Hazard Management

Dstl

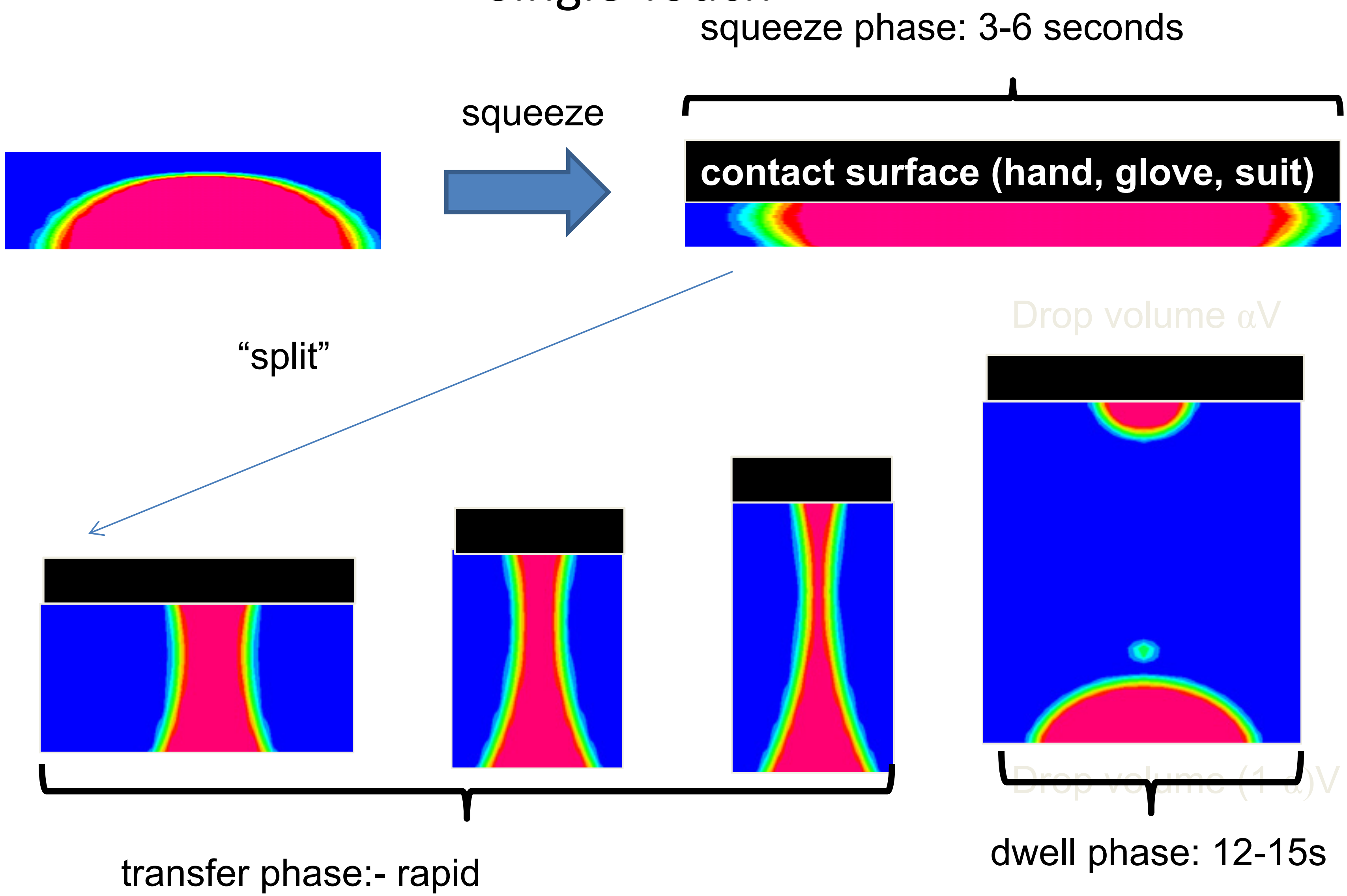
Requirements…

Improved technical and operational understanding of decontamination required to shape future military capabilities.

Need to better understand:

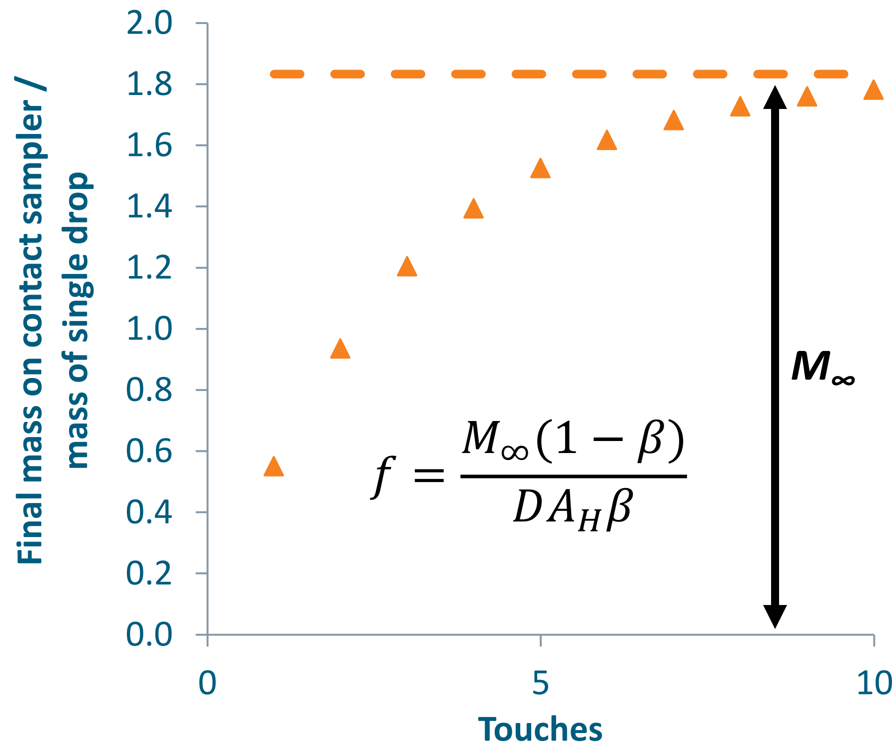
- An understanding of what is “clean enough” and the associated risks of operating ‘decontaminated’ equipment
- How clean can we actually get things?
- How long does this take, how much decontaminant and rinse water, how many people?
- Assessment of emerging technologies to determine scope for improved products and processes

Single Touch



Consecutive touches: transfer only

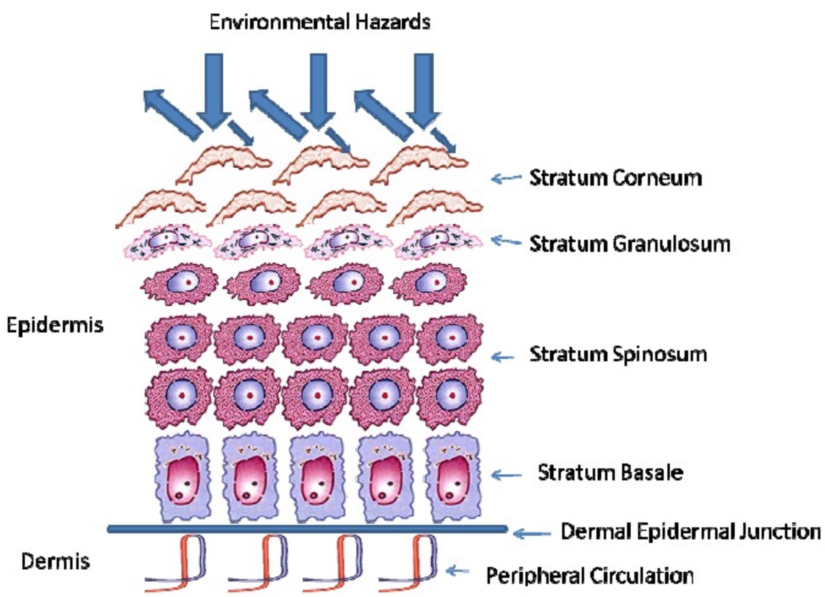
- Pre-decontamination: contamination density ***D*** gm[2], as drops of mass $\boldsymbol{M_0}$
- Post-decontamination: drops of mass $\boldsymbol{f.M_0}$
- During "touch", fraction ***β*** of each drop on hand transferred back to surface
- Total transferred mass tends asymptotically to constant value $\boldsymbol{M_\infty}$
- Area of hand in contact with surface $\boldsymbol{A_H}$ m[2]

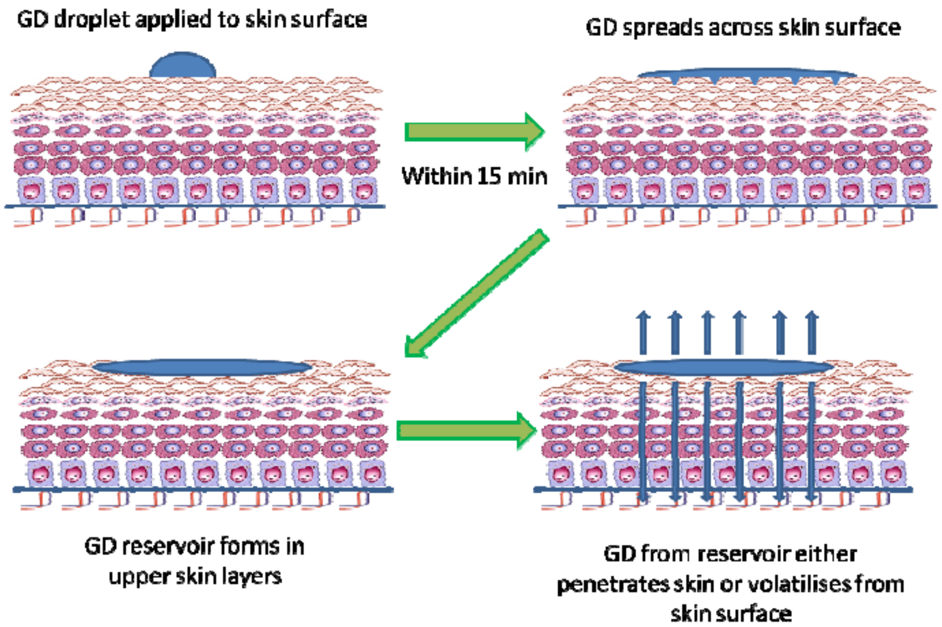


$$f = \frac{M_\infty(1-\beta)}{DA_H\beta}$$

- Same equations used to describe transfer of particles of explosives

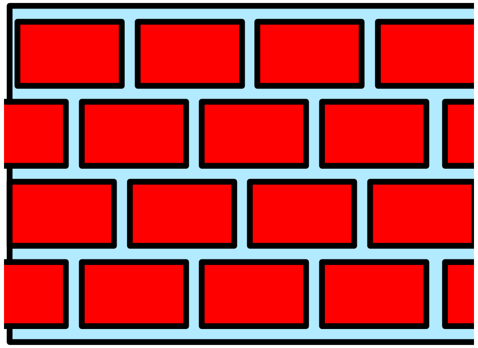
Chemical Warfare agents: skin penetration



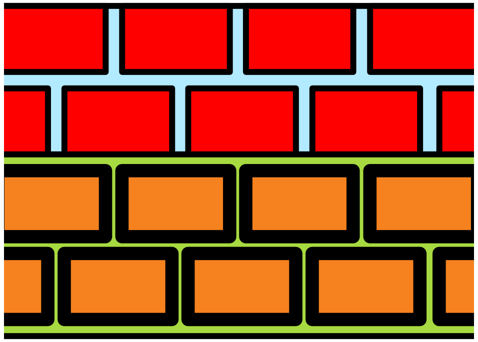


"Removal of Soman from Injured Skin by Haemostatic Materials", Dalton CH, PhD Thesis (University of Birmingham, UK), Oct. 2013

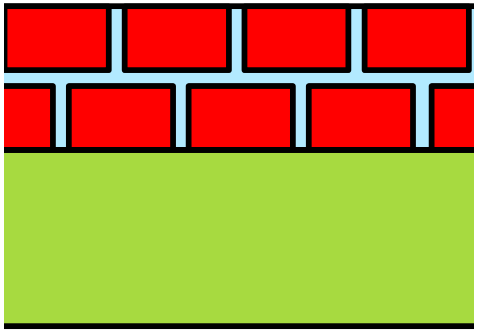
Modelling skin

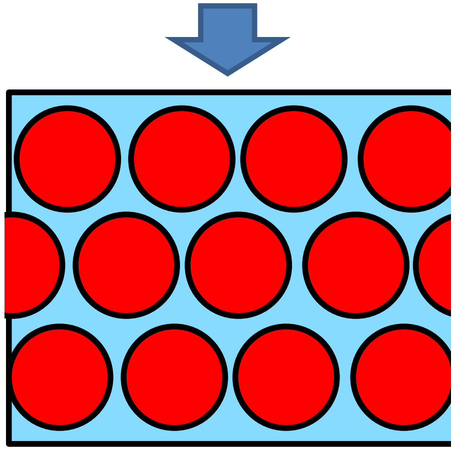


- “brick wall” model: - agent penetrates “cement”
- Diffusive transport into fluid-filled channels
- Characterised by “permeability” k_p (units distance/time)



- 2-layer model
- Different permeability constants
- Lower layer less permeable
- Initially, treat as impermeable

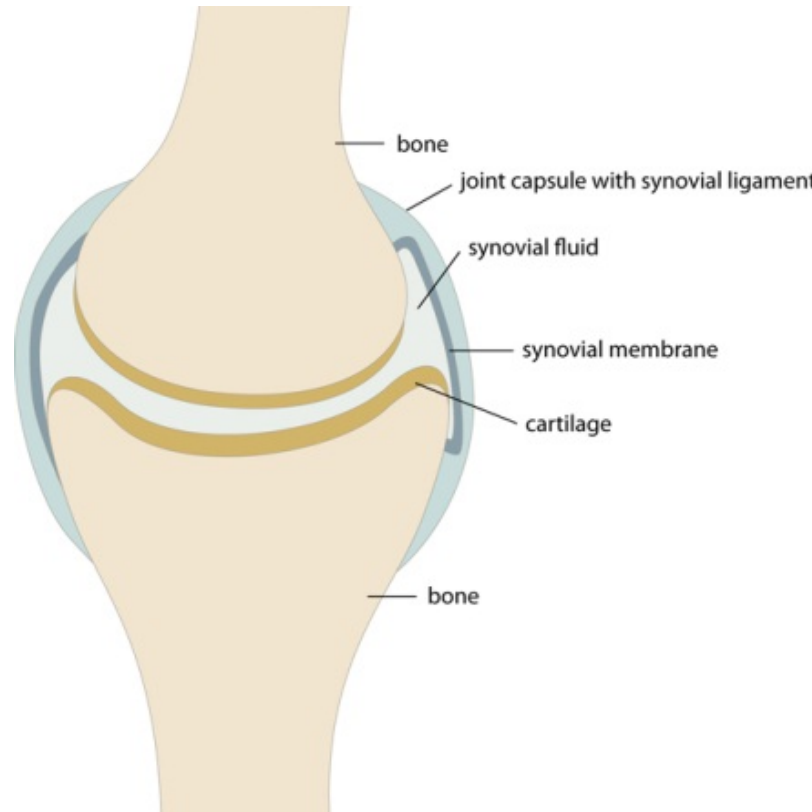




- Pressure effects: ***Darcy’s Law***
- Treat skin as “porous bed”
- Impermeable particles permeated by fluid
  - Fluid flow rate through bed related to applied pressure and fluid viscosity
  - Via “intrinsic permeability” ***k*** (units m^2)

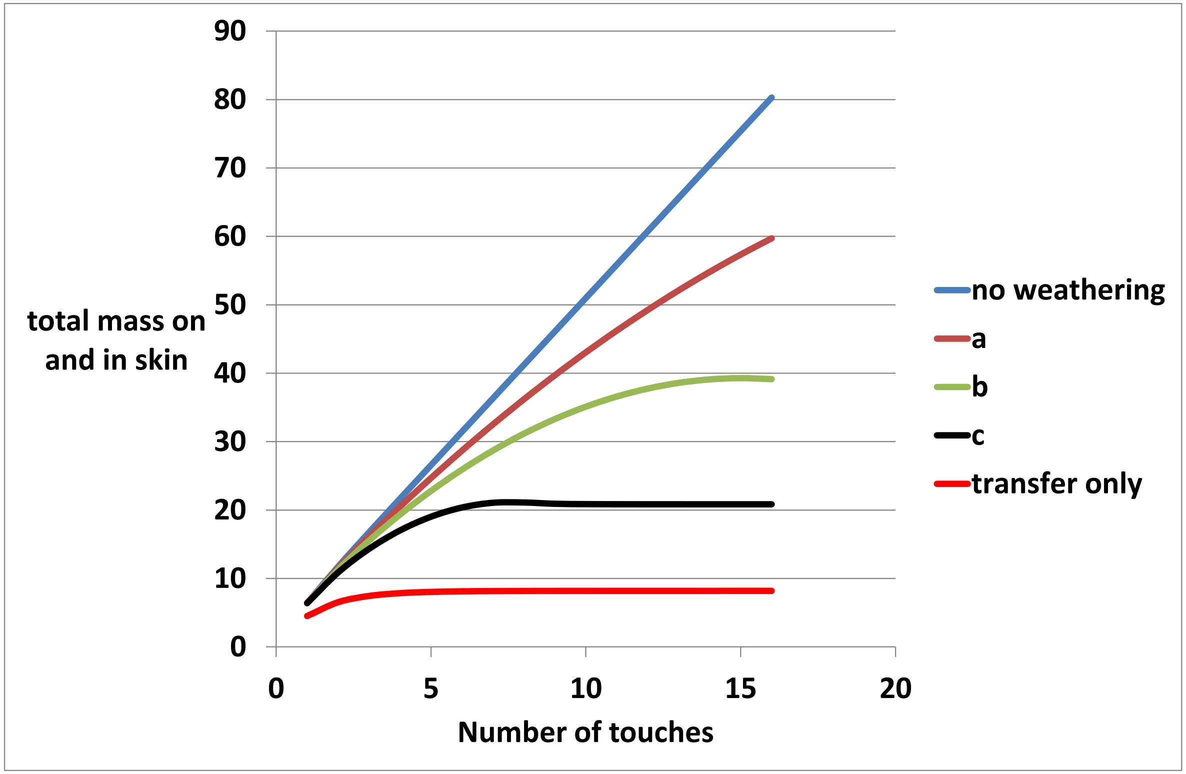
Squeeze flow over porous bed

- "Porous squeeze-film flow", Knox DJ, Wilson SK, Duffy BR and McKee S, IMA Journal of Applied Mathematics (2013)
- Treats cartilage as porous bed, characterised by Darcy's Law intrinsic permeability ***k***
- Femur applies constant force
- Synovial fluid experiences "squeeze flow"
- Radial velocity over porous bed non-zero
- Slip velocity depends on tangential stress
  - via ***k***
  - and Beavers-Joseph constant $\boldsymbol{\alpha_{BJ}}$ (dimensionless)



http://www.enpevet.de/Lexicon/

Towards the contact hazard



- Accumulated agent mass (schematic)
- "Weathering" completes in time required for

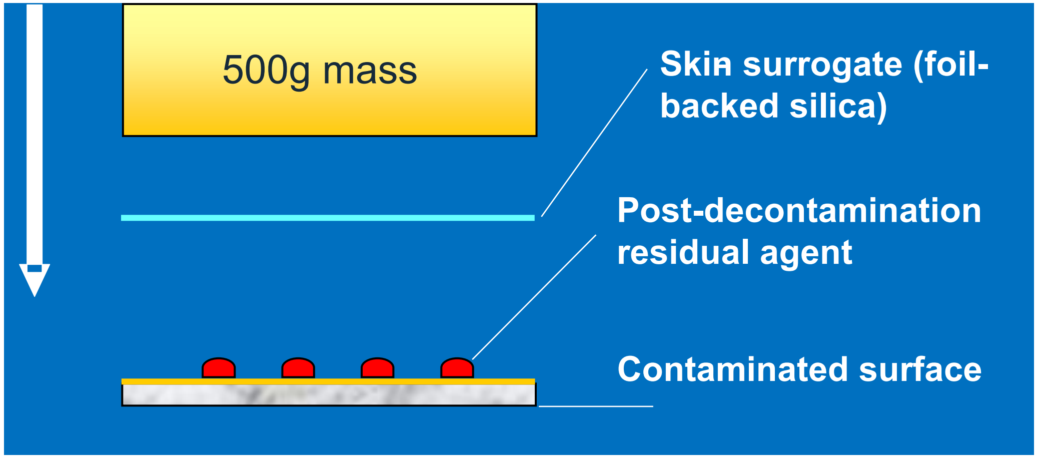
(a) 32 touches

(b) 16 touches

(c) 8 touches

Contact Hazard Test

- Surrogate skin contact sampler absorbs residual agent
- Intimate contact maintained by application of a weight for 15 minutes



- Limited number of experiments using porcine skin
- Silica skin surrogate absorbs ~ 10 times as much agent

- Can we relate results of this test to real-world consecutive touches situation?

- Would like to develop a better skin surrogate (probably a polymer0
- What properties of the polymer determine Darcy permeability?
- Does Beaver-Josephs slip parameter depend solely on surface roughness, or on polymer chemistry as well?

Model refinement: way forward

- Realistic weathering rates
- Agent transport into skin during dwell phase
- Realistic "touch"
  - Drop on skin may touch drop on surface
- Realistic drop distributions
  - "streaks" vs "drops"