Dermatological Engineering

A new approach to the prevention of damage to health from dermal workplace exposure

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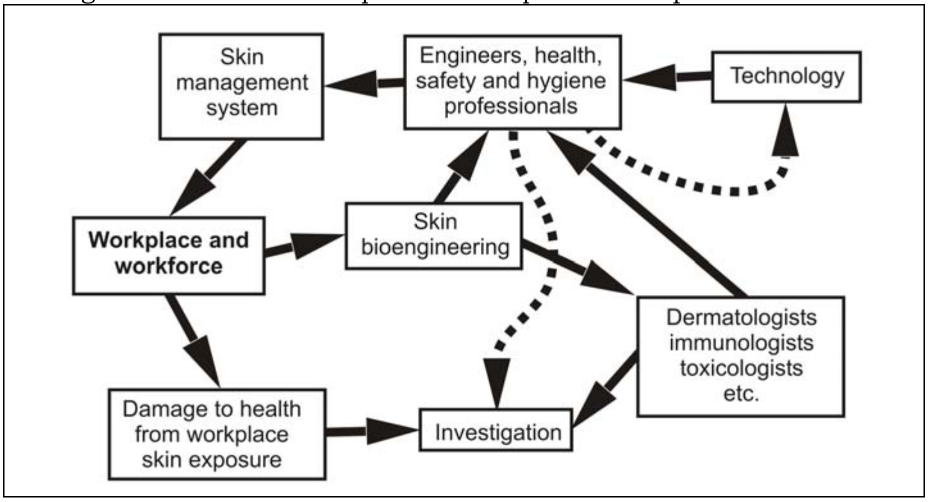
The term "dermatological engineering" was first coined by my wife, Hilary, when she was attempting to find a term that expressed what we, as EnviroDerm Services, actually did. We define dermatological engineering as:

> **Dermatological engineering:-** The process of matching dermatological knowledge to the engineering, technical or operating procedure so as to ensure that any risk of damage to health from skin exposure is minimised.

In other words, dermatological engineering can be described as an attempt to link the knowledge of the dermatologist, immunologist, toxicologist, biologist, chemist, and other scientific and medical disciplines, to the knowledge and expertise of the engineer or technician responsible for the operation such that the system can be designed, constructed and operated in a way that the probability of damage to health from workplace skin exposure is kept to a minimum.



Unfortunately, we tend to compartmentalise our different scientific and technological and medical disciplines. Whilst this may be necessary because of the sheer complexity and volume of scientific knowledge, it sometimes means that we are not as efficient in the transfer of the relevant knowledge across boundaries as would be desirable in order to achieve the aims of dermatological engineering.

Dermatologists and medical biophysicists are continuously extending our knowledge of the skin, its functions and reactions. Immunologists develop new insights into that incredibly complex world of our immune system. Toxicologists keep updating our knowledge of the effect that substances have on cells and organs within our body. Other disciplines, such as genetics, continue to add to our knowledge of the body and how it interacts with its surroundings.

Other scientists create new materials and technologies for use in our day-to-day world. New materials will have implications for the dermatologist; new dermatological knowledge may have implications on the way in which we handle these materials in the workplace. New technologies may serve to change the way in which we work and our ability to eliminate or at least reduce our exposure to harmful chemicals.

Those responsible for the health and safety of the workforce must understand the way in which the skin reacts with the working environment and how to structure the work so that any adverse effects are avoided or kept to an acceptable minimum.

Dermatologists, and others concerned with skin disease, need a better understanding of what happens in the workplace, so that diagnosis and treatment can be effective and so that they can better identify what information and guidance the health and safety professional requires.

Toxicologists and immunologists can target research at those areas, which present special problems so as to develop the knowledge and techniques, which enable us to create safer working conditions.

Management has the ultimate responsibility for workplace health and safety, but in most cases will rely upon the advice and support of design and production engineers. For health and safety issues management will also look for advice from health and safety professionals.

Design and production engineers are largely responsible for the form of the workplace, the equipment and the way in which this is used and work is carried out. Thus they are the people who can have the most influence on its safety. They have the technical expertise to design and maintain a workplace, which is intrinsically safe. However, they cannot do this unless they have an adequate knowledge of what is required, or the right advice. Dermatological engineering aims to provide them with the appropriate information, data and technical support to enable them to achieve high standards of skin management.

Thus, if we are to be successful in preventing occupational skin disease there will be input from many different people, each with their own area of special expertise. Some system will be required which ensures that all this input is co-ordinated to achieve the optimum in workplace safety. This is the aim of dermatological engineering.

Skin management versus skin care

Traditionally the emphasis has tended to be on the use of skin cleansers, protective and conditioning creams to prevent damage to the skin from workplace skin exposure. That this has not been adequate is illustrated by the continuing high incidence and prevalence of occupational skin disease. This suggests that we need to adopt a more comprehensive approach to the whole subject of the interaction between the skin and the working environment. Put simply:

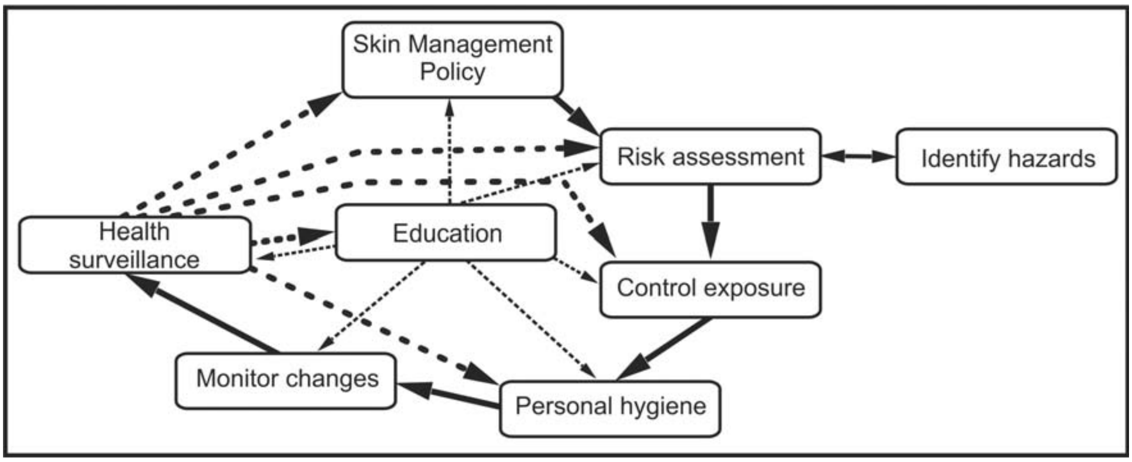
> "There is little purpose served in putting better products in the washroom if conditions in the workplace are putting health and risk due to skin exposure,"

Some years ago we coined the term "occupational skin management". Our current definitions for these two phrases as:

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

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

As the chart shows, skin management encompasses skin care (shown in the chart as personal hygiene). In the rest of this document we will be concerned to a large extent with the individual elements of a skin management system, how they can be developed and maintained and how they can be amalgamated to create an effective skin management system.



The following table takes each of the elements of a skin management system, describes briefly its purpose and who might be expected to contribute.

Skin Management Policy	
Purpose:- Create a framework within which an effective skin management system can be developed and maintained.	Main contributor:- Occupational health team/HR: Write policy and obtain management acceptance. Distribute. Other possible contributors:- Production/technical team, occupational hygienist, external advisers, e.g. dermatologist (Advise on content. Assist with management acceptance)
Identify hazards	
Purpose:- Provide the data on substances in the workplace so that risk assessment can be carried out	Main contributors:- Occupational hygienist/production team Identify skin hazards from substances as used in the workplace. Other possible contributors:- Chemist, toxicologist, dermatologist (Advise on properties of chemicals present)
Risk assessment	
Purpose:- Identify tasks where exposure of the skin to substances could cause damage to health and to assess the significance of the risk both of such damage occurring and its severity.	Main contributors:- Occupational health team, occupational hygienist, production/technical personnel Identify the various tasks and the exposure that is occurring. Assess the significance of the risk of damage to health. Other possible contributors:- Toxicologist, chemist, dermatologist (Advise on consequences of exposure so that risk can be assessed)

Risk management	
Purpose:- Introduce control methods which will eliminate the risks or at least control them to an extent which is acceptable.	Contributors:- Production/technical personnel/occupational hygienist Identify possible control methods and select most appropriate. Install control methods and test for performance. Where PPE is required identify most appropriate and create use system. Other possible contributors:- Occupational health team (Guidance on effects of actual/residual exposure), Procurement (selection and provision of personal protective equipment)
Personal hygiene	
Purpose:- Remove soiling from the skin and restore skin to an acceptable condition. In certain circumstances prevent cross-infection.	Contributors:- Occupational health team: Create and introduce an effective skin care system Other possible contributors:- Facilities management (Design, equipment and layout of hygiene facilities), Procurement (Selection and provision of skin care products)
Monitor changes	
Purpose:- Check that skin management system is performing to specification. Identify where changes have occurred so that appropriate action can be taken.	Contributors:- Production/technical team, occupational hygienist Identify changes in production methods and substances used. Check continued effectiveness of control measures. Other possible contributors:- Toxicologist re properties of new chemicals, occupational health team on potential changes in risk assessment
Health surveillance	
Purpose:- Identify where skin is being damaged by workplace conditions so that preventative action can be taken.	Contributors:- Occupational health team: Create skin health surveillance system if appropriate.
Education	
Purpose:- Ensure that both management and workforce understand the need for good skin management and what their role should be.	Contributors:- Occupational health team: Develop an effective education and training package and provide appropriate training.

Occupational Skin Management

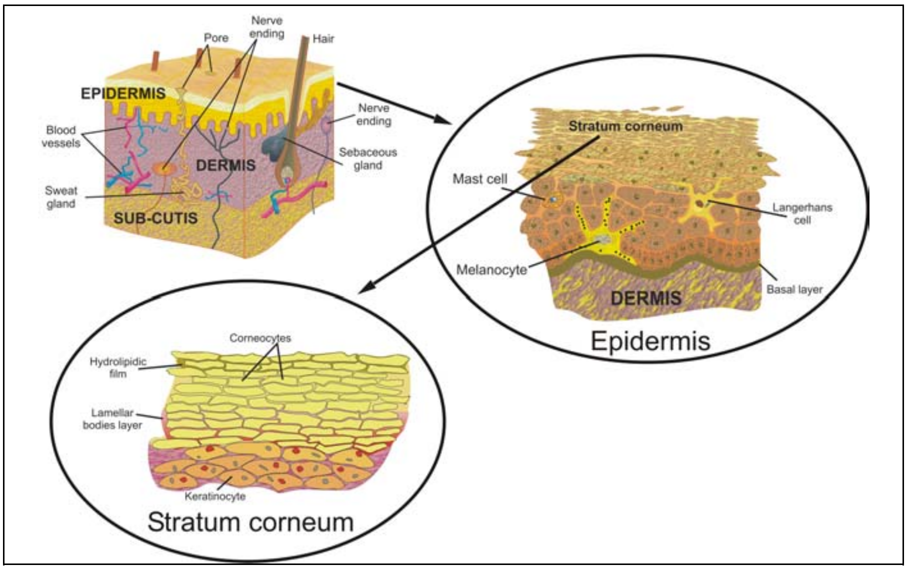
The aim of an occupational skin management system is, so far as possible, to reduce the potential for the interaction between the skin and the working environment to cause damage to the health of those within that environment. Unfortunately, this is far more complex than many realise. It is certainly beyond the scope of this document to describe each element of the skin management system in sufficient detail for this to represent a comprehensive guide.

However, as a basic principle, what we will need are:

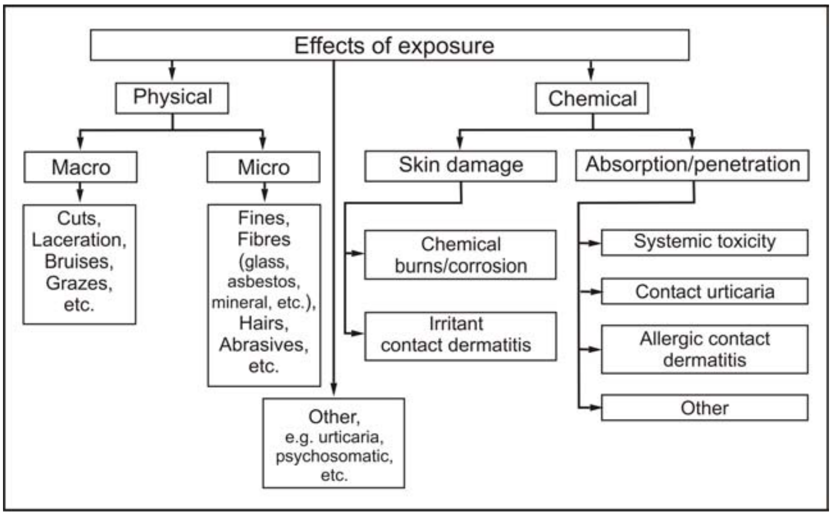
1. An understanding of the interaction between the skin and the working environment
2. The ability to recognise the real chemical hazards that exist when a task is being carried out
3. Techniques for assessing the risk of damage to health that might arise due to exposure to the working environment
4. A strategy for managing such exposure in order to achieve adequate control
5. A system for monitoring skin condition so that we can identify, hopefully at a sub-clinical stage, where skin is being damaged such that pre-emptive action can be taken

1. An understanding of the interaction between the skin and the working environment

This is far more complex than most people realise. Due to the complexity it is also an aspect of biology where our knowledge is far from complete. In fact, the actual barrier in our skin that both helps maintain the body in a healthy condition and protects the body from external hazards is extremely thin. The outer layer of the skin, the stratum corneum, that fulfils this function is, over most of our body, only 0.1mm thick. Within the stratum corneum is a layer of complex fats, known as lamellar bodies, that prevents excessive moisture loss. This layer is only around 0.002mm thick. If we lose a sufficient area of this layer, then we can die from dehydration. In the words of one of the pioneers in learning how this layer works, Prof. Bo Forslind: "**We are all only two microns from death!**"



So what are the possible effects that might arise due to this interaction between skin and working environment? The diagramme shows how hazards can be divided into two main types, physical and chemical. Of course, in reality there is no such simple division. Skin will be subjected to both physical and chemical exposures, and these may well be synergistic.



Again it is beyond the scope of this document to review these in detail. However, we will attempt to look briefly at two particular factors.

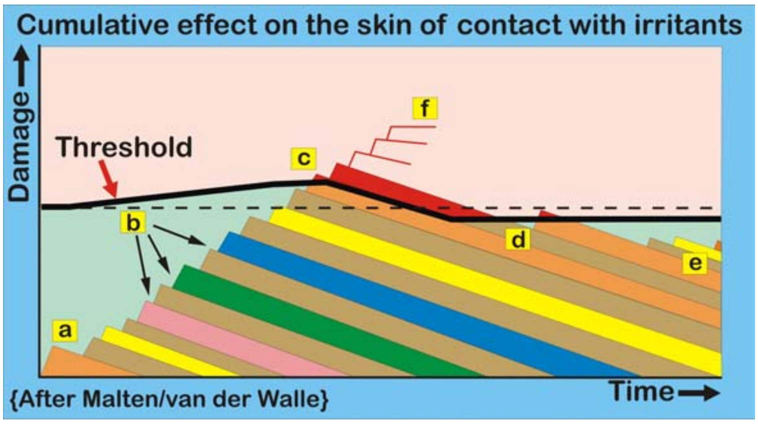
Systemic toxicity is damage to internal organs due to the body's uptake of toxic chemicals. Whilst traditionally inhalation was considered to be the major route of uptake, this is almost certainly no longer the case. Emphasis in occupational hygiene on controlling inhalation has resulted in skin absorption and penetration becoming more significant. Unfortunately we have no real data on the significance that skin uptake makes to systemic effects, although those studies that have been done suggest that it must be considered significant.

Keep in mind that for the internal organ or system the critical factor is the dose, irrespective of the route of uptake. Thus when considering the potential effect of exposure to a toxic substance what we need to assess is the total dose as a result of all three routes of uptake (inhalation, ingestion and dermal).

Irritant contact dermatitis is the most common form of occupational skin disease. However, irritant damage to the skin can render the skin barrier less effective, thus aiding the penetration of sensitisers. Irritant damage also leads to the increase of cytokines in the skin. Both of these factors can increase the potential for an allergic reaction.

It is important to recognise that irritant contact dermatitis is almost never the result of a single exposure or exposure to a single chemical. Rather, it results from repeated exposures to different irritant chemicals usually over an extended period. Many chemicals that can have an irritant effect on the skin will not be listed as "irritant", i.e. will not have had a risk phrase assigned to them.

The diagramme illustrates how exposure to an irritant causes damage to the skin. Given time the skin can recover. However, repeated exposures can result in an accumulation of damage. This remains unseen until a “threshold” is reached where the skin starts to break down and, very shortly, the contact dermatitis appears. (A more detailed explanation of this is contained in our Technical Bulletin on irritant contact dermatitis, details of which will be found on our website.)



2. The ability to recognise the real chemical hazards that exist when a task is being carried out

It is common to find that risk assessments for chemical exposure have been based on the data contained in the supplier’s safety data sheet. This can lead to a risk assessment that does not reflect the real chemical hazards that will be present as a task is complete.

In the first place several studies have shown that many safety data sheets contain errors, some of which can be significant. Secondly safety data sheets only provide information about the constituents that are present in the chemical as supplied. In general only those constituents that have been assigned a risk phrase will be shown. There are many chemicals that can cause damage to the skin but have no risk phrase. Furthermore, the safety data sheet provides no indication of factors such as bioavailability that can have a significant influence on the real hazard from skin exposure.

We need also to recognise that when many chemicals are absorbed into the skin changes due to the effect of substances such as enzymes in the skin can cause changes. This can result in changes in the hazards that the chemical represents. For example, methanol is not normally considered a sensitiser. However, with many people when absorbed into the skin metabolisation can taken place. One of the resultant metabolites is formaldehyde, a potent sensitiser.

When we purchase chemicals it is usually to use them for a specific purpose. In the process the chemical will frequently change. For example, we may react two chemicals together, resulting in the appearance of a new substance with different properties to the original ones. A chemical may oxidise, changing the hazard. The nature of the chemical may change as the task progresses or over time. Take a degreasing tank using toluene. This is only toluene until the first item is degreased. It is now a mixture of toluene and the chemicals removed from the item. As further items are degreased the constituents in the tank will change, both in concentration and possibly due to the introduction of new substances.

Thus a risk assessment for skin exposure, which is usually to mixtures rather than a single substance, requires us to identify the real chemical hazards present.

3. Techniques for assessing the risk of damage to health that might arise due to exposure to the working environment

Risk assessment for skin exposure is not always simple. Routes of exposure can be obscure and difficult to identify. We have no real way of measuring the effect of skin exposure to a chemical and no exposure limits for skin. Thus a risk assessment for skin exposure will depend upon the investigative and observational skills of the assessor. This requires a structured approach so that a consistent method of assessing each task and resulting hazard can be ensured.

When assessing the risk of damage to health arising from skin exposure keep the following in mind:

When conducting a risk assessment for skin exposure, only rarely can one consider a single chemical in isolation. It is the cumulative effect of repeated exposures to many different chemicals (not necessarily for the task under assessment) that is often the most significant factor in any such risk assessment.

Particularly with irritant chemicals we need to recognise that the average worker will only be at work for 8 out of the 24 hours of each day (ignoring weekends) and that his skin may well be exposed to quite potent irritants away from the workplace that may contribute significantly to the accumulation of sub-clinical damage.

4. A strategy for managing such exposure in order to achieve adequate control

Once we have established that there is a significant risk of damage to health from skin exposure, then we need to eliminate or reduce the exposure such that this damage is unlikely to occur. The basic principle of dermatological engineering is that this is done by controlling the process and not the person. In other words we need to try to make the process as intrinsically safe as possible rather than rely upon the worker to act in a certain manner, wear the appropriate personal protective equipment, etc. One way of considering the hierarchy of controls is shown in the table.

Controlling the process	Design workplace, process and equipment to eliminate or minimise exposure Select chemicals for minimum hazard Install engineering/process controls
Controlling the person	Provide handling equipment Establish safe working procedures Control exposure with personal protective equipment Minimise effect by rotating tasks, skin care, etc. Monitor skin condition

It is beyond the scope of this document to provide a detailed explanation of each of these elements, except to say that all are valid methods and that in many cases what will be needed is a combination.

However, I would like to draw attention to the position of personal protective equipment, for example gloves. All too often this is seen as an easy answer to an exposure problem whereas in reality, selection and use of personal protective equipment so that it provides genuine protection can be surprisingly complex. Remember also that personal protective equipment always fails to danger. So where the consequences of failure could be acute, severe and possibly irreversible, it is questionable whether personal protective equipment should be considered as primary protection.

A Technical Bulletin on the selection and use of gloves for protection against chemical hazards is available. Details will be found on the EnviroDerm Services website.

5. A system for monitoring skin condition so that we can identify where skin is being damaged such that pre-emptive action can be taken

Where there is potential for exposure that might result in damage to health, then a health surveillance system that includes skin condition should be considered essential. Ideally the skin health surveillance system should include techniques that can identify sub-clinical damage due to contact with irritants. This will allow us to investigate why and where the damage is occurring and take pre-emptive action before there is any visible sign on the surface of the skin, i.e. the clinically relevant contact dermatitis. Such a system will also allow us to check whether the measures we have taken as part of our action are actually having the required effect.

Simple, safe, non-invasive measurements, e.g. for skin hydration, are now possible and should form an integral part of any skin health surveillance system.

Conclusions

One fact should be obvious. The hygienist cannot be expected to achieve the necessary results on their own. This has to be a team effort, starting with senior management, who set the policy and make the resources available, then involving people at all levels within the organisation. Given the elements for dermatological engineering shown at the start of this document, it is also clear that we will also need to involve others outside the organisation.

EnviroDerm Services is a unique consultancy concerned specifically with the prevention of damage to health due to the interaction between the skin and the (working) environment. Our work involves risk assessment and management for skin exposure, advice on the selection and use of personal protective equipment for skin exposure, e.g. gloves, support on skin health surveillance, including the use of skin bio-engineering techniques, assistance with the investigation and management of existing skin problems and education and training for managers, health and safety professionals, and workers. The team consists of three partners. Chris and Hilary Packham first established the consultancy in 1991, although their concern with skin and the working environment dates form 1979. Dr. Helen Taylor (their daughter) is a biologist and specialist in skin condition measurement and analysis. Both Chris and Helen lecture at UK universities and are well known internationally for their specialist knowledge and expertise.

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