

DERMAL EXPOSURE:

- ASSESSING THE HAZARD

- EMERGING REGULATORY ISSUES

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WHY IS SKIN EXPOSURE IGNORED?

- Problem doesn't exist, or magnitude of problem overestimated
- Lack of tangible evidence of exposure
- Little historical evidence indicative of problem
- No solution

IS SKIN EXPOSURE A PROBLEM?

- Dermatitis
- Skin Absorption Compared to Lung
- Reviews of Literature

DERMATITIS

- Second leading cause of Occupational Illness¹
- 11% of Working Adults, or 13.7 million, experienced dermatitis. 2.8% specifically cited chemicals²
- 25% of all occupational illnesses are skin exposures³

¹ 1989 BLS Statistics

² 1988 Occupational Health Supplement to the National Health Interview Survey

³ "PPE for General Industry; Final Rule", Federal Register, April 6, 1994, pp. 16334-16364.

SKIN VS LUNG ABSORPTION

COMPARE:

AMOUNT ABSORBED VIA SKIN EXPOSURE

- Amount Absorbed = (Surface Exposed in cm^2) x (Absorption rate in $\text{mg}/\text{cm}^2/\text{hr}$) x (Time Exposed in hrs)

TO:

AMOUNT ABSORBED BY THE LUNG

- Amount absorbed = (Concentration in air in mg/m^3) x (Breathing Rate in $\text{m}^3/\text{hr.}$) x (Time Exposed in hrs.)

GLYCOL ETHERS

(2-ethoxyethanol and 2-ethoxyethyl acetate)

Amount absorbed by skin = (900 cm^2)
 $(0.8 \text{ mg/cm}^2/\text{hour}^1)(8 \text{ hours})$

= 5760 mg.

Amount absorbed from Air at TLV = 18
 $\text{mg/m}^3 \times 10 \text{ m}^3$

= 180 mg.

Dose to the skin exceeds the TLV dose by a factor of 32 times!

¹ Recommended BEI, **Appl. Occup. Envir. Hyg.** 8(5), May 1993.

ACRYLAMIDE

Amount absorbed by skin = $(900 \text{ cm}^2) (1 \text{ mg/cm}^2/\text{hour}^1)(8 \text{ hours})$

= 7200 mg.

Amount absorbed from Air at TLV = $0.038 \text{ mg/m}^3 \times 10 \text{ m}^3$

=0.38 mg

Dose to the skin exceeds the PEL dose by a factor of 19,000 times!

- 1 Absorption rate for DMF, Bergerova, **Appl. Occup. Envir. Hyg.** 4(8) 1989.

FACTORS WHICH AFFECT SKIN ABSORPTION

- OCCLUSION
- TEMPERATURE
- PRESSURE
- PRESENCE OF OTHER SOLVENTS
- AMOUNT OF EXPOSED SKIN
- CONDITION OF SKIN

EXAMPLES OF SKIN EXPOSURE

PBC'S in Transformers (Lees, Corn, and Breysse, **AIHA**, 49(3) 257-264 (1987):

"The author's conclude that exposure by the dermal route (i.e. skin absorption) is considerable (especially when compared to respiratory exposures), whatever the job task."

Toluene and Xylene from autobody work (Daniell, Stebbins, Kalman, O'Donnell, and Horstman, **AIHA**, 53, (1992) pp. 124-129.):

"Air sampling will substantially underestimate a worker's total solvent dose in the setting of moderate or high skin exposure. "

EXAMPLES CONTD.

Polynuclear Aromatics (PNA's) among Coke Oven Workers (VanRooij, Bodelier-Bade, and Jongeneelen, **Br. J. Ind. Med.**, 1993, 50, 623-632) :

Pyrene: avg. 75% (range 28%-95%) of total dose via skin

Benzoapyrene: avg. 51% (range 8%-92%) of total dose via skin

"Our results indicate that preventive measures to reduce exposure to PAHs should be focused more on the reduction of dermal contamination with PAHs than on the reduction of the inhaled dose."

EXAMPLES CONTD.

Toluene Diisocyanate (TDI) (Karol, Hauth, Riley, and Magren, **Tox.& Appl. Pharm.**, 58, 221-230, (1981):

"...1 drop (50uL) 100% TDI applied to the skin in the absence of any adjuvant caused antibody production in 100% of animals and pulmonary sensitization in approximately 30-40% of animals".

Occupational Chemical Exposures in an Academic Medical Center (Weaver, McDiarmid, Guidera, Humphrey, and Schaefer, **JOM**, 35, (1993), pp. 701-706.:

"A total of 253 exposures occurred during a 3 years period....Exposure by the dermal route was most common (37.9%)."

GLOVE PERMEATION IN SEMICONDUCTOR INDUSTRY¹

- GLYCOL ETHERS EXPOSURES POSSIBLY LINKED TO EXCESS SPONTANEOUS ABORTIONS
- RE-USE OF GLOVES RESULTED IN RAPID BREAKTHROUGH
- PERMEATION RATES OF GLYCOL MIXTURES GREATER THAN PREDICTED FROM PURE COMPONENTS

1 Zellers, et al, AIHA, 53, (1992), pp. 105-116.

REVISIONS TO THE PPE STANDARD

- **1910.138 HAND PROTECTION**

- (a): (General requirements) Employer shall require use "appropriate hand protection when employees' hands are exposed."
- (b): (Selection) Employers shall base selection on "an evaluation of the performance characteristics of the hand protection relative to the task(s) to be performed, conditions present, duration of use, and the hazards and potential hazards identified."

WHAT MEANS SHOULD BE USED TO ASSESS SKIN EXPOSURE AND THE EFFECTIVENESS OF PPE?

- **MONITOR SURFACE CONTAMINATION**
- **MONITOR SKIN EXPOSURE**
- **BIOLOGICAL MONITORING**

- **SAFETY AND HEALTH PROGRAM
STANDARD**

Emphasis will be shifted to the employer to enforce Safety and Health

- **EXPOSURE ASSESSMENT
STANDARD**

Items being considered as acceptable means of ensuring that exposures are minimized:

Skin exposure Monitoring

Biological Monitoring

**WHAT CAN WE EXPECT? (or at least:)
WHAT CAN WE HOPE FOR?**

A future in which OSHA stops being simply a policeman (albeit one who was rarely present) ...

To a future in which responsibility lies with the employer. OSHA's role may very well be one of an auditor, rather than an enforcer in this new OSHA.

SO WHAT DO WE DO ABOUT IT?

- Provide testimony in support of these changes
- Provide examples of successful programs for controlling skin exposure.

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Slide 1: Title

Slide 2: Why is skin exposure ignored?

Why is skin exposure ignored. Let's first explore some possible answers to this question, before further discussing this issue.

Problem doesn't exist, or magnitude of problem overestimated

Obviously, if this the case then we shouldn't dwell on the issue. Although, I believe that skin exposure is a significant problem, we cannot expect action on this matter until we have convinced ourselves and others of the extent and magnitude of the problem. Later on I'll present some evidence to indicate that it is a problem, but for now let's assume that the problem is real. What other reasons could explain the lack of inaction?

Lack of tangible evidence

We human beings are rather simple creatures. We seem to deal effectively with tangible problems, but are less responsive to problems with which we have not had direct experience. Skin exposure to toxic chemicals which are not strong irritants may be like this. Because we cannot smell, taste, see, or feel them, we do not perceive that there is a problem, despite the fact that absorption of significant levels of chemical through the skin may be occurring.

Little historical evidence indicative of problem

Industrial hygiene has traditionally focused on air exposures. Obviously, this was because many classic forms of occupational illnesses occurred via exposure to the lung. Silicosis and asbestosis are two classic examples which come to mind. However, even a historical review brings to mind the story of Percival Potts who recognized scrotal cancer as an occupational illness of chimney sweeps caused principally, if not entirely, by skin exposure to carcinogenic polynuclear aromatics contained in the chimney soot. Thus even history is not devoid of some evidence that skin exposure is a problem.

No solution

This response is the opposite of the first one. If our perception of the problem is that there are no solutions, then it is understandable that we might choose to ignore the problem. Our fear of the unknown may have caused us not to act on the problem because it appears to be insurmountable. Thus it seems important for us to really answer the question: Is skin exposure a problem?

Slide 3: Is skin exposure a problem?

What evidence is there to support the contention that skin exposure is a significant problem? Let's examine these three potential areas to determine the magnitude of the problem.

Slide 4: Dermatitis

Dermatitis

First of all there is the obvious one, dermatitis. Estimates of the extent of dermatitis in the workforce vary greatly. Prior to the recognition of ergonomic problems, dermatitis was recognized as the leading reported occupational illness. In a 1988 Occupational Health Supplement to the National Health Interview Survey it is reported that of 11% of working adults (3.7 million workers) surveyed experienced dermatitis. 3.1 million cases, or 2.8% attributed their exposures to the workplace. Higher estimates of the magnitude of the problem were reported to OSHA on the hearings regarding revisions of the PPE standard. In this testimony it was reported that occupational skin disease accounted for 25% of all reported cases of occupational illnesses. Additionally, BLS statistics for the construction industry indicate that 37% of all reported occupational illnesses from 1973 -1984 were dermatitis.

Slide 5: Skin Absorption Compared to Lung

Skin Absorption Compared to Lung

For chemicals which may not cause dermatitis but which might be systemic poisons, then comparing the potential amount of chemicals absorbed via skin contact with the amount absorbed through the lung is instructive. For the case of skin exposure we will assume that the hands are exposed to a pure or "neat" solution of the chemical for eight hours. For the lung exposure we will use the allowable air exposure level and assume that the average worker breathes 10 m³ of air in an eight hour shift.

Let's apply these formulas to a chemical which has gotten a lot of attention lately, ethylene glycol:

Slide: Glycol Ethers

Let's consider another example, in this case a chemical which is recognized as a potent skin absorber and a neurotoxin, acrylamide.

Slide : Acrylamide

Obviously, by comparison to the allowable body dose, it seems evident that skin exposure is not to be ignored. But aren't we "stacking the deck" to represent the worst case for skin absorption? After all the absorption rates shown above are for hands immersed in a neat (pure) solution of the substance. In the real world, workers don't submerge hands in chemicals for 8 hours a day, however they certainly do "submerge" their bodies in air which may be over the PEL.

This is true, but I think a couple of things should be pointed out before we assume that the skin values are gross overestimates of the problem.

Slide: Factors which affect skin absorption

Occlusion: Skin protected by a glove becomes hydrated, this process is called occlusion and is known to enhance the absorbitivity by a factor of 10.

Temperature: Increased surface temperature of skin enhances absorption..

Pressure: The pressure exerted while gloved significantly enhances absorption.

Presence of other solvents: Many solvents enhance the rate of absorption. (e.g.s glycol ethers)

Amount of exposed skin: The amount and type of skin exposed will obviously influence the absorption rates. Many areas of the body have a thinner stratum corneum, which increases the absorption rate.

Condition of skin: Damaged skin no longer provides a barrier to the absorption process.

Finally a number of studies have confirmed the importance of skin absorption:

Slide: Examples of Skin Exposure

And there are further examples of potential problems in this area:

Slide: More Evidence

This study demonstrates that diisocyanates upon skin contact can induce hypersensitivity. The last example in a medical setting further indicates the wide-spread nature of the problem.

Thus it seems evident that not only do estimates of the potential for skin exposure support the need for more attention in this matter, studies of exposed workers for PCB's, diisocyanates, PNA's, solvents, in occupations ranging from steel mills to hospitals demonstrate that skin exposure is a problem! SO THE ANSWER OBVIOUSLY IS SIMPLY PPE!

Wrong, O learned one! Permeation rates through gloves and protective clothing can be so rapid, such that with occlusion, absorption can even be enhanced. What is really needed is **assessment of the effectiveness of PPE**. The need for this is very evident in the semiconductor industry.

Slide: Semiconductor industry

Obviously this is not a work environment in which air exposures work routine operations are significant. Yet despite low air exposures, excess spontaneous abortions have been observed. The focus has been on the glycol ethers used in the photoresist process. Re-use of gloves and the effects of other solvents greatly reduced the breakthrough times for most gloves used in this industry.

Thus it seems obvious that it is essential that the effectiveness, (or the applicability) of PPE be verified. In this area, I am proud to say that OSHA has acted:

Slide: Revisions to the PPE Standard

The language of this standard strongly suggests that the employer must make some determinations regarding the potential for skin exposure and also some determinations that the selected PPE is effective.

Slide: What means should be used to assess the effectiveness of PPE?

IS THIS SOME "PIE IN THE SKY" IDEA?

Maybe not. In fact OSHA is drafting several "building block" standards which may have an impact on how skin exposure is assessed in the future:

Slide: Safety and Health and Exposure Assessment Standards

SAFETY AND HEALTH PROGRAM STANDARD

This standard will **require** that employer develop their own safety and health program. The emphasis (or burden depending upon your perspective) will be on the employer to provide a safe and healthful worker. This is a shift away from the current emphasis on complying with OSHA standards.

EXPOSURE ASSESSMENT STANDARD

The intent of this standard is to specify for the employer methods to assess worker exposures. Hopefully, the emphasis will be exposure assessment methods which truly characterize worker exposure, rather than simply focusing on air exposures.

Items being considered in this standard:

Skin exposure

Biological Monitoring

Slide: What can we expect?

WHAT CAN WE EXPECT? or at least: WHAT CAN WE HOPE FOR?

A future in which OSHA shifts being a policeman (albeit one you was rarely present because of the limited numbers of compliance officers) ...

To a future in which responsibility lies with the employer. OSHA's role may very well be one of an auditor, rather than an enforcer in this new OSHA.

SO WHAT DO WE DO ABOUT IT?

The we includes concerned occupational health specialist and industrial hygienist from both the private and the public sector.

Provide testimony/input on several key pieces of proposed OSHA legislation.