Occupational diseases due to cooling fluids

Contact dermatitis to cutting fluids is a very frequent cause of occupational skin disease, with different mechanisms for those caused by irritation or allergies. The different allergens in question are many and complex. Different batteries of patch tests are available but the interpretation of the relevance of positive tests is not simple. The aim of this work is to make clearer the investigative methods and the interpretation of the relevance of the results of patch tests, for more effective prevention.

Key words: contact dermatitis to cutting fluids, cutting oils, biocides, machine-tool workers

Epidemiology

Occupational skin diseases relating to cooling fluids are compensated in France according to table no. 36 of the recognized occupational diseases in the French general social security scheme. Identified cases represent only a small part of reality, but may give some indication of the evolution of these disorders. Statistics show a gradual reduction in the number of cases of occupational skin diseases due to cooling fluids and compensated, according to table 36, or 36b for cancerous skin diseases, during recent years:

– 146 cases compensated in 2004: 115 eczemas, 23 irritations, 5 oil folliculitis with 3 cancers;
– 94 cases in 2005: 80 eczemas, 10 irritations, 3 oil folliculitis with 1 cancer;
– 94 cases in 2006: 74 eczemas, 16 irritations, 4 oil folliculitis and no cancer;
– 84 cases in 2007: 63 eczemas, 17 irritations, 1 oil folliculitis with 3 cancers.

It is therefore interesting to analyze the results of clinical studies in specialized centers whose results can be compared [1]. Ten relatively recent studies allow us to get an idea of the skin diseases encountered in these professions and the responsible factors:

– a French study in 1993 of 56 cases of skin diseases among users of cutting fluids in two centers (Nantes and Lyon), showed the importance at this time of oil folliculitis and allergies due to formaldehyde, the oxazolidines biocides and the hexahydrotriazines [2];
– a German study in 1998 of 1787 patients tested with industrial biocides saw frequent allergies to Bronopol, GrotanBK and oxazolidines [3];
– a German study in 2001 observed a fall in oil skin dermatitis to 4th position over a ten year period, in 5285 cases of occupational contact skin diseases in Germany [4];
– a Swedish study in 2003 of 164 workers engaged in machining metals stressed the importance of allergic reactions to isothiazolinone mixtures, to glutaronitrile, to thiomersal, and to an extreme pressure additive [5];
– a French study in 2004 of 32 cases, emphasizing the roles of isothiazolinones and methylidibromoglutaronitrile and the difficulties of reintegration [6];
– two German studies in 2004, on 141 and on 160 metalurgy workers, showed the importance of allergies to amines (mono-, di - and triethanolamines), to ethylene diamine, to CS 1135 Bioban, but also to balsam of Peru, to fragrances, to isothiazolinones and to methylidibromoglutaronitrile [7, 8].
– a French study in 2005 involving metal workers with 20 skin diseases related to cutting oils, in particular due to an additive having a similar formula to mercaptobenzothiazole [9];
– a German study in 2006 emphasizing the return of allergies to formaldehyde releasers (hexatriazines) [10];
– a French study in 2008 of 88 cases of contact dermatitis to cutting fluids, showing the important role of isothiazolinones and of Bioban [11];
– a French study in 2009 showing the importance of irritation and often mixed and plurifactorial factors of contact dermatitis, with allergies to Kathon and benzoisothiazolinones clearly returning in the market of cutting oils [12].

Different operations of metal machining

– Drilling: operation whereby a part is drilled or a hole is made.
– Drawing: action of stretching metal by passing in calibrated holes or “chain”. The drawing is done with soft metals.
– Threading: making a net, a protruding Helix on one cylinder or a cone (the net of a screw, a bolt).
– Taping: inner threading of a cylindrical hole (taping a nut).
– Turning: action of round shaping (turn a pinion). The finished piece is round, circular.
– Milling: working the metal with a cutting tool driven by a rotating machine.
– Stamping: working a straight metal to round it.
– Correction: grinding a piece of metal to bring it to its final rating. This requires mechanical precision.
Role of cutting fluids: to cool with water lubrication or with fatty products to prevent corrosion

The studies of Taylor in 1883, on the organization of work in cutting metals are the first ones relating the use of soap for water cooling during metal machining. Cutting speeds increased, therefore, 30 to 40%, so as to space sharpening tools. Soap water filled well two essential functions still required by cutting fluids today:

– Cooling tools and metal pieces through the high thermal capacity of water.
– Lubricating the cut, thanks to the fatty soap content.

In addition, soap water was more “wetting” than pure water, but did not prevent corrosion. Soap water was replaced by vegetable or animal oils, then by mineral oil emulsions and, finally, by mixtures of mineral oils and fats to which additives were added to give them additional qualities. A new step was taken when, on the market, cutting fluids that contain no oil were found. This is why we currently more often use the term “cutting fluid”, which is broader than the term “cutting oils”.

Different types of cutting fluids

Used oil will be specific to the expected use, according to the type of machining metal and the machining tool. Vocabulary used for the classification of cooling fluids is complicated. There are two main types of cutting fluids:

– mineral oils or neat oils insoluble in water;
– water-based cutting fluids.

Water-insoluble mineral oils or neat oils

These contain few additives or polycyclic aromatic hydrocarbons (PAH). These neat oils contain various additives to improve lubrication, protection against corrosion, or to confer specific properties so as to increase anti-attrition or extreme pressure performances. They are currently highly refined to restrict the content of PAHs. These oils are less used than water-based fluids nowadays.

According to the ISO 6743-7 classification [13], these neat cutting oils mainly consist of mineral oils and additives to help cutting. These mineral oils have varying viscosities; they can be very fluid oils, deodorized oils right up to viscous oils. The refining of these oils is such that they do not contain polycyclic aromatic derivatives (at least in new conditions); they contain heavy alkylbenzenes and other aromatic compounds. Additives are mainly from phosphorus, sulphur, animal body fat or vegetable origin; they may also contain zinc dithiophosphates. The content of these additives rarely exceeds 10% by weight of the finished product. These additives have CAS numbers.

Water-based fluids

These contain many anti-corrosion, antifoaming additives and biocides to limit bacterial growth, which is made easier by the presence of water. Cooling is the principal object. Water-based fluids contain mineral oils (paraffinic or naphthenic) and a base oil with a high density (vegetable or animal). They are either emulsions (oil in water emulsion, milky appearance), micro-emulsions (thin oil in water emulsion, having an opalescent appearance and becoming opaque in service), or really transparent solutions (synthetic fluids). Destined for lubricating and cooling, these highly sophisticated and expensive products are fragile because they work in a closed circuit, absorb dirt (solvents, dust, metallic particles, etc.), are changed by heat (concentration variation), are denatured by microorganisms, and are contaminated by hydraulic fluids, chut oils and lubricating oils.

Emulsifying fluids are composed of fatty acids, heavy oil and esters. Emulsifying oils are used diluted in water; this dilution is performed by the user. Water is approximately 95% of the mixture. According to the ISO 6743-7 classification, water-based oils can be classified into three groups, according to the appearance of the product after mixing with water [13]:

– milky emulsion: with anionic and non-ionic emulsifying agents;
– semi-synthetic translucent emulsion: with a high pH, containing ethanalamines;
– and biocides and transparent synthetic fluids, with polyglycols.

“Milky” emulsions are used diluted in water (4 to 10% volume). They contain emulsifiers: mainly non-ionic and anionic emulsifiers. The most commonly encountered anionic emulsifiers are sodium or potassium alkylbenzene sulfonates, organic acids salts and mono- or triethanolamine. These emulsions or milky-appearance micro-emulsions contain other additives.

“Semi-synthetic” oils are those that give, after mixing with water, translucent emulsions, which can, by coalescence, become opaque in the long run. These products are used in concentrations of 2-5% by volume in water. Concentrated oils contain 10-30% oil, 30% water and a surfactant-active system. This biostatic property is obtained by using the effect caused by an excess of monoethanolamine salted by various combinations of boric acids, low molecular weight fatty acids, citric or tartaric acid. The biostatic effect is achieved by maintaining a pH of more than 9.2 (between 9.2 and 9.5) through this buffer effect. The biostatic effect is very often supplemented by the addition of fungicides or algaeicides. These products are widely used in centralized facilities machining in automobile plants.

Synthetic products are chemical solutions mainly used for grinding operations with anti-corrosion agents. A synthetic oil is an oil that contains no mineral oil. It contains no oil and leaves, after dissolution in water, perfectly transparent...
Irritation and allergy are located on the same parts of the body, obviously in hands ans forearms

Figure 1. Location of dermatitis in machine-tool workers.

products. For example, synthetic fluids are also called true solutions, containing polyglycols without oil. These fluids are transparent or coloured.

The proportions of synthetic oil and mineral oil are variable and a function of the objective of the manufacturing perspective. Additives, either in neat mineral oils or water-based fluids, are the same. The list of additives is not exhaustive. Additives are used to make it more efficient, more durable, more specific; they are numerous. High pressure fluids contain sulphur, chlorine or phenolic compounds. The main additives include antifoaming agents, corrosion inhibitors, lubricants, emulsifiers and biocides (antifungal and antibacterial) and extreme pressure additives.

**Occupational diseases**

Mechanical injuries or caustic lesions from simple irritation cause non-specific inflammatory lesions. These lesions can then be accompanied by specific, inflammatory lesions of an allergic type. Between irritation and allergy, diagnosis is not easy clinically.

The average age of patients with allergic dermatitis and with positive tests is higher, on average, by over 10 years. In our study, proven allergy patients had an average age of 39 years and irritation dermatitis patients an average age of 27. Similar facts have already been described [2, 14].

**Irritation contact dermatitis**

**Clinical aspects**

The observed lesions are located on the back of the hands, the dorsal side of finger joints, back faces of the fingers, spaces between fingers, wrists, external faces of forearms and sometimes palms. Thighs and legs are sometimes involved, in relation with dirty work clothing [15-17] (figure 1).

**Responsible factors**

Microtrauma caused by metal fragments, alkalinity, ethanolamine soaps and aggressive solvents, heat and humidity. Machining fluids are rich in potentially irritating components and some irritating factors cause damage to the protective film of the skin, especially among the additives. These include:

- cumulative and repeated contact with ethanolaminated products: boric esters today remain the most popular additives; however, their alkalinity certainly contributes to the appearance of irritation dermatitis [16];
- one observes that, above pH 9, irritation lesions appear in certain fragile subjects [1-3, 17];
- the addition of additives, e.g. biocides, when recommended dilutions of the manufacturers are not observed [18, 19];
- cleaning of hands with aggressive soaps [1-3, 15, 16];
- mechanical irritation caused by metal fragments included in waste oils, thereby facilitating percutaneous penetration of any allergenic components;
- handling of solvents;
- heat;
- wet work.

Mechanisms for infringement of the skin are thus complex and multi-factorial [12].

**Allergic contact dermatitis**

Allergic contact dermatitis is a skin inflammation caused by repeated skin exposure to contact allergens, mediated by CD8+ cells. CD4+ cells are responsible for the down regulation of eczema [18, 19].

**Clinical aspects**

Observed lesions are often very similar to those of irritation, in the same way being on the back of the hands, the dorsal side of finger joints, back faces of the fingers, spaces between fingers, wrists, external faces of forearms and sometimes palms. The face is rarely affected. Sometimes the thighs and legs are concerned, in relation to dirty work clothing [1-3, 15, 16, 20-22]. Erythema multiforme-like eruptions may be associated with contact dermatitis to cutting oil [20].

**Responsible factors**

These can be determined through patch-test positivity and through confrontation of the relevance of the results of these tests with the composition of oils, often given approximately by safety data sheets, at least as regards allergens which are not mentioned. Careful patch testing (standard battery, specific cutting oil battery, patch tests with the manipulated product) is necessary. Response and interpretation are not always easy. Other factors potentiate these toxic effects. They are linked either to environmental machining, or to changes in the machine fluid itself. Thus, the allergenic effect of metals, detergents, perfumes, metal cuts, and projected metal fragments cause micro-lesions or frank lesions. A vesicular reaction evokes an allergic reaction, a bubble reaction or a simply erythematous lesion directs to a caustic fluid action. The diagnostic approach must be early and rigorous, so as, by the establishment of
appropiate prevention measures, to maintain the worker in the work place. Vocational orientation and training information should result in more effective prevention.

Practice of patch-tests with the standard battery, specific battery, products handled

European standard battery
This is not very efficient; according to Bruze, it detected allergens in 2/11 cases (18%) [5]. It is useful because it contains metals (chromium, nickel, cobalt) [23]. Metal fragments which fall into the tray of fluid recovery may dilute in this fluid and will then be recycled. Metallic salts will be in contact with the skin during projection onto the work piece being machined. Using filters against metal fragments reduces this risk [15, 20-22]. Among the products tested by patch tests, results returned positive for 9 out of 40 (22.5%) for metals (nickel 6/40 (15%), cobalt 3/40 (7.5%), chromium 5/40 (12.5%) in our study [12]. For Venjean, in 88 cases of allergies: 32% were positive to metals; 8 positive for chromium (9%); 9 for cobalt (10%); 11 for nickel (12.5%) [11]. According to Bruze, nickel allergies observed among women are not relevant [5] (figure 2).

- Mercaptobenzothiazole (MBT) is widely used in various categories of oil corrosion inhibitors. In our study, we found 5/40 cases (12.5%), including 3 for “addition” having a formula near to that of MBT [12].
- Emulsifiers; cutting oil may contain up to 25% of colophony, allergenic for the skin and respiratory system. Geier found up to 8% positive tests [8].
- Fragrances are tested through the standard battery:
  - Balsam of Peru; in our study, we found 5 cases/40 (12.5%) [12].
  - Patch testing with fragrance mix, fragrance II mixture and lyral can detect an allergy due to the technical fragrance of pine essence or terpineol used in order to hide the smell of additives. In our study, we found 5 cases/40 (12.5%) [12]. Positive tests with metals or with substances like balsam of Peru or fragrance mix are somewhat specific but sometimes really relevant.
- Rubber components: the tests for rubber components are not without interest because of the wearing of latex or synthetic rubber gloves which is sometimes badly supported (thiuram mix, N-isopropyl-N-phenyl-4-Phenylendiamine, mercaptomix) [3, 15, 16, 21].
- In this standard battery there are substances used as a biocides, such as formaldehyde, Quaternium 15 (Dowicil 200), chloro- and methylisothiazolinones and methyldibromoglutaronitrile. We will indicate their impact below.

Specialized cutting fluid battery
This battery is two times more powerful than the standard battery according to Bruze: 4/11 were positive (36%) [5]. Its composition can be variable from one Center to another, but a number of substances are really on the list of cutting fluid allergens. The most important are biocides, of which there are multiple categories [24, 25].

- Biocides containing isothiazolinones: 1,2-Benzisothiazoline-3-one: is back in force on the market of cooling fluids. For Venjean, of 88 cases there were 6 positive tests (6.8%) [11]. In our study, there were 4/40 (10%) [12]. Geier mentions 4/160, (2.5%) [8].
- Allergies to Chloro+méthyl-isothiazolinone (Kathon CG) are observed in 2.3% to 15.6% of cases. Currently, this is responsible for many allergies, after a period where it had been partially excluded. For Venjean, of 88 cases, there were 2 Kathon allergies (2.3%) [11]. In our study, there were in 3/40 (7.5%) [12]. For Frimat, there were 5/32 (15.6%) [6].
- 2-n-Octyl-4-isothiazoline-3-one arrived recently on the market. For Venjean, of 88 cases, 6 were positive to 2-n-Octyl-4-isothiazoline-3-one (6.8%) [11]. Frimat mentions 1/32 (3.1%) [6], and in our study, 1/40 (2.5%) [12].
- Biocides containing methyldibromoglutaronitrile (dibromocyanobutane or Tektamer): 5.6% to 21.9% of cases. Euxyl K400 is a mixture of methyldibromoglutaronitrile and phenoxyethanol.

For Venjean, in 88 cases, there were 7 positive patch tests to methyldibromoglutaronitrile and to Euxyl K400 (8%) [11]. In our study, we found 3/40 (7.5%) [12]. Geier found 9 cases out of 160 (5.6%) [8]; for Frimat, there were 7/32 (21.9%) [6].

- Biocides containing oxazolidines. Bioban CS 1246 or ethylcycloooxazolidine is a mixture of bactericidal morpholines. For Venjean, of 88 cases, there were 3 positive patch tests to Bioban CS 1246 (3.4%) [11]; in our study 1/40 (2.5%) [12]; Geier mentions 1/60 (0.6%) (8), Frimat, 1/32 (3.1%) [6].
- Bioban 1135 or dimethyloxazolidine, is a bactericidal biocide. For Venjean, of 88 cases, there were 8 positives patch tests to Bioban CS 1135 (9%) [11]. In our study, we found 3/40 (7.5%) [12], for Geier, 5/160 (4%) [8]; and for Frimat, 1/32 (3.1%) [6].
- Biocides based on triazines. Hexahydro 1,3,5-tris(hydroxyethyltriazine) or Grotan BK. In our study we observed 2/40 (5%) [12]. Geier found 3/144 (2.1%) [8]; Venjean, no case [11] and Frimat 1/32 (3.1%) [6].
- Biocides releasing formaldehyde. Fuchs found on average 4% of allergy to these types of biocides [26]. Formaldehyde: in our study, there were 4/40 (10%) [12]. Geier located 2/160 (1.3%) [8], 2-bromo-2-nitropropane-1, 3 - diol or Bronopol, is a formaldehyde releaser and nitrite releaser which can produce nitrosamines in the presence...
of alkanolamines. Frimat observed 1/32 (3.1%) [6]. Nitrotris or trishydroxyxymethyltriaminomethane, is a deodorant, and formaldehyde releaser [26].

– Phenol-based biocides [15]. 4-chloro-3, 5 xylene or chlorodimethylphenol, is an antibacterial product giving cross reactions to 4 -chloro – 3 cresol allergies. 4-chloro-3 cresol or chloromethylphenol is a biocide and conservative giving cross reactions with 4-chloro-3, 5 xylene. Frimat found 2/32 (6.3%) [6]. 2-Phénylphénol or Dowicil, is a biocide, disinfectant and preservative.

– Biocides near to mercaptobenzothiazol (MBT). 4-Tert-butylbenzoïc acid, an irritant and sensitizing agent with a formula similar to MBT.

– Mercury based biocides. Thimerosal (Merthiolate) is a disinfectant and preservative: Frimat observed 2/32 (6.3%).

– Biocides based on iodine. Iodopropynyl butylcarbamate: a preservative, bactericide and fungicide, freeing iodine and causing cross reactions with rubber and pesticides containing carbamates (Zineb, Maneb). Seems to be frequently found in Finland [24].

– Biocides having also a fungicide action. Sodium-2-pyridinethiol-1-oxide, an antifungal and bacteriocidal agent. Zinc ethylenedis-thiocarbamate or Zineb, a biocidal, fungicide, insecticide. Biopan P 1487, or 4-nitrobutylmorpholine, an antibacterial and antifungal agent.

In our study 1/40 positive patch tests (2.5%) [12]. Frimat observed 1/32 (3.1%) [6].

– Biocides, pesticides and herbicides [7, 15, 16]. Dichlorophène, belonging to the chemical family of phenol. In our study, 1/40 positive patch tests (2.5%) [12]. Chloroacetamidé), or Parrmetol K 50, a preservative and pesticide. Frimat found 1/32 positive patch tests (3.1%) [6].

– Other preservatives. Quaternary ammonium salts are from time to time under investigation, but are hardly highlighted. In the standard battery, quaternium and benzalkonium chloride; 2/40 cases were observed in our study. N-méthylol chloracétamidé: a preservative and disinfectant.

Dihydrochloride, an ethylenediamine-based biocide. Mentioned by Geier [8]. Trichlosan, (igasan DP 300), a bactericide often found in toothpaste. Trichlorocarbanilide is present in the composition of soaps but less used in recent years [2]. Hydrazine sulfate is a carcinogenic and mutagenic agent. Sometimes discrepancies exist: the patch test with the biocide or other additive is negative while it is present in the formulation and vice versa: these findings emphasize the importance of knowledge of the exhaustive qualitative composition of the fluid. We should notice the importance of polysensitilizations: metal + biocides + ethanolamines+ MBT + perfumes + coconut derivatives (apart from only 3 associations balm of Peru + fragrances), 4/8 cases of allergies in our study.

– Anti-corrosion products. 1 H – benzotriazol, a lubricant and corrosion-resistant additive, irritating and sensitizing, rarely highlighted as an allergen. Triethanolamine, tertiary amine and triacohol, a pH compensator, an emulsifier and corrosion inhibitor, irritating and skin- and respiratory-sensitizing. Geier observed 1/160 (0.6%) [8]; in our study, 3/40 (7.5%) [12]; Frimat found 2/32 (6.3%) [6].

Triethanolamine appears not to have an important allergenizing power although widely used. Diethanolamine was found in our study in 1/40 cases (2.5%) [12]; Geier observed 6/160 (3.8%) [8]. One can test with monoethanolamine; Geier observed 13/160 (8.1%) [8]. Mercaptothiazole: a corrosion inhibitor found in the standard battery. In our study, we found 5/40 positive patch tests (12.5%) [12]. Amerchol L 101, an emulsifier corrosion inhibitor, responsible for cross-allergy to lanolin. In our study, we found 1/40 positive patch tests (2.5%) [12].

– Emulsifiers. Coconut diethanolamine, a lubricating agent and non-ionic surfactant and anti-foaming agent. Venjean found 3/88 allergies with diethanolamine coconut [11]. Geier observed 1/160 positive patch tests (0.6%) [8]; 3/40 cases (7.5%) in our study [12] and Frimat found 2/32 (6.3%) [6]. Dipentane (limonene) is an irritant and sensitizing dispersant wetting agent. Propylene glycol is an emulsifier and a corrosion inhibitor, an antifungal and antifreeze agent. Geier observed 3/160 cases (1.9%) [8].

– Fragrances. (Apart from fragrances included in the standard battery). Abietic acid; Venjean found 2/88 positive patch tests (2%) [11]. Geier observed 14/160 cases (10%) [8] and the same author in 2006, 8% [10]; Frimat mentioned 1/32 (3.1%) [6]. It is an allergen very often associated with colophony, since it is a major constituent thereof; in 11 allergies to colophony, 9 also had an allergy to abietic acid [24].

– Is it interesting to make other specific patch tests outside this cutting fluid battery? With methylenebis morpholine, Geier found 11/144 positive patch tests (7.6%). With benzylhemiformal, Jolanski observed 3/160 positive patch tests (1.9%). With extreme pressure additives, ethylhexylzinc dithiophosphate (Jolanski). With oak moss resin, (Geier). With myristyl alcohol, (Jolanski).

Patch tests with the fluids are frequently positive, but the specific battery, too, often has only a mediocre performance. Sometimes discrepancies exist: the patch test with the biocide or other additive is negative while it is present in the formulation and vice versa: these findings emphasize the importance of knowledge of the exhaustive qualitative composition of the fluid. We should notice the importance of polysensitilizations: metal + biocides + ethanolamines+ MBT + perfumes + coconut derivatives (apart from only 3 associations balm of Peru + fragrances), 4/8 cases of allergies in our study.

Patch Testing with work materials [27]

The formulation of fluids, even if followed (at constant quality), varies qualitatively from one batch to another because they are manufactured from raw materials containing variable unknown impurities. These products are never the same from one day to another, hence for exposed staff, the potential, variable, constant, transitional, multiple risks and assessment often remain most complex. Patch tests are very frequently positive, but it is necessary to test not only unused fluids respecting the dilution usage (1.5-12% usually), but also re-circulated fluids, so as to eliminate false negatives; indeed patch tests effected with diluted unused fluids are not representative of the reality of the exposure. It is also necessary to test the re-circulated fluids in order to eliminate the responsibility of other substances - metals included-, or rather to establish that of an additive maintenance; this is true for the bactericides, isothiazolines, which are commonly used. In the case of a positive reaction with cutting oil, patch-testing with the various components is often negative, probably because each factor may have a role in increasing the total effect [8].

In our study, among the products patch tested, results were positive in 10 cases out of 40 for products used by the patients. There was a degree of consistency between the various test results and knowledge of the composition oils obtained from safety data sheets (SDS). However, the FDS
do not mention most allergenic products that are contained in small quantities. In our study, we observed positive patch tests to oil called “WR 15N”, “Ecocool CAT”, “AS 118”, “MG5”, “Ecocut 204”, “5718”, “1605” (Fuchs manufacturer), Maxicool 125 GM and 145 (Fuchs manufacturer), to “Additin” added as additive of oils [12].

Also, conducting such allergologic checks is a fairly difficult task. Having a battery of substances to be tested is not sufficient, it must be exhaustive. But even if substances are dispersed at good concentrations in a suitable vehicle, the possibility of synergy is not taken into account. The effect of synergy between several additives may be desired, and even sought by the formulator; however this synergy can be the source of a skin lesion. Irritation or allergic skin lesions caused by oils are mostly due to multi-factor synergy, which may only be transient [21]. The components of oils evolve constantly. The systematic quest for a single responsible factor, which will very often remain hidden, is illusionary. Similarly, it is also often difficult to determine the respective liability of irritation factors.

Other dermatitis

Oil folliculitis. This has become rare since the improvement of hygiene conditions and the addition of antiseptics. It is caused by direct or indirect contact with neat oils (oil-soaked clothing). Comedones are present. Most cases of folliculitis or “oil acne” can be rapidly cleared. The comedones will be strengthened by the presence of chlorinated and sulphur extreme pressure additives. This could be due to fluid contamination by multiple germs of faecal origin from the hands of operators [1, 2, 15, 16, 20, 22].

Skin granulomas are observed, rarely, after accidental inoculation of oil under the skin [1, 2, 15-17, 21].

Pigment changes are rare. Depigmentation of the hands of workers was due to 4-tert-butylocatechol used as an antioxidant in the oil [1, 2, 15, 16, 21].

Squamous cell carcinomas have become exceptional in developed countries [28]. The main locations are the scrotum, the back of the hands, forearms, face and neck. They are linked to old (before 1975) exposure to polycyclic aromatic hydrocarbons (PAHs) in neat oils [29]. It should no longer be seen because of improved refining techniques [29]; these disorders are recognized as occupational diseases in France [1, 2, 14, 15, 21, 28, 29]. Measures taken to reduce this maximum risk have been effective. In 1973, the studies of Thony et al. in Cluses, Limasset and Lafontaine (in the French National Institute of Research and Security) clearly highlighted the risk of cancer among workers using neat oils [30]. Animal testing confirms the potency of little-refined mineral oils, aromatic extracts and waste oils; studies conducted by the international agency for research on cancer (IARC) registered mineral oils of petroleum origin on the list of carcinogens in humans.

Respiratory diseases

These can be of different kinds and concern the respiratory tree at different levels. They are linked to the presence of atmospheric aerosols emitted by the fluids used. The first signs warning of these disorders are coughing and spitting, along with syndrome of bronchial hyperreactivity [30]. These diseases have become less frequent with the development of the oil mist collection.

Throat and nasal irritation is frequent, with cough and a possible expectoration. It is more common with synthetic fluids because of flora changes during the storage and use of bacterial endotoxins [30].

Very few cases of asthma are reported in France. In the literature cases are reported related to exposure to synthetic fluids, despite low concentrations under the legal limits, but these are disappearing [31]. The most important factor is bacterial contamination of fluid machining, with aerosols. Environmental conditions such as alkaline pH, high temperature and the presence of metals promotes the development of a microbial population. This population produces antigens (protein or polysaccharides) [32].

Kennedy [33] showed, after exposure to machining fluid aerosols, a reversible decrease of FEV1, comparable to the one observed with smoking. Eisen [34] has shown, in employees exposed to water-based oils, a 3% decrease of FEV1 compared to the theoretical values and a discreet reduction of FVC in cases of long exposure.

The first case of hypersensitivity pneumonia was reported in 1977. Then, 98 cases in the car industry in the 1990s were reported with cough, dyspnea, and weight loss. Atmospheric measurements found a synthetic fluid concentration less than 0.5 mg/m3. Precipitating agents against mycobacteria, bacteria (pseudomonas), gram-negative and their endotoxin antibodies were found. These hypersensitivity pneumonias are probably often missed.

The first cases of lipid pneumonia were described as iatrogenic. Other cases are due to hot paraffins [34] or when using sprays containing mineral oils. The clinical picture is non-specific, combining dyspnea, cough and expectoration. Bronchiol-alveolar washing found macrophages with fat inclusions.

There are arguments in favour of a relationship between the use of machining fluids and different cancers: larynx, pancreas, rectum and bladder, and from exposure to neat oils. Concerning the esophagus and stomach, arguments are limited. In these cases water-based fluids would be under investigation without incriminating a specific substance. In the respiratory tract, there is no relationship between machining fluids and lung cancers [30].

N-nitrosodiethanolamine (NDELA) classified IARC 2B, is a well known carcinogen compound [30]. NDELA is formed by the reaction of amines with nitrates and sodium nitrite. Amines are used as biocides, but also coupling agents, emulsifiers and corrosion inhibitors. They are especially present in simple or sophisticated synthetic fluids. If experimental results leave no doubt as to the dangers of these products, there is no decisive evidence to establish the carcinogenic nature of these substances. Fluid formulated with nitrates must not be used, adding sodium nitrite should be discouraged and the nitrite content of fluids must be regularly checked. It should not exceed approximately 20 mg/L.

Collective prevention

Automation of tasks, isolated work

For maintenance operations, individual protection is indispensable. Frequent changes of oil circuits should be
performed. Filtering of metallic chips is essential and should be done regularly. Everything must contribute to limiting the dissemination of the molecules: aspiration at the source, prohibition of the use of blowing machines to get rid residual fluid parts; maintaining clean workplaces and machines.

Hygiene in the workplace

Similarly, hygiene at the workplace is important with accessible sanitary facilities, with clean, hot water.

Worker information and training

It is important that regular worker information and training is conducted on entry into the company, learning about the working of risky operations, the cleaning of workplaces and machines, as well as about good and bad actions. Learning about individual and collective preventive measures is essential.

The choice of cutting oils

The choice of good cutting oils is essential. Whenever possible, choose or prefer: specific and appropriately adapted metals oils (limit dissolved metals, very important for cobalt), highly refined mineral oils, cutting oils without biocides and prefer the least allergenic, least irritating and those with the fewest allergenic components (pH moderated from 9 to 9.2), and a limited number of different fluids, to reduce the risk of multiple and cross-sensitization and to facilitate avoidance of a product when it is necessary.

Avoid extreme usage conditions

Avoid extreme usage conditions: heat, pressure and time (formation of polycyclic aromatic hydrocarbons, nitrites, dissolved metals, variations in concentrations of liquids, etc.).

The manufacturers’ recommendations

The manufacturers’ recommendations must also be complied with for the quantity of additives used, proper maintenance and regular verification of pH. The concentration of fluids must be ensured and the presence of microorganisms must be checked. Greater attention should be paid to the maintenance of aqueous fluids. In coming years, the number of micro lubrication machining processes will tend to increase [35].

Individual prevention

General hygiene measures

Individual prevention begins with the application of general hygiene measures. Thus, it focuses on: wearing work clothes, regularly changing and washing these clothes, not keeping clothes soiled by chemicals, not keeping rags in pockets, changing out of work clothes and taking a shower if necessary before leaving work. Next, it concerns cleaning hands with clean, hot water, and moreover, in addition to the hands, the wrists and forearms. The detergent used must be chosen carefully. It should be used at a good concentration, should not be too abrasive, nor too acidic or too alkaline, adapted to the type of dirt (standards Afnor NF-T 73101 and 73 102 for detergent workshops). It must be rinsed off and followed by careful drying. Any organic solvent is proscribed for this use.

Personal protective equipment

The general principles of personal protective equipment (PPE) and skin protection measures must be remembered. Protective measures should be applied correctly on healthy skin. Gloves should be adapted to the worker’s professional hand gestures and the particular risk position, in particular when using nitrile gloves. The employee must accept the following usage rules: do not wear the gloves for too long; avoid sweating and maceration (if necessary, wear special cotton gloves or use a special cream underneath them); let the inside dry out before re-using them, regularly change dirty or worn out gloves; wear a cuff if the glove is too short to protect the exposed forearm, do not wipe using a rag soaked with solvent; if possible, wash hands after removing gloves. Avoid the wearing of gloves with a non-washable lining, a real trap of chemical contaminants [35]. The role of protective creams is to strengthen the protective power of the skin surface and to avoid the penetration and accumulation of substances deep in the skin and around the nails; they facilitate the cleaning of hands. Their adaptation is essential to the gestures used and to the professional risk. There is no universal cream providing effective protection for multiple products and their use is limited in time. It is necessary to renew the application according to the recommendations of the manufacturer, usually every 2 or 3 hours. The application must be explainedTheir effectiveness is known to be weak against allergens. In addition to barrier creams, there are moisturizing creams. They are applied after work, their role is to soften and moisturize the skin to restore natural protection [35].

Medico-social aspects

The occupational physician must inform and train the patient during his aptitude visit. He looks for skin diseases, both during hiring visits as well as during routine visits. He participates in prevention programs in the factory. Finding positive patch tests to oils must be treated with caution and not lead to hasty and premature conclusions about ability. Instead, it must be the start of multidisciplinary teamwork (employee, occupational physician, dermatologist, employer, suppliers of lubricants and oils). The social impact of the presence of occupational dermatitis with cutting fluids is often disastrous with, at best, a reclassification to a less exposed position, or even, when this is impossible, a reason for dismissal [6, 35].

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