



Occupational Contact Dermatitis in the Industrial Setting

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David Pesqué, Cecilia Svedman,
and Ana M. Giménez-Arnau

Introduction

The industrial sector, also called secondary sector, is in charge of transforming materials into goods. This sector has been classified into different industries: construction industry, fashion industry, chemical industry, pharmaceutical industry, power, and petroleum industry, automotive industry, electronic industry, food industry and paper industry, among others. In the USA, this economic sector accounted for 20% of the labor force, and, worldwide, 22.7% in 2019 [1].

The relevance of this chapter lies in the important workforce employed in the industrial sector not only in modern industrial countries, but glob-

ally, with differences in the specific types of industries. In addition, since this sector is heterogenous, the exposure of workers to irritants and allergens can be significantly different. One aspect to enhance is that irritant contact dermatitis may be common to different industrial jobs, for many entail working under wet conditions, heat, or getting in contact with irritant agents. Furthermore, it should be considered that the resulting final manufactured product usually requires different industrial jobs, thus enhancing the presence of multiple industrial tasks in industrial workplaces.

Table 13.1 summarizes the most characteristic irritants and sensitizers, classified according to the industrial sector.

D. Pesqué

Department of Dermatology, Hospital del Mar –
Institut Mar d'Investigacions Mèdiques, Universitat
Autònoma de Barcelona (UAB), Barcelona, Spain

C. Svedman

Department of Occupational and Environmental
Dermatology, Lund University, Skane University
Hospital, Malmö, Sweden

A. M. Giménez-Arnau (✉)

Department of Dermatology, Hospital del Mar –
Institut Mar d'Investigacions Mèdiques, Universitat
Autònoma de Barcelona (UAB), Barcelona, Spain

Department of Dermatology, Hospital del Mar –
Institut Mar d'Investigacions Mèdiques, Universitat
Pompeu Fabra, Barcelona, Spain

Table 13.1 Characteristic irritants and sensitizers classified according to the industrial sector

Industrial profession	Irritants	Allergens
Construction workers (including metal workers, cement workers, boat builders, air craft workers, glass workers)	Abrasive hand cleansers Carbon fibers Glass fibers Metal dust Metalworking fluids Sharp metal particles Wet working	Aluminum chloride Cobalt chloride Colophony Epoxy resin Formaldehyde Formaldehyde releasers (e.g., bioban CS-1135®) Methyldiethanolamine Nickel sulfate Polyester resin Potassium dichromate
Fashion industry (including textile workers, leather workers and fur workers)	Acetic acid Caustic soda Ethanol Formic acid Wet working	Disperse dyes (e.g., disperse Brown 1, disperse red 1, etc.) Formaldehyde Reactive dyes (e.g., reactive black 5, reactive blue 21, etc.)
Chemical industry	Exposure to a wide range of possible corrosive and irritant chemicals	Many potential allergens Cobalt chloride Formaldehyde Mercaptobenzothiazole Mercapto mix Nickel sulfate Potassium dichromate Thiuram mix
Cosmetic industry	See chemical industry	2-Bromonitropropanediol 3-Hexylthiophene Methyl heptine carbonate <i>p</i> -toluene diamine
Petrol industry	Barium sulfate Calcium hydroxide Calcium oxide Crude oil Diesel Ilmenite Potassium hydroxide Silicate Zinc bromide	Glutaraldehyde Isothiazolinones Polyamides Resins
Automotive industry	Metal dusts Metalworking fluids Solvents Welding fumes	Epoxy resins Isocyanates Polyvinyl chloride Styrene
Electronic industry	Fiberglass Hydrofluoric acid	Acrylate Cobalt chloride Colophony Epoxy resin Isocyanate Nickel sulfate
Food industry	Detergents and cleaning solutions Enzymes Flavoring agents Spices Sodium chloride Wet working	2-mercaptobenzothiazole Animal proteins Balsam of Perú Carba mix Latex Nickel sulfate Paraphenylenediamine Thiuram mix

Table 13.1 (continued)

Industrial profession	Irritants	Allergens
Paper workers	Ammonia Sodium hypochlorite Wet working	Carba mix Colophony Epoxy resin Formaldehyde Methylchlorisothiazolinone/ methylisothiazolinone Mercapto mix Thiuram mix

Industrial Jobs

Construction Industry

This category includes all those professions linked to infrastructure and industrial construction, which accounts for a significant part of the secondary industry. Examples in this category are metal workers, cement workers, aircraft industry workers, etc.

Metal workers are one of the best-studied groups as there is high risk of irritant hand dermatitis due to exposure to mechanical and chemical irritants or allergens. Prevalence rates of hand dermatitis in metalworking companies may exceed 20%, being frequently irritant contact dermatitis (ICD) [2]. Chemical irritants to be enhanced are cleaning detergents, solvents, and degreasers [3]. Sensitization most commonly occurs to metalworking fluids, which are chemicals used in the metal treatment, but ICD can also occur, being difficult to differentiate. Workers can be exposed through skin contact by splashes and aerosols or when handling parts, tools, and equipment covered with metalworking fluids. The most common causative agents of allergic contact dermatitis (ACD) are antimicrobials, fragrances, formaldehyde, and formaldehyde releasers present in metalworking fluids. Additionally, monoethanolamine, a reported cause of ACD, is used as feedstock in metalworking fluids to stabilize pH or inhibit corrosion. Less commonly, sensitization occurs to specific metals, being nickel, chromium, and copper the most important illustrating examples [4, 5].

There are some specific jobs in the metal industry with specific characteristics, particularly welding workers and grinders of hard metal. The former are in charge of joining metal parts with the use of heat and are exposed to different types of metals due to fume exposure when welding. Metal welding implies the generation of fumes, which can contain metals, and electricity, which generates ultraviolet (UV) radiation, particularly within the UVC region. Sensitizing agents may also be cobalt, chromium, nickel, copper, and aluminum [6]. Despite welders being protected against UV radiation, occasional exposure to UVC has been described, with consequent associated photodamage, exacerbation of previous dermatoses and even photodermatoses. [6]. Figure 13.1 below depicts a case of occupational-induced idiopathic photodermatitis by tungsten welding in a sensitized worker to potassium dichromate.

Grinders use abrasive machining tools to finish workpieces of metal pieces. This process can involve a dry technique, in which workers may be exposed to metals, or a wet process, which requires the use of metalworking fluids. Therefore, grinders may be sensitized to metals (cobalt, chromium, nickel), but also to agents present in metalworking fluids. [7].

Cement workers include a wide range of jobs that are in contact with different forms of cement (mortar or concrete). Bricklayers and concrete workers do not usually wear gloves and are exposed directly exposed to the material, which is a known cause of ICD. [8]. However, there can be ACD to cement, which has a chronic nature and may have a social implication with an



Fig. 13.1 A case of occupational-induced idiopathic photodermatitis by tungsten welding in a sensitized worker to potassium dichromate. A moderate erythema both in face and neck with eczematous patches can be observed

increased job switching. The culprit of allergic cement eczema is chromium, which is present in cement in form of water-soluble hexavalent chromate, Cr (VI). By adding ferrous sulfate to the cement, chromate is reduced from Cr(VI) to Cr(III) with a lower solubility and prevents the occurrence of allergic eczema to chromate. [9]. In addition, these workers also use products containing epoxy resins.

The construction of means of transport is also associated with occupational contact dermatitis. Boat builders deal with a varied exposure to different chemicals and have seldom been object of ICD and ACD. Boats construction require the use of different materials, including plastics, metals, and wood. Therefore, allergens have to be studied depending on the individual exposure. Plastic materials used usually contain polyester resin, epoxy resin, epoxy vinyl ester resins, and acrylates. Wood parts are made of pine or oak wood, and decorations may be made of tropical wood species. Glass fiber or carbon fiber are used as reinforcement. For finishing, waxes, fillers, varnishes, and paints are used. [10].

In contrast, aircraft industry workers present with well-studied occupational contact dermatitis,

with a significant number of workers affected in different studies [11, 12] ICD can happen when being in contact with metalworking fluids and solvents. ACD are due to the contact with resins, hardeners, coatings, and paintings, with common allergens like epoxy resins, epoxy resin accelerators, chromates, and nickel. In the clinical setting, a picture due to epoxy resin is characterized by dermatitis on the finger pulp spaces, the dorsa and sides of fingers and forearms. In addition, subungual pulpitis by exposure to epoxy resins is specific for the aircraft industry [13].

Wood artisans, such as cabinetmakers, are affected by wood-related contact dermatitis due to direct contact with wood and chemicals used in woodworking (glues, paints, and lacquers). Some woods, particularly tropical woods, contain different sensitizers such as quinones, terpenes, phenols, or stilbenes. A myriad of allergens can be used in woodworking materials (acrylates, epoxy resin, colophony, isothiazolinones) [14].

Glass workers present ICD due to thermal, chemical, and physical trauma during its manufacturing. However, contact allergy is seldom found in literature. Today, the cases of ACD are related to the decoration of glass with cutting fluids, biocides, and glass coating. In these latter products, epoxy resins, silane and polyester resins can be found [15]. In addition, glaziers are exposed to glues and sealants that contain epoxy resins and acrylates [16].

Fashion Industry

Textile contact dermatitis has its particular features. It can occur in an occupational setting, but not necessarily, and it is believed to be more frequently of an allergic background rather than irritant [17]. During the fabrication process, mainly in the stages of dyeing and finishing, workers are exposed to irritants and sensitizers. Exposure to dyes, formaldehyde-containing finishers, rubber compounds, metals, biocides, and smoothers can occur and those are believed to be the main responsible agents for ACD. Disperse dyes with sensitizing potential, which include azo, anthraquinone, and nitro chemical classes, are believed

to be the first cause of occupational textile contact dermatitis. Those are used for the coloring of synthetic fibers (polyester, polyamide, acrylic). Reactive dyes (azo, anthraquinone, and phthalocyanine classes) serve to color natural fibers (cotton, silk, and wool) and synthetic polyamides, but these induce contact dermatitis much less frequently. The second most common type of contact dermatitis in these workers are formaldehyde resins, present in the finishing stages. Other occupational textile allergens include p-phenylenediamine, mercaptobenzothiazole, colophony, and isothiazolinones.

The European Union and Japan have already taken initiatives to regulate textile allergens. Such regulations have led, for example, to the production and identification of clothing free from allergenic dyes and high levels of formaldehyde [17]. Nevertheless, the prevalence of both occupational textile dermatitis seems to be on the rise, likely as a result of changing textile manufacturing techniques, involving many new substances and potential skin sensitizers, which are probably largely undeclared [18].

Leather industry workers are differently tackled, for the steps of processing leather involves different stages and chemicals. Initially, alkaline leaches and acids are used, and to prevent leather damage, biocides are applied to it. Tanning is performed by using chromium derivatives. Afterwards, leather is retanned with synthetic tanning agents, amino resins, and polyacrylate or polymethacrylate solutions. Leather dyeing is based on azo dyes. However, with an increased automation in this field, occupational dermatoses are expected to become less frequent in Europe [19].

Fur industry also holds specific features as it involves storing and chemically or physically processing fur. In this context, workers are not only exposed to dyes, acids, and detergents but also to animal dusts.

Chemical Industry

The diversity of skin-hazardous substances to which workers may be exposed makes difficult to

comprehensively analyze the main groups involved. Many chemicals commonly used in the laboratory are corrosive or irritating to the skin, while some are allergenic. In clinical laboratories, automation and encapsulation have importantly led to a reduction of risk of exposure. However, in research and industrial laboratories, the manual handling of hazardous chemicals still poses an important defy.

Occupational dermatoses are normally a consequence of undesired, accidental exposure in the working milieu, such as spillage of a substance on the skin [20]. The working processes that entail a higher risk of skin exposure are synthesis of products and distillation or other purification procedures. Previous literature supports that, normally, the sensitizers are not the final product but intermediate derivatives [21].

Allergic occupational chemical dermatitis is reported more frequently than the irritant counterpart. Occupational contact allergic dermatitis has been primarily diagnosed among chemical students and post-graduates [20]. In fact, ACD in chemistry researchers can often be the first clue of a new potential contact sensitizer, clearly depicting that research chemicals often become future laboratory and industrial agents [22].

Chemical burns due to highly corrosive chemicals like concentrated alkalis, concentrated acids, and metal salts can be seen. ICD is frequent in this working group due to frequent hand washing (wet works, soaps, skin disinfectants), use of polymer gloves, organic solvents, and acid and basic liquids [22]. ACD can be secondary to well-known sensitizers, but also even due to rare, new chemicals, making difficult to establish the responsible agent.

Pharmaceutical and Cosmetic Industries

These industries, clearly related to the chemical industry, also present with a burden of occupational dermatoses. Despite in the past, workers in the pharmaceutical industry were considered to

present a high risk of irritant and allergic contact dermatitis [23], the current situation may be changing due to an increase of automatization, but occupational contact dermatitis in the pharmaceutical industry is still commonly reported [24]. Occupational dermatoses are usually located at the site of contact, which is generally the hands. However, for this type of industry, a wide spectrum of reactions has been described: airborne reactions on exposed and non-exposed areas, generalized reactions, photosensitivity, urticaria, and fixed drug eruption. Figure 13.2 shows a case of occupational ACD to tetrazepam in a pharmaceutical worker, whose patch tests can be seen below.

The mechanisms of irritancy are homologous to those seen in point 2.3. Chemical industry.

Delayed contact hypersensitivity may be triggered by many different families of drugs: analgesic and anti-inflammatory agents, anthelmintics, antiandrogens, antiarrhythmic agents, antibacterial agents, anti-gout agents, antihypertensive agents, antimalarials, antimuscarinic agents, anti-neoplastic agents, immunosuppressants, antivirals, neuroleptics, anxiolytics, corticosteroids, dermatology topical agents, diuretics, local anesthetics, among others [24–26].

In the cosmetic industry the burden of ACD is low. However, some occupational allergens have also come to light, as specified in Sect. 4.

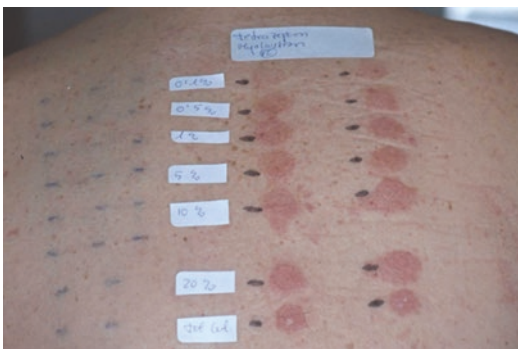


Fig. 13.2 Patch testing of tetrazepam in a pharmaceutical worker. The patient had become sensitized with this product working with the machinery used to manufacture the drug. Patch testing resulted positive on D2 (+++) for the drug “as if,” and at different concentrations (from 20% to 0.1%)

Power and Petroleum Industry

The power and petroleum industry sometimes present with occupational contact dermatitis, for example, oil rig workers and workers from the wind energy industry.

Oil rig workers task consists of drilling and maintaining the oil rig. The job categories related to this section are varied. Skin problems are the third largest work-related group of illnesses in the offshore oil industry after noise-induced hearing loss and traumatological problems, according to the Petroleum Safety Authority of Norway [27]. In this section, the focus will be on workers of the drilling operation and maintenance. As it happens with industrial workers, these jobs are characterized by hard physical manual work, unfavorable weather conditions, and exposure to chemical hazardous substances [27].

In the drilling process, drilling fluids are used to ease the process, but these contain hundreds of different types of chemical substances. Drilling fluids are classified depending on whether their primary base is water (called water-based fluids) or oil (oil-based fluids). Experience and reported evidence suggest that oil-based fluids present a further degree of skin damage. ICD of some degree is an expected finding and is almost universally evidenced when prolonged exposure to irritants occurs [27]. Petroleum hydrocarbons may remove the natural lipids from the skin, which can lead to dryness and cracking of the skin, easing latter irritation and sensitization. Different components of drilling fluids can act as irritants and allergens. In addition, working suits may contain epoxy resins, and amines are used in the treatment of hydrocarbons.

The increase in usage of renewable energies is also evidencing the presence of occupational dermatitis. The construction and manufacturing of aerogenerators and turbines in the wind energy industry have increased in Europe in the past decade [28]. Irritant contact dermatitis due to fiberglass can be seen. The use of adhesives, coating, and paints containing epoxy resins, places this allergen as the most commonly evinced in this sector [28].

Automotive Industry

The automotive industry of vehicles includes jobs associated to the production, retailing, and maintenance of vehicles, such as metal and plastic workers, vehicle assemblers, mechanics and car repair workers, etc. Nevertheless, the automotive industry is under constant change due to the use of new fabrication techniques and progressive automotive electrification. Due to this, it should be expected that the automotive industry will present similarities with the electronic industry. Similarly, metal workers of car parts present similar conditions as those seen in metal workers.

Workers in the assemble of vehicle parts and manufacture, deal with some hazardous chemicals, like isocyanates. A common binder used to manufacture sand cores is methylene diisocyanate, which can induce irritation and sensitization. Vehicle repair and maintenance workers are predominantly exposed to cutting fluids, mineral oils, lubricants, and solvents [29].

Electronic Industry

Electronic industry is considered greatly automated, and thus, safe. Notwithstanding the automation, the occurrence of occupational contact dermatitis has been reported. The tasks and materials related to the electronic industry can be summarized in two areas: semiconductor device fabrication and Printed Circuit Board (PCB) fabrication and assembly. The former involves semiconductor device fabrication, chip design, crystal purification and growth, wafer preparation, epitaxy and oxidation, photolithography, doping and type conversion, metallization, and interconnection formation, and encapsulation. Despite the vast size of the electronic industry workforce, there is little information available on how common occupationally related skin disorders in this industry are [30].

Both ICD and ACD appear to be important, mostly due to solvents, metals, soldering flux, epoxy and acrylate resins, oils and coolants, fiberglass, and rubber chemicals.

Food Industry

Contact dermatitis to food is usually related to workers of the primary economic sector, but food industry has also to be taken into account. Broadly speaking, most of these tasks involve wet working, and contact with cleansing and disinfectant agents. Therefore, in all the specific jobs that will be discussed in this section, irritant contact dermatitis may be a common finding. Allergic contact dermatitis related to the food industry is still both underreported and under recognized [31].

Meat industry workers, like slaughterhouse workers or poultry processors, can present with allergic contact dermatitis, mostly to rubber protection materials, and disinfectants or preservatives used in the different processes of meat transformation. In addition, contact urticaria and/or protein contact dermatitis to animal proteins has been described [32].

Cheese makers work daily with milk fat and protein, in the context of a wet work. The most important irritants in cheese dairies include contact with concentrated (20%) sodium chloride solutions and milk proteins [33]. Allergic contact dermatitis to different compounds (particularly antioxidants and allergens in rubber gloves), protein contact urticaria, and protein contact dermatitis have also been described [32].

Baking industry involves the use of flour, yeast, water, and other to produce bread and other products. Allergic contact dermatitis has been described for flours, amylase, wheat, cardamom, and gallates, among others. Contact protein dermatitis has been occasionally described [32].

Confectionery and candymakers work with a wide range of ingredients, flavors, preservatives, and antioxidants. The increased automation in the confectionery industry has led to an overall decrease in the number of occupational contact dermatitis [31]. As with other ranges of food industry, allergic contact dermatitis is a cause of occupational dermatitis, but in this case, flavorings are the most common cause. Some of the flavorings found include balsam of Peru, anethole, cardamom oil, cinnamic alcohol, citral,

geraniol, eugenol, ginger, or liquorice, among others. Other allergens may be related to gloves (rubbers) and use of antioxidants, preservatives, sweeteners, or emulsifiers [31].

Paper Industry

Pulp and paper manufacturing are complex processes that involve the use of multiple industrial chemicals. As seen in previous industries, these processes are becoming more automated, which reduces the workers' exposure to hazardous chemicals. Today, contact dermatitis is considered to be rare among pulp and paper workers.

In the process of fabrication, slimicides and their constituents (potent biocides) are used to prevent the growth of different microbes, which would reduce the quality of the paper. Slimicides are the most prominent agents causing allergic contact dermatitis among pulp and paper workers. In line with allergic contact dermatitis, paper dermatitis is also to be considered. Paper dermatitis is defined as allergic contact dermatitis caused by paper, which despite being rare, is a cause of occupational dermatitis. Colophony and formaldehyde are the most important allergens causing paper dermatitis [34].

Prevention and Conclusions

An early diagnosis, workplace exposure assessment and notification of industrial contact dermatitis is of utmost importance. Despite current legislation and policies, there is room for improvement, according to previous studies, in terms of legislation approach, research, and prevention [35]. Occupational risk assessment, as a part of primary prevention, is essential and should be focused on human, technical, and organizational aspects with the aim of reducing exposure to hazardous substances. An improvement in the detection and treatment of early stages of contact allergic dermatitis (secondary prevention) and the treatment of well-established occupational disease (tertiary prevention) are essential to pre-

vent relapses or chronicity, prevent workers from losing their job and promoting social rehabilitation and quality of life in workers.

The growth and development of the industrial sector worldwide, without uniform regulatory policies and surveillance, may pose an important defy with many unmet needs, since workplace assessment and research, as well as secondary and tertiary prevention may differ significantly.

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