Research Focus

As a member of the Space Suit Assembly Development Engineering Team, I designed and built test equipment systems to support the development of the next generation of advanced space suits. During space suit testing it is critical to supply the subject with two functions: (1) cooling to remove metabolic heat, and (2) breathing air to pressurize the space suit.

The objective of my first project was to design, build, and certify an improved Space Suit Cooling System for manned testing in a 1-G environment. This design had to be portable and supply a minimum cooling rate of 2500 BTU/hr. It needed to supply cooling water at a variable temperature and flowrate. My next project was to design and build a Breathing Air System that was capable of supply facility air to subjects wearing the Z-2 space suit. The system needed to intake 150 PSIG air and regulate it to two operating pressures. It also had to provide structural capabilities at 1.5x operating pressure.

Research Methods

Both projects followed a similar design methodology. The first task was to perform research on existing concepts to develop a sufficient background knowledge. Then mathematical models were developed to size components and simulate system performance. Next, mechanical and electrical schematics were generated and presented at Design Reviews. After the systems were approved by the suit team, all the hardware components were specified and procured. The systems were then packaged, fabricated, and thoroughly tested. The next step was to certify the equipment for manned used, which included generating a Hazard Analysis and giving a presentation to the Test Readiness Review Board.

Results

The Space Suit Cooling System is a robust, portable system that supports very high metabolic rates. It has a highly adjustable cool rate and is equipped with digital instrumentation to monitor the flowrate and critical temperatures. It can supply a variable water temperature down to 34°F, and it can generate a maximum water flowrate of 2.5 LPM.
The Breathing Air System is capable of supplying air at both 4.3 and 8.3 PSIG operations. It has instrumentation to monitor flowrate, as well as inlet and outlet pressures. The system has a series of relief valves to fully protect itself in case of regulator failure.

**Main Conclusions**

Both of these test support systems will perform critical roles in the development of next-generation space suits. They will be used on a regular basis to test the NASA’s new Z-2 Space Suit. The Space Suit Cooling System is now the primary cooling system for all advanced suit tests.

---

**Abstract (400 words)**

As a member of the Space Suit Assembly Development Engineering Team, I designed and built test equipment systems to support the development of the next generation of advanced space suits. During space suit testing it is critical to supply the subject with two functions: (1) cooling to remove metabolic heat, and (2) breathing air to pressurize the space suit.

The objective of my first project was to design, build, and certify an improved Space Suit Cooling System for manned testing in a 1-G environment. This design had to be portable and supply a minimum cooling rate of 2500 BTU/hr. The Space Suit Cooling System is a robust, portable system that supports very high metabolic rates. It has a highly adjustable cool rate and is equipped with digital instrumentation to monitor the flowrate and critical temperatures. It can supply a variable water temperature down to 34°F, and it can generate a maximum water flowrate of 2.5 LPM.

My next project was to design and build a Breathing Air System that was capable of supply facility air to subjects wearing the Z-2 space suit. The system intakes 150 PSIG breathing air and regulates it to two operating pressures: 4.3 and 8.3 PSIG. It can also provide structural capabilities at 1.5x operating pressure: 6.6 and 13.2 PSIG, respectively. It has instrumentation to monitor flowrate, as well as inlet and outlet pressures. The system has a series of relief valves to fully protect itself in case of regulator failure.

Both projects followed a similar design methodology. The first task was to perform research on existing concepts to develop a sufficient background knowledge. Then mathematical models were developed to size components and simulate system performance. Next, mechanical and electrical schematics were generated and presented at Design Reviews. After the systems were approved by the suit team, all the hardware components were specified and procured. The systems were then packaged, fabricated, and
thoroughly tested. The next step was to certify the equipment for manned used, which included generating a Hazard Analysis and giving a presentation to the Test Readiness Review Board.

Both of these test support systems will perform critical roles in the development of next-generation space suits. They will used on a regular basis to test the NASA’s new Z-2 Space Suit. The Space Suit Cooling System is now the primary cooling system for all advanced suit tests.
Space Suit Assembly Engineer

Team Role
Design and build space suit test equipment to support the development of the next generation of advanced space suits.

Personal Responsibilities:
- Design, build, and test a space suit cooling system for thermal testing in a 3D environment
- Engage systems to supply breathing air and liquid cooling
- Design, build, and test a space suit assembly testing system
- Use 3D modeling to determine external size/configuration for testing in the Mark III space suit

Space Vehicle Mechanisms (34 hrs)
- Space vehicle propulsion, including mechanical assemblies and high-performance materials used in the space environment
- Use computer-aided design (CAD) software to create detailed drawings
- Learn how to evaluate design concepts, including structural integrity

Detailing in Creo Parametric 2.0 (28 hrs)
- Learn how to create detailed drawings using Creo Parametric 2.0 software
- Learn how to create production drawings suitable for manufacturing

Professional Training

EMU/LCVG Adapter

Task Objective
Design an adapter for the Life Cycle Ventilation System (LCVG) for testing in the Mark III space suit.

Design Features:
- Space suit design is driven by operational needs
- Safety features include a redundant safety system
- Security features include an emergency power supply
- Corrosion-resistant materials used for enhanced cooling system efficiency

Space Suit Cooling System

Project Objective
Design and build a portable space suit cooling system to replace an existing 12V portable cooling system.

Current System: Portable Cooling Bag (PCB)
- Modified chest
- Submerged baffle provides ventilation
- 12V power supply - 400 watt input

Disadvantages of the PCB
- No backup water
- Water must be drained daily
- Ineffective method of cooling
- Can be uncomfortable on suit for extended periods
- No water temperature control
- No flow rate control
- No cooling pumps
- Water temperature too cold
- Water temperature too hot
- Body cannot cool itself

Technical Schematic: Space Suit Cooling System

Technical Schematic: Breathing Air System

Process Diagram: Instrumentation

Breathing Air System

Project Objective
Develop a system to supply breathing air to test subjects wearing the 3.2 space suit.

Design Requirements:
- Ultra-low breathing air
- Min Allowable Breathing Pressure: 55 PSIG
- Full compatible with a pressurized environment
- 8 - 10 PSIG (max air pressure)
- 1 - 3 PSIG (min air pressure)
- Provides an initial air supply at 3.4 operating pressures
- Flow 40 LPM at operating pressures
- Completely protected from environmental hazards

Digital Instrumentation:
- Flow rate/flow rate indicator
- Pressure transducer
- Air flow transducer
- Air temperature sensors

Design Overview:
- Pressure regulating valve: 8 - 10 PSIG
- 300 hour minimum air flow rate
- Three integrated solenoid valves to control the suit at all operating pressures
- Two main valves to control inlet valve based on desired operating mode
- Compressor system
- System instrumentation
- Analog displays and digital indicators
- Flow rate meter (VAC)