Options for Broad Chemical and Biological Protection and Mission Effectiveness

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Operation Tomodachi

“The Joint Service Lightweight Integrated Suit Technology (JSLIST) and mask were not adequate for this mission due to permeability.” Page 25

Initial Impressions Report, February 2012, Operation Tomodachi, Observation Insights, and Lessons

https://www.globalsecurity.org/military/library/report/call/call_12-08.pdf

U.S. UNCLASSIFIED

Operation United Assistance

“Recommendation for use in Ebola Outbreak Area: The JSLIST is a permeable protective garment; therefore, it is not an appropriate capability for use in the Ebola outbreak area…”

Joint Project Manager Protection (JPM P):

Individual Protective Equipment (IPE) and Personal Protective Equipment (PPE)

Capabilities and Suitability Recommendations in Support of the Ebola Virus Response

Revision 10 October 2014

The JPEO-CBD point of contact for all Ebola related inquiries is Mr. Mike Bailey

Salisbury, UK

"Ultimately, we believe that CBW [Chemical and Biological Warfare] agents will be … more capable, particularly in terms of their ability to defeat current or currently-emerging defensive countermeasures ... "

Occasional Paper 10: The Future of Weapons of Mass Destruction: Their Nature and Role in 2030

John P. Caves, Jr., and W. Seth Carus

Page 28

Center for the Study of Weapons of Mass Destruction

National Defense University

EXPERIENCES

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Balance of Thermal Burden and Protection … also need to consider Mission Effectiveness

- Threat landscape is ever changing
- Broad Protection is needed to ensure protection against the various types and forms of the agents
- Protection must be consistent and functioning even in light of the following: Applied Pressure, Environmental/External Contaminates, and Internal Contaminates
- Protection alone is not enough; for mission effectiveness you need to also consider the thermal burden of the system, weight, bulk, mobility

BALANCE & EFFECTIVENESS

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TRADITIONAL CHEMICAL & BIOLOGICAL PROTECTIVE CLOTHING SOLUTIONS

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Air and Moisture Vapor Impermeable

- Properly designed ensembles can provide broad protection
  - Material is a physical barrier to protect the user
  - Ensemble verification of protection is needed:
    - Material Level testing on bulk material, as well as on seams
    - System Level testing to verify garment design and construction
- Impermeable - greatly reduce heat dissipation - increase the risk of heat injury
  - " Evaporative heat loss becomes more important as ambient temperature increases, and accounts for all body cooling when ambient temperatures are equal or above skin temperatures."
    USARIEM TECHNICAL REPORT T13-3

Reference:http://www.dtic.mil/dtic/tr/fulltext/u2/a571324.pdf

AIR AND MOISTURE VAPOR IMPERMEABLE SYSTEMS

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- Air Permeable - Dissipation of Heat - Reduce the risk of heat injury compared to air impermeable and moisture vapor impermeable systems
- Lacks a continuous physical barrier to small particles and low surface tension liquids
- On 10OCT2014 the Joint Program Manager for Protection (JPM-P) in the United States recommended against the use of air-permeable systems for use in the Ebola Outbreak Area[1]
  - Current Air Permeable systems do not meet:
    - Liquid tight integrity shower test (per NFPA 1994 or 1999)
    - Viral Penetration Resistance

1) Reference: Mr. Michael A. Bailey, JBEO-CBD "Joint Project Manager Protection (JPM P): Individual Protective Equipment (IPE) and Personal Protective Equipment (PPE) Capabilities and Suitability Recommendations in Support of the Ebola Virus Response Revision 10 October 2014"

Legacy Carbon based Air Permeable

AIR PERMEABLE SYSTEMS

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Air and Moisture Vapor Impermeable

Legacy Carbon based Air Permeable

TRADITIONAL CHEMICAL & BIOLOGICAL PROTECTIVE CLOTHING SOLUTIONS

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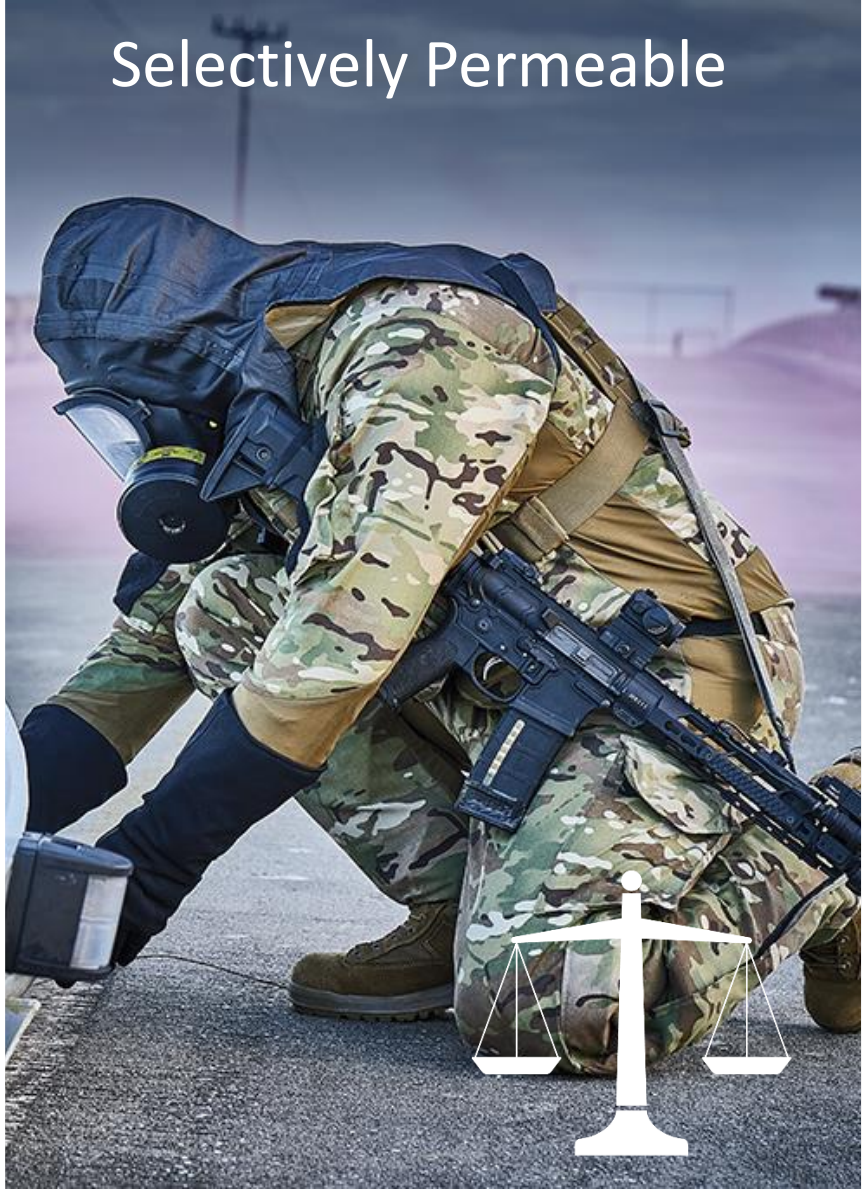
Air and Moisture Vapor Impermeable



Selectively Permeable

Legacy Carbon based Air Permeable

TRADITIONAL CHEMICAL & BIOLOGICAL PROTECTIVE CLOTHING SOLUTIONS

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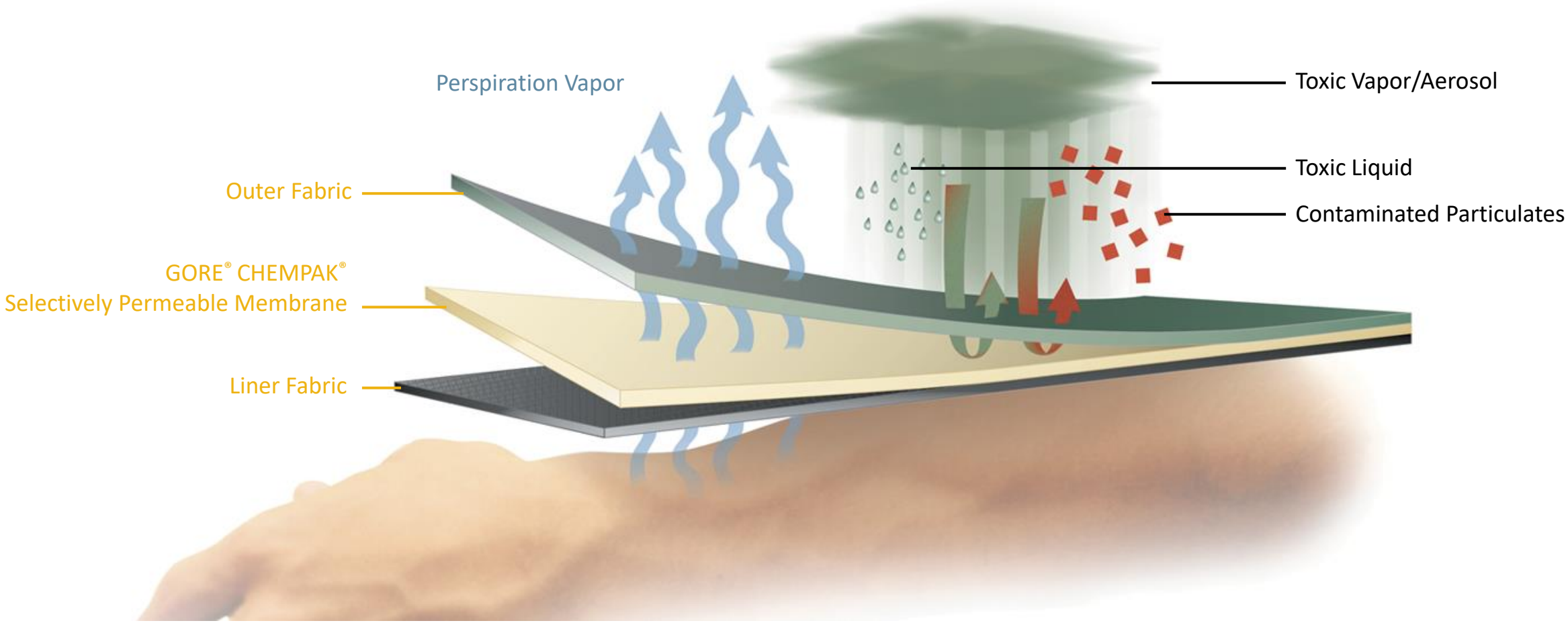

GORE® CHEMPAK® SELECTIVELY PERMEABLE MATERIAL (SPM) PRODUCTS

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- Vapor Permeation Protection
- Aerosol Protection
- Toxic Industrial Chemicals
- Liquid Protection
- Thermal Burden Performance
- Enhanced Mission Effectiveness

BROAD PROTECTION WITHOUT A TRADEOFF IN THERMAL BURDEN PERFORMANCE

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Traditional Carbon Technology

DEGRADATION IN WHOLE-BODY VAPOUR PROTECTION PERFORMANCE OF AIR-PERMEABLE PROTECTIVE ENSEMBLES WITH INCREASING WIND SPEED

Dr Scott Duncan[1] and Dr Eva Gudgin Dickson[2]
[1]Defence Research Establishment Suffield, PO Box 4000 Stn Main, Medicine Hat, Alberta, Canada TIA 7R2
[2]The Department of Chemistry and Chemical Engineering. The Royale Military College of Canada, Kingston, Ontario, Canada K7K 2

GORE® CHEMPAK® Fabrics

GORE® CHEMPAK® SPM Products are air impermeable and the protective performance property are independent of wind speeds.

VAPOR PROTECTION IN ALL CONDITIONS

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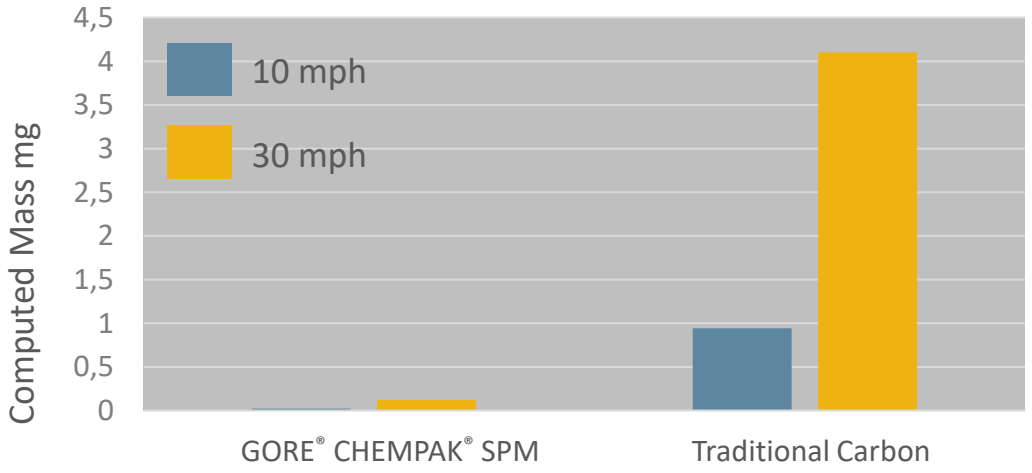
- Protection from particulates and wind driven contaminated sand
- Protection from aerosolized biological or chemical agents

AEROSOL PARTICLE DEPOSITION



Testing conducted at Research Triangle Institute (RTI). Exposure controlled to yield a total exposure CT of ~ 4,500 mg*min/m^3

AEROSOL PROTECTION

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Chemical Compound	Allowed Permeation	GORE® CHEMPAK® SPM Products	Traditional Carbon Technology
Ammonia (g)	6.0 mg/cm^2	< 6.0 mg/cm^2 Pass	< 6.0 mg/cm^2 Pass
Chlorine (g)	6.0 mg/cm^2	< 6.0 mg/cm^2 Pass	> 6.0 mg/cm^2 Fail
Acrolein (g)	6.0 mg/cm^2	< 6.0 mg/cm^2 Pass	< 6.0 mg/cm^2 Pass
Acrylonitrile (g)	6.0 mg/cm^2	< 6.0 mg/cm^2 Pass	< 6.0 mg/cm^2 Pass
Dimethyl Sulfate (l)	6.0 mg/cm^2	< 6.0 mg/cm^2 Pass	> 6.0 mg/cm^2 Fail

Testing conducted following the NFPA 1994 Standard on “Protective Ensembles for First Responders to CBRN Terrorism Incidents” 2018 Edition. Challenge density, chemical list, and times reflect the minimum performance standards allowed for a Class 3 Certified Material. Testing conducted at Proqares a TNO Company.

TOXIC INDUSTRIAL CHEMICALS

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GORE® CHEMPAK® Products provide a physical barrier to liquid entry when paired with appropriately designed respirators.

BENEFITS OF LIQUID INGRESS INTEGRITY:

- Protection from exposure to hazardous liquid chemicals
- Protection from exposure to liquid biological agents
- Facilitates effective liquid decontamination

LIQUID PROTECTION

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THERMOREGULATORY BALANCE

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Radiative Transfer Equation

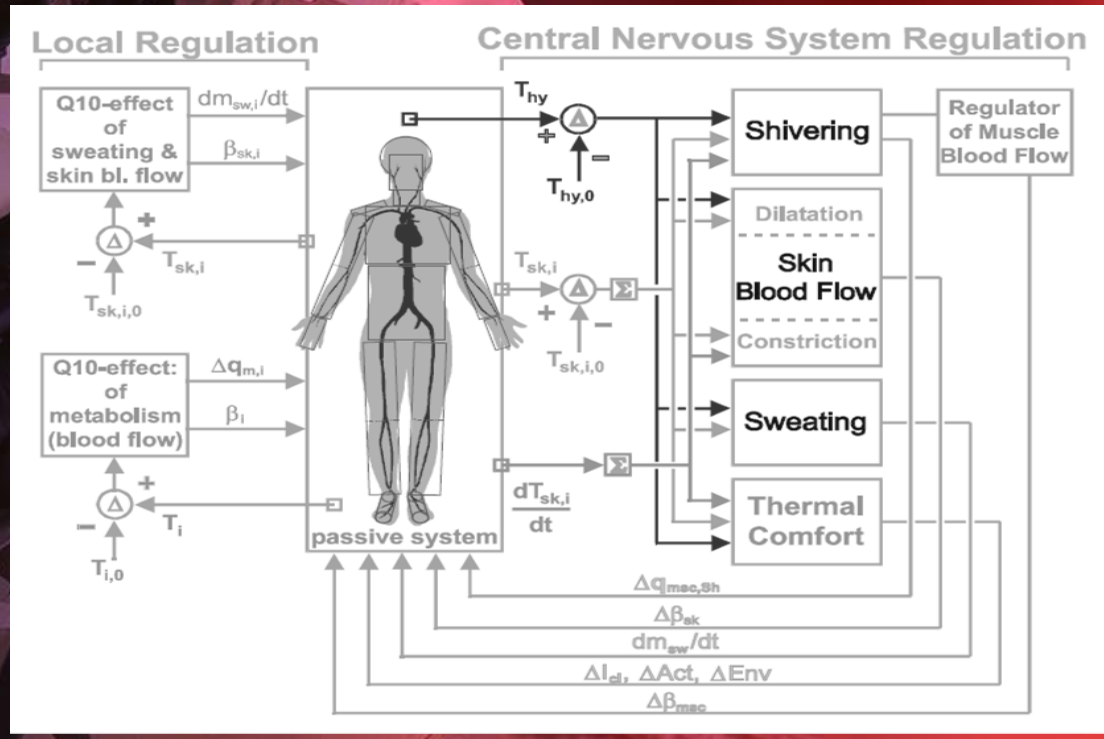
$$\frac{dI(\vec{r},\vec{s})}{ds}+(a+\sigma_s)I(\vec{r},\vec{s})=an^2\sigma\frac{T^4}{\pi}+\frac{\sigma_s}{4\pi}\int_o^{4\pi}I(\vec{r},\vec{s})\Phi(\vec{s}\cdot\vec{s}')d\Omega'$$

Storage

$$\frac{\partial}{\partial t}\left(\rho\int_{Tref}^{T}c_p dT\right)$$

Pennes Bioheat transfer

$$(\rho c_P)_t\frac{\partial T_t}{\partial t}=\frac{k_t}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T_t}{\partial r}\right)+\dot{Q}_p'''+\dot{Q}_m'''$$



Conduction

$$Qc=A\nabla\left(k_{ij}\nabla T\right)$$

Evaporation

$$Qe=h_{vap}\,A\,\frac{D\cdot(\Delta C)}{x}$$

HEAT BALANCE

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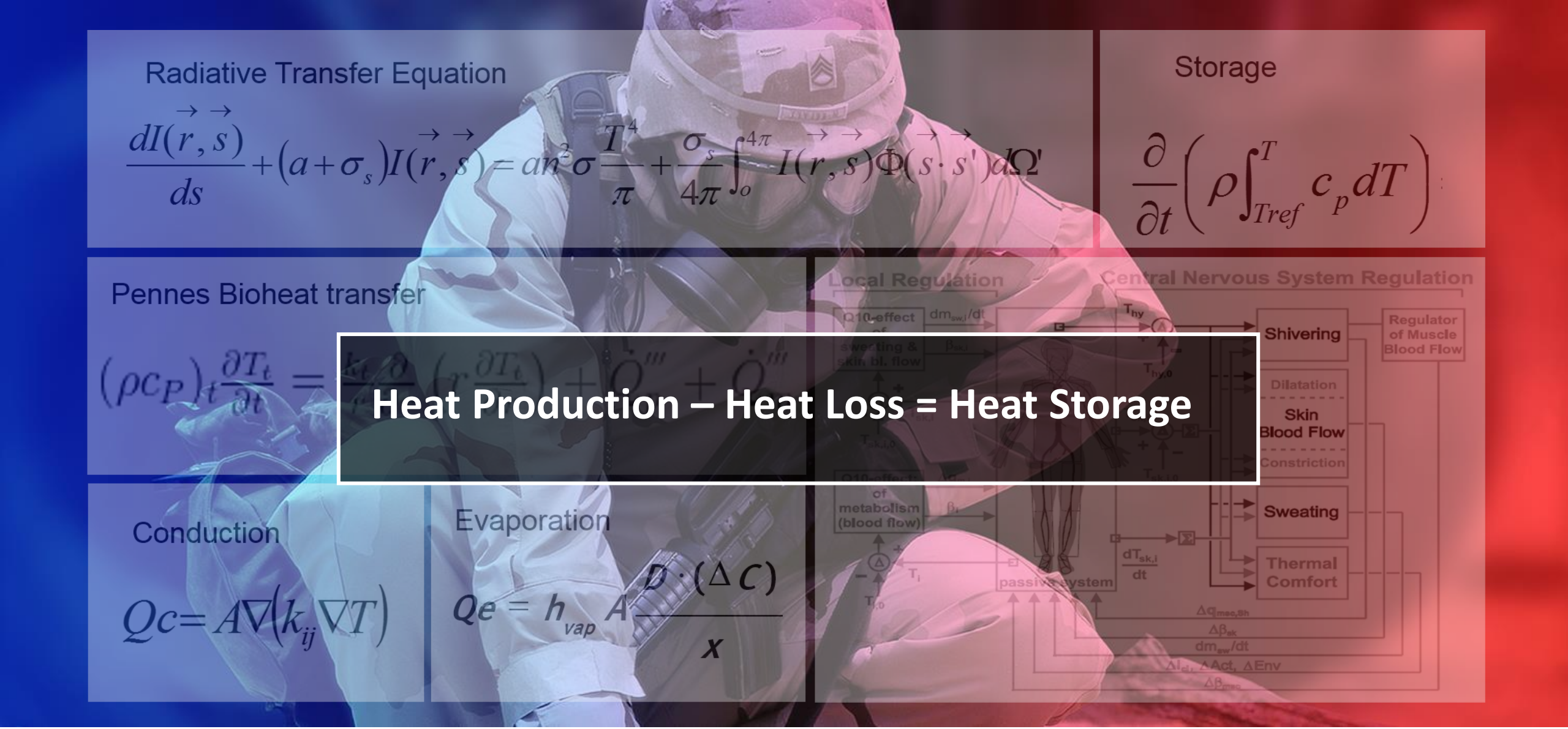

HEAT BALANCE

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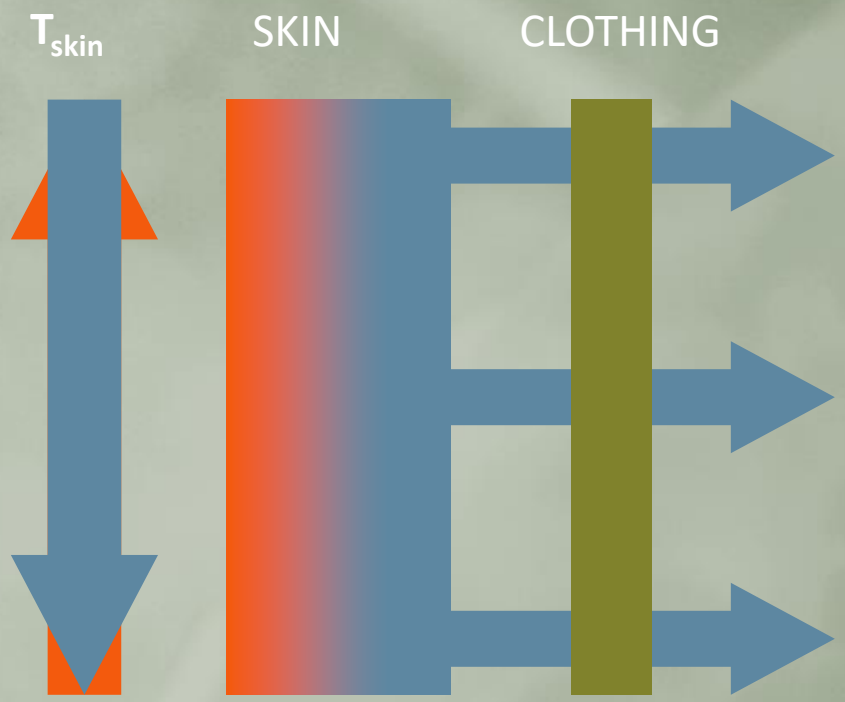

Sweat evaporation is an efficient heat removal process because vaporizing sweat pull heat out of the skin.

2420 J/g evaporated water x

1000 g/hr sweat rate =

670 W heat loss

ISO 11092 Testing of GORE® CHEMPAK® SPM Materials yield a result of 8.3 m^2*Pa/W.
This Ret is comparable to Traditional Carbon Technology values.

HEAT LOSS IN MOISTURE VAPOR PERMEABLE CLOTHING

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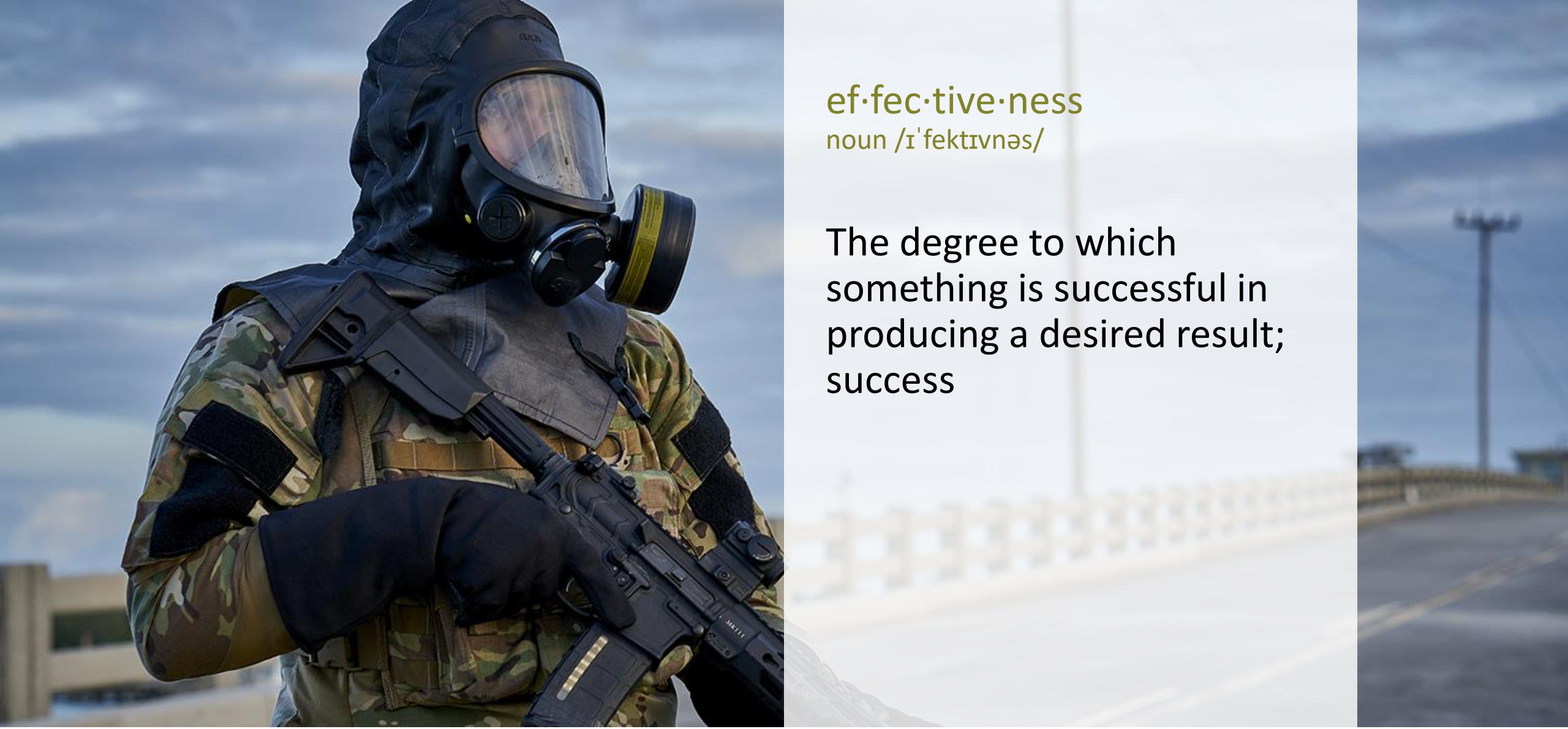

ef·fec·tive·ness
noun /ɪˈfektɪvnəs/

The degree to which something is successful in producing a desired result; success

EFFECTIVENESS

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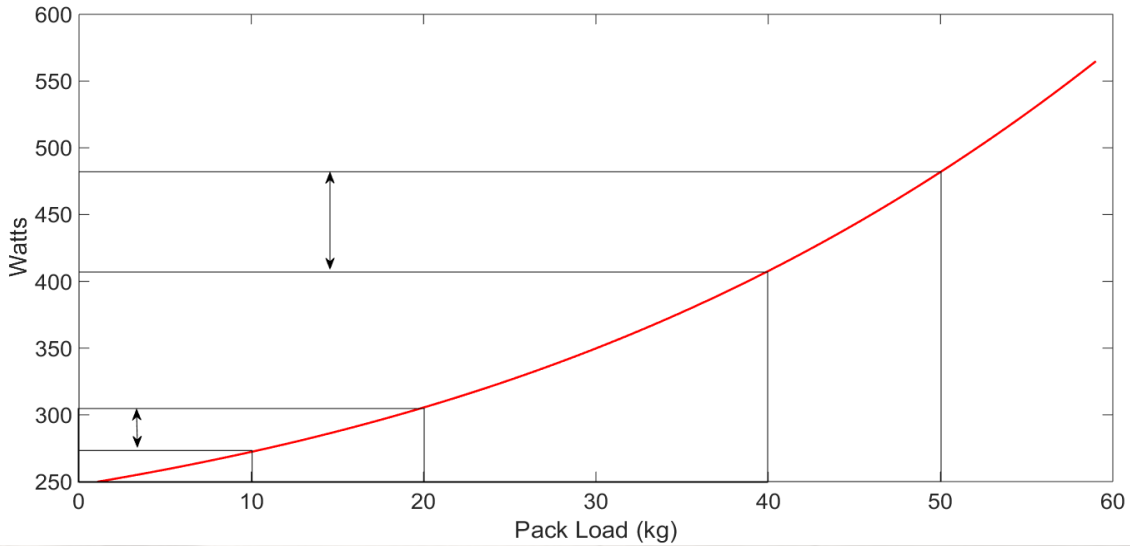
- Ability to manipulate and interact with your external environment
- Ensemble Bulk
- Weight
  - How much
  - Where it is



WHAT ELSE MATTERS AND WHY DOES IT MATTER?

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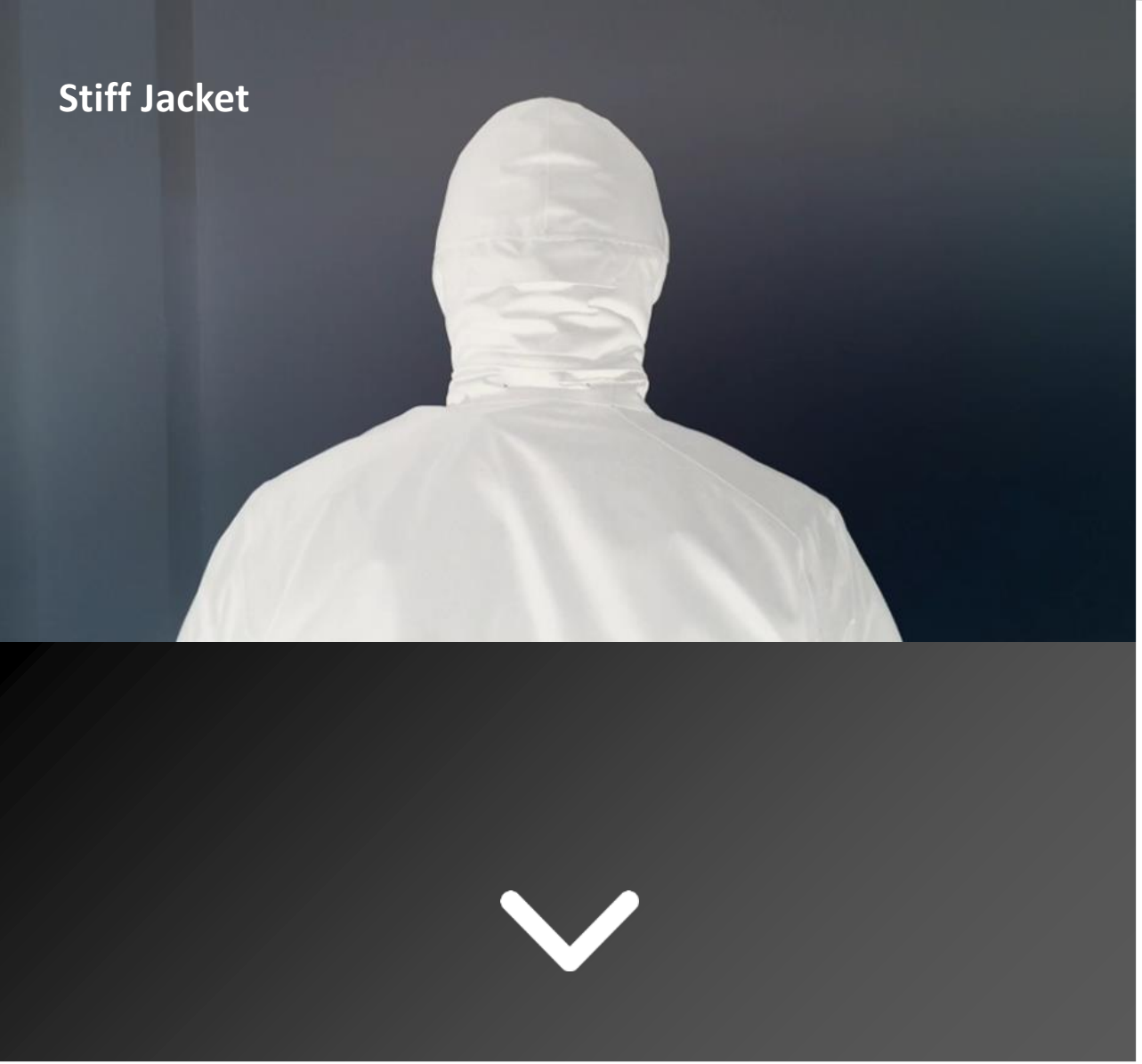

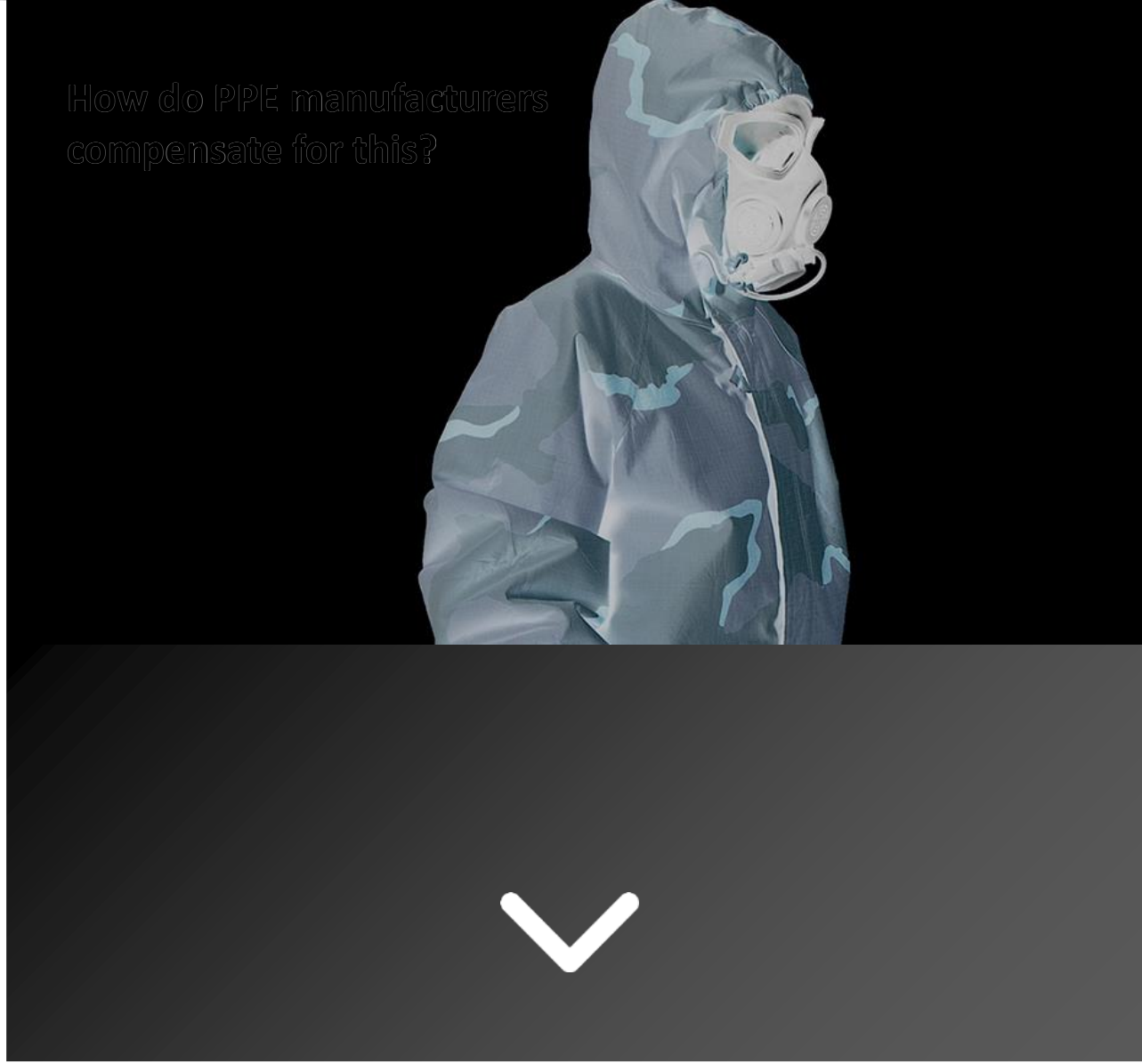

ERGONOMIC DISCOMFORT

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ELASTICITY

- No restriction of ROM
- Lower pressure against the skin
- Lower force necessary to move

SOLUTION

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INCREASED MISSION EFFECTIVENESS

- Broad protection
- Increased mobility
- Increased speed/agility
- Better thermal burden
- Reduced weight
- Reduced bulk and better pack
- Better interaction/manipulation of external environment
- Important Considerations:
- Proper fit (sizing) of the garment is critical for maximum performance

CPCSU-2 Flex Fit Design

GORE® CHEMPAK® PRODUCT OFFERINGS

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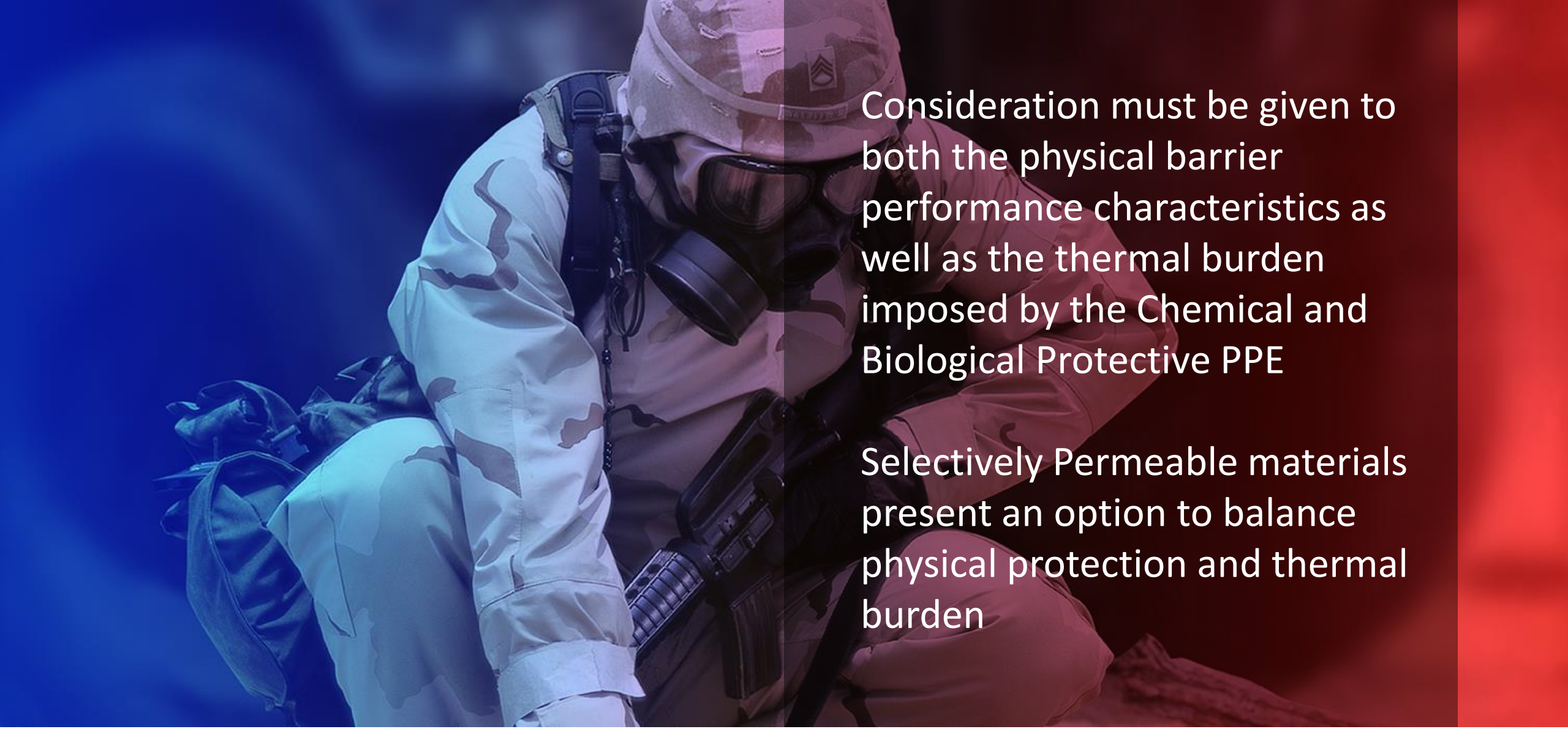

Consideration must be given to both the physical barrier performance characteristics as well as the thermal burden imposed by the Chemical and Biological Protective PPE

Selectively Permeable materials present an option to balance physical protection and thermal burden

IN SUMMARY

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GORE® CHEMPAK® Chemical & Biological Protective Combat Style Uniform – Increment 2 Flex-Fit (**CPCSU-2 FF**)

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GORE® CHEMPAK® Chemical & Biological Protective Clothing System (**CPCS**)

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NFPA 1994
Class 2

Italian Navy
CB Suit

US SOCOM All Purpose- Personal Protective Equipment (AP-PPE)

USCG CB
Drysuit

US SOCOM Uniform Integrated Protection Ensemble – Increment 1 (UIPE-I1)

Biological Protective Suit (BPS)

Alternative Footwear Solution (AFS) SOCOM Variant

Integrated Footwear System (IFS) Protective Sock

G9492 & US Military JB1GU CB FR Glove

M50 Hood

M53 Hood

JSAM

Fabrics that protect and perform even under the most adverse environmental conditions

NFPA 1994 Class 3

CPCSU-2

THE ONLY BREATHABLE PRODUCTS CERTIFIED TO THE NFPA 1994 STANDARD

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Thank you for your attention

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