Using Laboratory Data to Calculate Post-Decontamination Contact Hazards

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Introduction

Contact hazards are a result of personnel touching contaminated and decontaminated materials. How personnel interact with decontaminated assets determines the cumulative contact transferred dose. Laboratory data and results from the Decontamination System Performance Model (SPM) are used to demonstrate concepts and calculation approaches for contact transfer exposures. Contact transfer is a function of diffusive transfer across multiple materials, involves touch dynamics, and varies based on the properties of the contacting material. Laboratory results and simulations from the SPM are used to demonstrate how lab data could be used to evaluate contact exposures.

Contact Hazard Interpretation

- Current requirements use a health-based approach: decontaminants should reduce contact hazards below levels where negative health effects would be observed
- Contact transfer related health-based effects are a function of dose accumulated by personnel touch contaminated materials
- Requirements correspond to a skin surface concentration, though current calculation methods use material areas

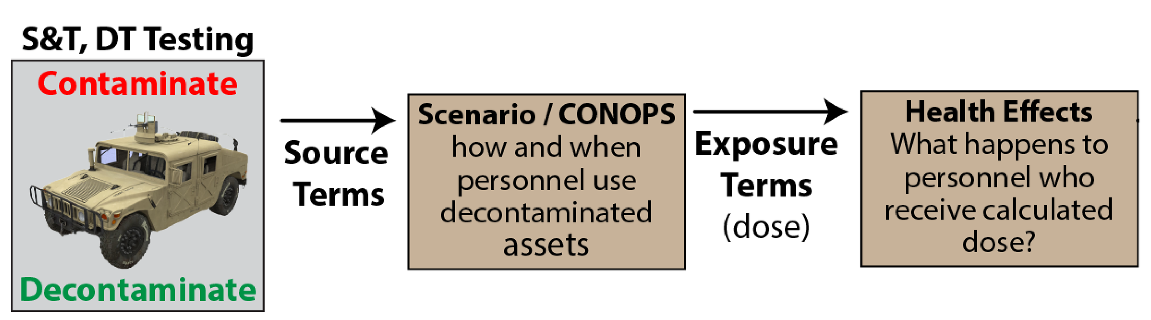
Example Contact Requirement

Derived Requirement	Threshold (T)
Thorough Decontamination Efficacy (Contact)	Decontaminate to the following Contact Exposure Levels: Nerve-G < 10 (mg/m²) Nerve-V < 0.3 (mg/m²) Blister-H < 15 (mg/m²)

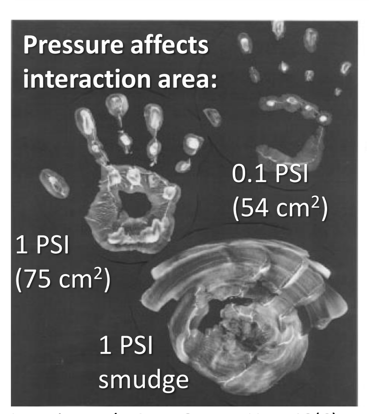
Values correspond to the average skin surface concentration if the toxicological dose were evenly distributed across the full body skin surface area of 1.8 m²

Interpretation of mg/m² → Material Area ☒ Current invalid interpretation
Interpretation of mg/m² → Skin Area ☑ Original value specification

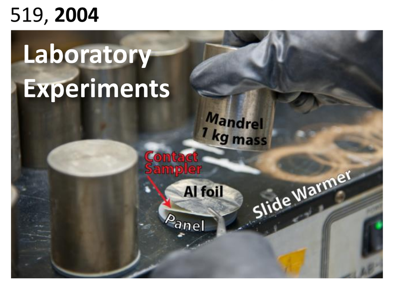
- Comparing (mass/material area) **is not a valid comparison** to (mass/skin area) specifications.
- Contact hazard assessment will move to exposure assessments and compare to dose metrics (mg/man)



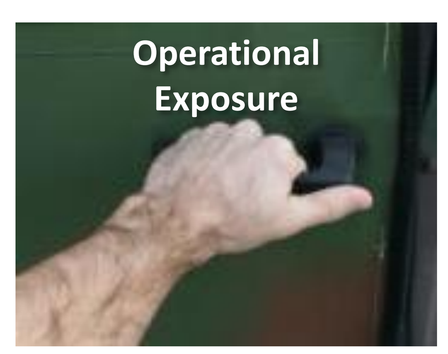
Contact Exposure Factors



Ivancic et al., Ann. Occup. Hyg. 48(6), 519, 2004



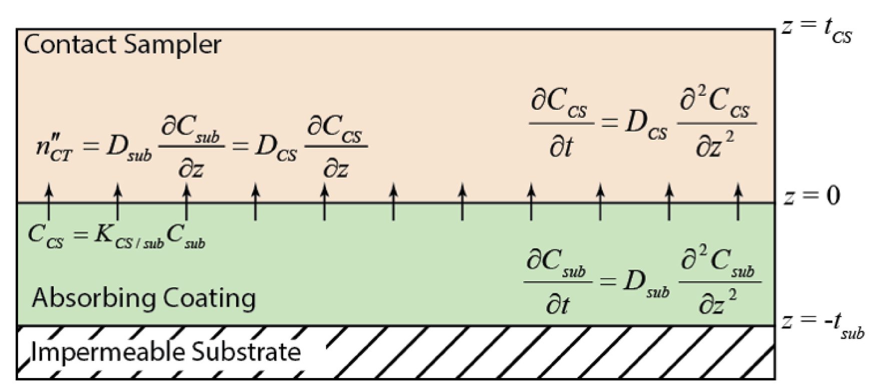
- Operational percutaneous exposure occurs when personnel touch contaminated materials
- Many factors affect the quantity of transferred mass (i.e., dose) including:
  a. Touch duration
  b. Contact area
  c. Number of touches
  d. Sample history (time since contamination, decontamination, previous touches)
  e. Operational effects such as pressure of the touch change the contact area

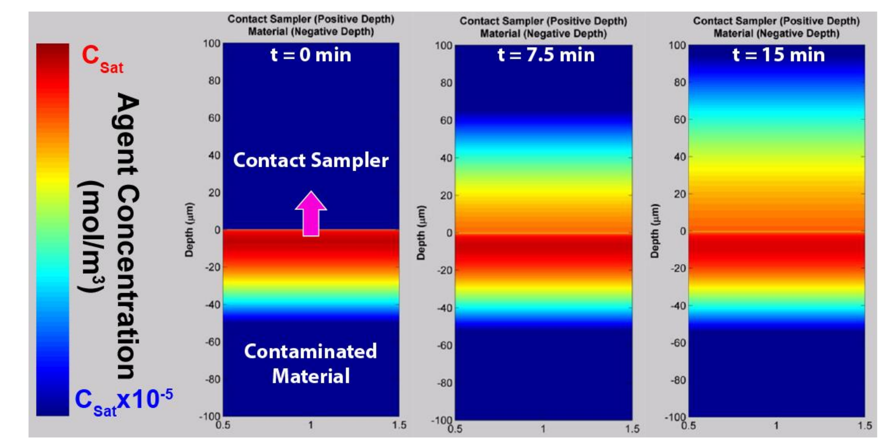


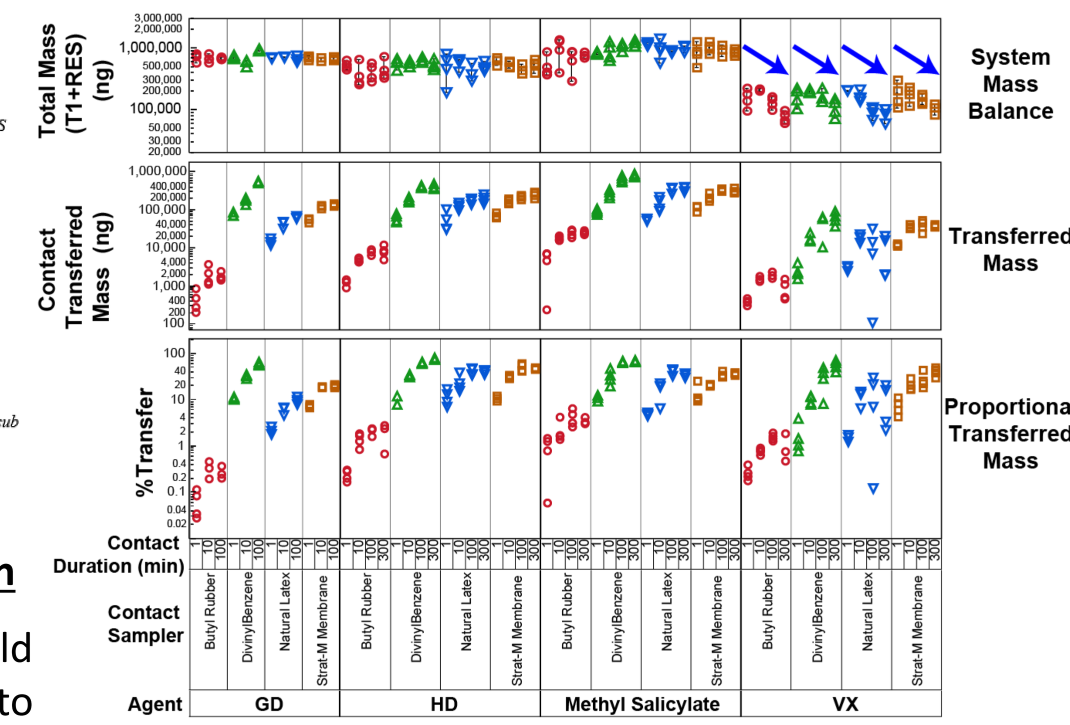
- Research aims to understand transfer mechanisms and dynamics to enable the use of laboratory data to determine an operational exposure dose that can be compared to toxicological data

Contact Transfer Dynamics

- Mass transfer is modeled using Fick's second law
- Contaminant mass is transferred from a material and accumulates in the contact sampler over time
- Total quantity (applied dose) and rate of transfer (dose rate) are based on the properties of the contaminant, contact sampler, contaminated substrate material, and contact duration, and distribution of contaminant in the material







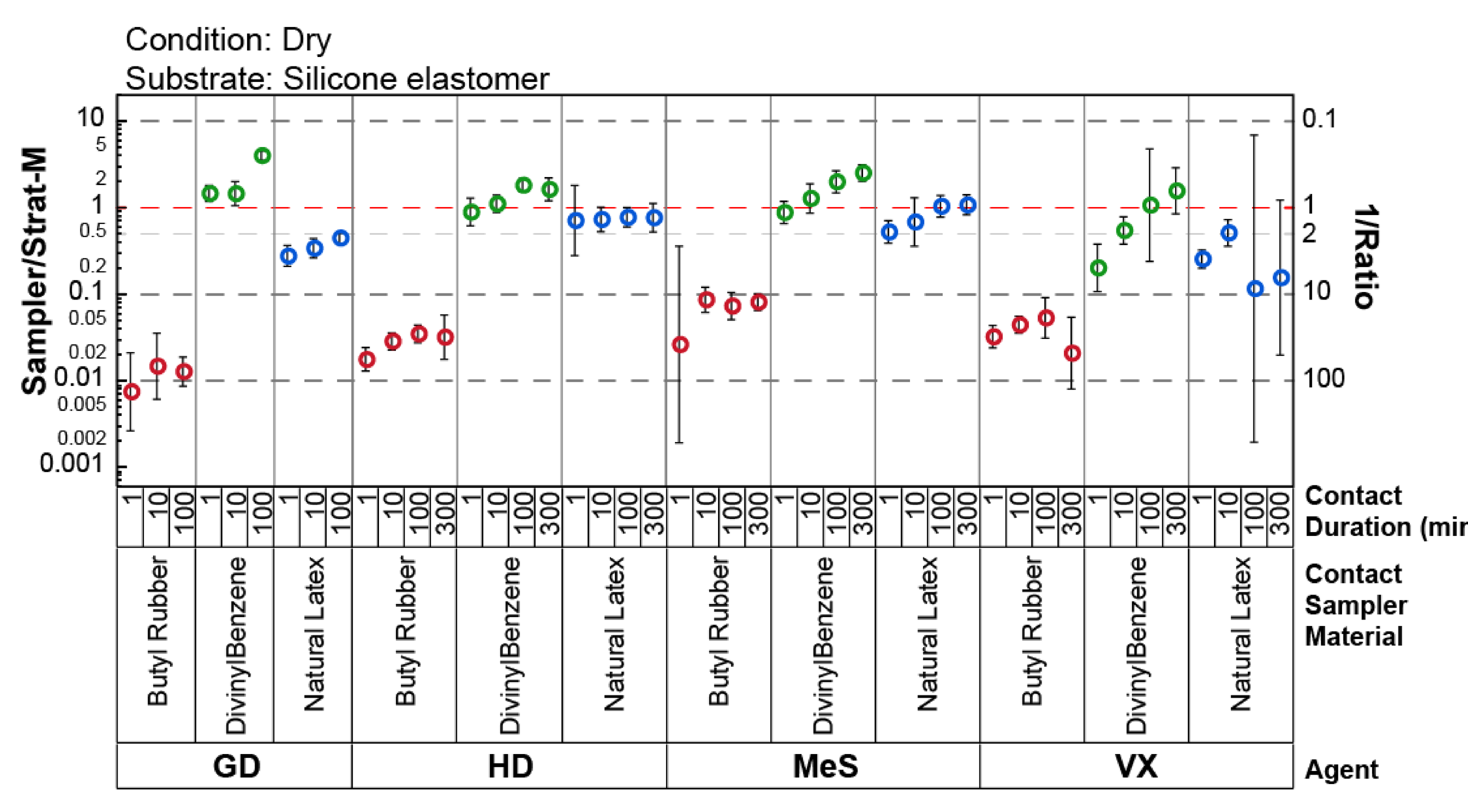
Contact Sampler Materials & Relation to Skin

- Contact exposure assessments should indicate the quantity of mass transferred to human skin
- Laboratory testing uses polymers to emulate skin
- Experiments performed to characterize contact transfer into various materials to provide initial sampler to skin correlation

Butyl Rubber – glove material
Latex – current lab sampler
Divinylbenzene – polymeric sampler
Strat-M – human skin simulant

Experiment

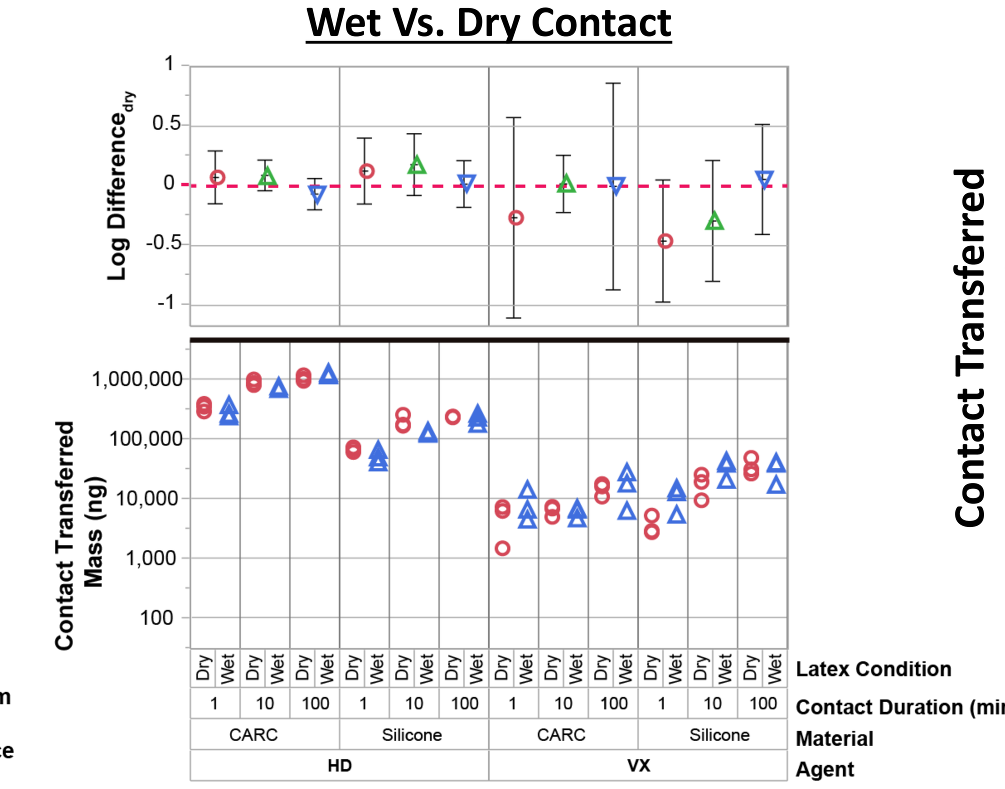
- A rubbery silicone polymer was contaminated with various chemicals to provide a contamination source with rapid material transport (minimize the substrate as being the rate limiting process)
- Panel was treated with a process to remove the bulk liquid and surface bound agent
- Contact sampler were placed in contact for variable contact durations

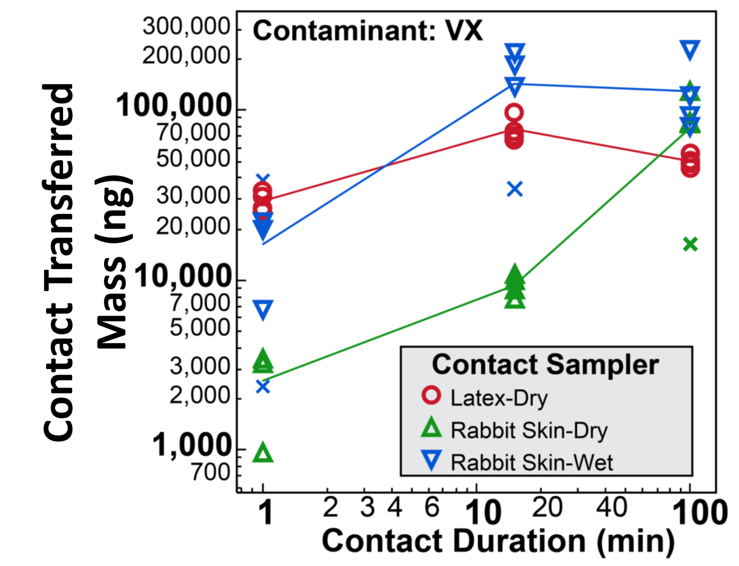


Results

- Contact sampler materials absorb different quantities of contaminant depending on chemical
- Ratio comparisons indicate similarity of samplers to Strat-M human skin simulant
- Data used to scale laboratory results to actual exposures with human skin

Wet Vs. Dry Contact

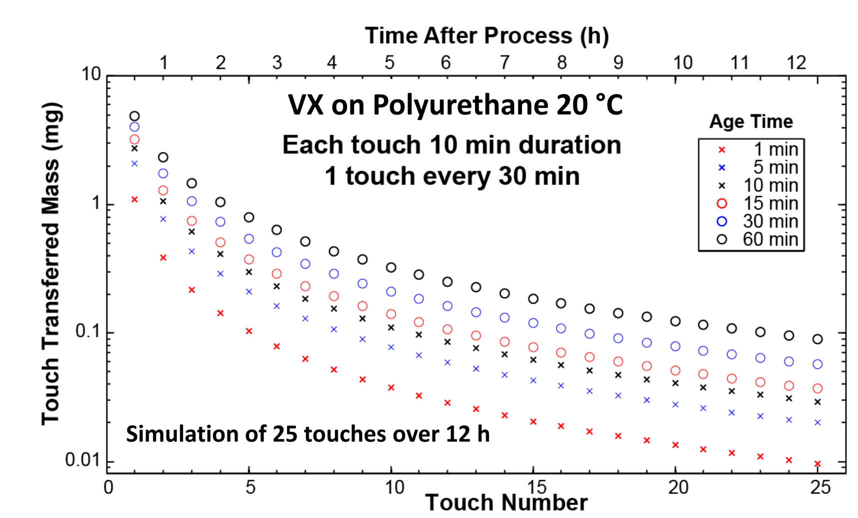


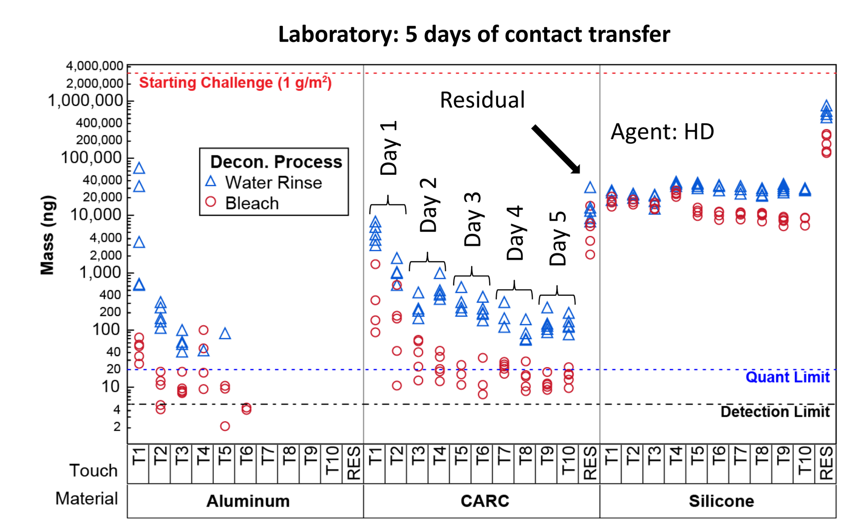


- Previous research demonstrated that dry vs. saline wetted skin (to emulate sweat) significantly affected contact transfer
- Similar testing using latex contact samplers did not exhibit the same response and understanding these effects is important for accurate human skin predictions

Effects of Sample History

- Each touch diminishes the quantity of chemical in the material and often results in each touch providing less contact transferred mass (left)
- Time duration that agent is in contact with the material (i.e., before decon) affects the magnitude of contact transferred mass
- Laboratory results illustrate model trends and demonstrate that contact hazards from materials can persist for weeks with or without decontamination with bleach (right)





Future Directions

- Determine mechanisms and parameters of contact transfer to facilitate the development of a simplified contact exposure assessment process for decontaminant and PPE evaluations
- Potential to link laboratory contact source terms to PBPK models

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