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Self-Contained Atmospheric Protective Ensemble (SCAPE) Propellant Handlers Ensemble (PHE)

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SCAPE-PHE

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Self <u>Contained Atmospheric Protective</u> <u>Ensemble</u> (SCAPE)

- Predates Shuttle Operations (1960s)
- Equipment has evolved to accommodate the needs for all programs
- Current SCAPE (Propellant Handlers Ensemble (PHE)) have been in use since 1987
- > Used in IDLH Environments



SCAPE-PHE Modes

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Available in two modes

- Category I: Self Contained Environmental Control Unit (ECU)
 - Mobile; not attached to an external air source
 - Internal Cryogenic Air Supply, ECU
- Category IV: Airline Supplied
 - Airline Supply Required
 - Portable Air Supply Required for Ingress/Egress



SCAPE-PHE Features

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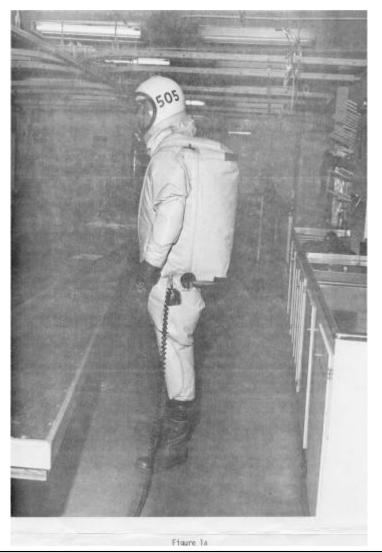
Features of the SCAPE-PHE

- Detachable, variable sized boots and gloves
- "Bubble" or Flat Visor
- Internal Air Distribution System



Category I SCAPE-PHE

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Category I SCAPE-PHE

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Ancillary Equipment of Category I SCAPE-PHE

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Environmental Control Unit

 Utilizes Locally Manufactured Liquid Air (20% - 30% Oxygen)





Category IV SCAPE-PHE

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Category IV SCAPE-PHE

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- Research for an improved ensemble began in late 1970s and was driven by:
 - NIOSH (78-172 and 76-149) recommended changes in Allowable Exposure Limits for fuels and oxidizer used by NASA and the Air Force
 - An incident involving a Rocket Fuel Handler's Coverall (RFHCO) in an Air Force TITAN Missile Silo and personnel injury



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- Design Challenges and Design Requirements
 - Single Point Failure Mode
 - Glove and Boot Disconnects and Seals
 - Visor
 - Vent Valves
 - Suit Fabric
 - Gloves
 - > Torso Closure
 - Communications
 - Emergency Air Supply



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Program Execution

- Survey of users of protective suits in propellant operations and of suit/component manufacturers
- Test program to evaluate propellant resistance and other characteristics of candidate materials and components for an improve suit
- Specification prepared to define and describe an improved ensemble



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Single Point Failure Mode

- Prevent/Minimize circulation of toxic vapors in the head area (breathing zone) in the event of a puncture or tear of the suit material
 - Evaluated manual mode change to head-only air
 - Evaluated neck ring with air to head first
 - Evaluated automatic mode change to head-only air
 - Evaluated internal face mask
- > Design Preference
 - Manual Mode change to head-only air
 - Distribute 60% of air supply to head area at all times



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Glove and Boot Disconnects and Seals

- > Prevent Liquid Impingement
- Visual and mechanical indicators that ensure reliable connections
- Design Preference
 - Aluminum Quick Disconnects with O-Ring Seal
- Gloves
 - Glove thickness limited dexterity and material became "sticky" when exposed to high concentrations of oxidizer
 - Design Preference
 - The current glove was selected because it was the only one that adequately resisted propellants



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Suit Fabric

- Develop a more "Robust" fabric
- Improve Flammability
- > Improve Maintenance
- > Design Preference
 - Thicker Fabric developed which incorporates a wearindicator
 - Validated protection through Permeation Testing and Physical Properties Testing
 - Reasonable flame resistance



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♦ Visor

- > Minimize/Prevent scratches
- Improve Chemical Resistance
- Design Preference
 - Polycarbonate material with Chemical Resistant Hard Coating



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Vent Valves

- Prevent vapor migration under steady state venting and negative pressure scenarios
- Testing performed in the NASA Lab using Helium to determine flow characteristics
- Design Preference
 - Implemented a diaphragm-type exhaust valve with a relief valve cover to direct air flow and provide impingement protection



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Torso Closure

- Current closure design worked against the positive pressure of the suit
- > Design Preference
 - Selected a zip-lock style closure with zipper reinforcement



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Communications

- Focus on standard system that would be common to all users
- > Design Preference
 - Selected a headset and connecting cable to a bulkhead feedthrough on the garment fabric
 - External bulkhead connector allows for adaptation to other communications systems



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Emergency Air Supply

- Provide egress capability in the event of breathing air supply failure
- > Design Preference
 - Internally worn Emergency Air Supply with SCUBA mouthpiece originally designed
 - Unit increased ensemble weight and was discontinued
 - Egress capability accomplished through SCAPE Ventilators



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Performance Validation of the SCAPE-PHE

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Protection factor testing

Overall Protection Factor of 50,000 for preoperational and operational exercises in Category I and Category IV Modes

Physiological Testing

- > High and Low Temperature Operation Tests
- Manned and Unmanned Carbon Dioxide Tests
- ECU Testing in non-vertical attitudes

Other Testing

- Liquid Impingement Testing of ensemble from all attitudes
- Ensemble Exposure Testing
- Ensemble Fire Testing



Maintenance Testing of the SCAPE-PHE

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- Maintenance testing validates continued performance:
 - Light Inspection (small holes)
 - Visual Inspection Material degradation and damage identified
 - Ensemble Leak Test
 - > Airline Flow Test
 - Exhaust Valve Reverse Flow (Leak) Test
 - > Quality Inspection/Verification
 - Boots and Gloves tested individually