Michigan Safety Conference

An Introduction to Dermal Exposure Assessment

April 16, 2025

Mark Betz, CIH, CSP
Global Director
EHS, Sustainability & Security
Kalsec
Kalamazoo, MI

Agenda

- Intro
- Function and Anatomy of the Skin
- Importance as Exposure Route
- Qualitative Assessment
- Quantitative Assessment
- Close

How we got here today

Dermal Exposure Assessment - Round Table

- **A New Qualitative Dermal Exposure Assessment Tool.** S. Paradis, 3M, St. Paul, MN.
- **IH SkinPerm.** R. Tibaldi, ExxonMobil, Annandale, NJ.
- **A Case Study Using the AIHA Decision Logic for Qualitative Dermal Exposure Assessment: Dermal Phenol Exposure Potential in a Phenolic Resin Molding Operation.** J. Sahmel, ChemRisk, Inc., Boulder, CO.
- **Enhanced Qualitative Dermal Exposure Assessment Strategy.** S. Leeson, ExxonMobil, Leatherhead, Surrey, United Kingdom
- **Dermal DNELs.** R. Roy, 3M, St. Paul, MN.
- **REACH Dermal Exposure Assessments.** J. Walton, 3M, St. Paul, MN.
- **ProtecPo: A Software for Predicting the Resistance of Polymeric Materials Used in the Manufacture of Chemical-Resistant Protective Gloves, Clothing, and Boots.** D. Drolet, IRSST, Montréal, QC, Canada.
- **Implementation of a Dermal Exposure Management Program.** K. Hacker, 3M, Knoxville, IA.

Western Michigan Industrial Hygiene Society

AIHA Exposure Assessment Strategies Committee
Dermal Project Team

Recognition, Assessments & Risk Management of Dermal Exposure Hazards

Rosalie Tibaldi CIH, CSP

Scientific Advisor
ExxonMobil Biomedical Sciences
Co-Chair AIHA EASC Dermal Project Team

Aleks Stefaniak, PhD, CIH

Research Industrial Hygienist
National Institute for Occupational Safety and Health
Co-Chair AIHA EASC Dermal Project Team

Background

Skin Function and Anatomy

Skin Function

- Physiological balance
  - Immune defense - Langerhan cells
  - Microflora – bacteria maintain pH
  - Excretion – sweating; metals detox
- Sensory
  - Temperature control - heat loss/gain
  - Taction - roughness, smoothness, etc.
  - Warning - pain, heat, cold
- Barrier to external environment
  - Most important for current discussion

Skin Function

Skin barrier

- Separates internal organs from environment
- Protects against penetration of stressors
  - Chemical
  - Physical
    - Electromagnetic (radiological)
  - Microbiological
- Prevents water loss to external environment
  - Moisture gradient across skin
    - Active water loss - sweating
    - Insensible water loss

Anatomy of the Skin

epidermis

stratum corneum

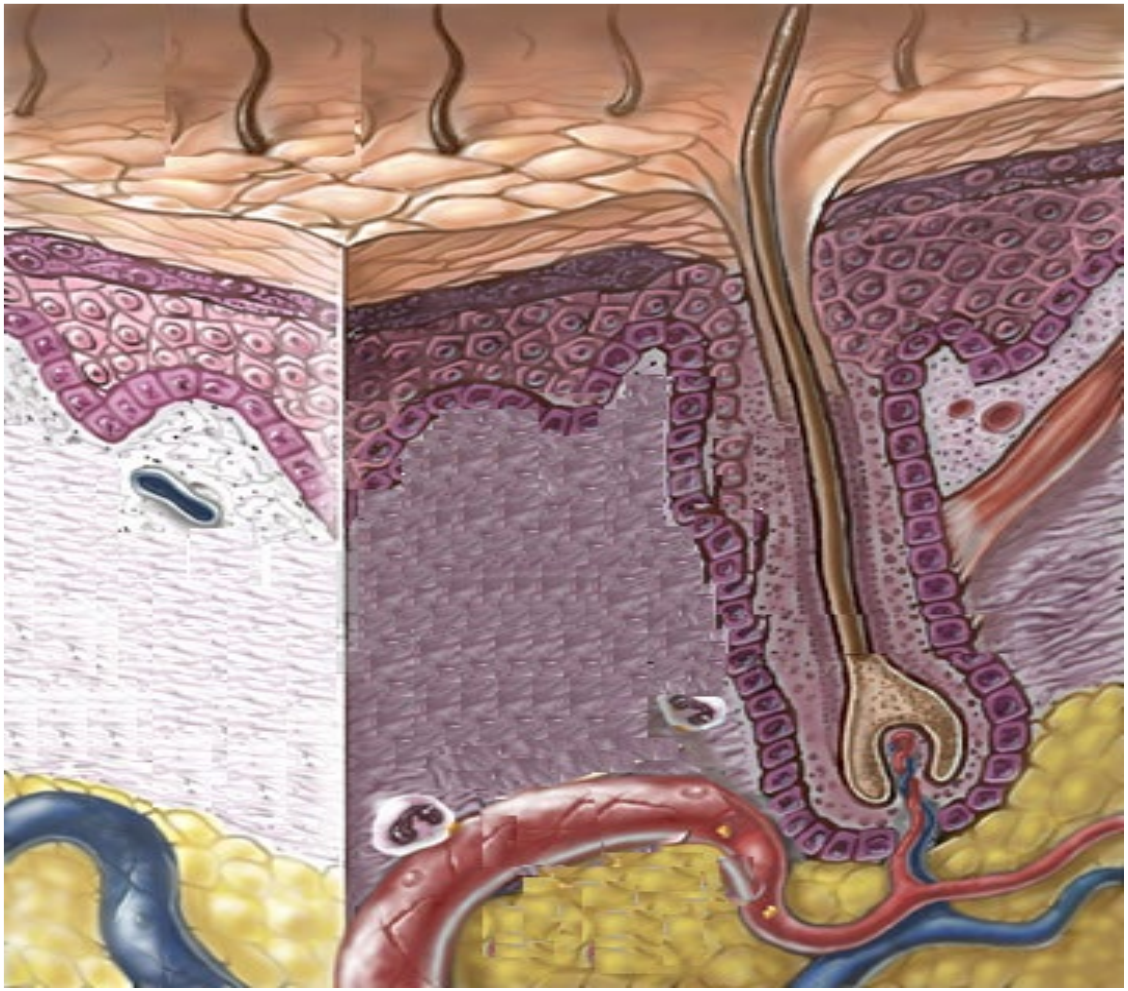
- dead corneocytes and lipid ‘glue’

viable epidermis

- immunologically active

dermis

- connective tissue
- sweat glands
- sebaceous glands



Anatomy of the Skin

Stratum corneum

- ‘Brick and mortar’ model
  - Corneocyte bricks
  - Lipid intercellular glue
- Permeable 2-way membrane
- Route of exposure
  - Permeation
    - Dissolution (inorganics)
    - Partitioning (organics)
  - Penetration

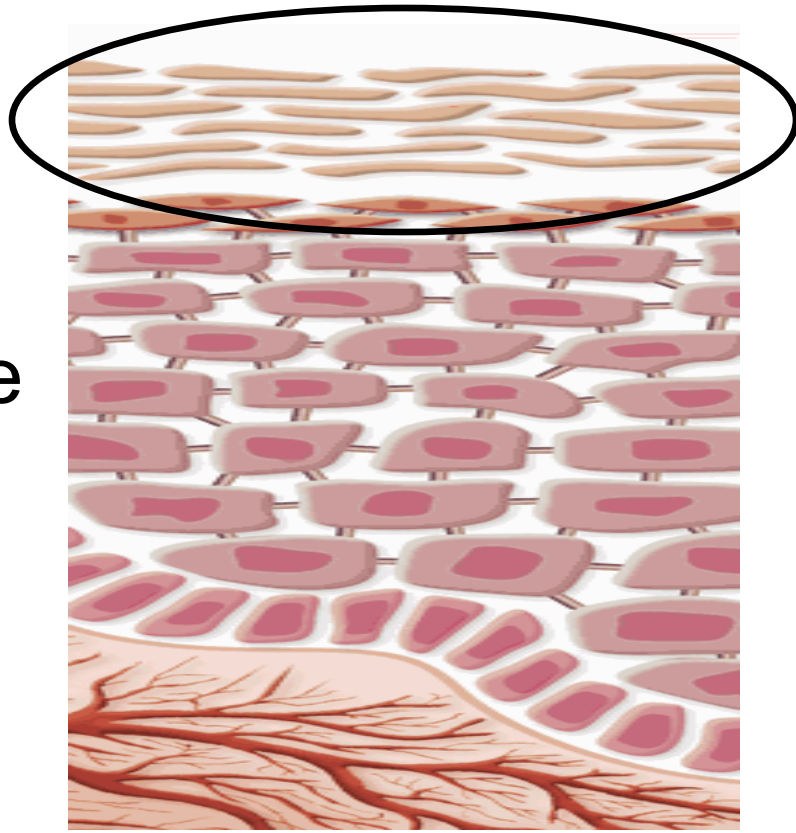
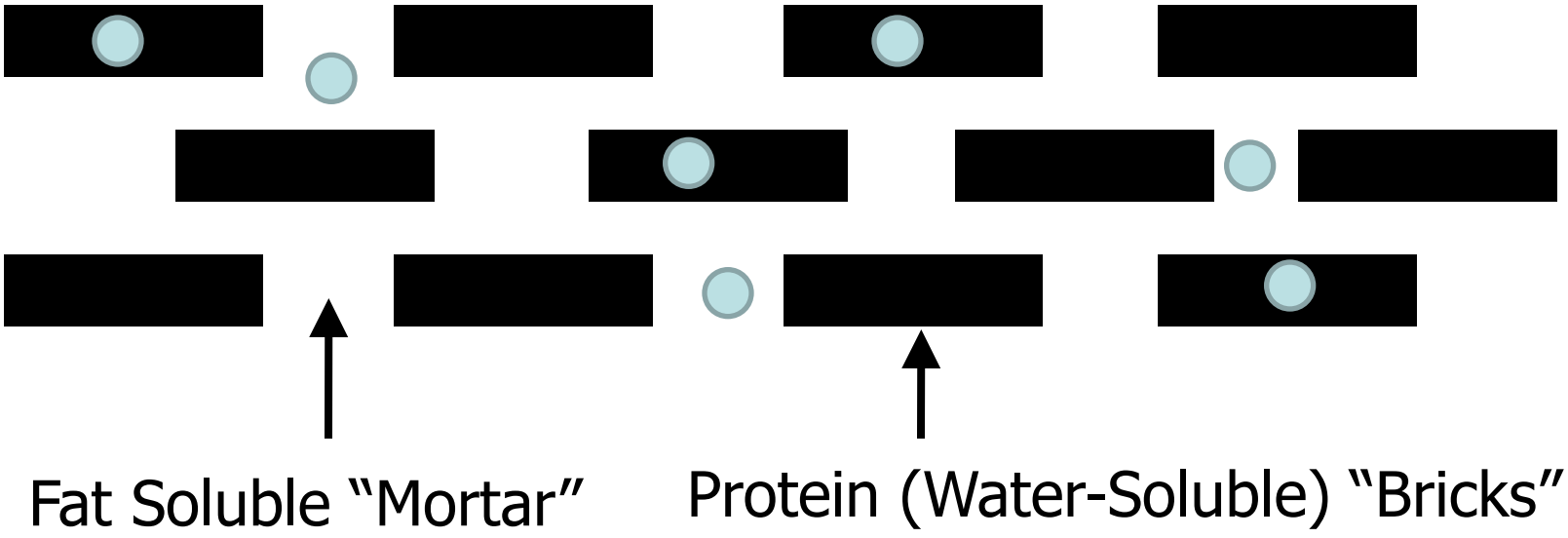


Image courtesy of S. Dotson, NIOSH

Skin Absorption: Bricks and Mortar

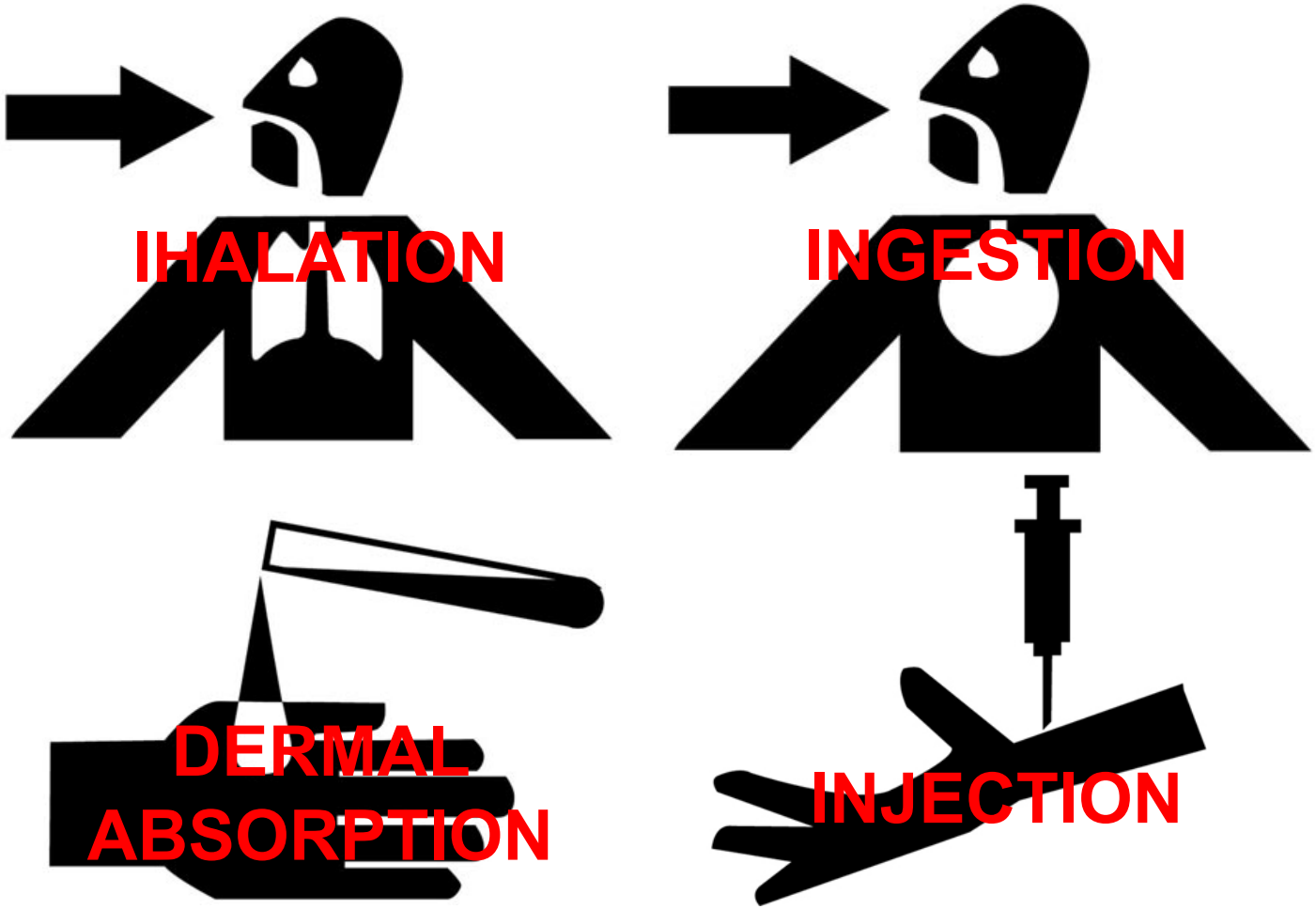
- Multiple pathways for skin absorption
  - Fat-soluble (lipophilic) chemicals
  - Water-soluble (hydrophilic) chemicals



Background

Importance as Exposure Route

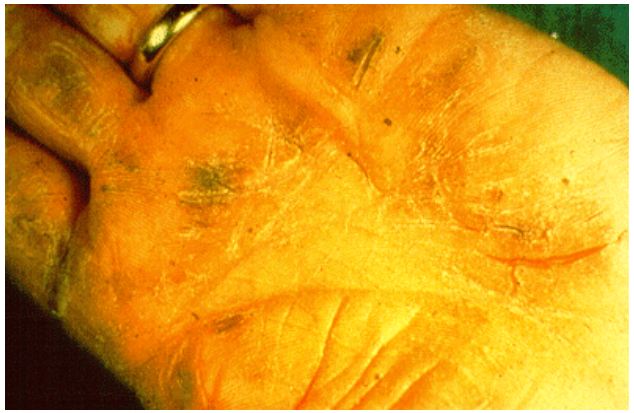
Importance as Exposure Route



Importance as Exposure Route

Target organ (direct damage)

Burns (heat/cold), cancer (UV), irritation (chemical/abrasion), corrosion (acid/base), cracking (repetitive motion), etc.



Cracking from repetitive motion

Skin destruction by frostbite

Skin trauma caused by anthrax

Images from Stefaniak et al.: Skin and the Work Environment.
In: The Occupational Environment- Its Evaluation and Control. AIHA Press, ppg. 537-559 (2011).

Importance as Exposure Route

Skin may be an exposure pathway

- Systemic toxicity – other target organs
  - Reproductive, neurological, hepatotoxicity, hemotoxicity
- Immune-mediated – sensitization
  - Photoallergenic, allergic dermatitis, isocyanate asthma

Allergic contact dermatitis to chromium

Image from Stefaniak et al.: Skin and the Work Environment.
In: The Occupational Environment- Its Evaluation and Control. AIHA Press, ppg. 537-559 (2011).

Qualitative Dermal Assessment

Making Dermal Exposure Judgments

Making Dermal Exposure Judgments

- What methods do you currently use to make judgments about dermal exposures?
- What are the key criteria that should be used to determine dermal exposure risk?
- What kinds of factors influence your dermal exposure judgments?

Making Dermal Exposure Judgments

Substance [CAS No.] (*Documentation* date)	ADOPTED VALUES TWA	STEL	Notations	MW	TLV® Basis
Pentaborane [19624-22-7] (1970)	0.005 ppm	0.015 ppm	—	63.17	CNS convul & impair
Pentachloronaphthalene [1321-64-8] (1970)	0.5 mg/m³	—	Skin	300.40	Liver dam; chloracne
Pentachloronitrobenzene [82-68-8] (1988)	0.5 mg/m³	—	[illegible]	295.36	Liver dam
Pentachlorophenol [87-86-5] (1992)	0.5 mg/m³	—	Skin; [illegible]3; BEI	266.35	URT & eye irr; CNS & card impair
Pentaerythritol [115-77-5] (1970)	10 mg/m³	—	—	136.15	Eye & URT irr
Pentane, all isomers [78-78-4; 109-66-0; 463-82-1] (1989)	600 ppm	—		72.15	Peripheral neuropathy
2,4-Pentanedione [123-54-6] (2010)	25 ppm	—	Skin	100.12	Neurotoxicity; CNS impair
Pentyl acetate, all isomers [628-63-7; 626-38-0; 123-92-2; 625-16-1; 624-41-9; 620-11-1] (1997)	50 ppm	100 ppm	—	130.20	URT irr
Perchloromethyl mercaptan [594-42-3] (1988)	0.1 ppm	—	—	185.87	Eye & URT irr
Perchloryl fluoride [7616-94-6] (1962)	3 ppm	6 ppm	—	102.46	LRT & URT irr; MeHb-emia; fluorosis
Perfluorobutyl ethylene [19430-93-4] (2001)	100 ppm	—	—	246.1	Hematologic eff
Perfluoroisobutylene [382-21-8] (1989)	—	C 0.01 ppm	—	200.04	URT irr; hematologic eff
Persulfates, as persulfate (1993)	0.1 mg/m³	—	—	Varies	Skin irr
Phenol [108-95-2] (1992)	5 ppm	—	Skin; [illegible]; BEI	94.11	URT irr; lung dam; CNS impair

TLV®–CS

Making Dermal Exposure Judgments

Skin

The designation "Skin" in the "Notations" column refers to the potential significant contribution to the overall exposure by the cutaneous route, including mucous membranes and the eyes by contact with vapors, liquids, and solids. Where dermal application studies have shown absorption that could cause systemic effects following exposure, a Skin notation would be considered. The Skin notation also alerts the industrial hygienist that overexposure may occur following dermal contact, even when exposures are at or below the TLV®.

Making Dermal Exposure Judgments

Legend: 1 = Poor / 4 = Excellent / NR = Not Recommended

Chemical	Neoprene	Nitrile	Latex	PVC	Chemical	Neoprene	Nitrile	Latex	PVC
Acetaldehyde	4	1	2	NR	Kerosene	4	4	1	2
Acetic Acid	4	3	3	2	Lactic Acid	4	4	4	4
Acetone	3	NR	3	NR	Lauric Acid	4	4	3	2
Acetonitrile	2	NR	2	NR	Linoleic Acid	4	4	1	3
Ammonium Hydroxide<30%	4	4	3	4	Linseed oil	4	4	1	4
Amyle Acetate	NR	4	2	1	Maleic Acid	4	4	1	3
Amyl Alcohol	1	3	3	NR	Methyl Acetate	3	1	1	NR
Aniline	3	NR	1	2	Methyl Alcohol	4	4	4	3
Animal Fats	4	4	1	3	Methylamine	3	4	4	4
Battery Acids	4	4	3	4	Methyl Bromide	NR	NR	NR	NR
Benzaldehyde	NR	NR	2	NR	Methylene Chloride	NR	NR	NR	NR
Benzene	NR	1	NR	NR	Methyl Cellusolve	4	2	1	-
Benzoly Chloride	NR	NR	1	NR	Methyl Ethyl Ketone (MEK)	3	NR	3	NR
Butane	2	4	1	1	Methylisobutyl Ketone	NR	1	2	NR
Butyl Acetate	NR	2	1	NR	Methyl Methacrylate	NR	1	1	NR
Butyl Alcohol	4	1	4	3	Mineral Oil	4	4	1	2
Butyl Cellusolve*	4	4	4	NR	Mineral Spirits	3	4	NR	2
Carbon Acid	4	1	1	3	Monoethanolamine	4	4	3	4
Carbon Disulfide	NR	NR	NR	NR	Morpholine	1	NR	3	NR

Dermal Exposure Scenario

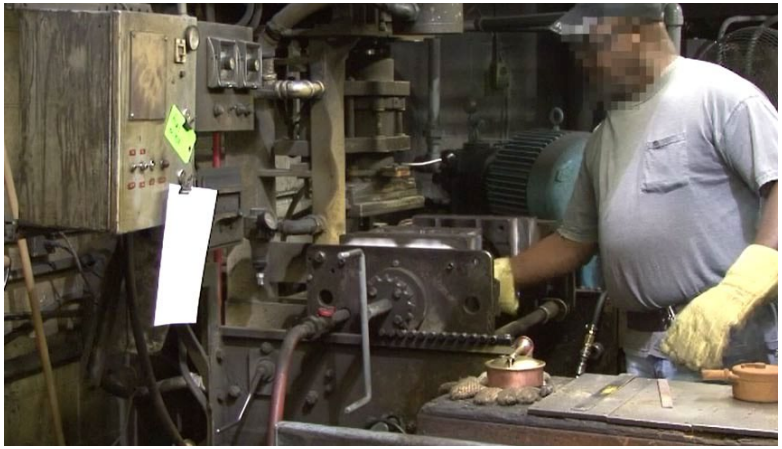
Employees at a foundry work with a cured phenol-based molding compound

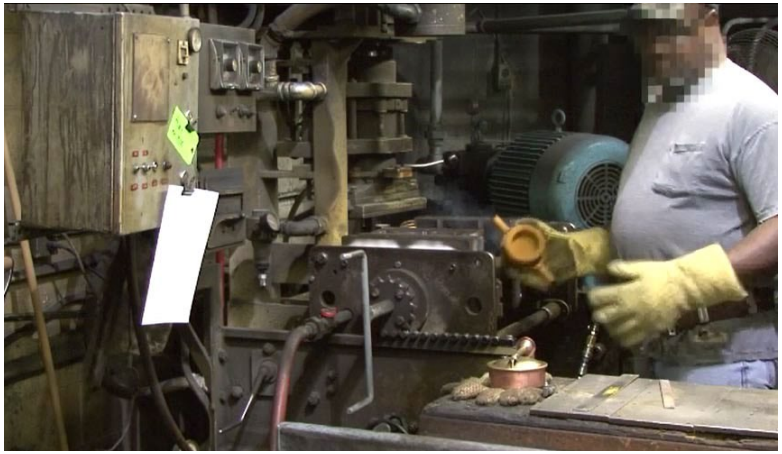
Workers:

- reach into oven
- pull out cured mold
- file mold to remove residual molding compound
- stack mold
- repeat process

It takes 30 seconds to remove, file, and stack each mold.

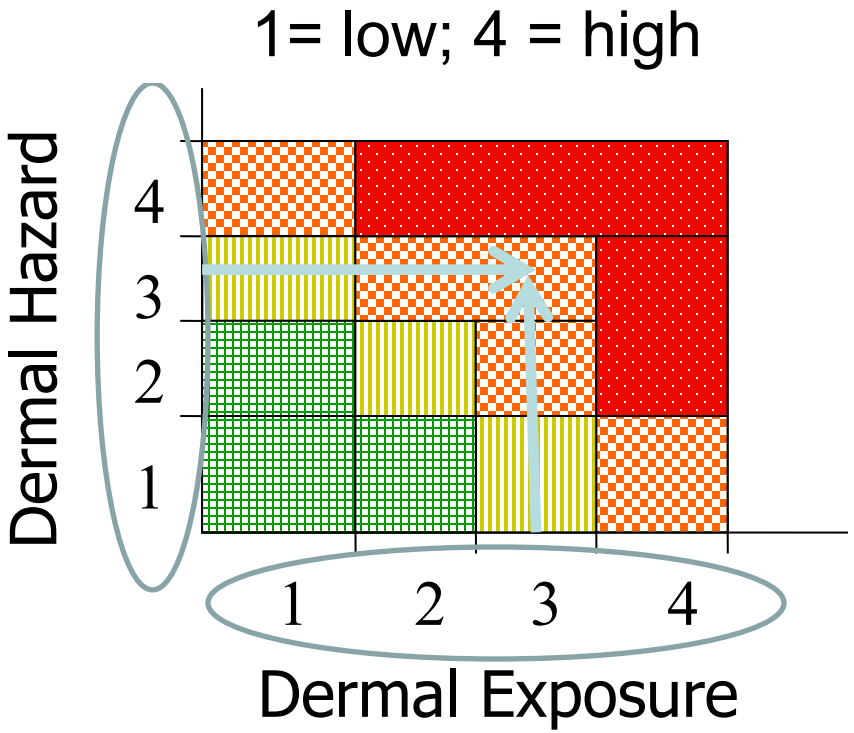
The worker continually repeats the process over the 8-hr work shift.





Dermal Risk Assessment: Qualitative Judgment Matrix

- Dermal hazard level for phenol?
- Assign 1, 2, 3, or 4
- Rate exposure potential?
- Select 1, 2, 3, or 4



Qualitative Dermal Assessment

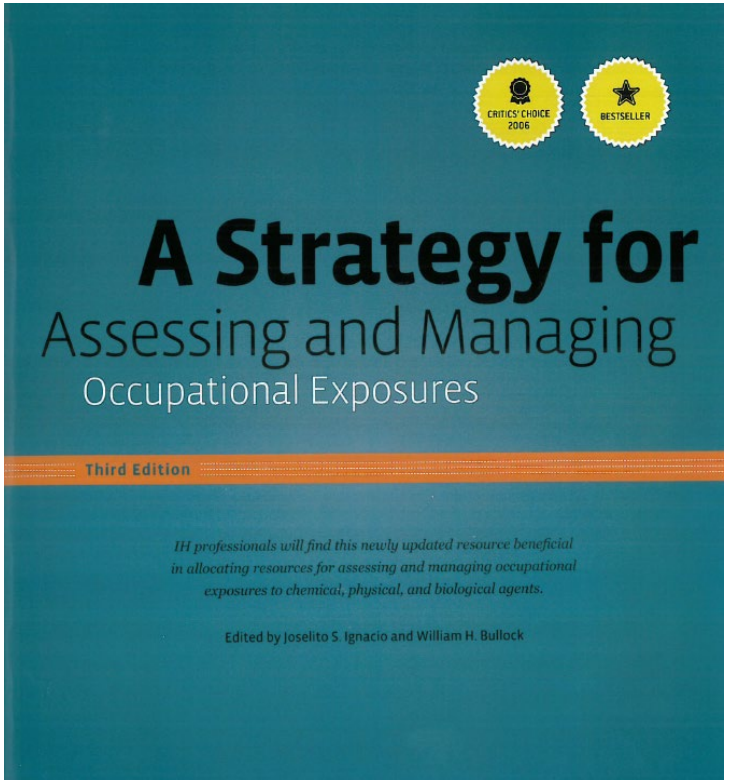
AIHA Dermal Exposure Assessment Framework/Tool

A Recommended Strategy for Dermal Exposure/Risk Assessment

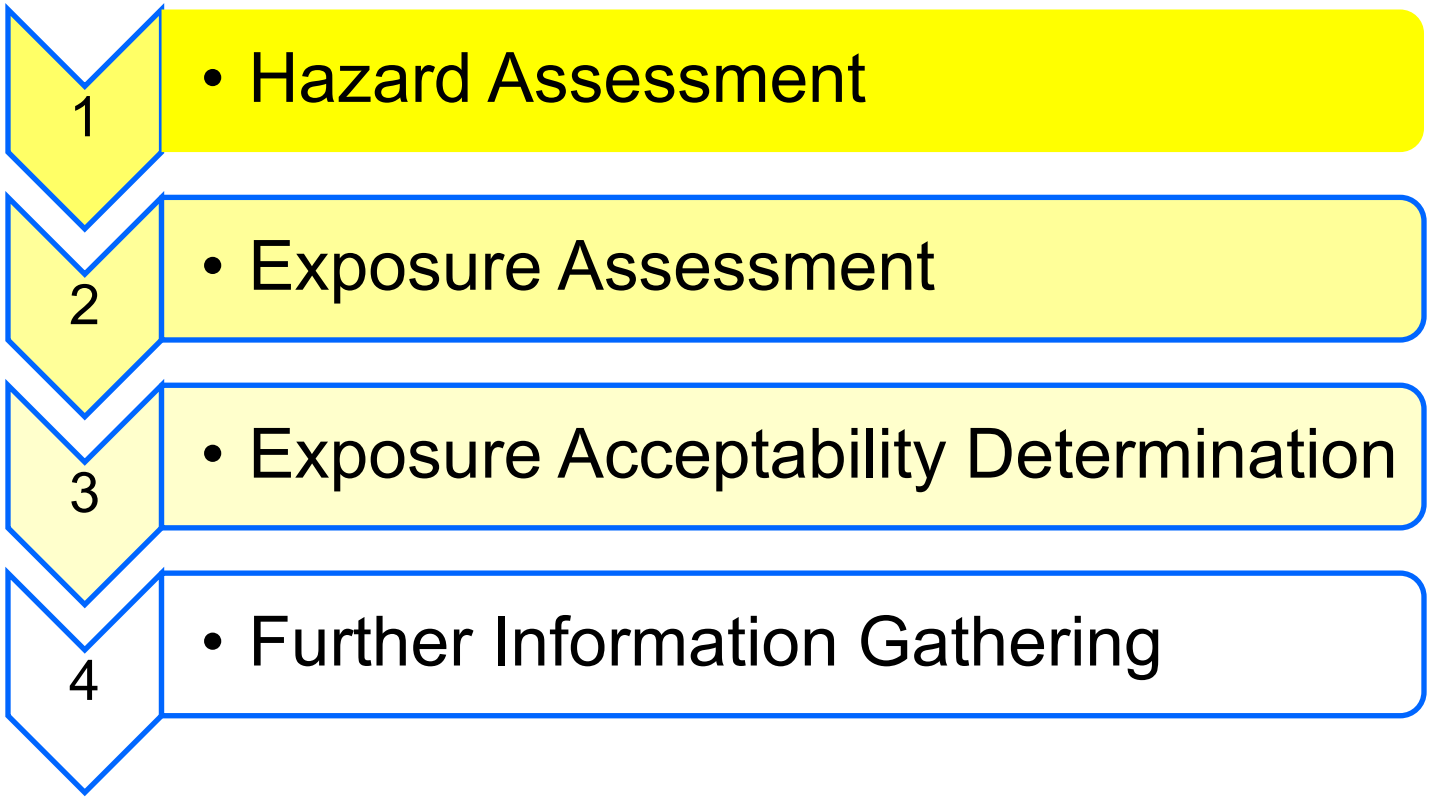
AIHA's -

"A Strategy for Assessing and Managing Occupational Exposures"

- Outlines a multiple step process for prioritizing dermal "risks"
- Screening tool
- Ranks hazard and exposure variables to estimate dermal risks



A Recommended Strategy for Dermal Exposure/Risk Assessment



Step 1: Sources for Dermal Hazard Assessment

Tools/resources to evaluate dermal hazards:

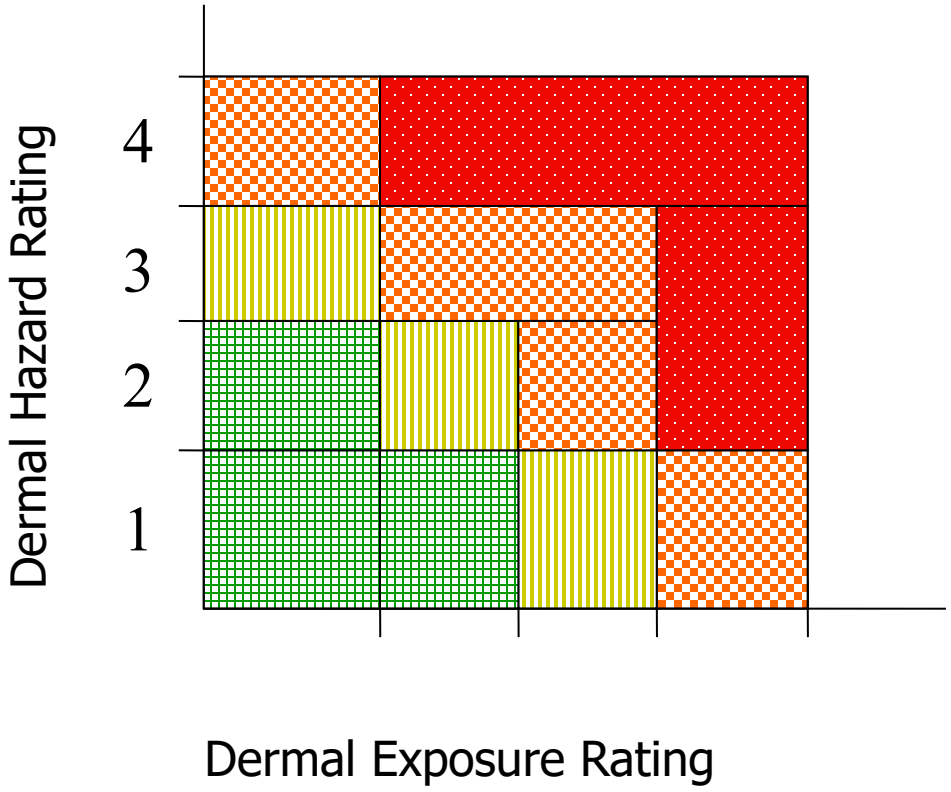
- SDS
  - *GHS* Classification
  - EU Risk Phrases
  - REACH
- Skin Notations
  (NIOSH, ACGIH, OSHA, SCOEL, OARS/TERA)
- Databases
  - SRC
  - GESTIS
  - TOXNET
- Flow process diagrams, etc.
- Published and unpublished studies

Step 1: Dermal Hazard Assessment

- The Hazard Assessment has two steps:
  1. Hazard Characterization
     - What are the possible adverse health effects due to skin exposure?
  2. Dose-Response Assessment
     - How toxic is the agent of concern by the dermal route?
- Hazard = Toxicity
- Determining a chemical's dermal hazard potential is key, but we will be focusing on exposure rather than hazard

Dermal Hazard Rating

Rating	Description
1	Reversible or very low skin or systemic toxicity
2	Moderate but reversible skin or systemic toxicity
3	Irreversible/chronic skin or systemic toxicity or sensitization
4	Life threatening skin or systemic toxicity or sensitization



Qualitative Dermal Exposure Judgment Tool

Dermal Exposure Assessment Summary Form

Dermal Hazard Rating
○1 ○2 ○3 ◉4

Category **4**

Dermal Contact Area

Contact possible to hands and forearms

*Exposure Rating = CA * C * CF * RT * PP* **24**

Dermal Concentration

Low concentration of agent likely to contact or load onto the skin

Dermal Contact Frequency

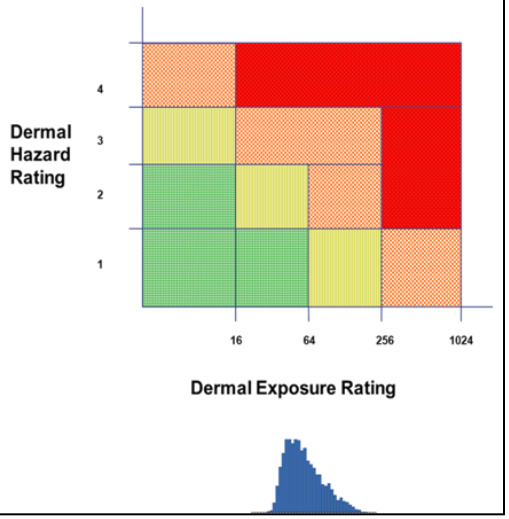
Up to 10 incidental contacts with skin; contact during less than 10% of work shift

Dermal Retention Time

Amount transferred may remain on skin for some time (i.e., some volatility or adherence to skin)

Dermal penetration Potential

Rare (large, insoluble particles)



Step 2: Dermal Exposure Judgments

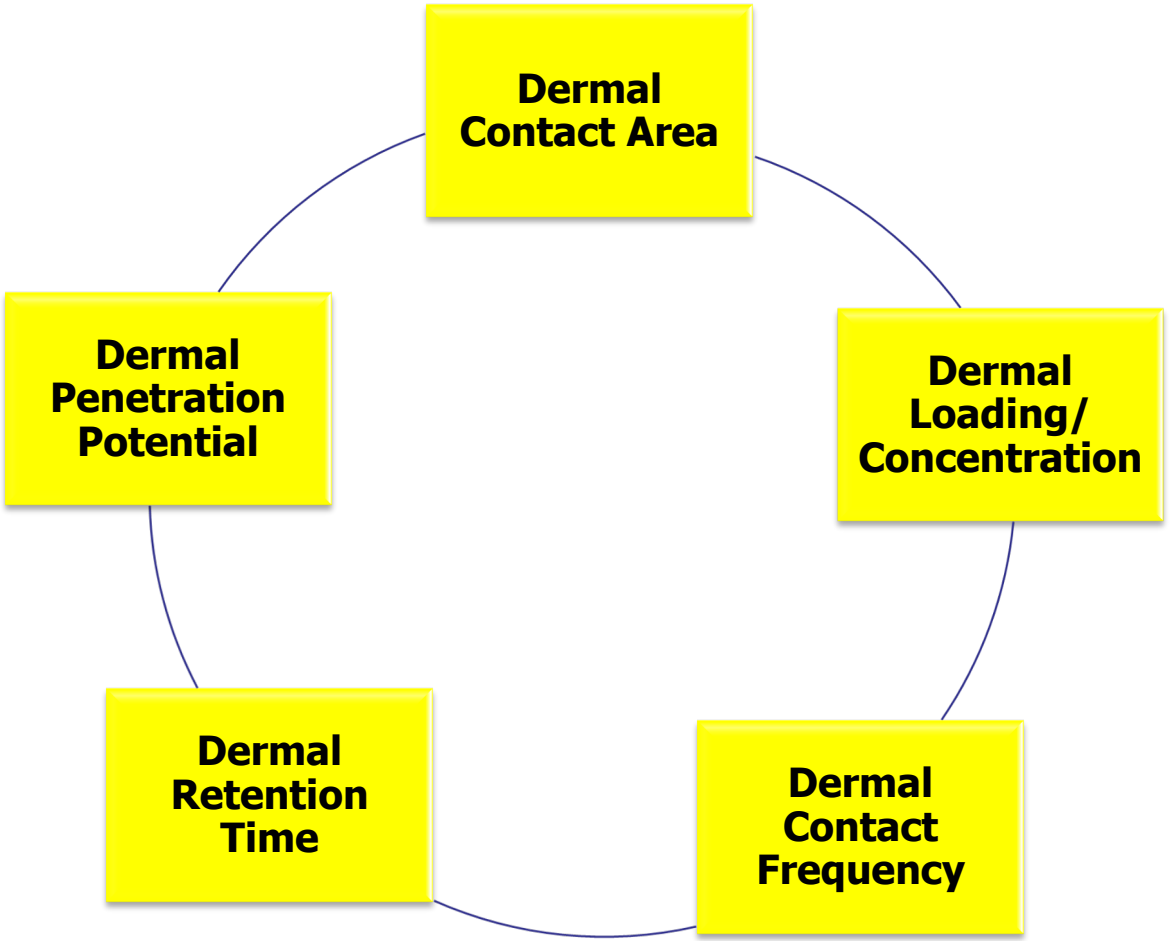
- Allergen vs. localized skin damage vs. systemic toxicity
- Which is more important for a particular assessment?
- How should workers and tasks be organized when assessing dermal exposures?
- How should concerns for dermal exposure and risk be rated?
- Is it necessary to collect additional information using modeling, skin/surface monitoring, or biological monitoring?

Dermal Exposure Assessment: Initial Observations

- Observe worker practices and interaction with chemical.
- Do workers have direct contact with dermal hazards via bare skin or do they wear PPE?
- Is splashing a risk?
- How do exposures occur?
- Do work practices differ between workers?
- How are tools shared in the workplace?
- How are tools cleaned/disinfected?
- What is the level of workplace housekeeping?
- What are the environmental conditions in each work area?
- How frequently do workers wash hands?

Dermal Exposure Assessment

Five dermal exposure determinants:



A. Dermal Contact Area

- Estimate total area of likely skin contact if the agent of concern is a systemic toxicant (one hand, two hands, fingers only)
  - Chemical concentration on a specific area of skin is an important consideration for potent allergens and corrosive agents
  - General skin contact area is important for systemic toxicants
- Assume no PPE used when estimating

B. Dermal Loading/Concentration on Skin

Systemic Toxins

- use the total mass per surface area of the agent on the skin as transferred (loading)
- loading will affect penetration rate or flux through the skin

Allergens or Irritants/Corrosives

- use the concentration of the agent that is transferred to the skin during work activities
  - For local irritants, concentration on the skin will affect severity of reaction and future reactions
  - For allergens, concentration will affect the rate of sensitization of the exposed population

C. Dermal Contact Frequency

- Estimate the frequency of contacts or the percentage of the total task during which the agent of concern comes in contact with the skin
- Consider the length of the task relative to the number of repeated contacts with skin

D. Dermal Retention Time

- Estimate likelihood that the agent of concern will remain on the skin following exposure contact
- Applicable to systemic toxicants, irritants (local effects) and allergens
- Consider factors such as vapor pressure and particulate characteristics that would make an agent more likely to remain on skin over time

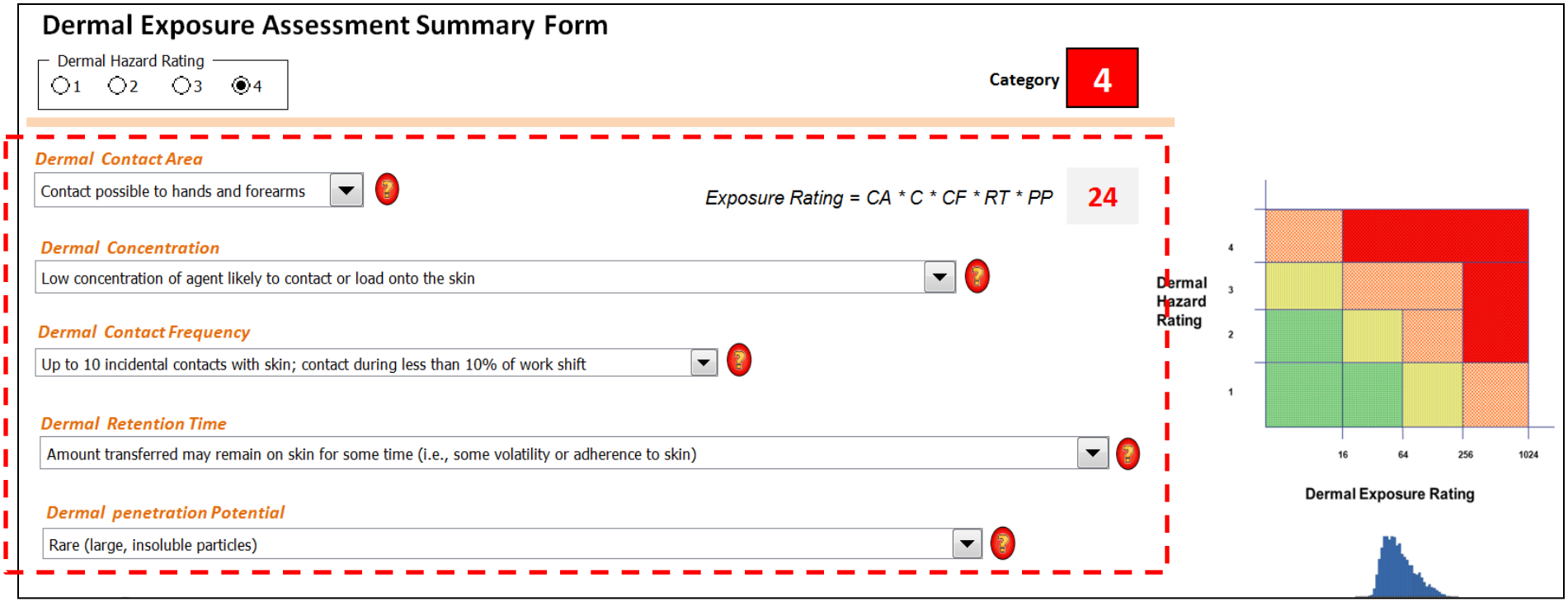
E. Dermal Penetration Potential

For systemic toxicants, evaluate the mass of chemical that crosses through the skin and becomes available for systemic distribution

Factors (increase/decrease absorption):

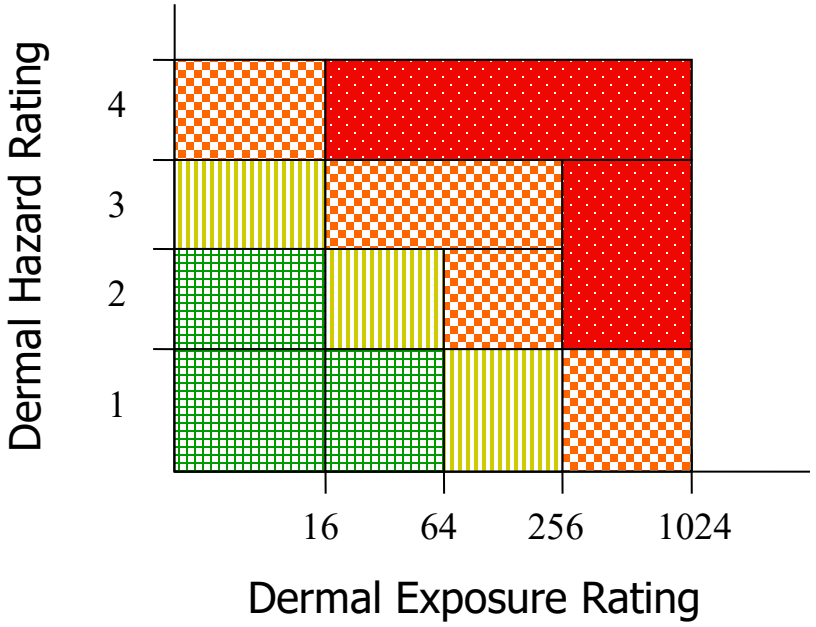
- Vapor pressure
- Molecular weight/size
- Solubility (Log $K_{o/w}$)
- Condition of the skin
- Covered vs. uncovered
- Environmental exposure conditions

Qualitative Dermal Exposure Judgment Tool



Step 3: Qualitative Dermal Judgments

- Risk Rating = Hazard X Exposure
  - Hazard Rating = 1 to 4
  - Exposure Rating = 1 to 1024
- Enter your judgments in the Dermal Tool
- Tool will determine:
  - Low risk (green zone)
  - Medium risk (yellow zone)
  - High risk (orange zone)
  - Very high risk (red zone)



Dermal Exposure Assessment Summary Form

Dermal Hazard Rating

100%	
0%	Reversible or very low skin or systemic toxicity
15%	Moderate but reversible skin or systemic toxicity
70%	Irreversible/chronic skin or systemic toxicity or sensitization
15%	Life threatening skin or systemic toxicity or sensitization

Dermal Contact Area

100%	
50%	Unexposed/unlikely
45%	Very small area of skin contact
5%	Contact possible to hands and forearms
0%	Contact possible to significant area of skin

Dermal Concentration or Loading

100%	
0%	Negligible concentration of agent likely to contact or load onto the skin
10%	Low concentration of agent likely to contact or load onto the skin
50%	Moderate concentration of agent likely to contact or load onto the skin
40%	High concentration of agent likely to contact or load onto the skin

Dermal Contact Frequency

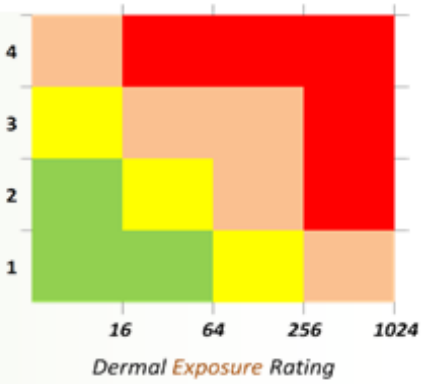
100%	
0%	Minimal contact with skin; one or two incidental contacts; contact during less than 5% of task
0%	Up to 10 incidental contacts with skin; contact during less than 10% of task
100%	Up to 50 incidental contacts with skin; contact during less than 50% of task
0%	Routine incidental contact with skin throughout shift; contact during 50-100% of task

Dermal Retention Time

100%	
100%	Amount transferred unlikely to remain on skin for any period of time (i.e., high volatility, dry and powdery)
0%	Amount transferred may remain on skin for some time (i.e., some volatility or adherence to skin)
0%	Amount transferred is likely to remain on skin for a significant period of time (i.e., low volatility, high MW, sticky or consolidated on skin even if not visible)
0%	Amount transferred very likely to remain on skin (i.e., substance not volatile, MW > 100, substance very likely to stick to skin)

Dermal Penetration Potential

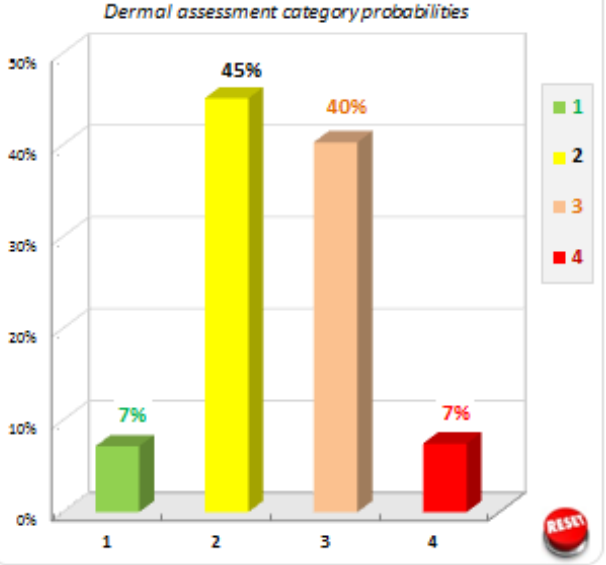
100%	
100%	Rare (large, insoluble particles)
0%	Less likely (small insoluble particle > 1 micron in size, or both poor lipid solubility and poor water solubility)
0%	Possible or slow (very small insoluble particles < 1 micron, or some lipid solubility and some water solubility, or marginal skin health)
0%	Probable or likely (good lipid solubility and good water solubility, or poor skin health)



Monte Carlo simulation

Start

iterations 2048



Quantitative Dermal Assessment

Skin & Surface Sampling Methods
Interpreting Results

Skin & Surface Sampling Methods

- Skin sampling
  - Identify worker exposures
  - Evaluate effectiveness of PPE
- Surface sampling
  - Identify sources of contamination
  - Evaluating effectiveness of controls
  - Monitor housekeeping actions

Skin Sampling Methods

- Three types
  - Removal
    - Wiping, washing or rinsing
  - Interception
    - Gauzes, charcoal cloths, pads, patches, etc.
  - *In situ*
    - Fluorescent tracers, etc.

- All techniques have limitations!

Skin Sampling- Removal Methods

Wiping

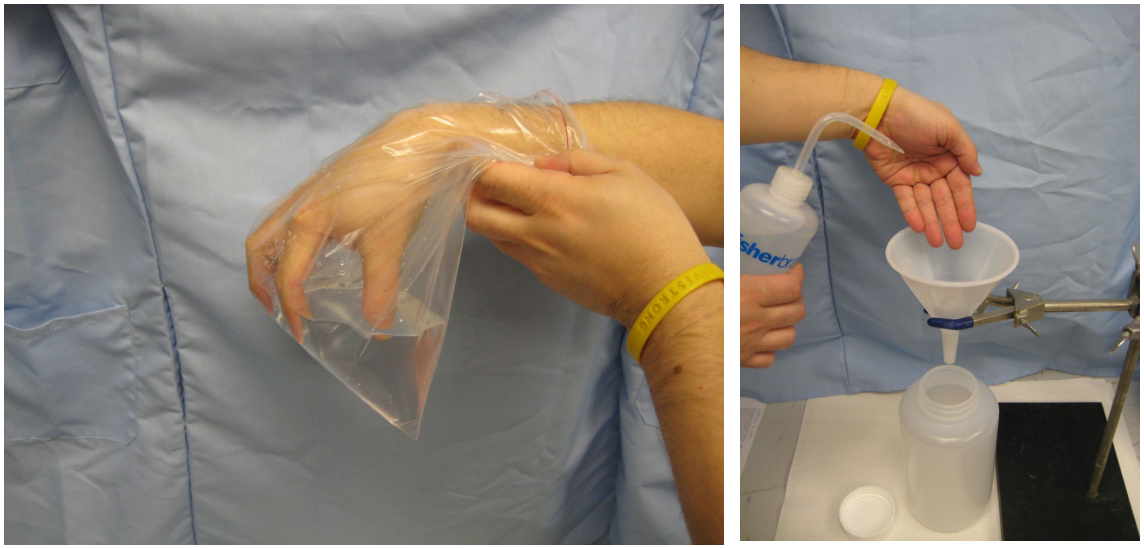
- Substrate: dry or pre-moistened wipe material
- Approach: wipe skin with substrate
  - Demarcation of area allows calculation of concentration

See also NIOSH Method 9105 - LEAD in DUST WIPES by Chemical Spot Test (Colorimetric Screening Method)

Skin Sampling- Removal Methods

Washing or rinsing

- Substrate: liquid (water, organic solvents, etc.)
- Approach 1: place hands into a liquid-filled container and wash by rubbing together
- Approach 2: hold hands over a container while liquid is poured onto the hands



Henriks-Eckerman et al. Ann Occup Hyg. (2007).

Skin Sampling- Interception Methods

Tape stripping

– Substrate:

gauzes, cloths, pads, patches, etc.

– Approach:

place substrate directly onto surface of the skin and/or on the outside/underside of clothing

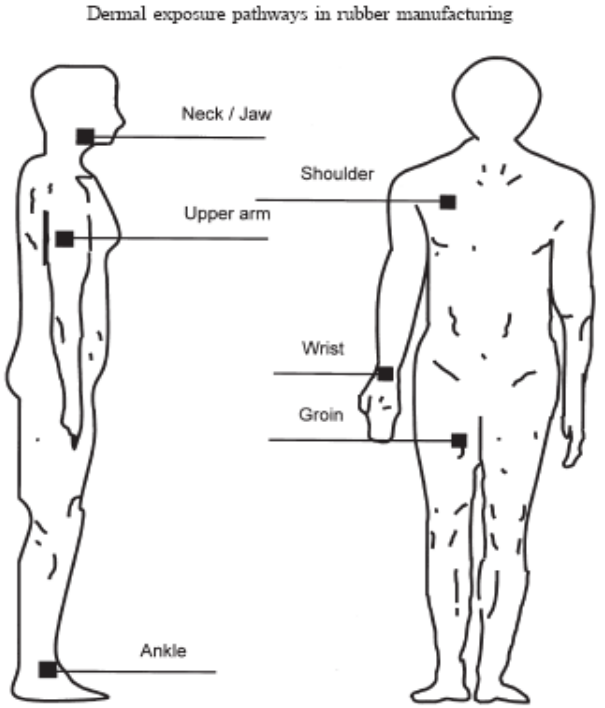


Fig. 1. Body location of individual pad samplers [figure adapted from van Rooij *et al.* (1993)].

Vermeulen et al. Ann Occup Hyg. (2000).

Skin Sampling- *In Situ* Methods

Direct visualization

- Substrate: fluorescent tracer
- Approach: add tracer to work substance then visualize dispersion using UV light

Harari et al. Pesticide Safety News. Vol. 7(3) (2003).

Surface Sampling Methods

- Three types of techniques
  - Wiping
  - Vacuuming
  - Direct detection
- Surface sampling is NOT a metric of skin exposure
- All techniques have limitations!

Surface Sampling

Wiping

- Substrate: wet or a dry wipe
- Approach: apply consistent pressure while wiping substrate across surface
  - Demarcation of area allows calculation of concentration

NIOSH Method 9100 - Lead in Surface Wipe Samples
NIOSH Method 9102 - Elements on Wipes
ASTM D6966 - Wipe Sampling Methods
ASTM D7659 - Strategies for Surface Sampling of Metals and Metalloids

Surface Sampling

- Vacuuming
  - Substrate: filter
  - Approach: collection nozzle is attached to a filter holder that is connected to an air sampling pump

ASTM D7144 - Standard Practice for Collection of Surface Dust by Micro-vacuum Sampling

- Direct detection
  - Colorimetric wipe indicators
    - NIOSH Method 9105 also applicable to surfaces

Interpreting Results

General limitations of skin/surface methods

- Sampling substrates do not possess the same characteristics as human skin
  - May result in under- or over-estimation
- Many analytical techniques provide estimates of total contaminant masses
  - May not be biologically meaningful

Interpreting Results

- Lack of method standardization

  Only limited guidance available

- Results are highly variable
  - Removal - pressure, demarcation of area, substrate
  - Interception - substrate, regional variation in exposure
  - Vacuuming – surface properties, flow rates, collection times, substrate

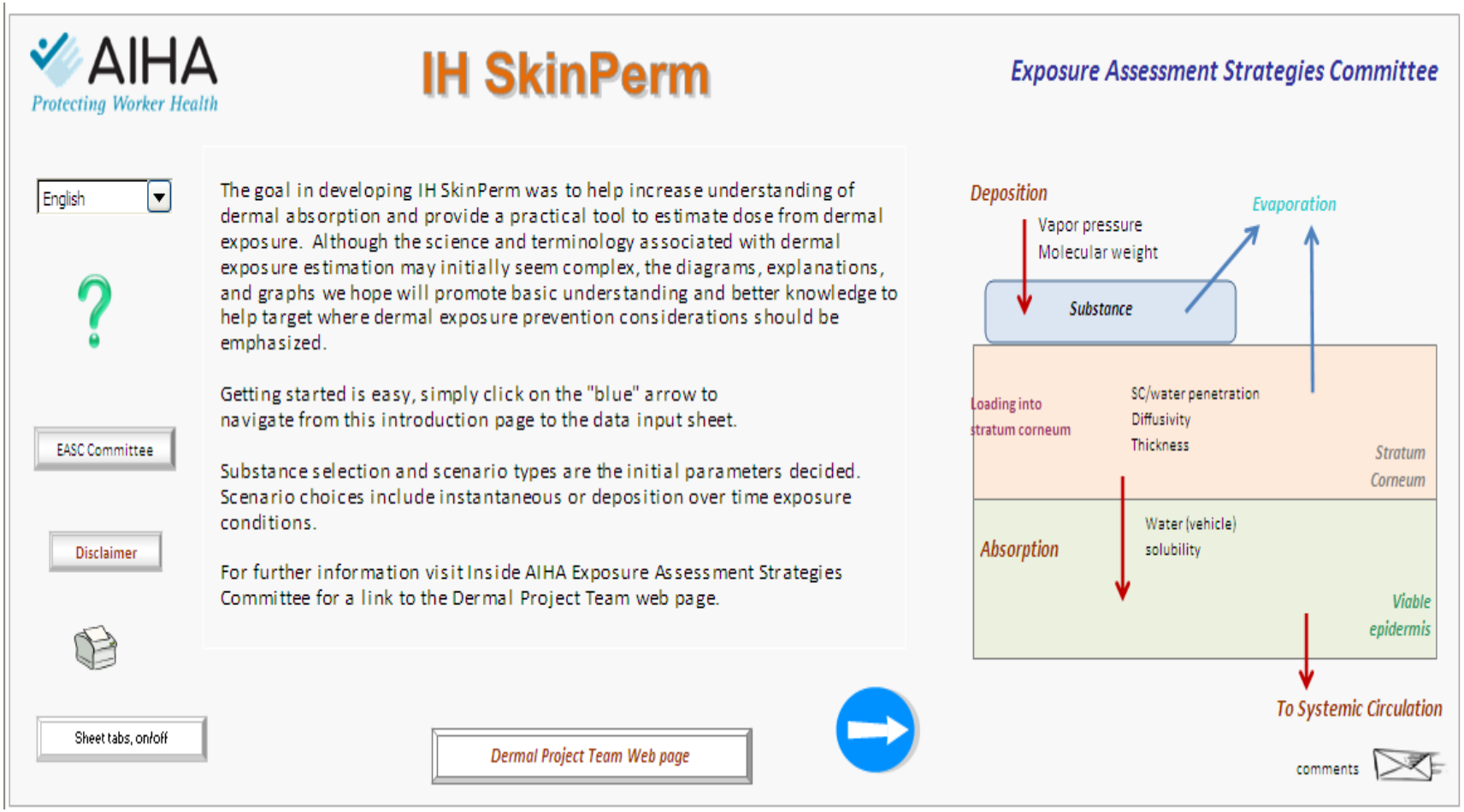
- Exposure is not the same as dose

Dermal Absorption Modeling

Exercises Using IH SkinPerm

Introduction

- Introduce the IH SkinPerm model
- Demonstrate examples of dermal absorption estimation



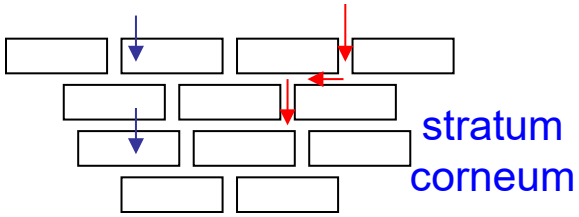
IH SkinPerm uses Quantitative Structure-Activity Relationships (QSARs)to Estimate Absorption

Aqueous Permeation Coefficient of human skin stratum corneum

$$Kp_{aq\ sc} = Kp_{lipids} + Kp_{corneocytes} \quad (cm/hr)$$

$$Log(Kp_{corneocytes}) = -1.37 - 1.36 * Log\ (MW)$$

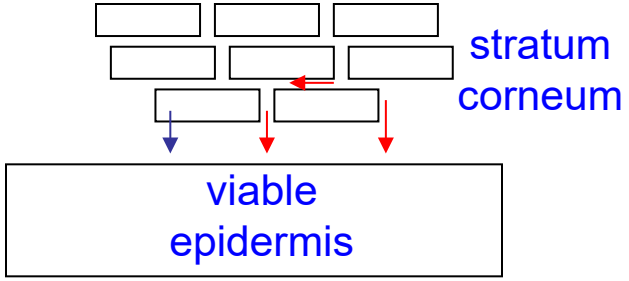
$$Log(Kp_{lipids}) = -2.59 + 0.732 * Log(Kow) - 0.00683 * MW$$



Derived from 182 measured and validated human aqueous skin permeation coefficients in vitro (ten Berge 2009, Vecchia and Bunge 2002a)

Partition Coefficient of stratum corneum/water

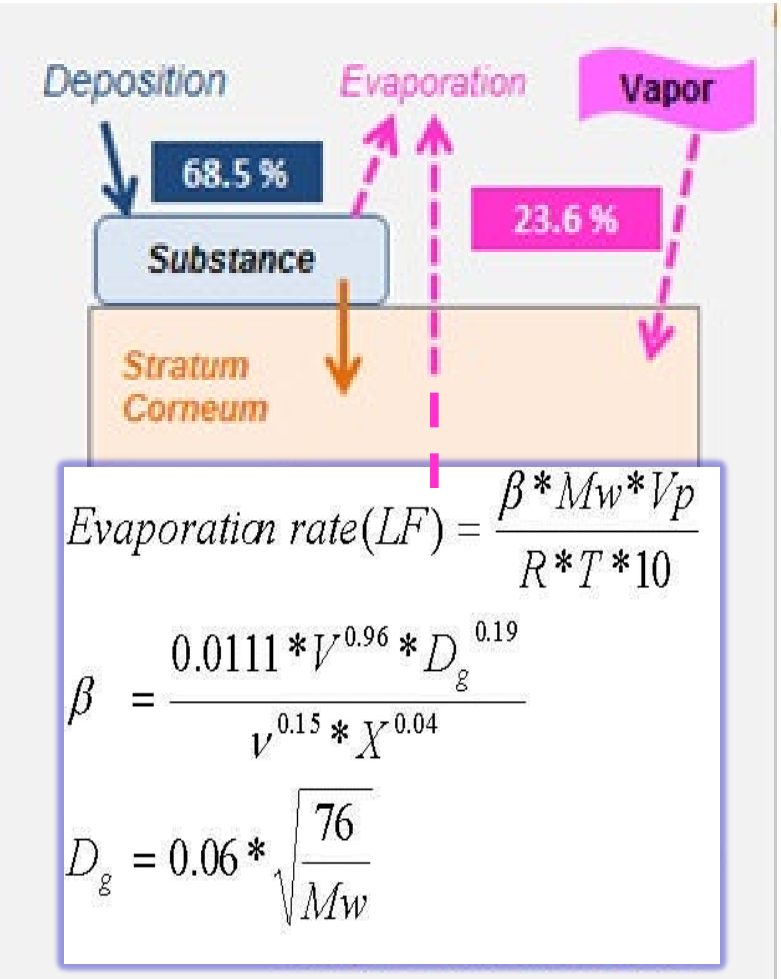
$$Psc/w = 0.72 * Kow^{0.43}$$



Derived from 97 measured and validated human stratum corneum/water partition coefficients in vitro (ten Berge 2009 and Vecchia and Bunge 2002b)

Substance Evaporation

- IH SkinPerm accounts for evaporation rate
  - referenced in EU REACh technical guidance R.14: Occupational exposure estimation
  - method reported by Gmehling et al (1989) and Weidlich et al (1986)



$$Evaporation\ rate(LF) = \frac{\beta * Mw * Vp}{R * T * 10}$$

$$\beta = \frac{0.0111 * V^{0.96} * D_g^{0.19}}{\nu^{0.15} * X^{0.04}}$$

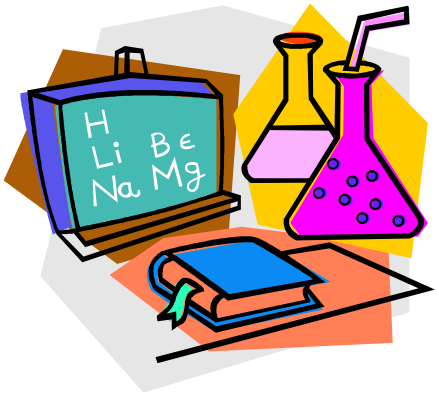
$$D_g = 0.06 * \sqrt{\frac{76}{Mw}}$$

IH SkinPerm functionality

Three types of skin exposures can be modeled.

- Instantaneous deposition
- Deposition over time
- Vapor to skin absorption

IH SkinPerm functionality



- Contains two libraries
  - IH SkinPerm

    100+ substances prepopulated with key physical chemical properties (MW, VP, water solubility, LogKow, density)
  - user library
- Modeling inputs
  - scenario choice
  - dermal exposure

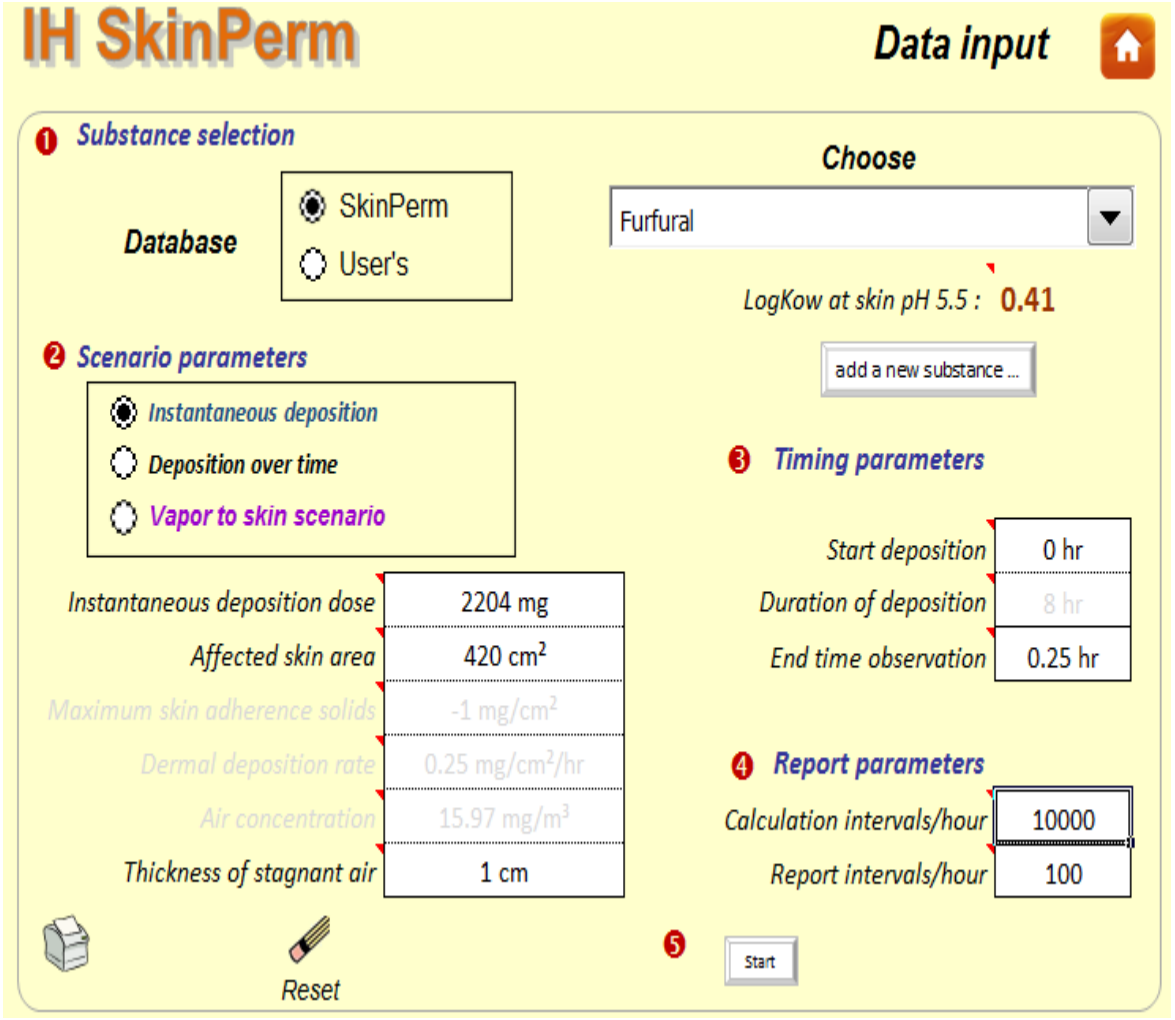
    (mg, mg/cm^2/hr, or mg/m^3)
  - skin surface area affected
  - exposure duration
  - observation period

Scenario 1: Instantaneous skin deposition

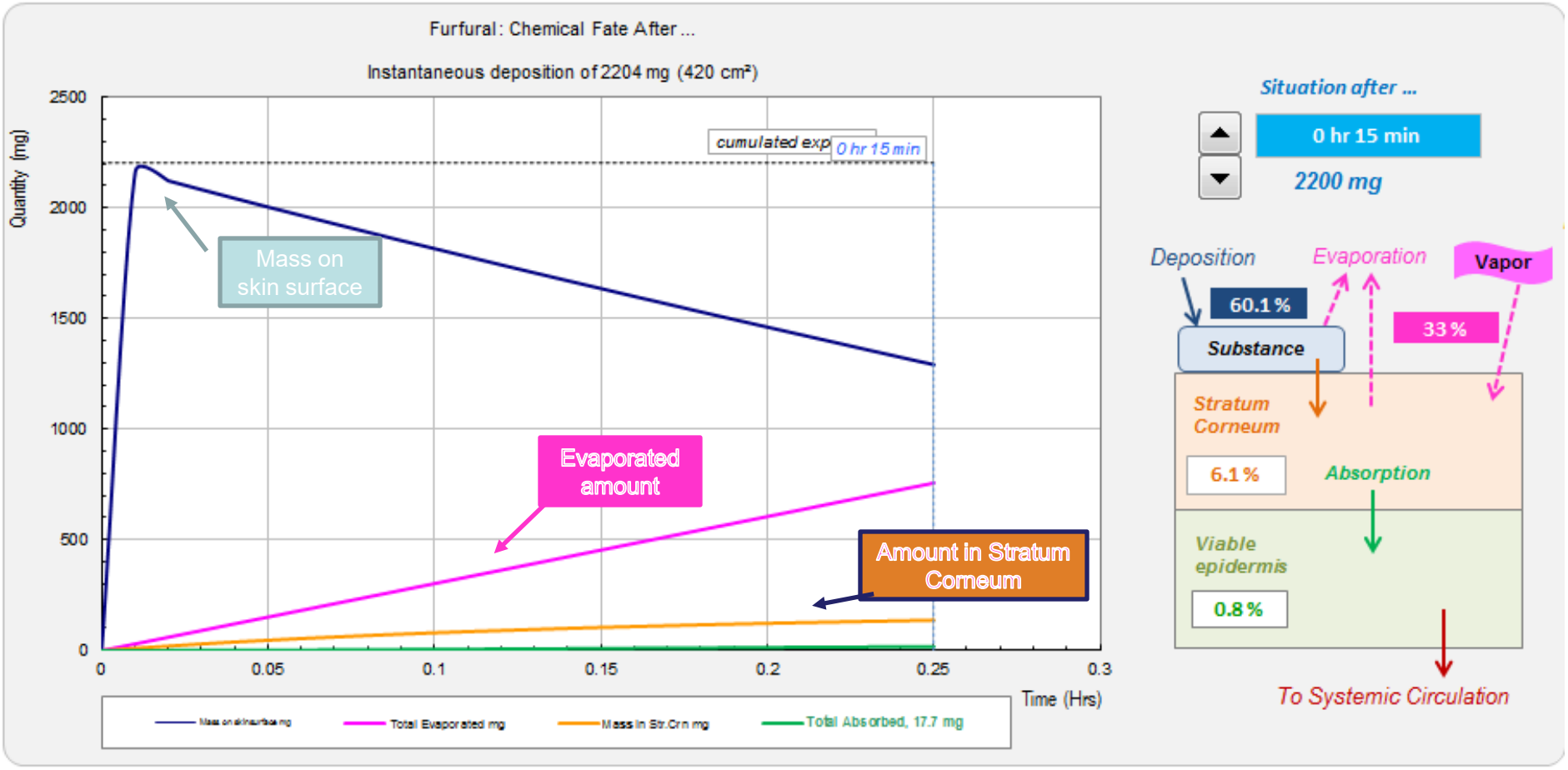
- Unloading 95 wt% furfural solution w/out gloves.
- A bad connection results in skin exposure to one hand.
- How much furfural absorbed before washing 15 minutes later?

Scenario 1: Data Input

- volume: 2 ml
  - convert ml to mg (2204 mg)
- skin surface area
  - 1 bare hand ($420 cm^2$)
  - thickness of stagnant air (1 cm)
- exposure duration
  - 15 minutes (0.25 hr)



Scenario 1: Graphical Results



Scenario 1: Numerical Results

IH SkinPerm

Substance	**Furfural**		
Deposition	**Instantaneous**		
Duration			
Tot. Deposition	2204 mg		
Fraction absorbed	0.8%		
Amount absorbed	17.719 mg		
	WATER	**AIR**	
Kp-lipids (vehicle water)	1.13E-3 cm/hr	1.15E+1 cm/hr	K
Kp-keratins (vehicle water)	8.61E-5 cm/hr	8.73E-1 cm/hr	K
Lag time stratum corneum	17.755 min		
Diffusivity of Stratum corneum	2.30E-6 cm^2/hr	3.20E+2 cm/hr	Kp-stagnant air layer
Skin/Water partition ratio	1.0805	10958	Skin/Air partition ratio
	WATER	**AIR**	
Permeation coefficient water	1.22E-3 cm/hr	1.19E+1 cm/hr	Permeation coefficient air
5th percentile water	8.49E-4 cm/hr	8.38E+0 cm/hr	5th percentile air
95th percentile water	1.75E-3 cm/hr	1.68E+1 cm/hr	95th percentile air
Max. derm. abs.	1.01E-1 $mg/cm^2/hr$		

Example considerations:

- 17 mg furfural dermally absorbed at fifteen minutes compared to OEL equivalent inhalation dose 78 mg.
- Compare furfural lag time for maximum absorption to exposure duration.

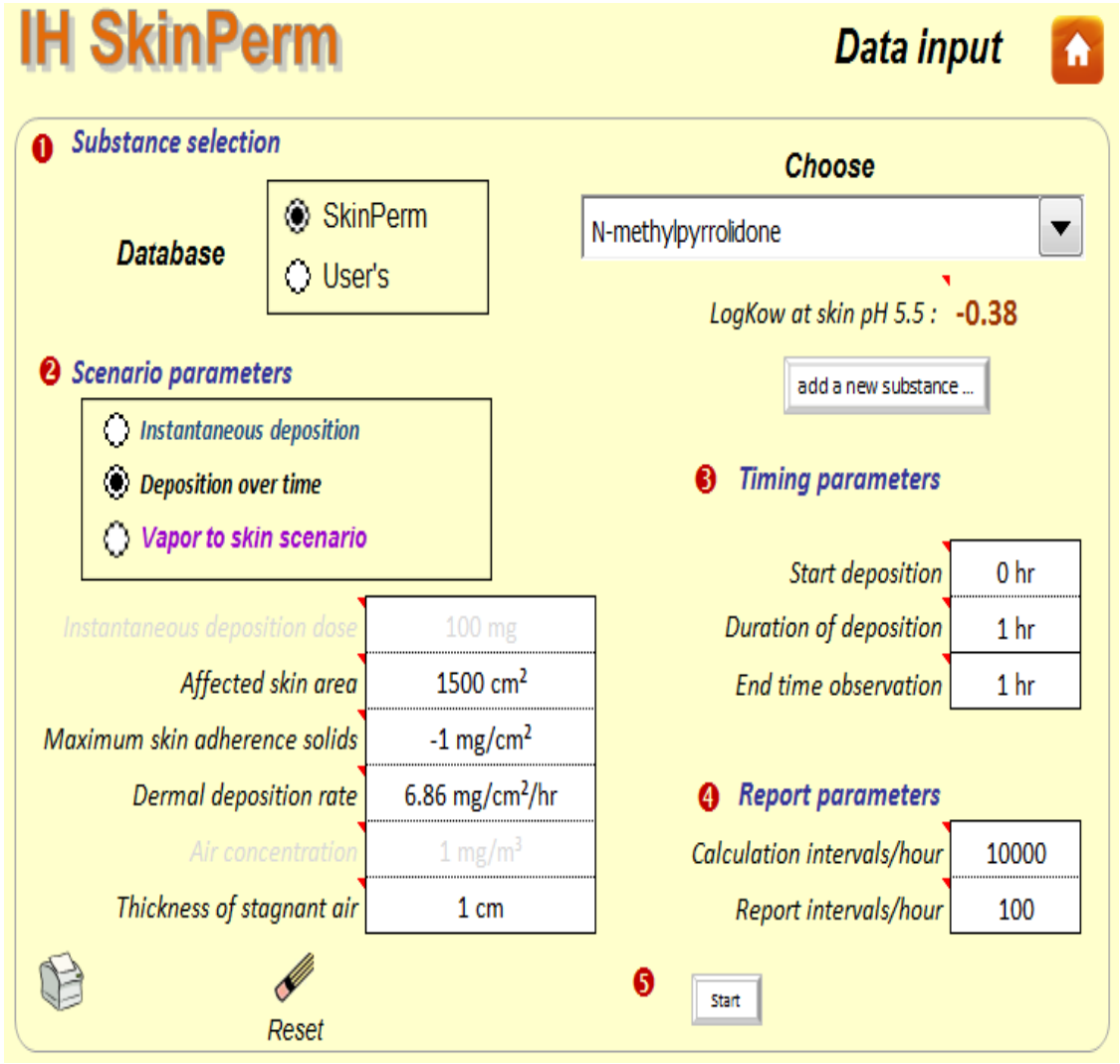
Other data outputs include:
permeation rates, other coefficients calculated by the model, and the confidence limits around them.

Scenario 2: Deposition over time

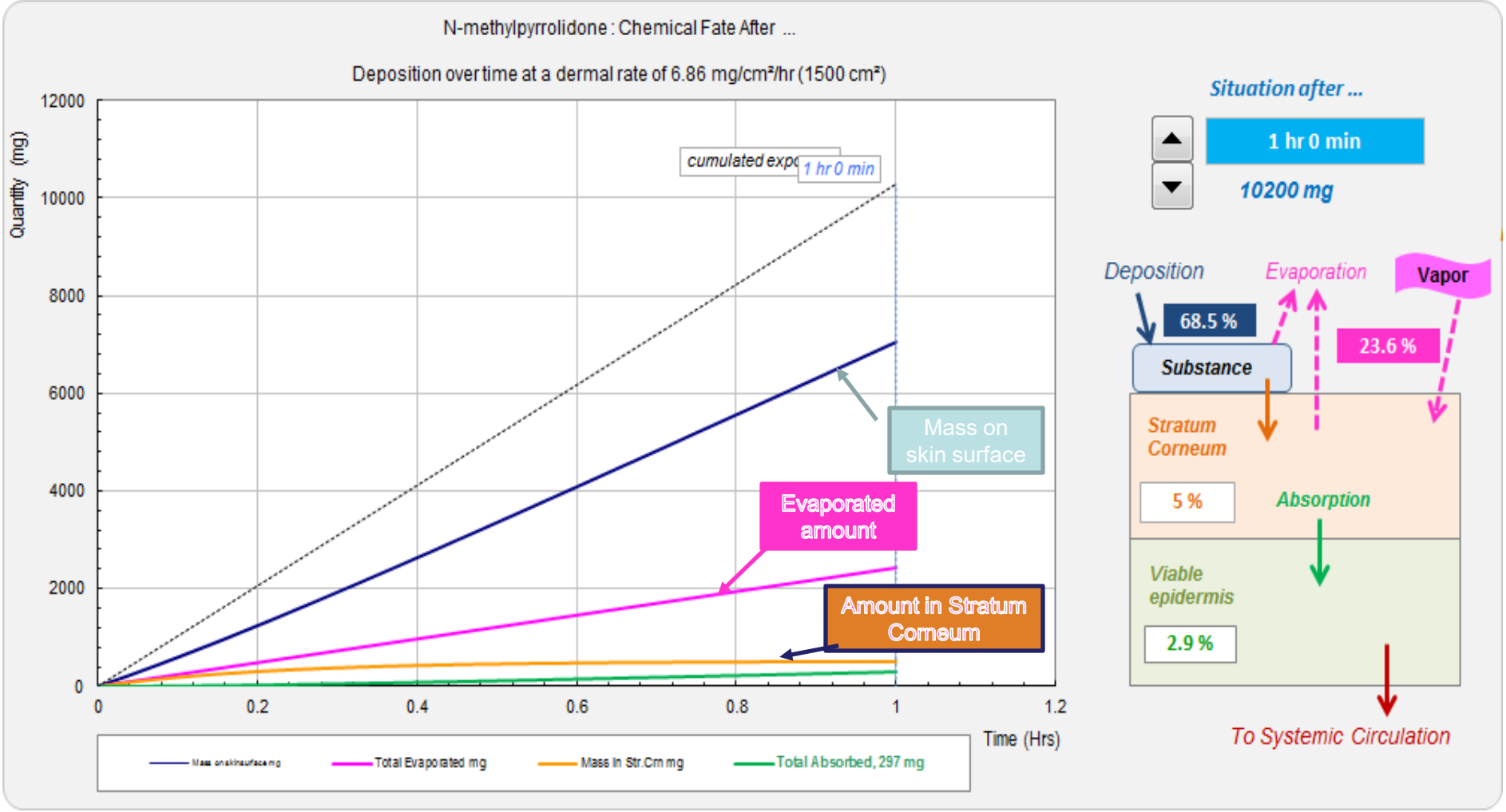
- Removing paint with NMP based solvent.
- Applied at a rate of 7.5 L/hr.
- Assume overspray lands on bare skin.
- Estimate NMP 10 ml/hr on skin.
- About how much NMP is absorbed into skin after 1 hour?

Scenario 2: Data Input

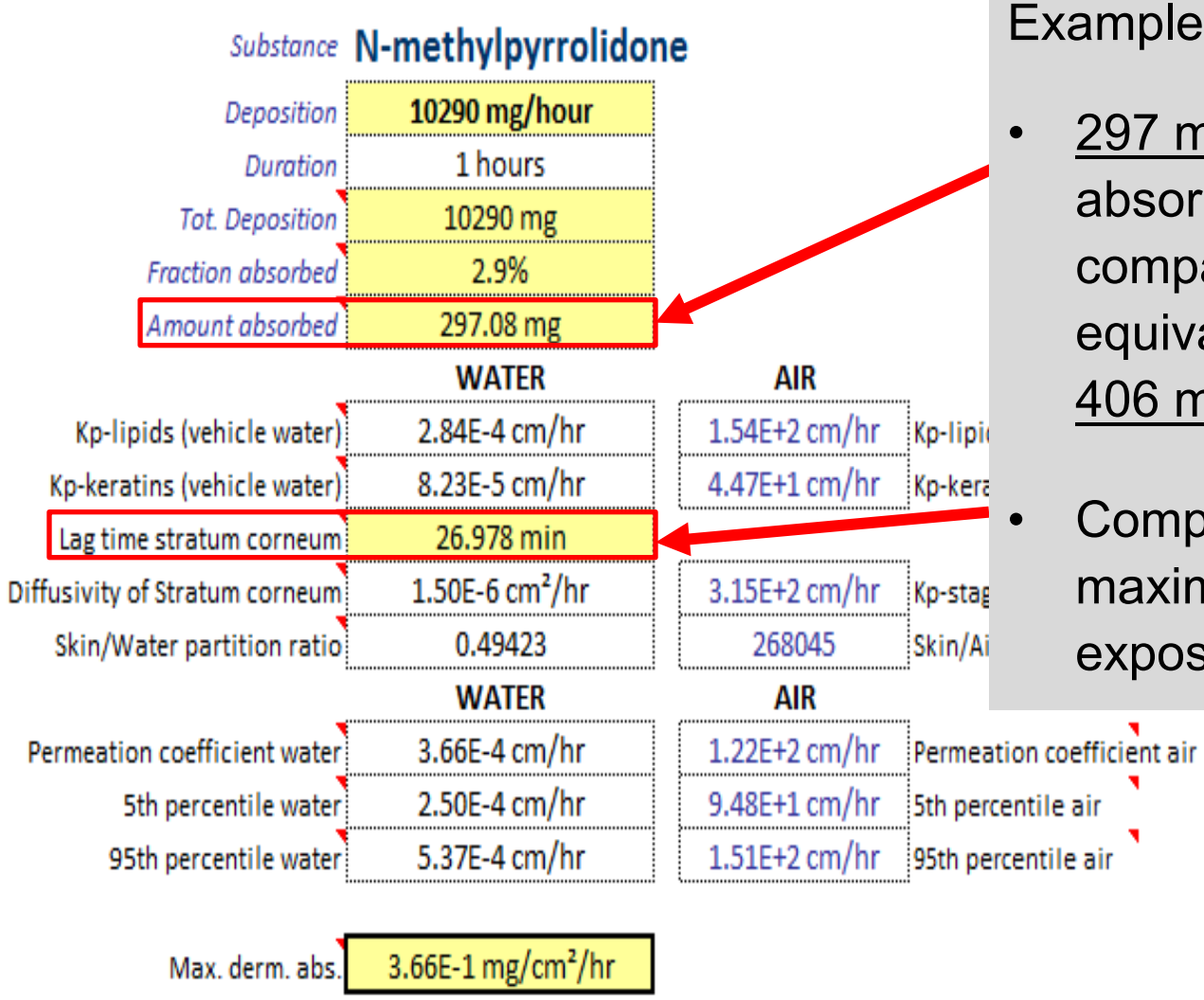
- volume: 10 ml
  - convert ml to mg (10,300 mg)
  - convert to rate (6.86 $mg/cm^2/hr$)
- skin surface area
  - (1500 cm^2)
  - thickness of stagnant skin air (1 cm)
- exposure duration
  - (1 hour)



Scenario 2: Graphical Results



Scenario 2: Numerical Results



Substance	N-methylpyrrolidone
Deposition	10290 mg/hour
Duration	1 hours
Tot. Deposition	10290 mg
Fraction absorbed	2.9%
Amount absorbed	297.08 mg

	WATER	AIR	
Kp-lipids (vehicle water)	2.84E-4 cm/hr	1.54E+2 cm/hr	Kp-lipi
Kp-keratins (vehicle water)	8.23E-5 cm/hr	4.47E+1 cm/hr	Kp-kera
Lag time stratum corneum	26.978 min		
Diffusivity of Stratum corneum	1.50E-6 cm²/hr	3.15E+2 cm/hr	Kp-stag
Skin/Water partition ratio	0.49423	268045	Skin/Ai

	WATER	AIR	
Permeation coefficient water	3.66E-4 cm/hr	1.22E+2 cm/hr	Permeation coefficient air
5th percentile water	2.50E-4 cm/hr	9.48E+1 cm/hr	5th percentile air
95th percentile water	5.37E-4 cm/hr	1.51E+2 cm/hr	95th percentile air

Max. derm. abs.	3.66E-1 mg/cm²/hr

Example considerations:

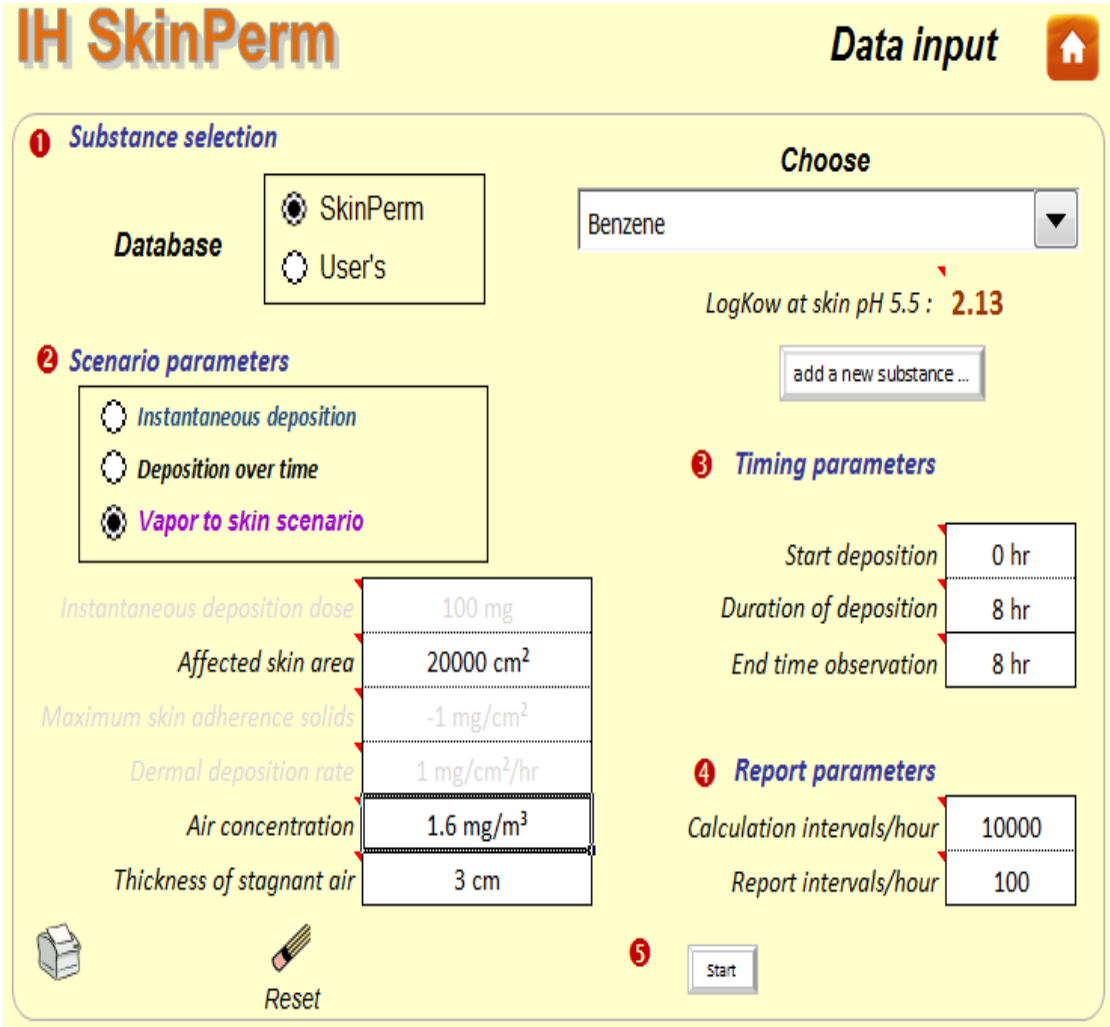
- 297 mg NMP dermally absorbed at 1 hour compared to OEL equivalent inhalation dose 406 mg.
- Compare NMP lag time for maximum absorption to exposure duration.

Scenario 3: Vapor to skin

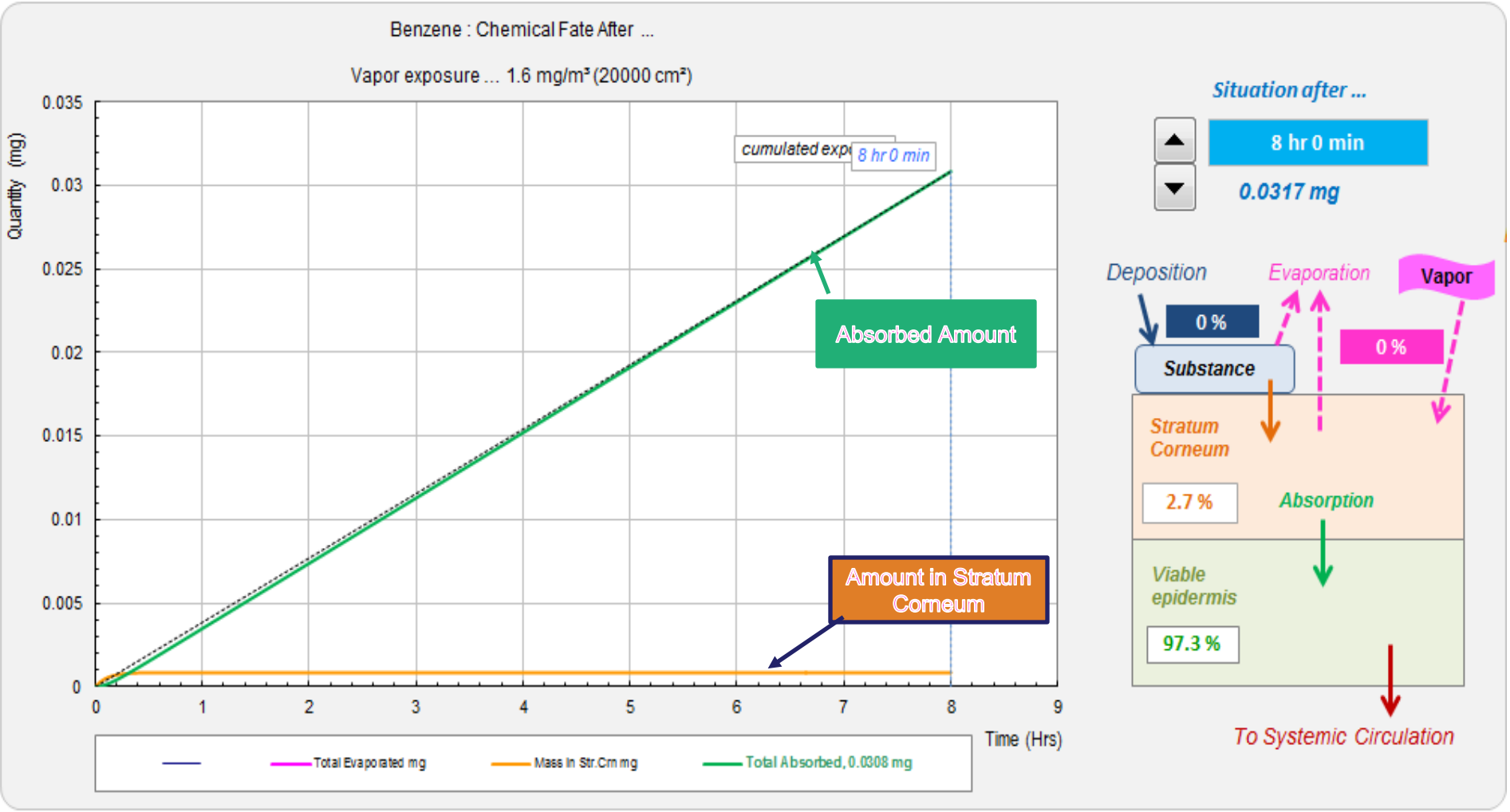
- 0.5 ppm benzene air concentration inside a storage tank.
- Airline respiratory protection used.
- Is there risk for skin absorption to the vapor?

Scenario 3: Data Input

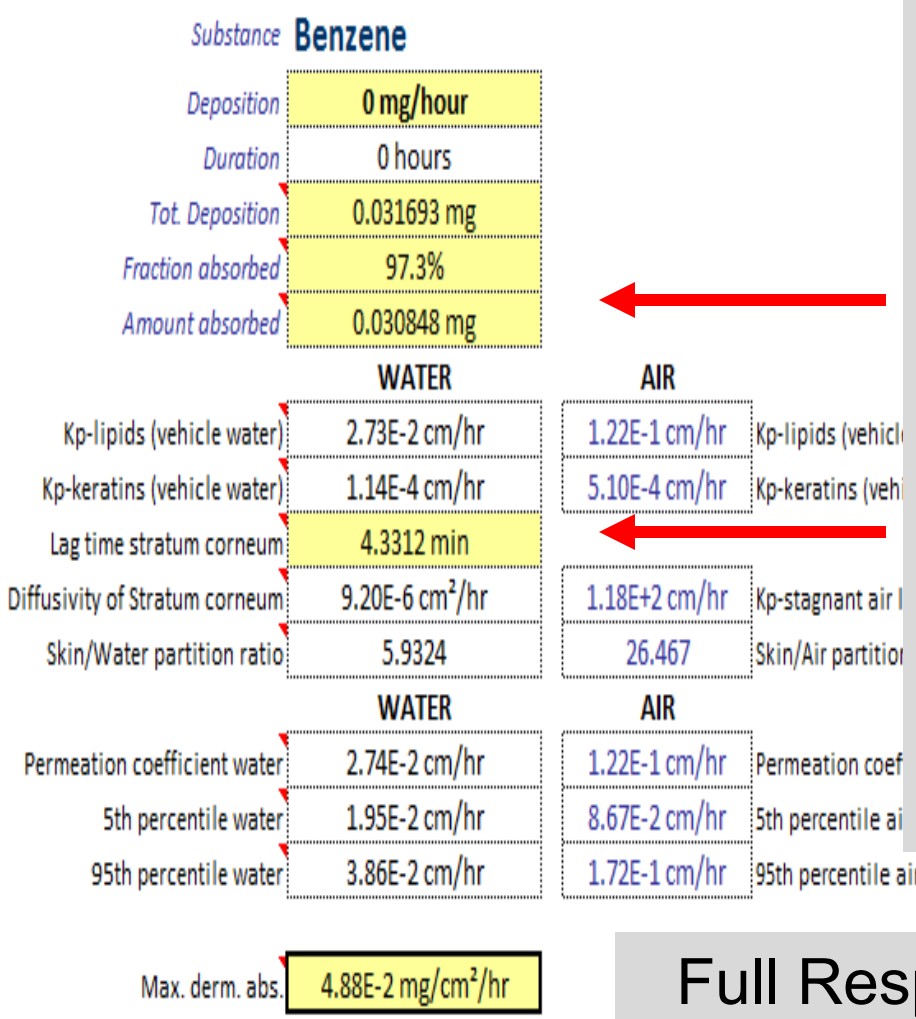
- air concentration
  - convert 0.5 ppm to mg/m^3
  - ($1.6\ mg/m^3$)
- worst case skin surface area
  - standard work clothing is used
  - ($20{,}000\ cm^2$)
  - thickness of stagnant air
  - (3 cm)
- exposure duration
  - (8 hour)



Scenario 3: Graphical Results



Scenario 3: Numerical Results



Substance	Benzene		
Deposition	0 mg/hour		
Duration	0 hours		
Tot. Deposition	0.031693 mg		
Fraction absorbed	97.3%		
Amount absorbed	0.030848 mg		
	WATER	AIR	
Kp-lipids (vehicle water)	2.73E-2 cm/hr	1.22E-1 cm/hr	Kp-lipids (vehicl
Kp-keratins (vehicle water)	1.14E-4 cm/hr	5.10E-4 cm/hr	Kp-keratins (veh
Lag time stratum corneum	4.3312 min		
Diffusivity of Stratum corneum	9.20E-6 cm^2/hr	1.18E+2 cm/hr	Kp-stagnant air l
Skin/Water partition ratio	5.9324	26.467	Skin/Air partitio
	WATER	AIR	
Permeation coefficient water	2.74E-2 cm/hr	1.22E-1 cm/hr	Permeation coef
5th percentile water	1.95E-2 cm/hr	8.67E-2 cm/hr	5th percentile ai
95th percentile water	3.86E-2 cm/hr	1.72E-1 cm/hr	95th percentile air
Max. derm. abs.	4.88E-2 $mg/cm^2/hr$		

Example considerations:

- 0.03 mg benzene vapor is dermally absorbed after 8 hours compared to OEL equivalent inhalation dose 16 mg.
- Compare benzene lag time for maximum absorption to exposure duration.

Full Respiratory protection provided 99.9% protection against benzene vapor for clothed whole body skin.

Comparison of IH SkinPerm to empirical data

Vapor Studies on Dermal Absorption

- IH SkinPerm predicted vapor absorption within a factor of 3 to values measured experimentally

Model Absorption Estimates

- Comparing maximum dermal absorbed dose rates from IH SkinPerm to data measured from in-vitro studies are generally within an order of magnitude

Reference: ten Berge WF. (2009). A simple dermal absorption model: Derivation and application. Chemosphere 75, 1440-1445

Dermal Modeling Limitations

Limitations to be considered when evaluating skin absorption with models.

- Assumes healthy not damaged skin
- The solution the substance is in can influence absorption
- Model assumes un-occluded conditions
- Most applicable to:
  - Log Kow -3 to 6
  - MW < 600

Summary

- IH SkinPerm can provide a useful starting point in quantitatively estimating risk from skin exposure under different scenarios
- Enables quantification of skin absorption with few properties (e.g. MW, Log Kow, VP, water solubility, density)
- Accounts for substance evaporation for better estimate of absorbed dose
- Graphical output promotes visual understanding
- Configured for language translation
- Free Download IH SkinPerm from AIHA EASC DPT Website

Risk Assessment and Control

Tying it all together!

Risk Assessment and Control

- Identify the hazard(s)
- Characterize the “exposure”
- Is there information about uptake through the skin?
- Compare “exposure” with some limit value
- Implement appropriate controls

Risk Assessment and Control

- Eliminate dermal hazards where possible
  - Use the IH hierarchy of controls
- Avoid contact with the skin
  - Enclose the process
  - Avoid immersion
  - Use tools rather than the hands
  - Control emissions to the air
- Protect the skin
  - Chemical protective gloves and clothing
  - Skin care
  - Pre-work creams if determined to be effective

Dermal Project Team

To create a broader understanding of dermal exposure assessment within the EASC, and determine how it can be utilized to build a more effective (comprehensive) exposure assessment and control program.

To determine how dermal exposure assessment truly fits into the AIHA model, and to modify the model as necessary to more appropriately address dermal exposure.

Thank You!

Questions?

Mark Betz, CIH, CSP
Director – EHS, Sustainability & Security

Kalsec
Allegan, MI

269 341 1673
mbetz@kalsec.com