not adapted to cope with these changes. This disconnection causes the sorting operatives to run a set of risks through intensification of their work and occurrence of overflow and excessive workload situations, resulting in psychosocial risks, and risks of MSDs, falls, etc. The technical and organisational techniques implemented (assignment of additional staff, addition of dustbins or containers in the sorting centre, etc.) are not sufficient to regulate this disconnection. These results, given at national level, made it possible to construct an assessment grid for assessing the existing and future occupational risks. The grid, incorporated into Eco-emballage's criteria for selecting service provider companies, was integrated into the process for assessing bids for invitations to tender by local authorities and sorting centres. It will be used for gradually generalising the extension of the sorting instructions to all sorting centres in France.

Discussion

This study made it possible to better understand the relations between the various decision levels and to use these relations as a basis for improving prevention action. The players at national level have undertaken actions with the local players so that they develop cooperation with the corporate players, thereby making it possible to reconcile economic and environmental performance with the issues of preventing occupational risks and of improving working conditions. Through the assessment grid for assessing occupational risks, the sorting centres and the local authorities are gradually reinforcing their role as prevention players.

This work has been the subject of a thesis report, of five publications of conference proceedings, and of seven presentations. It will be incorporated into the INRS training courses (prevention in the waste sector, "Risks and Organisation" session, approving of CARSAT inspectors and engineers).

2016 > 2022

Effect of night work on occurrence of ischemic cardiovascular diseases

Stéphanie BOINI-HERRMANN and Eve BOURGKARD
Occupational Epidemiology Division

This epidemiological study of the case-control type proposes to examine the link between night work, which concerns about 15% of employees, and the occurrence of ischemic cardiovascular diseases. This study will be conducted in partnership with external research teams (CONSTANCES cohort, InVS/DST, INSERM/CHU). It is expected that the results will facilitate dissemination and implementation of specific prevention measures in companies on the theme of ischemic cardiovascular diseases.

2017 > 2021

Smart planning of goods transport delivery rounds (SMART PLANNING)

Virginie GOVAERE and Liên WIOLAND
Working Life Division

The Smart Planning project proposes to develop a set of new knowledge in implementing compromises for preparing schedules or plans for goods transport by road, incorporating social, economic, environmental, and safety concerns in optimising resources. The contributions will be validated by field experiments conducted on two industrial partners. INRS is handling the "modelling the constraints and compromises specific to goods transport by road" aspects.

2017 > 2019

Health risk management by middle managers: an exploratory study

■ **Jacques MARC**
Working Life Division

This study is looking at the role of middle managers in preventing health risks, in a context in which their "room for manoeuvre" or "latitude" seems to be decreasing. The study will endeavour to explore the mechanisms whereby middle managers detect alerts relating to the risks for the safety and health of themselves and of their staff, and the way in which they respond to such alerts. The study will also seek to identify the indicators that make it easier for middle managers to attend to the health risks among the other risks they have to manage.

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.

2016 > 2019

Analysis of the profession of production system designer: contributions from occupational psychology and from engineering for transforming design practices in favour of the health and safety of operatives

■ **Edwige QUILLEROU-GRIVOT**
Working Life Division

■ **Aurélien LUX**
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.

2017 ▷ 2020

For a prevention culture in occupational health: social and organisational exploration of prevention work

Éric DRAIS
Working Life Division

The development of a prevention culture is considered to be an essential means for action in primary prevention. The study will look to delimit the concept of prevention culture with regard to the technical, social, and legal dimensions of risk prevention work. It will test the conditions for managing such a prevention culture on the basis of observing prevention schemes and of analysing what can be learned from them. Finally, it will seek to verify the conditions for providing instruments for measuring a prevention culture with the aim of contributing to developing a diagnostics tool that is intended for the prevention network.

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.

2014 ▷ 2017

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

■ **Anne-Marie SAILLENFAIT**
Toxicology and Biological Monitoring 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 SAILLENFAIT**
Toxicology and Biological Monitoring 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 improve 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 ▷ 2018

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 evaluate 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 toxinic 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.**

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 bioaerosols emitted 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: biological monitoring and atmospheric assessment

■ **Sophie NDAW and Alain ROBERT**
Toxicology and Biological Monitoring 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).

© G. Kerbaol - INRS

2017 > 2019

Methodology for assisting with biological risk assessment

■ **Sarah BURZONI**
Pollutants Metrology Division

■ **PhD Thesis: Sarah BURZONI**
University of Lorraine (Ecole doctorale BioSE) – Luc FERRARI

In order to help companies in conducting their biological risk assessment approaches enabling them to define suitable preventive measures, the objective of the study is to propose a methodology of qualitative risk assessment that is appropriate to all work situations. The approach will be validated internally and externally on a sample of establishments having biological risks, before it is made available to prevention specialists.

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.

2015 > 2017

CENSUR - Challenges in estimating relative survival

■ **Michel GRZEBYK and Guy HEDELIN**
Occupational Epidemiology Division

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

2017 > 2021

Exposure to cutting fluids and biomarkers of early effects: oxidative stress, inflammation and genotoxicity (OxIGenoCOM)

■ **Eve BOURGKARD, Valérie DEMANGE**
Occupational Epidemiology Division

■ **Fanny JEANDEL**
Toxicology and Biological Monitoring Division

The absence of data relating to pollutants present in oil mists, resulting from the use of cutting fluids, makes it impossible to identify effects on health. The aim of this study is to analyse the relationships between various parameters giving the details of occupational exposure to oil mists and biomarkers of exposure and of effect at various physiopathological levels (oxidative stress, inflammation, genotoxicity). Knowledge of the determinants of exposure and of its consequences as regards early effects will make it possible to optimise the actions for preventing the occupational risks of oil mists at the workplace.

2017 > 2020

Study of variations in the potassium concentration of utricle explants exposed to solvents

■ **Monique CHALANSONNET and Pierre CAMPO**
Toxicology and Biological Monitoring Division

The objective of this study is to determine whether solvents can cause malfunctioning at the peripheral balance receptors, in particular in the vestibule, and to understand the mechanisms that cause such disruptions. This *in vitro* approach will make it possible to better understand the physiopathological mechanisms of dizziness due to malfunctioning of the peripheral balance receptors, and to have a quick test available for prioritising the molecules that requires chronic exposure of the "whole body" type in *in vivo* studies.

2013 > 2017

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

■ **Fabrice MARQUET and Jean-Paul PAYAN**
Toxicology and Biological Monitoring 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 > 2017

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

■ **Jérôme DEVOY**
Toxicology and Biological Monitoring 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 Biological Monitoring Division

■ **PhD Thesis: Anaïs KIRSH**
University of Lorraine (Ecole doctorale BioSE) - Hervé SCHOHN

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

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 biological monitoring 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.

Skin contact with bitumen in road surfacing work: analysis of the work activity and prevention *(completed in 2016)*

■ **Florence HELLA**
Working Life Division

■ **PhD Thesis: Nathalie JUDON**
University of Bordeaux - Alain GARRIGOU

Outline of reasons and objectives

Building roads involves laying asphalt, i.e. bitumen-coated aggregate, which, in particular, contains polycyclic aromatic hydrocarbons, some of which are classified as proven carcinogens. In the current context of uncertainty about the chemical risks in road surfacing works, the aim of the study was to find new preventive solutions making it possible to enrich the existing prevention systems.

© F. Hella for INRS

Approach

An approach centred on involving workers from all hierarchical levels, based on sharing and comparing knowledge and representations held by these various stakeholders (operatives, supervisory staff, prevention specialists, and decision takers) was developed. The iterative approach deployed for the study, on two road surfacing worksites, comprised four stages. It was based on various methodological tools: 1- using analyses of individual work activity, physiological measurements, and chemical sampling to feed the construction of the project; 2- confronting the operatives with audio and video data, and with the data from the measurements and sampling taken, to make them think about their own activity; 3- co-construction of an expression on the work through debates with colleagues based on the data; 4- a final co-analysis with all of the stakeholders to construct shared avenues for prevention that can then be put into action by the decision takers.

Main results

The study made it possible to identify the phases of activity, the jobs, and the work tools that expose workers the most to skin contact. The sample confirmed that this level of exposure differs depending on the phases of activity and on the job. The confrontations with the observations made it possible to better understand the protection deficiencies observed among the operatives and their perception of the hazard related to bitumen, assessed on the basis of the perceived odour of certain asphalts. The interviews revealed that perception of the risks varied depending on the hierarchical level and that knowledge on the substances used remained incomplete at all levels of the company. On the basis of debates between operatives about the activity data, it was discovered that they took precautions to ensure that their family was not exposed to the substance residues on their work clothes. The final step made it possible to define these occupational representations and this occupational know-how. It proved to be rich in "trade" exchanges and made it possible to highlight new possibilities for collective commitment in the companies, for putting in place prevention solutions that were better suited to the reality of the activity, e.g.: changing the communications on chemical risks or involving the site managers when drawing up the talks for the "safety quarter-of-an-hour" sessions.

Discussion and conclusion

The originality of the approach was to create a space for discussion that made it possible to compare the points of view of stakeholders of different levels in each company by developing a new way of approaching chemical risk prevention during road works. It was based on implementing a process involving, in particular, the decision takers of the company, with a view to constructing shared solutions. The participant companies and professionals from the road building sector undertook to continue the thinking for using the know-how of each unit in order to promote participation of operatives in the actions that will construct their own occupational safety.

The study is underpinned by ergonomics PhD work, at the University of Bordeaux, defended in 2017. The results of this study have been the subject of several articles in scientific and risk prevention journals, and of presentations at conferences. Training tools intended for field stakeholders will be produced in collaboration with the Training Division.

© F. Hella for INRS

Developing a method for personal sampling and analysis of bitumen fumes *(completed in 2016)*

■ **Benjamin SUTTER**
Pollutants Metrology Division

Outline of reasons and objectives

The primary objective of this study was to develop a method of sampling and analysing bitumen fumes generated by road works. Cooperation with the Union des Syndicats de l'Industrie Routière and the Groupement des Producteurs de Bitume made it possible to conduct this work, using the MétroPol (pollutants metrology) frame of reference. The secondary objectives were to transfer the method to the Interregional Chemistry Laboratories (Laboratoires Interrégionaux de Chimie, LICs) of the CARSATs, and also to compare the method developed by INRS with the method implemented with our German counterpart IFA.

Approach

This study was conducted in three parts:
- developing and validating the MétroPol method using a fume generation facility;
- transferring the MétroPol method to the LICs, with two inter-laboratory tests being performed to validate the quality of the implementation of the method; and
- cross-comparing the MétroPol method with our German counterpart's method, firstly in the laboratory and then out in the field, in France and in Germany.

Main results

The main result of this study is the development and publication of the MétroPol M-2 method for personal sampling and analysis of road bitumen fumes with a view to assessing the exposure of employees to such fumes.
Other main results were that the method was actually transferred to the LICs and two national sampling campaigns were conducted.
Finally, international validation of the method constitutes the last main result of this study.

Discussion

In compliance with the recommendations made by ANSES on the subject of assessing the exposure of employees to bitumen fumes, the MétroPol M-2 method developed quantifies the total organic matter making up the fumes. This is a change of frame of reference that was discussed at length with the trade associations. Historically, the exposure to fumes was assessed by quantifying the tracer Benzo[a]pyrene, present in large quantities in tars, unlike bitumens. The absence of an occupational exposure limit related to this new measurement method nevertheless makes it possible to put the health and safety recommendations into practice and to assess their effects on exposure.
A thesis on chemically characterising fumes is in progress at INRS in order to answer a certain number of questions raised by this work. A research project on hot asphalts and their additives (or thinners/cutback agents) is being discussed with our Quebec counterpart IRSST.

Study of personal sampling devices for sampling thoracic fractions of sulphuric acid aerosols *(completed in 2016)*

Peter GÖRNER
Pollutants Metrology Division

Outline of reasons and objectives

Sulphuric acid (H2SO4) is used in many sectors of activity and the workers in question are exposed to it.
In 2009, European Commission Directive 2009/161/EU set the Indicative Occupational Exposure Limit Value (IOELV) at 0.05 mg.m-3, with mist being defined as the thoracic fraction.
The aim of this laboratory study was to measure the sampling efficiency and the performance of devices for sampling the thoracic fractions of the aerosols. In particular, the idea was to select the device(s) that offered the highest performance so that they could be qualified, for measuring occupational exposure to sulphuric acid aerosols. The ultimate aim was to make the selected devices available to the prevention network ("réseau prévention") in order to make it possible to monitor personal exposures of people working in the presence of sulphuric acid mists.

Approach

The methodology consisted in testing, in airflow tunnels, the instruments for sampling the thoracic fraction of the aerosols, in measuring their sampling efficiency depending on the diameter of the particles, and in assessing their performance by plotting maps of concentration measuring bias for a series of polydisperse aerosols. The instruments were then compared with specifications describing the ideal sampling device so as to make it possible to select the instrument(s) having the most promising characteristics for measuring the concentration of a sulphuric acid aerosol in air. Whenever a candidate device did not meet one or more specifications, it was removed from the study.

Main results

Of the ten sampling devices considered for the laboratory study, three personal samplers and one static sampler gave results and characteristics appropriate to efficient sampling of the thoracic fraction, some after their sampling flow rate had been optimised.
They were the cyclones BGI GK2.69 and BGI GK4.162, the impactor SKC PPI-T for personal sampling, and the CATHIA-T for static sampling.

Discussion

The study of the thoracic samplers made it possible to acquire in-depth knowledge of the sampling efficiencies and performance levels of the currently available sampling devices. The results made it possible to choose one or more high-performance techniques for sampling thoracic aerosols. This knowledge is now available for measuring the concentration of any substance that is or that will in the future have to be sampled as a thoracic fraction.
To address the specific question of sampling liquid particles of sulphuric acid in occupational atmospheres, field tests are the subject of another study that is in progress.
The laboratory study has been disseminated through three presentations at international conferences, and a scientific article is being finalised for publication in a peer-reviewed journal.

2013 > 2018

Study of combining supercritical CO_2 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.

2011 > 2017

Study of the performance of semi-volatile organic aerosol samplers

Benjamin SUTTER and Eddy LANGLOIS
Pollutants Metrology Division

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

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

2011 > 2017

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 Biological Monitoring 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 exposures but also to lower exposures. 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 biological monitoring data: application to beryllium and to chromium

■ **Aurélie REMY**
Toxicology and Biological Monitoring Division

■ **PhD Thesis: Aurélie REMY**
University of 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 inorganic data that it has not 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 biological monitoring 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

■ **PhD Thesis: Christelle GHAZALY**
University of Lorraine (CNRS/LCPME) – Marc HEBRANT

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 in a simultaneous manner 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.

2017 > 2021

Contribution to the European human biological monitoring initiative (the European Commission's HBM4EU Programme)

■ **Alain ROBERT and Sophie NDAW**
Toxicology and Biological Monitoring Division

The Directorate-General for Research has launched an initiative whose objective is to build a lasting European biological monitoring system. The action by INRS for this initiative will relate to collecting occupational exposure data through harmonised methods. INRS will make available to the European platform the data it has on the groups of priority substances set by the Commission. INRS will also take part in compiling a knowledge base on the relationships of cause and effect between exposure and associated pathologies, by using, in a first stage, the group of bisphenols as a model.

2016 ▷ 2019

Assessment of chemical and biological risks related to emanations of oil mist in industrial environments

■ **Ronan LEVILLY**
Process Engineering Division

The proposed study aims to identify the chemical and biological substances that can be present in the families of cutting fluids. The knowledge obtained should make it possible to make finer assessments of worker exposure, and should provide food for thought for epidemiologists, toxicologists, metrologists, and prevention specialists about the issue of oil mists. The results obtained will also enable companies to adjust their risk assessments and to adapt their prevention approaches.

2017 ▷ 2018

Study of the performance of personal sampling pumps with regard to the needs of risk preventers

■ **Eddy LANGLOIS and Alain BOULET**
Pollutants Metrology Division

The personal sampling pump is an essential tool in the process of assessing occupational exposure to chemical and biological agents. The aim of this study is to assess the performance levels of pumps that are available on the French market by subjecting them to the tests of Standard NF EN ISO 13137 that sets the requirements to be satisfied by such equipment. Additional tests will be conducted for characterising uses under particular conditions.

2016 ▷ 2020

Thermal spraying and welding: biological and atmospheric evaluation of exposure to chromium and to nickel

■ **Nadège JACOBY and Ogier HANSER**
Toxicology and Biological Monitoring Division

The objectives of this study consist in assessing occupational exposure to Cr and to Ni and the effect of such exposure on health during thermal spraying and welding (having lower exposure to ultrafine particles), by taking atmospheric measurements and urine assays for exposure and early effect biomarkers. This work aims to propose a biological monitoring strategy suited to operatives exposed to these two metals and usable by occupational physicians.

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.

Separating out ultrafine particles generated by metal-working processes *(completed in 2016)*

■ **Denis BEMER**
Process Engineering Division

■ **PhD Theses: Loïc WINGERT and Maria Cecilia CADAVID RODRIGUEZ**
University of Lorraine - Dominique THOMAS

Outline of reasons and objectives

Thermal metal spraying, metal cutting, and arc welding processes generate large quantities of ultrafine particles (UFPs) (size < 100 nm) that clog up industrial filters. The aim of the study conducted was to find solutions to the problem of clogging of filters, in particular by working on unclogging. Other solutions for separating out UFPs were also studied: separation in a liquid medium by means of a bubble column, filtration by granular beds, and electrofiltration

Approach

In 2009, INRS conducted a study aiming to understand the mechanisms lying behind clogging of filters. That study required a test bench to be developed that made it possible to reproduce a thermal spraying operation, in order to test the performance of an industrial filter cartridge. This means of testing made it possible to determine the conditions under which the filters clog up, such clogging giving rise to an increase in head loss, and above all the conditions under which they are unclogged. The study made it possible to highlight certain avenues for improvement, the two most noteworthy of which being the pre-coating technique and unclogging, by means of a rotary probe fed with compressed air. Despite its effectiveness, the pre-coating technique was discarded because it generated large quantities of particles contaminated by the metals, and only unclogging by means of a rotary probe continued to be studied. Three other separation processes were studied in addition to filtration via a filter medium: separation in a liquid medium (bubble columns were studied), filtration by granular beds, and electrofiltration. Separation in a liquid medium was the subject of a thesis that was competed at the end of 2014.
This study on separation by granular beds, initiated in 2013, was also the subject of a thesis that was completed at the end of 2016. A large number of studies on electrofilters were identified, and it was decided not to do an in-depth study on that process. Only tests made using a commercially available electrofilter were conducted.

Main results

Unclogging cartridges by using a rotary probe was very encouraging, but this solution struggled to convince industrial users because of the extra costs it would generate. Studying separating out UFPs in a liquid medium, by using a bubble column, showed the advantages and drawbacks of the technique. Despite the various avenues for improvement that were explored, this technique suffers from a separation minimum that is very marked for particles of diameter in the range 0.1 µm to 0.3 µm and that it does not seem possible to reduce without prohibitive energy consumption.
Studying separating out metal UFPs using granular beds highlighted the potential of the technique. The diversity of the parameter on which it is possible to act in order to optimise the performance (size and type of the particles, layer thickness, filtration speed, etc.) is an advantage because it makes it easy to adapt the technique to each situation.
Electrofilters offer very interesting prospects for separating out metal UFPs, but this technique is currently out of favour in the industrial field in question, for reasons that are ill-identified.

Discussion

Technical solutions for separating out metal UFPs exist that are directly applicable (unclogging by compressed-air probe, and electrofiltration) but they are struggling to convince industrial users in the sector for practical and economic reasons. Other processes could be considered, such as separation in liquid media or by granular beds, but additional studies would be necessary in order to consider developing them in the industrial environment.

© S. Morillon - INRS

Three-dimensional simulation of aerosolization of powders when transferring materials in powder form *(completed in 2016)*

■ **Emmanuel BELUT et Jean-Raymond FONTAINE**
Process Engineering Division

■ **PhD Thesis: François AUDARD**
University of Toulouse - Olivier SIMONIN

Outline of reasons and objectives

The vast majority of industrial sectors are concerned by production or handling of materials in power form: agri-food, metallurgy, pharmaceuticals, flour milling, baking, fine chemicals, mineral industry, etc. When such materials in powder form are handled or bagged, a fraction of them is dispersed into the surrounding atmosphere, thereby generating deposition on surfaces and suspension in the air, and potentially leading to risks of occupational exposure to dust or to hazardous substances, and to risks of fire and explosion.

The objective of this study was 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.

Approach

The study was conducted in the form of a PhD thesis, through a partnership agreement with the laboratoire Particules, Spray et Combustion (PSC, Particles, Spray and Combustion Laboratory) of the Institut de Mécanique des Fluides de Toulouse (IMFT, Institute of Fluid Mechanics of Toulouse, UMR 5502 CNRS (a joint research unit of the CNRS)). After developing the models, a numerical reconstruction of emptying of a silo was performed and the simulation results were compared with two reference experimental cases in order to define the advantages and the limitations of the model.

Main results

The model developed appeared capable of reproducing the behaviour of the plume of dust at the hopper outlet for particles of diameters greater than 100 µm and for ratios between hopper orifice diameter and particle diameter greater than 17. In particular, the model then correctly predicts the flow rate of polluted air entrained by the plume and that needs to be captured. Conversely, for more cohesive particles that are 60 µm in diameter, the model underestimates the expansion of the plume and the flow rate of entrained air. In order to prevent a plume of dust from forming, the results also show the importance of ensuring that the powder has good flowability as it exits from the silo, so that a continuous flow is generated that does not disperse very much. Avenues are proposed for improving that flowability. It also appears that a simplified model makes it possible to calculate the flow rate of air entrained by the plume in certain cases, thereby constituting a useful tool for assisting in designing capture systems.

Discussion

From a practical point of view, the study conducted has made it possible to clarify the mechanisms of expansion of the plume of dust at the outlet of a silo. This clarification already makes it possible to propose avenues for action for limiting the dispersion of dust into the environment and for assessing the flow rate of polluted air to be captured. The model developed is quite comprehensive and should be assessed in working situations other than emptying a silo in order to specify its exact performance levels before it is used more systematically for prevention purposes. It is therefore planned to continue to work with IMFT on this subject.

2014 > 2017

Advantage and limitations of wet scrubbing in industrial hygiene

■ **Fabien GÉRARDIN and Emmanuel BELUT**
Process Engineering Division

■ **PhD Thesis: Gaël CHERRIER**
University 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

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.

2014 > 2017

Reduction at source of PAHs during pyrolysis operations

■ **Hubert MONNIER**
Process Engineering division

■ **Catherine CHAMPMARTIN**
Toxicology and Biological Monitoring Division

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 VALLIÈRES

The objective is to study the feasibility and the viability of treating diesel engine exhaust gases 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.

2016 > 2019

Impact of wind on the robustness of ventilation installations

■ **Romain GUICHARD**
Process Engineering Division

■ **PhD Thesis: Argyrios PAPADOPOULOS**
Eindhoven University of Technology – Bert BLOCKEN

The aim of the study is to develop a methodology for predicting the impact of wind on the efficiency of a ventilation system (examples: keeping pollutants confined regardless of the strength of the wind on a building site, a pollutant discharge outlet of an extractor hood subjected to gusts of wind). Acquisition of new knowledge on the subject will make it possible to make recommendations for prevention specialists and designers of ventilation installations.

2017 > 2020

Indoor air quality in storage spaces

■ **Laurence ROBERT and Romain GUICHARD**
Process Engineering Division

This study is addressing the subject of indoor air quality in storage spaces, such as covered markets or shopping areas, shops, or their adjacent tertiary areas, where manufactured products are stored that have high volatile organic compound (VOC) emission capacities. The aim is to assess the air quality in such spaces, to deduce the chronic exposure of the staff who work in or around them, and to put in place a tool for predicting exposures. The tool will make it possible to develop solutions applicable as of the design stage of such workspaces, such solutions relating to ventilation strategies, environmental parameters, or laying out and fitting out the workspaces.

2017 > 2020

Impact of momentary airflow disturbances on the confinement of ventilated enclosures

■ **Sullivan LECHENE and Emmanuel BELUT**
Process Engineering Division

This study will be based on two approaches. From an experimental point of view, the testing method that is developed should highlight interruptions in the confinement of the ventilated enclosure subjected to an airflow disturbance in unsteady-state conditions. In parallel, a numerical approach of the large-scale simulation type associated with a description of the "immersed boundaries" type will make it possible to simulate the movement of a disturbance and to determine its effects on the ventilated enclosure. The objective is to define airflow recommendations enabling enclosures to continue to procure good performance even when faced with momentary airflow disturbances encountered in the work space.

2017 > 2021

Site plant air cleaners for protecting operatives from gas and vapour: performance and life span

■ **Stéphanie MARSTEAU and Bruno GALLAND**
Process Engineering Division

The study aims to qualify the performance levels of gas and vapour scrubber units, and to propose a technical solution for detecting the quality of air inside a plant cab in real time. It aims to provide responses to the question of the effectiveness of scrubbing of the toxic atmosphere by the unit, and therefore to determine its life span.

2017 > 2017

Characterisation of emissions from additive manufacturing machinery – An investigative preparatory study

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

The objective of this study is to identify the various methods of additive manufacturing that exist in industry (aviation, defence, automobile, medical, etc.) and whose development is steadily growing. These various techniques can generate vapours and/or dusts that are potentially dangerous for the health of operatives. Based on this inventory, a new study and a search for partners may be launched to define the additive manufacturing machines to be characterised more precisely and to be prioritised depending on the risk.

2017 ▷ 2020

Diagnostics tools for checking the interior atmosphere of a maritime container and the effectiveness of the forced ventilation on opening

■ **Bruno GALLAND and François-Xavier KELLER**
Process Engineering Division

Various studies have revealed that the interior atmospheres of maritime containers can contain gases and vapours that are health hazards for the operatives who have to open these confined spaces, staff handling transport and logistics, or customs officers. Such gases either come from the fumigation of the containers, or else from emissions from the goods themselves. The study plans to assess the exposure to gases and vapours of workers in charge of unpacking containers, to study the tools for performing real-time analysis of the quality of the air; and to study the effectiveness of the ventilation of the polluted atmospheres.

© G. Kerbaol - INRS

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 ▷ 2017

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.

© G. Kerbaol - INRS

2014 > 2017

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 identifying and detecting events that are precursors of hazardous 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 hazardous 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.

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.

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.

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.**

Work situations with high emotional loads, and organisational prevention practices *(completed in 2016)*

Corinne VAN DE WEERDT
Working Life Division

Outline of reasons and objectives

In the working world, emotions are increasingly being examined. This has not always been the case. For a long time, they were studied as aspects to control, since they were considered as interfering with cognition. For about fifteen years now, we have known that emotions are necessary for cognitive processes. In sectors in which added value lies in the quality of service, emotions are even considered to be central. The employees of the tertiary sector face high emotional demands. This study consisted in studying emotions at work in relation to health, in examining personal and collective regulating of emotions in real situations, and in developing an intervention methodology focused on emotions, in order to act on transforming work in favour of risk prevention.

Approach

The study comprised three stages. Firstly, the results of previous work on emotions that was conducted in electricity transport and in domestic care services were looked at in more depth. This made it possible to clarify the concepts of emotion at work and of emotional load, and to characterise finely the process of regulating emotions in a working situation. Secondly, on this basis, a psycho-ergonomic occupational health intervention methodology centred on emotions was constructed and then tested in a sector not yet addressed: home help services. The data was collected in a small enterprise by means of interviews, observations, subjective descriptions of working situations by the employees, and collective self-confrontations. Finally, the results obtained in this newly addressed sector were compared with those coming from the first stage of the study, in order to bring out both generalisation and specificity criteria. This work was enriched by launching a debate between six researchers guided by INRS about these theoretical, methodological, and practical outcomes.

Main results

It transpires that, for employees, the emotional load emanates not only from interpersonal relations, as described by the literature, but also from working conditions assessed as being unfavourable, independently of the quality of the relations. The study also shows that the emotional load specific to the situations results from an accumulation of felt emotions, either of high intensity or of low intensity, but of high frequency. It has an influence on the overall emotional load, ultimately leading to a disengagement from the work and to harmful effects on health. Emotional regulating implemented by employees does, however, moderate its effects. Such regulating depends on the use of

personal, collective, and organisational resources that are identified and used by employees. In addition, there is a subtle balance between the numbers of situations experienced that have positive valence and that have negative valence, and that are of variable intensity levels. When the balance is positive, it makes it possible to help employees withstand constraining or stressful situations, and, conversely when the balance is negative, it reduces motivation and meaningfulness at work. Implementing the intervention methodology centred on emotions made it possible to develop prevention actions co-constructed in initiated discussion spaces, and contributing to reinforcement of the various resources and also to making the job more rewarding.

Discussion

Analysis of emotions as the main subject of study makes it possible to achieve transformation of work in favour of occupational risk prevention. The exportable nature of the prevention actions implemented will facilitate their transfer to other sectors. The methodology constructed was tested and validated, and remains to be consolidated in other contexts. Its re-use will enable prevention specialists to anticipate situations having high emotional loads and to help employees cope with them. Dissemination of the approach procured by the study could help other companies to reduce the emotional demands and to increase the resources. A future orientation will be to use the balance model brought to light here to construct a positive prevention approach aiming to reinforce the commitment to work and to promote the health of the employees.

© C. Van de Weerdt for INRS

Assessment of PSR and MSD prevention interventions

(completed in 2016)

■ **Christian TRONTIN**
Working Life Division

■ **Stéphanie BOINI-HERMANN**
Occupational Epidemiology Division

■ **Dominique CHOUANIÈRE**
General Management

Outline of reasons and objectives

During the 2000s, the emergence of PSRs and the increase in MSDs recognised as occupational diseases caused a significant rise in the number of interventions for preventing them, whether such actions were conducted by institutional prevention specialists or by private consultants. In view of the diversity and the singularity of the beneficiary structures who benefited from the interventions, and faced with the challenges represented by preventing these multi-factor problems, a range of "complex" approaches emerged that refer to various models and academic disciplines (ergonomics, sociology, occupational psychology, epidemiology, etc.). In the absence of assessment methods able to cope with the complexity and the diversity of these interventions, the players performing them often assessed the results empirically, which does not make it possible to come to a formal conclusion about "what works and what does not" and to optimise the intervention practices on factual, documented, and objective bases. These observations led INRS and Anact (the French National Agency for the Improvement of Working Conditions) to initiate, in 2011, a partnership project that aims to promote the practice of assessment by making available to the players performing the interventions an in-depth base of knowledge in the field of assessment of complex interventions, and a methodological guide adapted to assessing interventions for preventing MSDs and PSRs.

Approach

This project has involved various complementary actions:

- a bibliographic analysis of assessment, for each of the academic disciplines and with regard to the complex interventions, in particular for preventing PSRs and MSDs;
- research seminars, through the participation of about thirty experts, for analysing the theoretical aspects of assessment depending on the disciplines, and for identifying the field practices as regards assessing PSR and MSD prevention interventions;
- summary seminars for comparing the various assessment approaches and for developing a summary model adapted to suit the interventions;
- writing a methodological guide based on:
  - the bibliographic and theoretical contributions from the seminars;
  - the needs and practices identified from 47 intervention players gathered together into 5 "trades groups": CARSAT (Occupational Health and Pension Insurance Fund), Aract (Regional Agency for the Improvement of Working Conditions), SST (Occupational Health Service), private consultants and combined public and private regional group; and
  - the results of 32 assessment approach experiments conducted in the public or private beneficiary structures by 27 intervention players from the trades groups; and
- writing a collective work, recapitulating the research work, and that involved about fifty authors.

Main results

The project has enabled an assessment approach to be developed that is able to cope with the complexity of the PSR and MSD prevention interventions, and with all of the intervention models (ergonomic, sociological, etc.). It proposes, by combining quantitative and qualitative methods, to measure 37 types of effect of the interventions, grouped together by themes: changing knowledge, perceptions and behaviours of the beneficiary structure players with regard to PSRs and MSDs, transforming relations between players, changing organisations and working situations, reducing risk factors, improving the health of the operatives and the performance of the beneficiary structures. It then recommends analysing the observed effects in the light of the expected effects while taking into account not only the initial situation of the beneficiary structure and the changes that might have occurred during the intervention, but also how the intervention actually went and any contingences that arose.

Finally, the assessor is guided, in a last stage, in taking all of the lessons useful for their practice in the future. After experimentation, the approach was set out in a guide made available to intervention players on the INRS and Anact websites. The collective work, which is to a large extent finished, will be published in 2017.

Discussion

The research work conducted made it possible to produce an assessment approach that, more than a mere compilation, is a genuine synthesis and summary of numerous existing assessment methods. It has benefited from the research/field practice complementarity of the two bodies involved, from the high degree of multi-disciplinarity of the stakeholders in the project, and from the expertise of numerous external specialists and academics. Beyond a supplementary analysis of the data collected during the experiment, such an analysis making it possible to hone the assessment recommendations, it is also planned to set up training for intervention players in using the assessment guide and to organise an awareness-raising symposium. The work will continue to be disseminated in 2017 (articles, conferences, etc.).

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.

2016 ▷ 2019

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

■ **Vincent GROSJEAN**
Working Life Division

■ **PhD Thesis: Ophélie MORAND**
University of Lorraine - Éric BRANGIER

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 regarding use 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 Workers (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 and Stéphanie BOINI-HERMANN**
Occupational Epidemiology Division

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

© P. Delapierre for INRS

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.).**

On-site management and MSD prevention: representations and actions

(completed in 2016)

- **Aude CUNY**
  Working Life Division
- **PhD Thesis: Aude CUNY**
  University of Grenoble - Sandrine CAROLY

Outline of reasons and objectives

On-site managers, i.e. first-line supervisors, play a part in preventing musculoskeletal disorders (MSDs) by influencing the way work is done by the operatives managed by them. This study aimed to produce knowledge about the representations and the actions of first-line supervisors as regards preventing MSDs, by emphasising the organisational context in which they act. The idea was to identify new levers for preventing MSDs, on the basis of an analysis of the activity of first-line supervisor. This action was conducted in the meat cutting sector on staff doing their work on the premises of a client company, in a relationship of internal subcontracting.

Approach

The methodology was based on analysis of two mobilising cases: interviews, observations of the activities of two subcontractor first-line supervisors, and self-confrontations. The representations of the MSD risk were analysed. The strategies of the first-line supervisors for coping with occurrence of situations of MSD risk for the operatives, and the conditions underpinning drafting of those strategies were identified. Their effects on the working conditions of the supervised operatives (and thus on the risk of MSDs) were analysed. The analysis led to establishment of categories of critical situations, of types of strategies, and of conditions associated with drafting of such strategies.

Main results

The first-line supervisors' representations of MSD risks show conditions under which activities associated with subcontracting are done that are considered to be obstacles to prevention of such risks (payment based on throughput rates, absence of influence on the conditions under which activities are carried out that are defined by the client company, etc.). The way they handled MSD risk situations appeared to be related to their possibilities for action, referred to as "situational room for manoeuvre" or "situational latitude". Such room for manoeuvre firstly involves components related to the characteristics of the supervisor or manager (including their representation of MSDs) and on the means provided by the external company. Secondly, it appears that, in a situation of subcontracting taking place on the client's premises, the supervisors or managers increase their situational room for manoeuvre by mobilising components related to the means provided by the client company and collective components that

are developed with the group of supervised operators and employees (operatives and supervisors) of the client company. The room for manoeuvre being enriched by the latter two components supports the supervisors in drawing up collective strategies (cooperation and mutual assistance) that are useful for preventing MSDs in the supervised operatives.

© S. Morillon - INRS

Discussion

By proposing content that is specific to the activity of first-line supervisors in subcontracting situations, the results contribute to identifying resources and thus levers for action (personal, organisational, and also collective) in favour of preventing MSDs. They aim to enable first-line supervisors to better understand and integrate MSD prevention, and will be disseminated to prevention specialists and companies. The results have also been the subject of an ergonomics thesis and will be fed into exchanges between researchers on this subject.

Ageing, Staying in Employment, and Preventing Occupational Exclusion

INRS studies and research in this field have three focuses:

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

2013 ▷ 2017

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 career management policies.

2014 ▷ 2019

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 the 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 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 stages of collection 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.

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 Project Teams

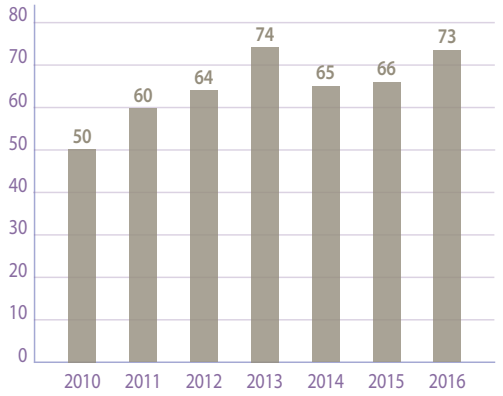
1. **Filtration and Adsorption (LFA, Laboratoire de Filtration et Adsorption):** between CNRS's Process Engineering and Reactions Laboratory (LRGP, Laboratoire de Réactions et de Génie des Procédés), and INRS's Pollutant and Air Cleaning Process (PROCEP, Procédé et Epuration des Polluants) Laboratory: the work conducted in 2016 concerned modelling of PAH formation in pyrolysis processes, and developing a pilot unit for validating the models. The work for modelling the adsorbents implemented in respiratory protective devices has made it possible to assess the key parameters in the operating cycles (use, storage).
2. **Joint Pollution Prevention Laboratory (LMPP, Laboratoire Mixte de Prévention de la Pollution):** between the Energetics and Theoretical & Applied Mechanics Laboratory (LEMTA, Laboratoire d'Energétique et de Mécanique Théorique et Appliquée), a CNRS-University of Lorraine joint research unit, and INRS's Aerodynamics Engineering (Ingénierie Aéraulique) Laboratory: The thesis on wet scrubbing has already made it possible to model the phenomena, and a pilot for validating that model is being produced. .
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: a thesis is in progress. The work concerns characterising the acoustic attenuation of noise due to relief in the walls of industrial premises.
4. **Safe Design of Working Situations Laboratory (LC2S, Laboratoire 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: one thesis was completed in 2016, another is in progress, and several master's degree students were taken in in 2016. The work aims to characterise the risk creation processes in designing work equipment.

Other French national partnerships

INRS is monitoring the actions scheduled by the framework agreement between **ANSES** (the French National Agency for Food, Environmental and Occupational Health & Safety) and INRS, signed on 4 March 2015, and its provisional schedule of work. It takes part in specialised expert committee meetings addressing, in particular, occupational exposure limit (OEL) values, consumer products, and the REACH programme, and in the atypical hours and toxicovigilance of chemicals working groups. It takes part in the steering committee and in the "clinical emergence" ("émergence clinique") working group, enabling INRS to access the data of the RNV3P (National Network for the Monitoring and Prevention of Occupational Diseases) that is necessary for studies, research, and assistance. INRS has worked with **ANACT** (the French National Agency for the Improvement of Working Conditions) to produce a guide for assessing interventions relating to MSDs and PSRs (to be published in early 2017). It took part in the governance committee of INERIS and in the scientific board of its chemical risks portal. Collaboration with **Santé Publique France** (Public Health

France) involved exchanges with the infectious diseases department, and taking part in European Vaccination Week from 25 to 30 April 2016, with messages being relayed on INRS's website. Through its agreement with **CEPN** (Centre d'étude sur l'évaluation de la protection dans le domaine nucléaire, or "Nuclear Protection Evaluation Centre"), INRS sat on the scientific board and on the steering committee for the RELIR (feedback on radiological incidents) network. INRS took part in the inter-institutional group on prevention of occupational cancers of **INCa** (Institut national du cancer, the French National Cancer Institute).
Finally, for several years now, most INRS studies have been conducted with external collaborations. Thus, 39 studies involved French engineering schools or universities, 22 involved French research centres, and 14 involved French pensions and health insurance funds (CARSATs, CRAMIF) or chemistry or physics laboratories of such funds.

Percentage of studies with external collaborations



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 2016, 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 wellbeing of workers in the changing world of work (Associer les connaissances au service du bien-être des travailleurs dans un monde du travail évolutif)". It was agreed that INRS would organise the next "Well-being at work" conference in Paris in 2019, in partnership with the PEROSH network.
- The participation in the "Recommendations for procedures to measure occupational physical activity and workload" Group continued in 2016. It led to recommendations being proposed in a PEROSH report and to an article being submitted to the international journal Applied Ergonomics at the end of 2016.
- INRS has continued to collaborate in the "indIR-UV" Project on exposure to UV and IR radiation of people working in arc welding environments.

Bilateral international relations

INRS is working in various fields with IRSTT, its counterpart in Quebec, with whom a 5-year framework partnership agreement has just been renewed for the second time. Collaborations are in progress on collaborative robotics, focused on implementing safety functions, on maintaining and servicing machinery in the agri-food business, and on personal hearing protectors.
The partnership framework agreements 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) have led to various actions: For example, joint thinking between INRS and NIOSH experts has been conducted on the strategy for preventing co-exposure noise-solvent and on the potential contribution from EchoScan in assessing peripheral auditory fatigue. A workshop was held at INRS in June 2016. In addition, the scientific exchanges with IRSST and IFA on the modes of use of inertial sensors, both on a methodological level (calibration…) and on a practical level (positioning, fastening techniques…) led to a symposium at the 9th PREMUS Conference in Orlando (Canada) in June 2016.
Finally collaborations are in progress with the Florida Institute of Technology (FIT, USA), the Centre Hospitalier Universitaire de Montréal (Canada), the Institut für Prävention und Arbeitsmedizin (IPA- Germany), and the Eindhoven University of Technology (Netherlands).
In all, 16 studies are being conducted in collaboration with non-French partners.

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)

- **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 have been implemented in 2016.
- **ExproPNano:** 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.
- **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 enables pilot tests to be conducted by one of the partners of the consortium.
- **OxIGenoCOM "Exposure to cutting fluids and markers of early effects: oxidative stress, inflammation and genotoxicity".** This project, steered by INRS aims to explore in detail the risk related to the use of cutting oil. It will relate the precise contents of the cutting oils during their use to exposure and early effect biomarkers. The pathologies covered by the study are cancers and respiratory allergies. This study, in collaboration with the Équipe d'accueil EA 4483 IMPECS (IMPact de l'Environnement Chimique sur la Santé humaine, Impact of the Chemical Environment on Human Health team) of the University of Lille and the IST (Institut Universitaire Romand de Santé au Travail (Institute for Work and Health) was launched at the end of 2016.

Two ANR (French National Research Agency) projects

- **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.
- **The project SMARTPLANNING.** (Smart planning of goods transport delivery rounds). The SmartPlanning project aims to overcome various underlying scientific and technological obstacles to implementing robust planning assistance systems for sustainable transport. Sustainable transport means transport that takes into account the economic, environmental, and social issues in terms of health and safety both for the drivers and for the planners of such transport. The ambitions of this project involve interdisciplinary issues that require mobilisation of skills and players from engineering sciences (Ecole des mines d'Albi), and from ergonomics (Institut universitaire Champollion and INRS), and two industrial partners (MMain Forte, Deret transport).

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 about twenty or more PhD students (31 in 2016), 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 2016, the following theses were defended:

- **Leïla BOUDRA:** Durabilité du travail et prévention en adhérence. Le cas de la dimension territoriale des déchets dans l'activité de tri des emballages ménagers (Work sustainability and prevention "in connection". The case of the territorialized dimension of waste in the activity of waste sorting workers). Université Lumière de Lyon.
- **Aude CUNY:** Régulation et marges de manœuvre situationnelles des encadrants de proximité en sous-traitance (Regulation and situational room for manoeuvre of first-line supervisors in subcontracting) University of Grenoble.
- **Nicolas DE GALVEZ:** Caractérisation et évaluation du niveau de risque des situations de travail (Characterisation and evaluation of the risk levels of working situations). ENSAM ParisTech.

© S. Pierrat - INRS

- **Khaoula HAMDI:** Développement d'un analyseur en temps réel des BTX sur les lieux de travail (Development of a workplace real-time BTX analyser). University of Lorraine
- **François VUONG:** Modélisation du comportement des cartouches de protection respiratoire: exposition à des atmosphères complexes de vapeurs organiques et effet des cycles d'utilisation (Modelling the behaviour of respiratory protective device cartridges: exposure to complex atmospheres of organic vapours and effect of utilisation cycles). University of Lorraine
- **François AUDARD:** Développement et validation d'un système ambulatoire pour l'évaluation des postures et des mouvements du membre supérieur en conditions réelles de travail (Developing and validating an ambulatory system for evaluating postures and upper limb movements under real working conditions). University of Toulouse.
- **Gautier MATER:** Caractérisation des mesures d'exposition à des produits chimiques dans les bases de données françaises COLCHIC et SCOLA pour la prévention des maladies professionnelles (Characterisation of measurements of exposure to chemicals in the French databanks COLCHIC and SCOLA for preventing occupational diseases). University of Lorraine.
- **Ludivine WATHIER:** Modification de l'amplitude du réflexe de l'oreille moyenne après inhalation de solvant (Alteration in the amplitude of acoustic middle ear reflex after inhalation of solvent). University of Lorraine.

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 officially supervise PhD students. Currently, nine people at INRS have this diploma.

Presentations and Publications in 2016

Presentations in 2016

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

187 presentations were given at various events in 2016, including 98 at international conferences, and, in particular:

- 11 presentations at the 34th Congrès national de Médecine et santé au travail (National Conference on Occupational Health Medicine) in Paris
- 11 presentations at the 22nd European Conference on Aerosols, in Tours
- 9 presentations at the 25th Epidemiology in Occupational Health Conference (EPICEPICOH), in Barcelona
- 9 presentations at the Nanosafe Conference, in Grenoble
- 9 presentations at the 9th International Conference on the Prevention of MSDs (PREMUS), in Toronto
- 6 presentations at the 13th Congrès français d'acoustique (CFA, French Acoustics Congress), in Le Mans.

In parallel with the symposia in which it took part, INRS organised various science and technology events in 2016:

- **Endocrine disruptors and sensitising substances. Chemical substances representing special hazards: What risks at work? What prevention?".** International ISSA Conference in partnership with BG RCI (Germany), SUVA (Switzerland), AUVA (Austria), and INAIL (Italy) Paris 1-3 June 2016
- **Passive sampling** – Technology Day, Paris, 11 October 2016
- **Atypical hours** – Technology Day, Paris 2 November 2016
- **Preventing chemical risks related to opening containers,** Le Havre, 14 October 2016, and Marseille, 21 October 2016, in collaboration with Assurance Maladie Risques Professionnels (Occupational Risks branch of French National Health Insurance) and Carsat Sud-Est.
- **Prospective analysis: Working in good health in 2040.** Delivery of the prospective (foresight) exercise organised by INRS in partnership with Assurance Maladie-Risques Professionnels, Anact, Anses, Dares, France Stratégie, Aravis/Aract and Futuribles, Paris 23 November 2016
- **Asbestos-analytical TEM: assessment and prospects,** Nancy, 6 December 2016

Publications in 2016

The findings of the "studies & research" are published in scientific and technical journals. **149 were published in 2016.**

Of these publications, 93 articles were published as follows:

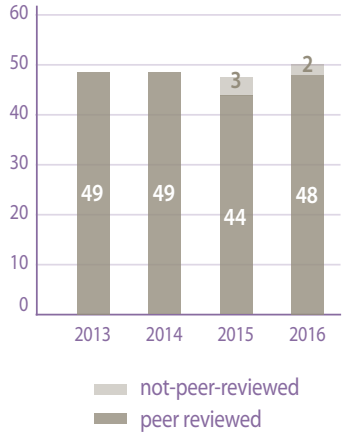
- 50 in international journals
- 43 in national journals, including:
  - 32 in the INRS journal "*Hygiène et Sécurité du Travail*"
  - 3 in the INRS journal "*Références en Santé au Travail*"

In addition:

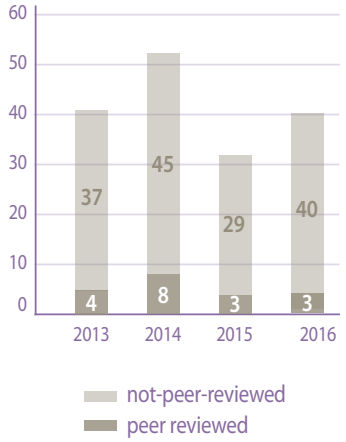
- 11 chapters in works, 34 conference proceedings, and 10 scientific and technical notes were published.

The results of the research into the intrinsic variability of movement were published in English under the title "*Intrinsic movement variability at work*". "*How long is the path from motor control to design engineering*" received the prize for the best article in the journal Applied Ergonomics for 2016, which is a mark of the recognition of the scientific quality of the work.

Publications in international journals



Publications in national journals



Publications at scientific events

The list of publications for the year 2016 is given below.

List of publications of 2016

Accidentology, and Perception & Acceptability of Occupational Risks

- *Ergonomics (IF: 1,85)*

CHANG W.R., LECLERCQ S., LOCKART T.E., HASLAM R.
State of science: Occupational slips, trips and falls on the same level. (Etat de l'art: Les glissades, trébuchements et chutes de plain-pied au travail). *2016, DOI: 10.1080/00140139.2016.1157214.*

- *Fall Prevention and Protection: Principles, Guidelines, and Practices, CRC Press - Taylor & Francis, In: Hongwei Hsiao (ed), 2016*

LECLERCQ S.
Hazard Concept and Falls. (Chutes accidentelles et concept de danger), *pp.159-173.*

- *Psychologie du Travail et des Organisations: 110 notions clés. Dunod, avril 2016*

FAVARO M.
Accident du travail - accidentologie, *pp. 24-27.*

Occupational Allergies

- *BMC Public Health (IF: 2,264)*

MEVEL H., DEMANGE V., PENVEN E., TRONTIN C., WILD P., PARIS C.
Assessment of work-related asthma prevalence, control and severity: protocol of a field study. (Evaluation de la prévalence, du contrôle et de la qualité de vie de l'asthme en relation avec le travail: protocole d'une étude de terrain). *2016, 16:1164. DOI 10.1186/s12889-016-3824-0*

Noise, Vibration, Electromagnetic Fields, and Optics

- *Journal of Sound and Vibration (IF: 1,813)*

KHANFIR A., FAIZ A., DUCOURNEAU J., CHATILLON J., SKALI-LAMI S.
Scattered acoustic field above a grating of non-parallel rectangular cavities. (Champ acoustique réfléchi au-dessus d'un réseau de cavités rectangulaires non parallèles). *2016, Vol. 361, pp. 251-260.*

- *Review of Scientific Instruments (IF 1,584)*

DENIEL J.M.
Optimizing array spectroradiometer readings using adaptative bracketing. (Spectroradiomètres CCD: des relevés pertinents et précis par bracketing adaptatif). *2016, 033108, 9 p.*

- *Ergonomics (IF: 1,556)*

PERRIN N., CHEVRET P.
Effect of noise on comfort in open-plan offices: application of an assessment questionnaire. (Effet du bruit sur le confort des salariés travaillant en open space: application d'un questionnaire). *2016, DOI:10.1080/00140139.2016.1172737.*

- *Applied Acoustics (IF: 1,462)*

BROCOLINI L., PARIZET E., CHEVRET P.
Effect of masking noise on cognitive performance and annoyance in open plan offices. (Effet du bruit de masquage sur les performances cognitives et la gêne dans les bureaux ouverts). *2016, Vol. 114, pp. 44-55.*

- *LUX, la revue de l'éclairage*

DARMON J., SANSELME B., DENIEL J.M., MARTINSONS C., THOME J.
Industries. Prévention au travail et éclairages LED. *2016, Vol. 285, pp. 37-45.*

Hygiène et sécurité au travail

ARZ J.P.
Comment étudier l'effet d'un protecteur auditif sur l'audibilité des signaux avertisseurs de danger ? *Juin 2016, n° 243, NT40, pp. 64-69.*

CARUEL E., AMARI M., DONATI P.
Risque vibratoire et postural au poste de conduite des engins mobiles. *Mars 2016, n° 242, DO12, pp. 25-28*

BOULDI M., PASQUIER C.
Exposition du travailleur en environnement IRM. *Hors-série, décembre 2016, pp. 152-155.*

DEMARET P.
Oseray, un outil simple pour une première estimation de l'exposition aux champs électromagnétiques. *Hors-série, décembre 2016, pp. 94-97.*

DEMARET P.
Les sources de rayonnements électromagnétiques industrielles. *Hors-série, décembre 2016, pp. 32-36.*

BARLIER-SALSI A.
Mesure des rayonnements optiques artificiels incohérents au poste de travail. *Hors-série, décembre 2016, pp. 55-59.*

BARLIER-SALSI A.
Evaluer les risques liés aux rayonnements optiques émis par les projecteurs de scène. *Hors-série, décembre 2016, pp. 112-116.*

DENIEL J.M.
Rayonnements Optiques Artificiels: évaluation des risques sans mesure. *Hors-série, décembre 2016, pp. 50-54.*

JACQUES M.
Les moyens de prévention et de protection contre les ROA. *Hors-série, décembre 2016, pp. 64-68.*

MARCHAL P.
Equipements de protection contre les risques dus aux LED d'éclairage. *Hors-série, décembre 2016, pp. 69-73.*

MOUREAUX P., MATHIEU P.
Transposition de la directive 2013/35/UE en droit français: un nouveau dispositif réglementaire dès janvier 2017. *Hors-série, décembre 2016, pp. 41-47.*

Référence en santé au travail

GAUTIER M.A., MORELOT Q., DENIEL J.M., BARLIER-SALSI A.
Exposition à la lumière bleue. Quels sont les risques ? Quel serait l'intérêt de lunettes à filtres anti-lumière bleue ? *Septembre 2016, n° 147, pp. 121-123.*

22nd International Congress on Acoustics, September 5-9, 2016, Buenos Aires, Argentina

RABISSE K., DUCOURNEAU J., FAIZ A., TROMPETTE N.
Physically-based numerical sound propagation modeling in rooms with non-flat walls. (Modélisation numérique de la propagation du son dans des locaux présentant des parois non-planes). *Proceedings, 10 p.*

6th American Conference on Human Vibration (ACHV), Junes 8 -10, 2016, Milwaukee, WI, USA

NOEL C.
Modeling the biodynamic response of a pre-loaded vibrated phalanx and preliminary results for a whole hand. (Modélisation de la réponse biodynamique d'une phalange vibrée précontrainte et premiers résultats pour une main entière.). *Proceedings, pp. 21-22.*

22nd Congress of the European Society of Biomechanics, July 10-13, 2016, Lyon, France

NOEL C.
A spectral dissipative constitutive law of soft tissues for modeling the dynamic response of a preloaded phalanx. (Une loi de comportement de la dissipation des tissus mous pour modéliser la réponse dynamique d'une phalange précontrainte). *Proceedings, 1 p.*

BioEM 2016, July 5-10, 2016, Het Pand, Ghent, Belgium

BOULDI M., DEMARET P., FLEURY G.
Workers exposition near electromagnetic forming process: an experimental and simulation study. (Exposition des travailleurs près des dispositifs de formage électromagnétique: métrologie et simulation). *Proceedings, pp. 547-551*.

CFA 2016, 13ème Congrès Français d'Acoustique, 11-15 avril 2016, Le Mans, France

GETTLIFFE J.P., ARZ J.P., DUBOIS F.
La perception de signaux d'alarme sous protecteurs auditifs dans un contexte ferroviaire. *Actes, pp. 2662-2667.*

TERROIR J.
Dangerosité des bruits impulsionnels en milieu professionnel: réglementation, connaissances et mesures. *Actes, pp. 2654-2659.*

RABISSE K., DUCOURNEAU J., FAIZ A., TROMPETTE N.
Méthode de simulation de propagation du son dans un milieu confiné en présence de parois à relief géométrique. *Actes, pp. 1610-1615.*

KOSTALLARI K., PARIZET E., CHEVRET P.
Indicateurs de confort acoustique dans les bureaux ouverts. *Actes, pp. 1560-1565.*

DUCOURNEAU J., FAIZ A., RABISSE K., TROMPETTE N.
Validation et limites d'un dispositif de mesure du coefficient de diffusion acoustique des parois à relief dans les bâtiments. *Actes, pp. 2376-2381.*

LE MUET Y., CHEVRET P.
Les dessous de la norme NF S 31-199 sur les bureaux ouverts. *Actes, pp. 1346-1351.*

Note Scientifique et Technique

NOEL C.
Une stratégie de modélisation multi-échelles pour la prédiction de certains effets des vibrations sur le réseau vasculaire digital. Première étape: validation d'un modèle éléments finis à l'échelle macroscopique d'une phalange précontrainte vibrée. *NS 339, 2016, 78 p.*

BARLIER-SALSI A.
Mesurer et évaluer l'exposition professionnelle aux rayonnements optiques artificiels (hors laser) Guide méthodologique. *NS 347, septembre 2016, 51 p.*

Design of Work Equipment, Workplaces, and Working Situations

Journal of Engineering Design (IF: 1,036)

SADEGHI L., DANTAN J.Y., SIADAT A., MARSOT J. -
Design for human safety in manufacturing systems: applications of design theories, methodologies, tools and techniques. (Conception sûre des systèmes de production: revue de la littérature sur l'application des théories et des méthodes de conception, de leurs outils et techniques). *2016, http://dx.doi.org/10.1080/09544828.2016.1235262.*

International Journal of Occupational Safety and Ergonomics (IF: 0,494)

LUX A., MAWO DE BIKOND J., ETIENNE A., QUILLEROU E.
FMEA and consideration of real work situations for safer design of production systems. (AMDEC et prise en compte des situations réelles de travail pour une conception plus sûre des systèmes de production). *2016, http://dx.doi.org/10.1080/10803548.2016.1180856.*

Hygiène et Sécurité du Travail

DAILLE-LEFEVRE B., ROIGNOT R.
Acquérir une machine: de l'importance du cahier des charges. Décembre 2016, n° 245, dossier "De la conception au recyclage d'une machine, la sécurité avant tout" - *Article 2, pp. 27-29*.

CANETTO P., MARSOT J.
Conception des espaces de travail: la prévention en amont. *Mars 2016, n° 242, NT35, pp. 42-45.*

AHFE 2016, 5th International Conference on Applied Digital Human Modeling and Simulation, June, 27-31, 2016, Orlando (Floride) USA, pp. 169-179.

SAVIN J., GILLES M., GAUDEZ C., PADOIS V., BIDAUD P.
Movement variability and digital human models: development of a demonstrator taking the effects of muscular fatigue into account. (Développement d'un démonstrateur prenant en compte les effets de la fatigue musculaire sur la variabilité du mouvement). *Proceedings, pp. 169-179.*

XXVIth CIRP Design Conference, June, 15-17, 2016, Stockholm, Sweden

DEGALVEZ N., MARSOT J., MARTIN P., SIADAT A., ETIENNE A.
Proposition of an approach applicable during the design process of working equipment to identify potential hazards for workers. (Proposition d'une approche applicable durant le processus de conception d'un équipement de travail pour identifier les phénomènes dangereux potentiels pour les opérateurs). *Procedia CIRP 50, 2016, pp. 258-263.*

- *CIRP CMS 2015 - 48th CIRP Conference on MANUFACTURING SYSTEMS – June, 24-26, 2015, Naples, Italy*

DEGALVEZ N., MARSOT J., MARTIN P., SIADAT A., ETIENNE A., GODOT X.
Design for safety: proposition of a model to detect hazards through energy flows analysis. (Conception sûre: proposition d'un modèle de détection des phénomènes dangereux par l'analyse des flux d'énergie). *Proceedings, 2016, pp. 1107-1112.*

- *JCM 2016 - 7th Joint Conference of ADM - INGEGRAF - AIP PRIMECA – September, 14-16, 2016, Catania, Italy*

FENO M.R., MARTIN P., DAILLE-LEFEVRE B., ETIENNE A., MARSOT J., SIADAT A.
Safety of manufacturing equipment: methodology based on a work situation model and need functional analysis. (Sécurité des équipements de production: méthodologie basée sur un modèle de situation de travail et l'analyse fonctionnelle du besoin). In Proceedings, Lecture Notes in Mechanical Engineering. *Springer, 2016, pp. 1151-1158.*

- *11ème Conférence Francophone d'Optimisation et Simulation- MOSIM'16 – 22-24 Août 2016, Montréal, Québec, Canada*

DAILLE-LEFEVRE B., MARSOT J., DEMARZIANI A., ETIENNE A.
Le concept de tâches en conception sûre d'équipements de travail. *Actes, clé USB, 8 p.*

Waste and Recycling

- *Hygiène et Sécurité du Travail*

POIROT P., CLERC F.
Exposition chimique des salariés dans les activités de dépollution des sols contaminés par hydrocarbures. *Décembre 2016, n°245, pp. 72-77.*

Multiple Exposures: Chemicals and Noise

- *Neurotoxicology (IF: 3,379)*

WATHIER L., VENET T., THOMAS A., COUR C., NUNGE H., BONFANTI E., COSNIER F., PARIETTI-WINKLER C., CAMPO P., TSAN P., BOUGUET-BONNET S., GANSMULLER A.
Membrane fluidity does not explain how solvents act on the middle-ear reflex. (La fluidité membranaire n'explique pas les effets des solvants sur le réflexe de l'oreille moyenne). *2016, Volume 57, pp. 13-21.*

- *American Journal of Industrial Medicine (IF: 1,632)*

MATER G., PARIS C., LAVOUE J.
Descriptive analysis and comparison of two French occupational exposure databases: COLCHIC and SCOLA. (Analyse descriptive et comparative des deux bases de données françaises d'exposition professionnelle: *COLCHIC et SCOLA). 2016, Vol. 59, pp. 379-391.*

- *ARET 2015, 4-5 Juin 2015, Paris, France*

WATHIER L., VENET T., PARIETTI-WINKER C., CAMPO P.
Aromatic solvents disturb the stapedial reflex involved in hearing. (Les solvants aromatiques perturbent le réflexe stapédien impliqué dans l'audition). *In ARET ACTUALITES - supplément de la Lettre N°90 - Mars 2016.*

CAMPO P.
Interactions entre traumatismes sonores et nuisances des produits chimiques sur l'audition. *In ARET ACTUALITES - supplément de la Lettre N°90 - Mars 2016.*

- *Thèse de doctorat en Sciences de la Vie et de la Santé, 17 Décembre 2016, Université de Lorraine, Nancy*

WATHIER L.
Modifications de l'amplitude du réflexe de l'oreille moyenne après inhalation de solvant. conséquences physiologiques pour les expositions au bruit. *Mémoire de Thèse, 101 p.*

Manufactured Nanomaterials

Particle and Fibre Toxicology (IF: 7,11)

GRACZYK H., LEWINSKI N., ZHAO J., SAUVAIN J., SUAREZ G., WILD P., DANUSER B., RIEDIKER M.
Increase in Oxidative Stress Levels Following Welding Fume Inhalation: A Controlled Human Exposure Study . (Augmentation des niveaux de stress oxydatif après inhalation de fumes de soudage: une étude d'exposition humaine contrôlée)**.** *2016, 13:31, DOI 10.1186/s12989-016-0143-7.*

Toxicology Letters (IF: 3,522)

GATÉ L., DISDIER C., COSNIER F., GAGNAIRE F., DEVOY J., SABA W., BRUN E., CHALANSONNET M., MABONDZO A.
Biopersistence and Translocation to Extrapulmonary Organs of Titanium Dioxide Nanoparticles after Subacute Inhalation Exposure to Aerosol in Adult and Elderly Rats. (Bio-persistance et translocation vers les organes extra-pulmonaires des nanoparticules de dioxyde de titane après exposition subaiguë par voie inhalatoire à un aérosol chez les rats adultes et âgés). *2016, Vol. 265, pp. 61–69***.**

Atmospheric Environment (IF: 3,281)

ILLUMINATI S., BAU S., ANNIBALDI A., MANTINI C., LIBANI G., TRUZZI C., SCARPONI G.
Evolution of size-segregated aerosol mass concentration during the Antarctic summer (Northern Foothills, Victoria Land). (Evolution de la distribution en masse de l'aérosol en Antarctique lors de l'été). *2016, Vol. 125, pp. 212-221.*

Mutation Research - Genetic Toxicology and Environmental Mutagenesis (IF: 2,415)

DARNE C., COULAIS C., TERZETTI F., FONTANA C., BINET S., GATE L., GUICHARD Y.
In vitro comet and micronucleus assays do not predict morphological transforming effects of silica samples in Syrian Hamster Embryo cells. (Les tests des comètes et du micronoyau *in vitro* ne prédisent pas les effets de transformation cellulaire d'échantillons de silices dans les cellules embryonnaires de hamster syrien). *2016, Vol. 796, pp. 23–33.*

Journal of Aerosol Science (IF: 2,278)

GUICHARD R., BELUT E. - Simulation of airborne nanoparticles transport, deposition and aggregation: experimental validation of a CFD-QMOM approach. (Simulation du transport, du dépôt et de l'agrégation de nanoparticules dans l'air: Validation expérimentale de l'approche CFD-QMOM). *2016, Vol. 104, pp. 16–31.*

Aerosol and Air Quality Research (IF: 2,094)

COSNIER F., BAU S., GROSSMANN S., NUNGE H., BROCHARD C., VITON S., PAYET R., WITSCHGER O., GATÉ L. - Design and characterization of an inhalation system to expose rodents to nanoaerosols. (Conception et caractérisation d'un système d'inhalation pour l'exposition de rongeurs aux nanoaérosols). *2016, Vol. 16, pp. 2989-300.*

WITSCHGER O., LEVIN M., BAU S., JANKOWSKA E., KOPONEN I., KOIVISTO A., CLAUSEN P., JENSEN A., MOLHAVE K., ASBACH C., JENSEN K. - Can we trust real time measurements of lung deposited surface area concentrations in dust from powder nanomaterials? (Quelle confiance accordée aux mesures en temps réel des concentrations en surface déposées pour des aérosols issus de nanomatériaux en poudre ?). *May 2016, Vol. 16, n° 5, pp. 1105-1117.*

Journal of Analytical Chemistry (IF: 0,812)

DEVOY J., BRUN É., COSNEFROY A., DISDIER C., MELCZER M., ANTOINE G., CHALANSONNET M., MABONDZO A. - Optimization of mineralization methods of TiO2 nanoparticles: Determination of titanium levels in rat organ tissues. (Optimisation des méthodes de minéralisation de nanoparticules de TiO2: Détermination des niveaux de titane dans les tissus d'organes de rat). *2016, Vol. 71, n° 4, pp. 418-425.*

Gefahrstoffe Reinhaltung der Luft (IF: 0,328)

BAU S., WITSCHGER O., GALLAND B., MARTIN P.
Real-time metrology of hazardous substances at workplaces: advantages and limitations. (Métrologie en temps réel de substances chimiques au poste de travail: intérêts et limites.). *2016, Vol. 76, n°11-12, pp. 442-445.*

Spectra Analyse

BAU S., TOUSSAINT A., PAYET R., WITSCHGER O.
Développement d'une méthodologie pour la vérification des compteurs de particules dans l'air. *Décembre 2016, n° 313, pp. 34-41.*

Hygiène et sécurité du travail

CHAZELET S., FONTAINE J.R., BINET S., GATE L., HEDELIN G., MALARD S., RICAUD M., ROUSSET D., WITSCHGER O.
Dioxyde de titane nanométrique: de la nécessité d'une valeur limite d'exposition professionnelle. *Mars 2016, n°242, NT36, pp. 46-51.*

L'ALLAIN C., CAROLY S., DRAIS E.
Une intervention ergonomique dans une entreprise utilisant des nanomatériaux. *Mars 2016, n° 242, EC14, pp. 58-62.*

Indoor and Outdoor Nanoparticles, Determinants of Release and Exposure Scenarios, Hdb Env Chem, M. Viana Editions, 2016

MACCALMAN L., SANCHEZ-JIMÉNEZ A., BELUT E., GUICHARD R., VAN TONGEREN M., TRAN L., CHERRIE J.
Quantitative Modelling of occupational exposure to airborne nanoparticles. (Modélisation quantitative de l'exposition professionnelle aux nanoparticules aéroportées). *Vol. 48, pp. 181–207.*

ICMF 2016, 9th International Conference on Multiphase Flow, May, 22-27, 2016, Firenze, Italy

BELUT E., CHRISTOPHE T.
A new experimental dataset to validate CFD models of airborne nanoparticles agglomeration. (Un nouveau jeu de données expérimentales permettant la validation de modèles CFD de transport et de coagulation des aérosols de nanoparticules). *Actes, 6 p.*

Note Scientifique et Technique de l'INRS

BAU S., WITSCHGER O.
Dispositif de contrôle des Compteurs (DCC): développement, qualification et mise en place d'une procédure opérationnelle. *NS 343, Juin 2016, 56 p.*

CAROLY S., DRAIS E.
Concevoir la prévention des risques liés aux nanomatériaux à partir de l'activité des travailleurs et la discussion sur le travail: cas des laboratoires publics de recherche et du secteur industriel. *NS 348, novembre 2016, 89 p.*

Organisation, Health and Safety at Work

Traitement Automatique des Langues

LEFEUVRE-HALFTERMEYER A., GOVAERE V., ANTOINE J.Y., ALLEGRE W., POUPLIN S., SLIMANI S., SPAGNULO A.
Typologie de facteurs de risques pour une analyse éthique de l'impact des technologies numériques: application au TALN. *Décembre 2016, vol. 57 n°2, pp. 47-71.*

Terrain & Travaux

ROSSIGNOL K., DRAIS E., FAVARO M.
Evaluer l'organisation de la santé-sécurité au travail. Trajectoire d'un outil de mesure au sein du système français de prévention. *2016, n° 28, p.153-173.*

Santé & Travail

WIOLAND L.
Les enjeux de santé et sécurité liés aux évolutions du métier de chauffeur routier. *Avril 2016, n° 94, pp 32-33.*

Hygiène et Sécurité au Travail

GOVAERE V., WIOLAND L.
Déficits d'attention en conduite: le cas du transport routier de marchandises. *Septembre 2016, n° 244, pp. 42-46.*

LECLERCQ S., QUILLEROU E., SAVESCU A.
Aller de l'avant avec l'Ergonomie. *Juin 2016, n°243, pp. 76-81.*

22nd International Conference on Urban transport and the Environment, 21-23 June 2016, Hersonissos, Grèce

WIOLAND L., GOVAERE V.
Prevention of accidents and occupational diseases in the logistics of goods distribution in city centres: the case of electric trucks. (Prévention des accidents

et des maladies professionnelles dans la logistique de distribution des marchandises en centres villes: le cas des poids lourds électriques). *Proceedings, In: WIT Transactions on The Built Environment, volume 164, 2016, WIT Press, Urban Transport XXII, pp. 105-117.*

- *3ème Congrès de la Société Internationale d'Ergologie, 29-31 août 2016, Aix-en-Provence, France*

BOUDRA L., DELECROIX B., BÉGUIN P.
Mobiliser une approche développementale dans l'intervention ergonomique: réflexions sur la démarche d'action et la posture de l'intervenant. *Actes, 8 p.*

- *Thèse de doctorat, 1er juillet 2016, Université de Toulouse, Toulouse*

KHADEMI K.
Les processus cognitifs dans les activités d'ordonnancement en environnement incertain. *Mémoire de thèse, 177 p.*

- *Projet partenarial « Innover ensemble pour une performance globale »*

DELECROIX B., DRAIS E., MORVAN E.
Regards pluridisciplinaires sur les liens entre santé, qualité de vie au travail et performance globale. *Juin 2016, 137 p.*

Prevention of Occupational Cancers

- *Environmental Health Perspectives, (IF: 7,977)*

PARIS C., THAON I., HERIN F., LACOURT A., LUC A., COUREAU G., GISLARD A., GALAN P., HERCBERG S., WILD P., PAIRON J.C., ANDUJAR P.
Occupational Asbestos Exposure and Incidence of Colon and Rectal Cancers in French Men: The Asbestos-Related Diseases Cohort (ARDCo-Nut). (Exposition à l'amiante et risque de cancer colorectal: une étude d'incidence dans la cohorte (ARDCoNut)). *DOI: 10.1289/EHP153, http://dx.doi.org/10.1289/EHP153.*

- *Scandinavian Journal of Work, Environment and Health, (IF: 3,454)*

WILD P., SCHILL W., BOURGKARD E., DRESHER K., GONZALEZ M., PARIS C.
The 2-phase case–control design: an efficient way to use expert-time. (Le protocole d'étude cas-témoins en deux phases: une façon efficace pour l'utilisation du temps d'expertise). *2016, vol. 2, n°2, pp. 162-169.*

- *Environmental Health Insights, (IF: 1,452)*

DANISMAN BRUSCHWEILER E., WILD P., KHANH HUYNH C., SAVOVA-BIANCHI D., DANUSER B., HOPF N.
DNA Damage among Wood Workers Assessed with the Comet Assay. (Dommages à l'ADN parmi les travailleurs exposés à la poussière de bois évalués par le test des comètes). *2016, Vol. 10, pp. 105-112.*

- *Journal of the International Society for Respiratory Protection*

CHAZELET S., SILVENTE E., EYPERT-BLAISON C., BELUT E.
Asbestos fibre sampling through a facepiece visor to measure workplace protection factor. (Prélèvement de fibres d'amiante à l'intérieur de masques respiratoires pour la mesure de facteur de protection). *2016, vol. 33, 2, pp. 21-35.*

- *Journal of Environmental Protection*

SUTTER B., PELLETIER E., RAVERA C., LANGLOIS E.
Performances of a bitumen fume and condensate generation system fo sampling method development. (Perfomances d'un système de génération de fumée de bitume et de condensat pour le développement de méthodes de prélèvement). *2016, Vol. 7, pp. 973-984, http://dx.doi.org/10.4236/jep.2016.77086.*

- *Hygiène et sécurité du travail*

CHAZELET S., SILVENTE E., ROMERO-HARIOT A.
Expositions à l'amiante selon le poste occupé: zoom sur les préleveurs. *Septembre 2016, n° 244, EC16, pp. 64-68.*

- *Note Scientifique et Technique de l'INRS*

CHAZELET S., SILVENTE E.
Synthèse de la campagne INRS pour la détermination des facteurs de protection assignés des appareils de protection respiratoire utilisés en chantier de désamiantage. *2016, NS 341, 22 p.*

Reproduction and Work

- *Journal of Applied Toxicology (IF: 2,982)*

SAILLENFAIT A.M., NDIAYE D., SABATE J.P., DENIS F., ANTOINE G., ROBERT A., ROUILLER-FABRE V., MOISON D.
Evaluation of the effects of deltamethrin on the fetal rat testis. (Evaluation des effets de la deltaméthrine sur le testicule fœtal de rat). *2016, DOI 10.1002/jat.3310.*

- *Toxicology in vitro (IF: 2,903)*

SAILLENFAIT A.M., NDIAYE D., SABATE J.P.
The estrogenic and androgenic potential of pyrethroids *in vitro*. Review. (Potentiel estrogénique et androgénique des pyréthrinoïdes. Synthèse). *2016, Vol. 34, 2016, pp. 321–332.*

- *Regulatory Toxicology and Pharmacology (IF: 2,227)*

SAILLENFAIT A.M., MARQUET F., SABATE J.P., NDIAYE D., LAMBERT XOLIN A.M.
Repeated dose oral toxicity of N-ethyl-2-pyrrolidone in Sprague Dawley rats. (Toxicité de la N-ethyl-2-pyrrolidone après des administrations orales répétées à des rats Sprague-Dawley). *2016, Vol. 81, pp. 275-283.*

- *International Archives of Occupational and Environmental Health (IF: 2,196)*

NDAW S., REMY A., JARGOT D., ROBERT A.
Occupational exposure of cashiers to Bisphenol A via thermal paper. Urinary biomonitoring study . (Exposition professionnelle des agents de caisse au Bisphénol A lors de la manipulation de papier thermique. Biométrologie urinaire). *2016, Vol. 89, pp. 935–946.*

- *Occupational medicine (IF: 1,025)*

HENROTIN J.B., VAISSIERE M., ETAIX M., DZIURLA M., RADAUCEANU A., MALARD S., LAFON D.
Deprivation, occupational hazards and perinatal outcomes in pregnant workers. (Précarité, risques professionnels et issus de grossesse défavorables chez les femmes enceintes au travail). *November 7, 2016, doi:10.1093/occmed/kqw148.*

- *Archives des Maladies Professionnelles et de l'Environnement*

NDAW S., ROBERT A., REMY A., JARGOT D., MARSAN P.
Bisphénols A et S dans le papier thermique – Exposition professionnelle ? *Juin 2016, Vol. 77, n°3, pp. 474-475.*

- *Santé publique*

HENROTIN J.B., VAISSIERE M., ETAIX M., DZIURLA M., MALARD S., LAFON D.
Codage d'emplois (PCS 2003): retour d'expérience d'une étude menée en service de santé au travail. *2016, Vol 28, n° 4, pp. 471-480.*

- *Hygiène et sécurité du travail*

HENROTIN J.B.
Perturbateurs endocriniens en milieu de travail: priorité à la surveillance et aux développements des connaissances. *2016, n° 245, pp. 66-71.*

- *Références en santé au travail*

NDAW S., ROBERT A., REMY A., JARGOT D., BERTRAND N., LAFON D., MALARD S., AUBRY C.
Expositions professionnelles au bisphénol A lors de la manipulation de papier thermique. *Juin 2016, n° 146, TF238, pp. 51-64.*

Biological Risks

- *Aerosol Science and Technology (IF: 2,413)*

SIMON X., BAU S., BOIVIN A., DUQUENNE P., WITSCHGER O., GORNER P.
Particle-collection efficiency of the CIP 10-M personal sampler's rotating cup containing aqueous or viscous collection fluid. (Efficacité de collecte du dispositif de prélèvement d'aérosols CIP 10-M: influence de la présence de liquides aqueux ou visqueux dans la coupelle rotative.). *2016, Vol. 50, n°5, pp. 507-520.*

- *Archives des Maladies Professionnelles*

NDAW S., ROBERT A., ANTOINE G.
Mycotoxines: stratégie pour un repérage des expositions professionnelles. *Juin 2016, Vol. 77, n° 3, pp. 478.*

Chemical Risks

Journal of Analytical and Applied Pyrolysis (IF: 3,652)

BENSABATH T., MONNIER H., GLAUDE P.A.
Detailed kinetic modeling of the formation of toxic polycyclicaromatic hydrocarbons (PAHs) coming from pyrolysis in low-pressuregas carburizing conditions. (Modélisation cinétique détaillée de la formation d'hydrocarbures aromatiques polycycliques (HAP) toxiques provenant de la pyrolyse dans des conditions de cémentation gazeuse à basse pression). *2016, Vol. 122, pp. 342–354*.

Toxicology Letters (IF: 3,522)

DEVOY J., GÉHIN A., MULLER S., MELCZER M., REMY A., ANTOINE G., SPONNE I.
Evaluation of Chromium in Red Blood Cells as an Indicator of Exposure to Hexavalent Chromium: an *In Vitro* Study.. (Évaluation du chrome dans les globules rouges comme un indicateur d'exposition au chrome hexavalent: une étude *in vitro*.). *2016, Vol. 255, pp. 63–70.*

RADAUCEANU A., GRZEBYK M., EDME J.L., CHEROT-KORNOBIS N., ROUSSET D., DZIURLA M., DE BROUCKER V., HEDELIN G., SOBASZEK A., HULO S.
Effects of occupational exposure to poorly soluble forms of beryllium on biomarkers of pulmonary response in exhaled breath of workers in machining industries. (Effets de l'exposition professionnelle aux formes peu solubles de béryllium sur les biomarqueurs de la réponse pulmonaire dans l'air exhalé chez les travailleurs des industries de l'usinage). *2016, Vol. 263, pp. 26-33.*

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

DORRIBO V., WILD P., PRALONG J., DANUSER B., REBOUX G., KRIEF P.
Respiratory health effects of fifteen years of improved collective protection 3 in a wheat-processing worker population. (Effets sur la santé respiratoire de quinze ans de protection collective améliorée dans une population exposée aux poussières de blé). *2016, Vol. 22, n°4, pp. 647–654.*

Annals of Occupational Hygiene (IF: 2,101)

BONTHOUX F.
Factors Affecting the Capture Efficiency of a Fume Extraction Torch for Gas Metal Arc Welding. (Etudes des facteurs influents sur l'efficacité de captage des torches MIG/MAG aspirantes). *2016, doi:10.1093/annhyg/mew016, pp. 1–10.*

Journal of Occupational and Environmental Hygiene (IF: 1,166)

ROUSSET D., DURAND T.
Beryllium solubility in occupational airborne particles: sequential extraction procedure and workplace application. (Solubilité du béryllium particulaires dans l'air des lieux de travail: procédure d'extraction séquentielle et application dans des environnements de travail). *January 2016, Volume 13, Issue 1, pp. 71-83.*

VUONG F., CHAUVEAU R., GREVILLOT G., MARSTEAU S., SILVENTE E., VALLIERES C.
Predicting the lifetime of organic vapor cartridges exposed to volatile organic compound mixtures using a partial differential equations model. (Prédiction du temps de vie des cartouches de masque à gaz soumises à des mélanges de vapeur organique à l'aide d'un modèle aux équations aux dérivées partielles). *2016, vol. 13, n° 9, 675-689.*

CHATA F., BELUT E., KELLER F.X., TANIERE A.
Particulate pollutant source evaluation using an inverse method under steady-state conditions. (Évaluation des sources de polluants particulaires en utilisant une méthode inverse sous des conditions stationnaires). *2016, vol. 13, n° 3, 223-233.*

Mechanics & Industry

DEVIENNE R., FONTAINE J.R.
Thermal plumes above hot sources: characterization and capture efficiency. (Panaches thermiques au-dessus de sources chaudes: caractérisation et efficacité de captage). *2016, Vol. 17, Issue 609, 12 p.*

Archives des Maladies Professionnelles

JACOBY N., ANTOINE G., MELCZER M., REMY A., ROBERT A.
Projection thermique: évaluation biologique et atmosphérique des expositions au chrome et au nickel. *Juin 2016, Vol. 77, n°3, pp 481.*

HANSER O., NDAW S., BARKIN N., VIDAL M., GUILLEUX A., PASSERON J., PILIERE F., MELCZER M., DENIS F., ROBERT A.
Suivi biométrologique des équipes médicales exposées aux médicaments cytotoxiques durant les chimiothérapies hyperthermiques intrapéritonéales (CHIP et PIPAC). *Juin 2016, Vol. 77, n°3, pp 479*.

Salles Propres

BEMER D., MORELE Y., GRIPPARI F., APPERT-COLLIN J., THOMAS D.
Filtration des particules ultrafines métalliques générées par des procédés industriels. *Juin-juillet 2016, 105, 105, Vol.105, pp. 44-49.*

Soudage & Techniques Connexes

BONTHOUX F.
Etude des facteurs influents sur l'émission de fumées et l'efficacité de captage des torches MIG/MAG aspirantes. *Mai - juin 2016, pp. 41-47.*

Techniques hospitalières

BOGEY A., DEMANGE V., HONNERT B.
Risques chimiques associés au nettoyage et à la désinfection pour les personnels en milieu de soins. *Mai-juin 2016, Vol. 757, pp. 29-33.*

Conseil et Orientation pour le Travail, AIPTLF, l'Harmattan, Paris, janvier 2016.

JUDON N., HELLA F., GARRIGOU A.
Créer des espaces intermédiaires pour construire la prévention. Cas des travaux de revêtements routiers. *In: DI FABIO A., LEMOINE C., MAJER V., SALENGROS P., pp.125-136.*

Hygiène et sécurité du travail

BURZONI S.
1,3-butadiene: bilan des mesures de prévention mises en œuvre en 2013. *Juin 2016, n°243, NT 38, pp. 50-57.*

BEMER D., MONNIER H., LECLER M.T.
Contrôle de la concentration en particules à l'émission des engins à moteur diesel équipés d'un filtre à particules. *Septembre 2016, n° 244, NT41, pp. 50-55*.

GERARDIN F.
Trichloramine: de l'émergence d'un risque aux solutions de prévention. *Décembre 2016, n°245, NT44, pp. 58-65.*

BONTHOUX F.
Expositions professionnelles aux fumées de soudage à l'arc. *Mars 2016, n°242, CC12, pp. 66-70.*

WFC 12 – 12th World Filtration Congress, 2016, May, 11-15, 2016, Taipei, Taïwan

WINGERT L., BEMER D., CHARVET A., BARDIN-MONNIER N., THOMAS D.
Modeling granular beds clogging by nanoparticles. (Modélisation du colmatage de lits granulaires par des nanoparticules). *Proceedings, 6 p.*

WINGERT L., BEMER D., PACAULT S., CHARVET A., BARDIN-MONNIER N., THOMAS D.
Improvement of granular bed filtration performances. (Amélioration de la filtration par lit granulaire). *Proceedings, 7 p.*

ICMF 2016, 9th International Conference on Multiphase Flow, May, 22-27, 2016, Firenze, Italy

AUDARD F., FEDE P., BELUT E., FONTAINE J.R., NEAU H., SIMONIN O.
Eulerian simulation of 3D freely-falling granular jet. (Simulation Eulérienne tridimensionnelle d'un jet granulaire en chute libre). *Proceedings, 6 p.*

CHERRIER G., BELUT E., TANIERE A., RIMBERT N., GERARDIN F.
Aerosol scavenging by drops: deriving a collection kernel from microphysical modelling. (Capture d'aérosol par des gouttes: mise en place d'un noyau de collecte à partir de la modélisation des phénomènes microphysiques). *Proceedings, 5 p.*

FEDE P., AUDARD F., BELUT E., FONTAINE J.R., SIMONIN O.
Analytical and practical analysis of frictional-kinetic model for dense and dilute gas-solid flows. (Etude analytique et pratique de modèles cinétique-frictionnels pour les écoulements gaz/solides concentrés). *Proceedings, 6p.*

Mechanical Risks and New Technologies for Accident Prevention

International Journal of Industrial Ergonomics (IF: 1,208)

PERRIN N., LUX A., WILD P., MARSOT J.
Preventing plant-pedestrian collisions: Camera & screen systems and visibility from the driving position. (Prévention des collisions engins-piétons: systèmes caméra-écran et visibilité au poste de conduite). *2016, Vol. 53, pp. 284-290.*

KANBrief

REBELLE J.
L'INRS et le BGHW ont évalué l'efficacité de plusieurs Systèmes à Gain de Stabilité (SGS) implantés sur certains chariots élévateurs du marché.. *KANBrief 2/16, 2016, pp. 15-17. (P2016-041)*

Hygiène et sécurité du travail

LAMY P., BLAISE J.C., SGHAIER A., HARDY S.
Les risques professionnels liés aux systèmes industriels automatisés. *Juin 2016, n° 243, compte rendu SIAS 2015, Königswinter (Allemagne), 18 au 20 novembre 2015, pp. 76-79.*

TIHAY D.
Méthode de choix d'un dispositif de protection sensible pour sécuriser une machine. *Mars 2016, n°242, note technique 37, pp. 52-57.*

COMELLI N., BLAISE J.C.
Comment intervenir en sécurité sur une machine ? Décembre 2016, n° 245, dossier "De la conception au recyclage d'une machine, la sécurité avant tout" - *Article 3, pp. 30-32.*

REBELLE J.
Un système de retenue pour cariste basé sur le principe des airbags. *Septembre 2016, n° 244, note technique 45, pp. 56-62.*

Note scientifique et technique de l'INRS

BAUDOIN J., BELLO J.P.
Servomotor press design - Safety recommendations. (Conception de presses à servomoteur - Préconisations de sécurité). *NS 340, janvier 2016, 74 p.*

POIROT R., REBELLE J., DOFFIN F.
Conception innovante de béquilles latérales pour chariots élévateurs. Utilisation lors de renversements partiels en suivant le code d'essai normalisé EN 16203. *NS 342, juin 2016, 50 p.*

(Lambda Mu) - 20ème congrès de maîtrise des risques et de sûreté de fonctionnement - Maîtriser les risques dans un monde en mouvement, 11-13 Octobre 2016, Saint-Malo, France

LAMY P., TISSOT C.
Analyse de récits d'accidents du travail pour identifier des dérives d'usage et apport de traitement automatique de langues (TAL). *Actes, 10 p.*

Psychosocial Risks

International Journal of Occupational and Environmental Health (IF: 1,365)

KOP J.L., ALTHAUS V., FORMET-ROBERT N., GROSJEAN V.
Systematic comparative content analysis of 17 work environment questionnaires using a new taxonomy. (Analyse systématique du contenu de 17 questionnaires de facteurs psychosociaux au travail sur base d'une taxonomie nouvelle). *2016, April 2016, Vol. 22, issue 2, pp. 128-141.*

Production Journal (IF: 0,23)

VAN DE WEERDT C., BARATTA R.
Changes in working conditions for home healthcare workers and impacts on their work activity and on their emotions. (Evolution des conditions de travail de soignants à domicile et impacts sur leur activité de travail et leurs émotions). *Avril/juin 2015, Vol. 25, n° 2, p. 344-353.*

■ *Le Travail Humain (IF : 0,129)*

VAN DE WEERDT C.
Analysis of activity and emotions: a case study based investigation of an evolving method. (L'analyse de l'activité et des émotions: regard sur une méthode en évolution à partir d'une étude de cas). *2016, Vol. 79, n° 1, p. 31-52.*

■ *Le Concours médical*

FAVARO M.
Violences au travail: proposition d'un modèle-cadre pour comprendre et intervenir. **2016, tome** *138, n°1, pp. 64-66.*

■ *Psychologie du Travail et des Organisations: 110 notions clés. Dunod, avril 2016*

CAHOUR B., VAN DE WEERDT C.
Emotions au travail: définition, processus et approches méthodologiques, *pp. 164-168.*

GROSJEAN V.
Bien-être au travail, *pp 61-63.*

ALTHAUS V., KOP J.L., GROSJEAN V.
Qualité de vie au travail, *pp. 344-346.*

MARC J., LADREYT S. - Isolement au travail et solitude professionnelle, *pp. 260-263.*

■ *Hygiène et sécurité du travail*

GROSJEAN V., LEICHLE J., THEVENY L.
Les nouvelles formes d'organisation du travail: opportunités ou illusions ? *Décembre 2016, n° 245, DC15, p.6-9.*

VAN DE WEERDT C.
Les émotions au travail des intervenants à domicile. *Juin 2016, n° 243, DO13, pp 42-46.*

GROSJEAN V., GUYOT S.
Bien-être et Qualité de Vie au Travail, risques psychosociaux: de quoi parle-t-on ? *Mars 2016 n° 242, DC12, pp 6-9.*

GROSJEAN V., GOVAERE V.
TIC et objets connectés: quels enjeux de santé au travail. *Septembre 2016, n° 244, pp. 108-112.*

■ *Note Scientifique et Technique de l'INRS*

GROSJEAN V., KOP J.L., FORMET-ROBERT N., ALTHAUS V.
Approche « bien-être au travail » pour la prévention des RPS. SATIN version 3.0: Questionnaire d'évaluation des conditions de travail et de la santé. Manuel d'utilisation. *NS 344, mai 2016, 44 p.*

KOP J.L., FORMET-ROBERT N., ALTHAUS V., GROSJEAN V.
Validation psychométrique croisée de la version 3 de SATIN dans deux échantillons. *NS 346, septembre 2016, 55 p.*

■ *L'activité en débat: dialogues épistémologiques et méthodologiques sur les approches de l'activité, 2016, 14-16 janvier, 2015, Lille, France*

VAN DE WEERDT C.
Adapter les auto-confrontations collectives dans une intervention en entreprise. *Actes, 11 p.*

■ *51ème Congrès de la Société d'Ergonomie de Langue Française (SELF), 21-23 Septembre 2016, Marseille, France*

VAN DE WEERDT C., BARATTA R.
Emotions au travail et ergonomie: regard sur une discipline en évolution à partir d'une étude de cas. *Actes, pp. 638-646*

■ *51ème Congrès de la Société d'Ergonomie de Langue Française (SELF), 21-23 Septembre 2016, Marseille, France*

CHOUANIERE D.
Evaluation des interventions complexes en santé au travail.

VAN DE WEERDT C., BARATTA R.
Emotions au travail et ergonomie: regard sur une discipline en évolution à partir d'une étude de cas.

■ *XXIIe Journées Internationales de Psychologie Différentielle, 22-24 Juin 2016, Chambéry, France*

KOP J.L., FORMET-ROBERT N., ALTHAUS V., GROSJEAN V.
Validation d'un questionnaire d'évaluation de la santé et du bien-être au travail: quelles sont les sources pertinentes de variation des réponses ?

- *Journée d'Etude « Emotions en actions: dimensions sociales et au travail », le 25 Mars 2016, Amiens, France*

VAN DE WEERDT C.
Les émotions comme déterminants de l'activité de travail.

- *Bureaux Expo, 5-7 Avril 2016, Paris, France*

GROSJEAN V.
Table Ronde consacrée au « bonheur au travail".

- *Journée d'étude "Gérer les risques au travail: place et rôle du droit", le 18 Avril 2016, Paris, France*

LAPOIRE-CHASSET M.
Le droit comme ressource de l'action collective sur les risques psychosociaux.

- *Rencontre de Villermé consacrée au bien-être au travail, 25-26 Mai 2016, Montpellier, France*

GROSJEAN V.
Bien-être et performance.

- *2ème journée d'étude de l'Association Reliance et Travail « la prévention des RPS: un travail d'équipe ! », le 30 Septembre 2016, Marseille, France*

FAVARO M., MARC J.
Modéliser les pratiques de prévention des risques au travail: une opportunité de lecture et d'action pluridisciplinaire.

- *Préventica Rennes Grand Ouest, 4-6 Octobre 2016, Rennes, France*

GROSJEAN V.
Réflexions relatives au vécu subjectif au travail, au bien-être et aux risques disruptifs dans le secteur tertiaire.

- *Club RPS. Comment mieux être au travail ? Les entreprises s'engagent., le 18 Octobre 2016, Montpellier, France*

GROSJEAN V.
Bien-être au travail, QVT, RPS… de quoi parle-t-on ?

- *Journée d'études "Le travail comme objet interdisciplinaire", le 20 Octobre 2016, Paris, France*

FAVARO M., MARC J.
Modéliser les pratiques de prévention des risques au travail: une opportunité de lecture et d'action pluridisciplinaire.

- *Expoprotection, 7-9 Novembre 2016, Paris, France*

GROSJEAN V., LANGEVIN V.
Stress Burnout, Harcèlement. Informer pour prévenir. Suivi de Bien-être au travail, Qualité de Vie au Travail, RPS: Quelles spécificités, quelles complémentarités ?

Occupational Road Acident Risk

- *Hygiène et sécurité du travail*

AMATO J.N., HACHE P
L'influence des médicaments psychotropes sur la conduite automobile. *Septembre 2016, n° 244, pp. 28-33.*

Musculoskeletal Disorders of the Limbs and of the Back

- *Arthritis Care & Research (IF: 2,23)*

DESCATHA A., ALBO F., LECLERC A., CARTON M., GODEAU D., ROQUELAURE Y., AUBLET-CUVELIER A.
Lateral epicondylitis and physical exposure at work? A review of prospective studies and meta-analysis. (Epicondylite latérale et exposition physique professionnelle. Revue d'études prospectives et méta-analyse). *2016, 1002/acr.22874, 48 p.*

- *Ergonomics (1,85)*

GAUDEZ C., CAIL F.
Effects of mouse slant and desktop position on muscular and postural stresses, subject satisfaction and performance. (Effets de l'inclinaison de 3 types de souris et de leurs positionnements sur le plan de travail sur les sollicitations biomécanique du membre supérieur, la performance et le ressenti des sujets). *Ergonomics, 2016, vol. 59, n° 11, pp.1473-1486.*

■ *Applied Ergonomics (1,332)*

GAUDEZ C., WILD P., AUBLET-CUVELIER A.
A better way of fitting clips? A comparative study with respect to physical workload. (Quelle est la meilleure façon de poser les clips ? Etude comparant quatre techniques de pose). *2015, Vol. 51, pp. 236-243.*

■ *Work (IF: 0,715)*

PETIT A., MAIRIAUX P., DESARMENIEN A., MEYER J.P., ROQUELAURE Y.
French good practice guidelines for management of the risk of low back pain among workers exposed to manual material handling: Hierarchical strategy of risk assessment of work situations. (Recommandations françaises pour la gestion du risque lombalgique des salariés exposés à la manutention manuelle). *Work, 2016, Vol. 53, n°4 pp. 845-850.*

■ *Arthrose et activités professionnelles, Collection médecine de réadaptation et pathologies professionnelles, Fouquet B., Descatha A., Roulet A., Herisson C., 2016*

AUBLET-CUVELIER A., DESPREAUX T., KERANGUEVEN L., DESCATHA A
Biomécanique de l'arthrose. *pp. 15-23.*

PALLUEL M., ROQUELAURE Y., PETIT A., AUBLET-CUVELIER A., DESPREAUX T.
Epidémiologie de l'arthrose des membres inférieurs dans le monde du travail. *pp. 24-32.*

PALLUEL M., DESPREAUX T., AUBLET-CUVELIER A., ROQUELAURE Y., PETIT A., DESCATHA A.
Epidémiologie de l'arthrose des membres supérieurs dans le monde du travail. *pp. 33-38.*

■ *Note Scientifique et Technique de l'INRS*

GAUDEZ C., CAIL F.
Effets sur les sollicitations musculaires et posturales, sur la performance et le ressenti des utilisateurs de différentes souris informatiques et de leur positionnement sur le bureau. *NS 345, septembre 2016, 40 p.*

Ageing, Staying in Employment, and Preventing Occupational Exclusion

■ *Références en Santé au Travail*

PICHENEHOUARD A., LAPOIRE-CHASSET M., MARTEL L., GAUDARD C.
Les départs précoces des pâtissiers salariés de l'artisanat: comprendre pour agir en prévention. *Septembre 2016, n° 147, pp. 51-68.*

■ Director of Publication
Stéphane Pimbert

■ Chief Editor
Didier Baptiste et Fahima Lekhchine

■ Editing and Coordination
Patricia Bernard et Pascal Wild

■ "Studies & Research"
Data Collection
Catherine Aubry, Chantal Rolin

■ Translation
Stephen Walsh

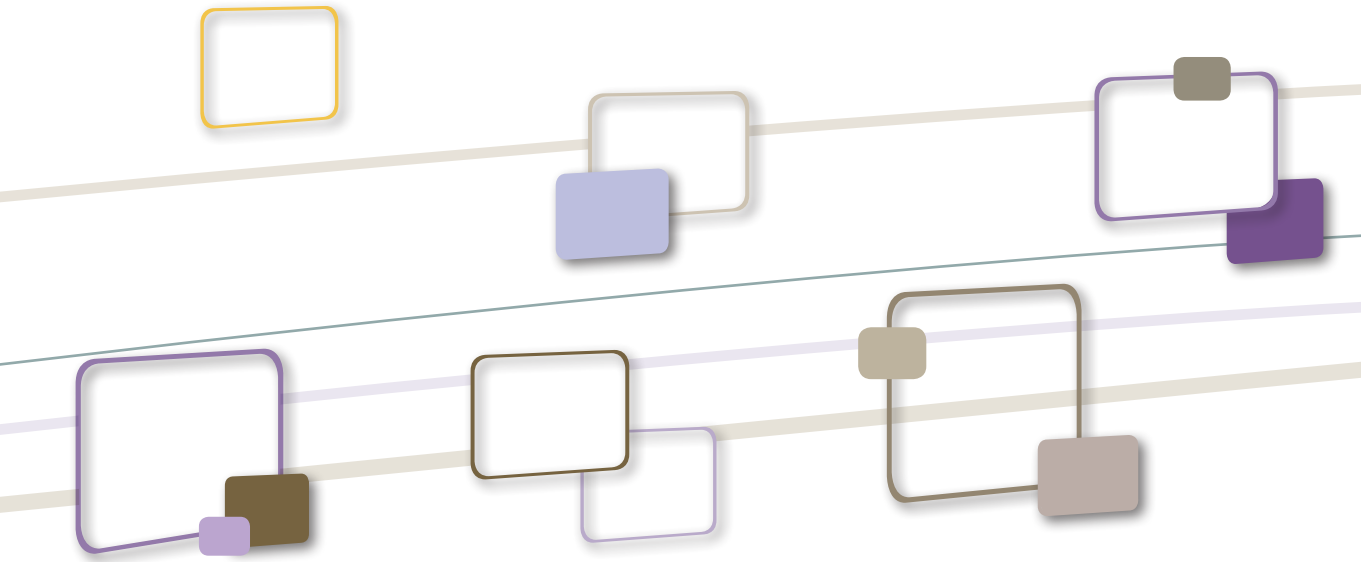
■ Co-ordination of the English version
Michel Talarmin

■ Also contributed to the publication
The INRS researchers

■ Graphic Design and Artwork
Trait d'Union - www.traitdunion-com.fr

■ Printing
Société Jouve

INRS Edition: ED 4480
July 2017 - ISSN 2265-0504



Our job: making yours safer

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

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

E-mail: info@inrs.fr

www.inrs.fr