# Body Cooling Technology Study for Shipyard Worker Safety and Performance

Interim Project Status Report, September 2024

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# Body Cooling Technology Study: Project Info

- Prime/Lead
  - HII – Ingalls Shipbuilding
- Team Members
  - HII – Newport News Shipbuilding
  - Bath Iron Works
  - Pearl Harbor Naval Shipyard (unfunded participant)
- Objective
  - Explore commercially available and high TRL developmental body cooling technologies, for improved safety and performance of shipyard workers
- Duration
  - 12 Months (2/24-2/25)

- Key Tasks
  - Select test garments based on cooling technologies and methods
  - Pilot test several options and assess key parameters for heat relief, comfort, ergonomics, and health safety
  - Draft potential implementation plans and costs
  - Assess financial feasibility to make body cooling widely available to shipbuilders

- Deliverables
  - Stakeholder analysis, with KPIs
  - Market survey of available products
  - Test plan for pilot demonstration
  - Test results
  - Implementation plan
  - Final report

# Stakeholder Analysis Completed

- Study performed:
  - Interviewed 28 participants from 4 shipyards: Newport News, Ingalls, Bath Ironworks, Pearl Harbor NSY
  - Half were shipyard workers from Operations and Maintenance teams; half were shipyard experts from Environmental Health & Safety, Human Resources, Research & Development, and Labor Relations

- Key performance indicators include:
  - Fire-retardant/flame-resistant – approved for hot work
  - Not bulky, i.e. not prohibiting or restricting movement
  - Not producing water from room-air condensation
  - Worn over clothing vs. worn under jumpsuit; tethered vs. free-moving
  - Cooling method and technology (convection, evaporation, phase change, etc.)
  - Material phase-change temperature (for PCM, water/ice, etc.)
  - Made/manufactured/shipped from a U.S. company
  - Durability, longevity, maintainability, affordability and ownership

Question Categories
- Part 1: Environmental Health and Safety
- Part 2: Operational Conditions
- Part 3: Prior or Anticipated Use of Cooling Garments

- Some common features would be evaluated for each of the body cooling garments tested

# Three Test Scenarios for this Study

### Scenario 1:

- **Cooling garments are worn under a jumpsuit**
- Needed for Stationary work. Worker can be tethered to compressed air source
- Example of worker:
  - Paint Blasters
  - Grinders

### Scenario 2:

- **Cooling garments are worn under worker PPE**
- Needed for active, full mobility work
- Example of worker:
  - Firefighters
  - Hazmat Teams
  - Welders

### Scenario 3:

- **Cooling garments need to be lightweight, affordable, and provide SPF coverage**
- Needed for full mobility work in small spaces
- Example of worker:
  - Machinery
  - Electrical
  - Piping

# Garments Selected by Underlying Technology

**Phase Change Materials (PCM)**

Materials that store thermal energy. When they absorb heat, they melt (solid to liquid) and must be recharged (frozen) to be used again

- WATER/ICE changes phase at 32 deg F; easy to access but uncomfortably cold on skin surface
- PCM used in cooling vests melts at 65 deg F; more comfortable and takes longer to melt

**CONDUCTION – PHASE CHANGE**

**Forced Air Cooling**

Forced air flow picks up moisture and cools the skin

- TDA cooling shirts have a battery-operated fan attached to the hip which blows air through channels in the shirt and out to environment
- ALLEGRO vests use compressed air (supplied by shop air) plus a vortex tube attachment, which separates warm/cool air then cool air blows through the vest

**CONVECTION – VORTICITY**

**Wet Cooling Materials**

AKA “Hydro Active” technology for wet cooling. The garments are wetted prior to wearing, which accelerates natural evaporation (due to exposure to the human body) to cool down the body.

**EVAPORATION – PHASE CHANGE**

**Dry Cooling Materials**

AKA “Vapor Active” technology for dry cooling features. The material wicks away sweat off the skin, dispersing out the moisture over a greater surface area so it evaporates faster. User feels cool and dry.

**EVAPORATION – WICKING**

# Test Articles

Technology Legend

| |
|---|
| PCM |
| Hydro (wet) |
| Forced Air |
| Vapor (wick) |

## Testing Scenario 1

8450 Low Profile Vortex Cooling Vest (forced air)

8300 Vortex Cooling Vest (forced air)

Full Mask Vortex Cooling Respirator (forced air)

## Testing Scenario 2

HyperKewl Hydro-Active Orange Vest

TDA Prototype Cooling Shirt (with Fan)

GlacierTek PCM Cool Vest

Baseline against TechNiche Vests

## Testing Scenario 3

Mission Hydro-Active Safety Shirt

Mission Hydro-Active Helmet Liner

Tech Niche Hydro-Active Helmet Liner

Tech Niche Hydro-Active Neck Shade

Mission Hydro-Active Bandana

Ergodyne UV Dry Wicking Long Sleeve

Arctic Cool Wicking White Shirt

Mission Vapor-Active Beanie

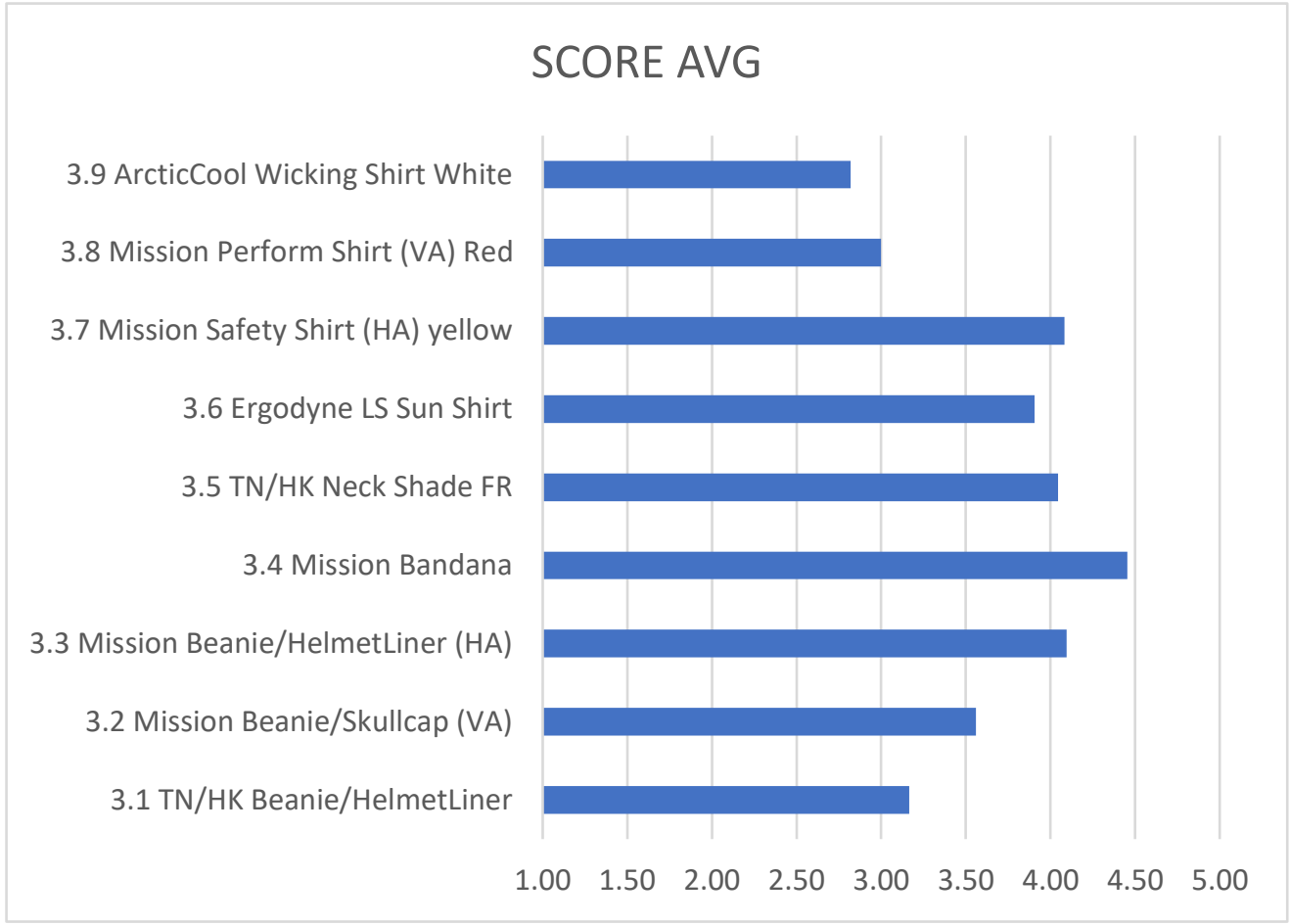
Hydro-Active Wet Feel vs. Vapor-Active / Wicking Dry Feel

# Response Matrix (with some prelim results)

| | | 1.1 Allegro 8300 vest | 1.2 Allegro 8450 low profile vest | 1.3 Allegro 9902 Respirator | 2.1 TDA black shirt | 2.2 GlacierTech PCM Vest | 2.3 TN/HK Orange Evap Vest | 2.4 TN/HK Blue Ice Vest | 3.1 TN/HK Beanie | 3.2 Mission Beanie/Skullcap (VA) | 3.3 Mission Beanie/HelmetLiner (HA) | 3.4 Mission Bandana | 3.5 TN/HK Neck Shade FR | 3.6 Ergodyne LS Sun Shirt | 3.7 Mission Safety Shirt (HA) yellow | 3.8 Mission Perform Shirt (VA) Red | 3.9 ArcticCool Wicking Shirt White |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11.0 | Did the garment condensate / collect moisture? | | | | | | | | | | | | | | | | |
| 12.0 | Did you feel wet while wearing the garment? | | | | | | | | | | | | | | | | |
| 13.0 | Did this product fit well into your work attire requirements? | | | | | | | | 4.3 | 4.4 | 4.2 | 4.8 | 4.8 | 4.0 | 4.7 | 3.4 | 4.1 |
| 14.0 | Did the garment keep you cool for a full work shift? | | | | | | | | | | | | | | | | |
| 15.0 | Did the garment interfere with your ability to perform your work? | | | | | | | | 2.2 | 2.9 | 3.5 | 3.2 | 3.4 | 2.9 | 2.9 | 2.8 | 3.2 |
| 16.0 | Did this make an improvement in your work day comfort? | | | | | | | | 2.8 | 3.2 | 3.5 | 4.0 | 3.5 | 3.8 | 3.8 | 2.6 | 2.8 |
| 17.0 | Do you think the garment would fit multiple body types? | | | | | | | | | | | | | | | | |
| 18.0 | Were you satisfied with the cooling effectiveness if this garment? | | | | | | | | 3.4 | 3.6 | 3.6 | 4.2 | 3.3 | 3.9 | 4.0 | 3.6 | 3.1 |
| 19.0 | Do you think the garment enhances your personal safety? | | | | | | | | | | | | | | | | |
| 20.0 | Do you think the garment enhances your job productivity? | | | | | | | | | | | | | | | | |
| 21.0 | Was the garment fast and easy to put on and remove? | | | | | | | | | | | | | | | | |
| 22.0 | If this was readily available, would you use this garment? | | | | | | | | 3.2 | 3.6 | 4.1 | 4.5 | 4.0 | 3.9 | 4.1 | 3.0 | 2.8 |
| | # Samples Averaged | | | | | | | | 32 | 32 | 32 | 32 | 32 | 23 | 30 | 11 | 12 |

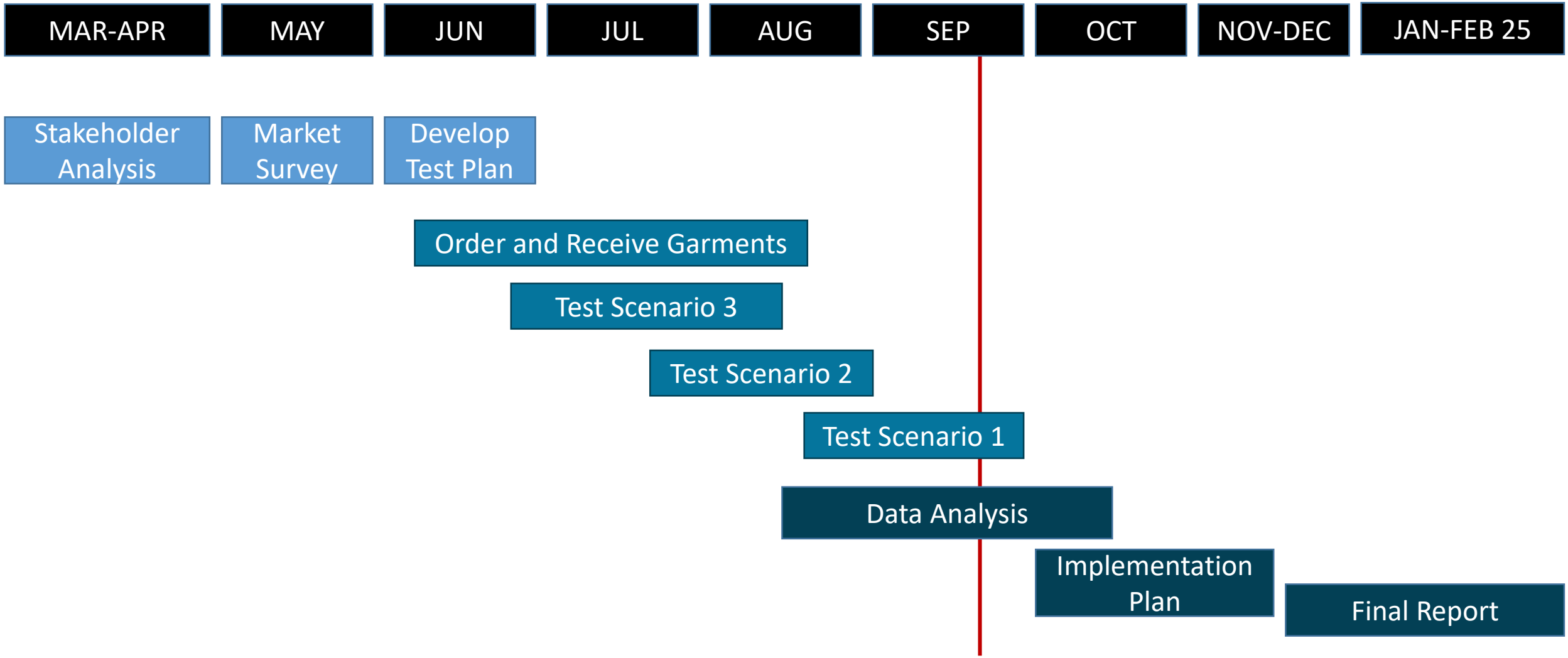
# Preliminary Results Q22 on Scenario 3 Garments

## Q22: If this was readily available, would you use this garment?




Response Options
1 = Strongly disagree
2 – Disagree
3 = Undecided
4 = Agree
5 = Strongly Agree

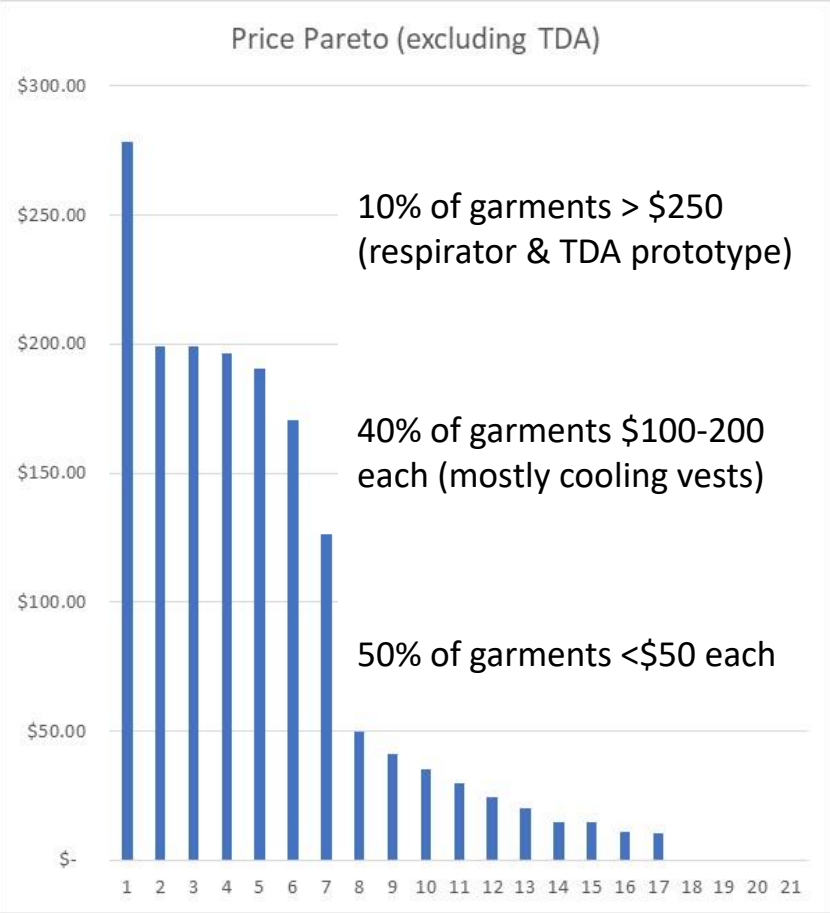
# Activities and Timeline 2024-25



# Initial Success Stories

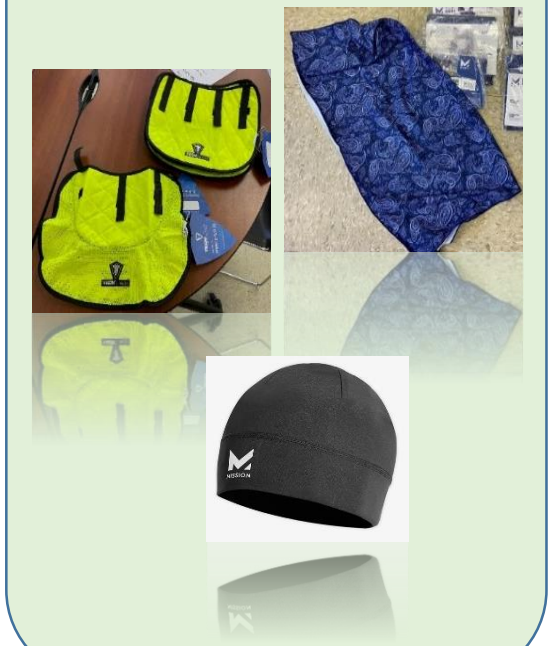
- We are already hearing of cases where a volunteer tester liked their garment so much that they bought one for their own personal use:
  - *A manager in the test program liked the cooling bandanas so much he agreed to go out and purchase garments for him and his crew*
  - *Another manager in the test program said he felt the body cooling technology garments were raising team morale*
  - *One test participant said he liked the Ergodyne long-sleeve SPF cooling shirts so much that he purchased several of his own*
- This means the cooling garments have their own PULL – which is a good sign for implementation

# Garment Groupings Based on Cost Category




## Lower cost (<$20)

- Example: Bandanas, beanies, neck shades

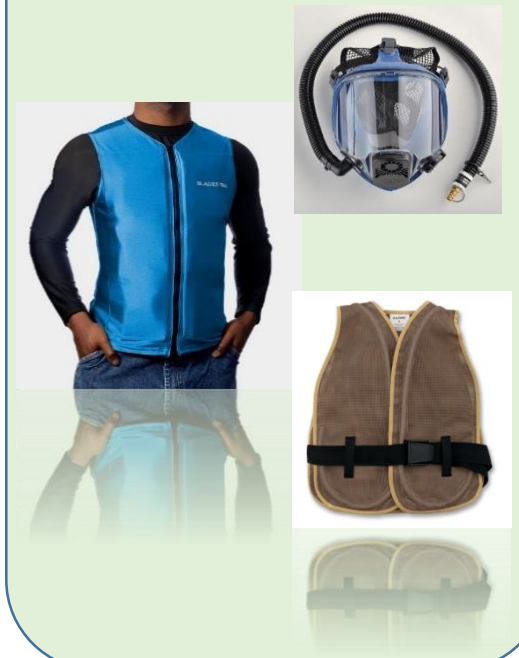


## Medium cost ($20-50)

- Example: SS and LS shirts; UV sun shirts

## Higher cost ($100-300)

- Example: Cooling vests, respirator



*Half of the garments tested are relatively affordable ($10-50 each)*

# Lessons Learned: Ordering & Testing

- **Bilingual Surveys:**
  - At one point, we couldn't get surveys back from one particular set of craft workers. Upon further investigation it was found they only spoke Spanish. They couldn't read the surveys, so we translated the surveys for them.

- **More Time for Orders:**
  - When multiple vendors provide garments, a competitive bid may be necessary, which adds to the procurement process and timeline.
  - Lead times can take longer than expected and supplies can run low, especially in the warmer months. This can make it harder to meet aggressive delivery schedules.

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