Chemicals and the skin – what might we be missing and the consequences

Notes to accompany talk by Chris Packham of EnviroDerm Services on 4th December 2017

On the interaction between the skin and the (working) environment

The interaction between the skin and the working environment is far more complex than many realise. It is also an aspect of occupational safety and health where there are many myths and much misinformation. What may appear logical may, in reality, be counterproductive.

We know a great deal already about the interaction between the skin and the immediate environment. However, there is still an enormous amount that we do not yet know.

The talk, and these notes, aim to provide an overview of some of the facts that experience indicates many are not aware of. Note that it is only an overview and highly selective. There are many other facts that were not covered in the presentation due to lack of time.. More information is available from EnviroDerm Services.

It is really that much of a problem

The simple answer is 'yes'. Statistics show that the incidence of occupational skin problems exceeds that of occupational respiratory problems. The very comprehensive German statistics reveal that in excess of 30% of all recognised cases of occupationally caused ill health are skin diseases.

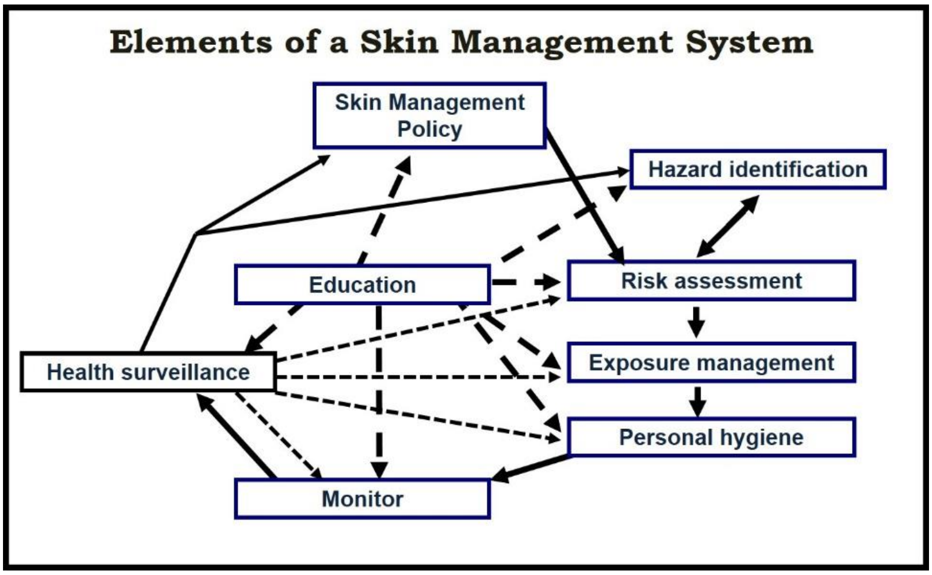
Skin diseases can result in permanent life-changing conditions and, in some cases be fatal.

Elements of a skin management system

In our work we differentiate between skin care and skin management.

Skin care:- The provision and use of products to be applied to the skin for the purposes of cleaning and conditioning the skin.

Skin management:- The process of structuring the workplace, equipment used and the work done so as to minimise any risk of skin exposure causing damage to health.



Skin care (part of 'Personal hygiene) is just one element in a skin management system, but only one of several, as illustrated in the diagram.

A full examination of all these elements would require a very substantial document indeed. As an example of the complexity already mentioned, probably the definitive work on the subject is Kanerva's Occupational Dermatology. The second edition of this work runs to in excess of 2,000 pages in three volumes! This document, therefore, will be selective, dealing with those elements that were discussed during the presentation at the IOSH meeting on 4th December, 2017.

A structured approach to risk assessment for skin exposure

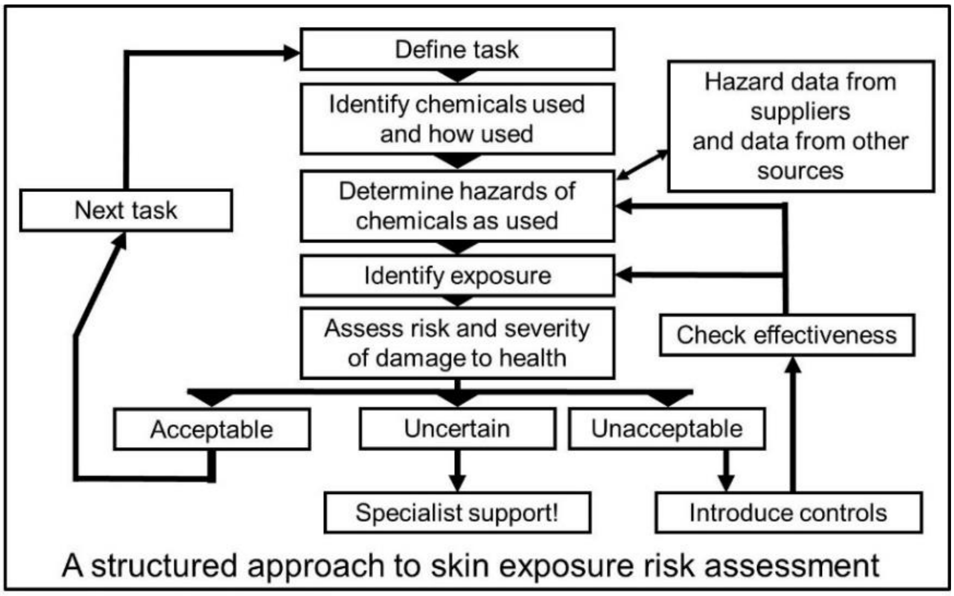
If we are to prevent skin exposure in the workplace from causing damage to health it is clear that we need first to identify those situations where such damage might occur. When considering chemical exposure, the 'traditional' approach has been to collect information all chemicals present in that workplace that have been classified by a national (or international) standard as hazardous to the skin. Following this the assessor determines where exposure to these chemicals occurs and compares the data on the hazard, usually as presented in the safety data sheet, with the exposure that occurs to assess the potential for this to result in occupational skin disease.

The author disagrees with this approach on several grounds. We usually purchase chemicals for one or more particular purposes. In using them it is not uncommon that we change their properties. As a result we may change the hazard. How the changes occur and the effect on the hazard will depend to a large extent on the nature of the task. Different tasks may result in different changes in the same chemical and thus also the hazard.

It is only when exposure of the user, or others, occurs that the damage to health can result. This will usually only occur when the task is being carried out. Thus risk assessment for skin exposure should start with the task

Risk assessment starts with the task

The diagram shows a structured system for assessing the risk due to workplace skin exposure and how this can be managed.



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Defining the task

The assessment starts by identifying and defining the task, i.e. what exactly is done during the task. It also identifies the chemicals used during the task <u>and how they are used</u>.

Determining the real hazard

Once we have the information on the chemicals used during the task and how they are used we need to identify the hazard that they represent <u>as used</u>. This can be very different from the hazard that is shown on the safety data sheet. Indeed, many chemicals may not appear on any safety data sheet but still represent a hazard to health if skin contact occurs. The safety data sheet is not a reliable guide to establishing the real hazard that a chemical represents when used. Indeed, the same chemical can represent different hazards when used for different tasks.

This is recognised in COSHH. Paragraph 10 of the current Approved Code of Practice (ACoP) for COSHH states:

> "Employers should regard a substance as hazardous to health if it is hazardous <u>in the form in which it may occur in the work activity</u>. A substance hazardous to health need not be just a chemical compound, it can also include mixtures of compounds, micro-organisms or natural materials, such as flour, stone or wood dust."

The table shows some of the changes that can occur.

Contamination	e.g. cleaning chemicals becoming contaminated with the soiling removed, solvents used for degreasing items or cleaning paint brushes/spray guns
Reaction	when two or more chemicals are mixed together resulting in the appearance of new chemicals with different hazards compared with those of the individual constituents. Examples would be two pack paints and adhesives, mixing acid based toilet cleaner with bleach (which can result in release of chlorine).
Processes	that change the properties of the material. For example, vulcanising rubber causes some constituents to disappear and new, often unknown, chemicals to appear.
Dilution	could reduce the potential for exposure to cause damage to health. However, it could increase the potential for the diluted chemical to cause damage. An example is the rate by which 2-butoxyethanol penetrates the skin. Dilution with water actually increases this rate. A toxic chemical unable to penetrate the skin might, if diluted, be able to do this, thus increasing the risk of systemic toxic damage.
Heating	can cause changes and release of chemicals. For example, solder flux can release airborne sensitizers.
Metabolisation	within the skin. For example, methanol can metabolise releasing formaldehyde.
Oxidisation	e.g. d-limonene can oxidise resulting in the creation of sensitizers.
Changes over time	e.g. biocides that are formaldehyde releasers.
Physical changes	such as leaching of metals into metalworking fluid, grinding dust, etc.

Possible changes when chemicals are used

Note that a chemical may undergo more than one of these changes during a single task. Identifying the real hazard is often the most difficult aspects of a risk assessment for skin exposure.

What might the effects be for the person exposed?

The following is a brief overview of the effects that can result from skin exposure. Here we encounter another problem, namely attempting to establish exactly what the skin exposure is. The measurement of skin exposure is extremely complex. Indeed, there are no methods for direct workplace skin exposure that are practicable for most workplace environments. In the first place we need to decide what we are measuring. The table illustrates this.

What lands on the skin?	Arguably the actual exposure, but how relevant is it to the risk of damage to health?
What remains on the skin?	May cause direct damage to the skin tissue, i.e. corrosion or irritant damage
What is absorbed into the skin?	May activate the immune system and elicit allergic contact dermatitis
What penetrates through the skin?	May damage internal organs or systems
A combination of these?	Many chemicals can do this!

We will also have to decide where we will measure as the skin on different parts of the body will react differently. Furthermore, other factors such as seasonal variations in skin properties and ambient conditions will need to be included in any data.

Is it just skin exposure?

Another complication is that we may not be dealing with just skin exposure. There is now abundant evidence that considering the three main routes of exposure, namely inhalation, ingestion and skin, in isolation will, in many situations, exclude some of the potential hazards and their adverse health effects. This is particularly important if we consider the potential for chemicals to cause damage to internal organs and systems.

The table shows some of the potential cross-overs between the three routes and the potential effect.

Exposure route	Inhalation	Ingestion	Dermal
Chronic Obstructive Pulmonary Disease	■		
Workplace Aggravated Asthma	■		■
Occupational Asthma	■		■
Systemic Toxic Effect	■	■	■
Chemical Skin Burn			■
Systemic Contact Dermatitis	■	■	■
Irritant Contact Dermatitis			■
Allergic Contact Dermatitis	■	■	■
Allergic Contact Urticaria	■	■	■
Non-allergic Contact Urticaria			■
Effects on health arising from single or multiple routes of exposure			

The shaded boxes indicate where the route can cause the particular health effect. Keep in mind that in some situations where there is more than one route of exposure this can result in a cumulative effect.

Systemic toxic effects

There are many chemicals that may penetrate the skin and cause damage to internal organs or systems. Penetration may be on its own or when the chemical, that perhaps would not penetrate the skin on its own, is mixed with another that can act as a vehicle and thus enable the toxic chemical to enter the body. It is also important to remember that it is the total dose reaching the target organ or system that is the critical factor.

Allergic skin reactions

There are two types of allergic skin reaction. An allergic skin reaction is where cells that for part of our immune system (there to protect us from infection) overreacts to a particular chemical and releases excessive amounts of chemicals that cause the rash, irritation, etc. There are two main types of allergic skin reaction. The less common one is allergic contact urticaria, commonly due to proteins entering into the skin. This usually occurs within a short time from contact with the causative substance. Far more common is allergic contact dermatitis. This is a delayed reaction. The skin rash, irritation, etc. does not appear for some time, usually at least 24 hours, but sometimes days later. There are over 4,000 chemicals known to dermatologists as being able to cause allergic contact dermatitis. The majority of these will not have been classified under the CLP regulations as '*H317 - may cause an allergic skin reaction*'.

Once allergic to a chemical this is usually a life-long condition and can have a serious effect on that person's quality of life, ability to work, etc.

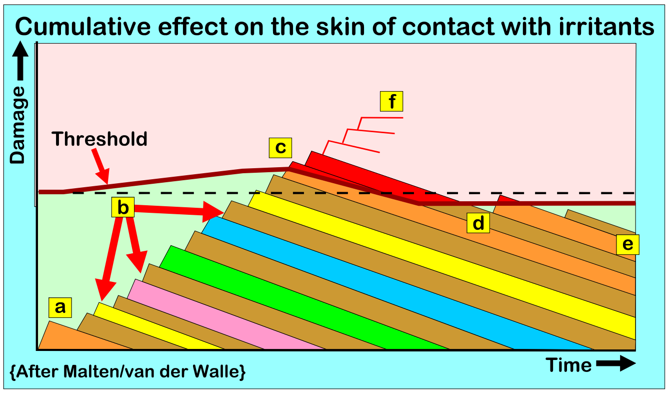
Systemic contact dermatitis

Dermatologists differentiate between allergic and systemic contact dermatoses. The former is due to skin contact with the causative chemical; systemic contact dermatitis is an allergic skin reaction due to contact by routes of uptake other than skin, i.e. through inhalation or ingestion. There are many case studies showing how systemic contact dermatitis can be induced by exposure to chemicals via these routes. Particularly when there is potential airborne exposure to skin sensitizers consideration should be given to this both in the risk assessment and when investigating a case of occupational skin disease suspected to have occupational causation.

Irritant contact dermatitis

Irritant contact dermatitis is the most common form of occupational skin disease. In contrast with allergic skin reactions, which will only occur where a person's immune system is sensitised to a particular chemical, skin exposure to any irritant will cause damage to the skin of the exposed person, even though this may not be apparent.

The diagram illustrates how repeated exposure to many different irritants can accumulate without there being any visible or sensory indication that this is happening. Eventually a situation may be reached where the skin can no longer resist and the visible- and clinically relevant – dermatitis appears. It is important to recognise that the irritant damage will occur due to both occupational and non-occupational exposures and it is difficult to quantify the role that each may play in the development of the irritant contact dermatitis. One way of monitoring and preventing this is by an effective pro-active skin health surveillance system, as described later in this document.



Furthermore, sub-clinical irritant damage can predispose to sensitisation and the resultant allergic contact dermatitis.

Assessing the risk and severity of damage to health

Again, this is often not as easy as many assume.

> "However, there is no scientific method of measuring the results of the body's exposure to risk through dermal contact. Consequently no dermal exposure standards have been set." *- from "Occupational skin diseases and dermal exposure in the European Union (EU-25):policy and practice overview - European Agency for Safety and Health at Work*

One problem is the fact that each person may respond differently to contact between the skin and the chemical. There is a large group of people whose genetic make-up means that they tend to have a more vulnerable skin than others. The condition is known as atopy. These people may react at levels of exposure that will not affect others. This is another reason why there are no exposure limits for skin. There are other factors that can affect the possibility of skin exposure resulting in occupational contact dermatitis or urticaria.

What we should aim at in our assessment is a level of consistency, i.e. that we apply the same criteria to our assessment of each task so that we can ensure that we can rank the risk for each task appropriately and implement the required exposure management measures.

Managing skin exposure

Assuming we have identified that for the particular task the way in which chemicals are present and used constitutes a risk of damage to health such that we need to eliminate or reduce contact to an acceptable level, we now have to consider how we can manage the exposure. There is a generally accepted hierarchy of control measures, as shown in the table.

1.	Design workplace and equipment to eliminate exposure
2.	Select chemical(s) for minimum hazard
3.	Install engineering/process controls
4.	Provide handling equipment
5.	Establish safe working procedures
6.	Minimise effect by job rotation, skin care, etc.
7.	Monitor effects on workers
8.	Control exposure with personal protective equipment

As far as possible control of exposure should be by means that make the workplace intrinsically safe, such that there is no possibility of incautious or careless acts on the part of individuals resulting in exposure to hazardous chemicals. This means that emphasis should be on methods 1 to 3 in the table. Of course, all methods are valid in our effort to control exposure, but methods 4 to 8 will depend upon the behaviour of individual workers and here compliance becomes an issue.

It is beyond the scope of this document to review all eight methods in any depth. However, method 8 - the provision and use of personal protective equipment - is one where the complexities often result in failure, with workers being exposed, albeit neither employer nor employee being aware of this. Gloves are almost certainly the most commonly used form of personal protective equipment, so this document looks briefly at the selection and use of gloves as protection against chemical hazards.

Selection and use of gloves as protection against chemicals

There are four main ways in which gloves can fail to protect. These are:

Misuse:- For example, using the wrong gloves, using them for longer than they can protect for, not donning or removing them correctly.

Physical damage:- Holes, cuts, tears, possibly so small that they are not easily detected.

Degradation:- This is where the chemical attacks and destroys the glove material. There is no glove material proof against all chemicals. However, degradation is almost always detectable due to the visible or sensory change in the properties of the gloves.

Permeation:- This is where the chemical passes through the glove at a molecular level and emerges on the inside of the glove as a vapour. There is no change in the properties of the glove and the presence of the chemical inside the glove will only become apparent to the wearer when the damage to health becomes evident.

There are EN standards for gloves sold for protection against chemical hazards and manufacturers are required to provide information on permeation breakthrough times measured according to an EN standard test procedure.

However, (and the standard recognises this) the data provided is not a reliable indicator of the real performance that will be achieved when gloves are worn for a particular task. The table shows some of the factors that will affect the SMUT (Safe Maximum Use Time) for the particular glove, chemical and task.

Shorten time that glove will protect		May increase time that glove will protect
Degradation	Manufacturer's published performance data	Voltatility
Physical damage		Intermittent contact
High temperature		Incomplete contact, e.g. splashing
Flexing		Low temperature
Stretching		Dilution
Mixtures of chemicals		Frequent glove washing
Poor maintenance		
Ageing		

Factors affecting glove performance

There is no simple method of combining this information to obtain a performance level that will be achieved in practice for the task for which the gloves are to be worn. Note that the performance of the glove will be specific to that task rather than generic for the particular chemical hazard. Gloves may perform differently for different tasks, even though the chemicals involved may be the same. The only way to be certain is to test the gloves under actual conditions of use and a method exists whereby this can be done.

Gloves as a hazard to the skin

Gloves worn as protection against chemical hazards will be 'occlusive', that is they will not allow water to pass through. The consequence of this is that the water being emitted by the skin, both as trans-epidermal water loss and sweat will not be able to evaporate and will be reabsorbed into the skin. This leads to hyperhydration which can have adverse health effects. The Personal Protective Equipment recognises this and requires that precautions are taken to prevent this. The only practicable method to achieve this is by wearing separate cotton gloves underneath the protective glove so that water passing out from the skin can be held and not allowed to pass back into the outer layers of the skin.

Protective creams – magic answer or myth?

Claims are still made for the protection afforded by the so-called protective, pre-work or 'barrier' creams. This despite the view of the Health and Safety Executive:

> **Do not** use prework creams, sometimes sold as barrier creams, as a replacement for carefully selected gloves. They are not PPE because:
> (i) they do not provide protection against hazards;
> (ii) workers may not apply them properly, leaving part of their skin uncovered;

(iii) there is no information available on the rate of penetration of substances through prework creams; and

(iv) protection may be removed while working without workers noticing.

From 'Personal protective equipment (PPE) at work, INDG174 REV 2'

Skin health surveillance

The latest ACoP for COSHH stipulates where health surveillance, which will include skin health surveillance, is required. This includes the following situations:-

- where there have been previous cases of work-related ill health in the workforce/place;
- where there is reliance on PPE, eg gloves or respirators, as an exposure control measure; eg printers wearing gloves to protect against solvents used during press cleaning, or paint sprayers using two-pack paints wearing respirators to prevent asthma. Even with the closest supervision there is no guarantee that PPE will be effective at all times;
- where there is evidence of ill health in jobs within the industry; eg frequent or prolonged contact with water (termed 'wet working') causing dermatitis in hairdressers and health care workers, or breathing in mists from chrome plating baths causing chrome ulcers in platers;

The requirement is to detect any adverse effects as early as possible. Where skin is being exposed to irritant chemicals this can be achieved by measuring skin hydration and a simple instrument to measure skin hydration is now available. This can assist in creating a pro-active skin health surveillance system. More information is available on skin health surveillance from EnviroDerm Services who hold regular courses on this invaluable element in any skin management system.

Measuring skin condition can be invaluable in indicating where damage is occurring at a still asymptomatic stage, thus identifying exposure to irritant chemicals at a level that is not being adequately controlled.

Finally – a word of caution

The time allowed for the presentation meant that many aspects of occupational skin management could not be included. Therefore this document it is not a comprehensive explanation of the many factors affecting the interaction between the skin and the (working) environment, <u>nor is it a comprehensive guide to the development and operation of an effective occupational skin management system</u>.

The aim is to raise awareness of the complexities associated with skin in the working environment and its management such that those responsible for the prevention of damage to health due to workplace skin awareness are aware of the complexities and the myths and misinformation that they may encounter and can recognise where external assistance may be advisable.

Due to the limitations of both the presentation and this document neither the author, nor EnviroDerm Services can accept any liability arising out of the use of the information contained herein. Should the reader feel that they need additional information, support or training then we will be happy to discuss how this can be provided.

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