

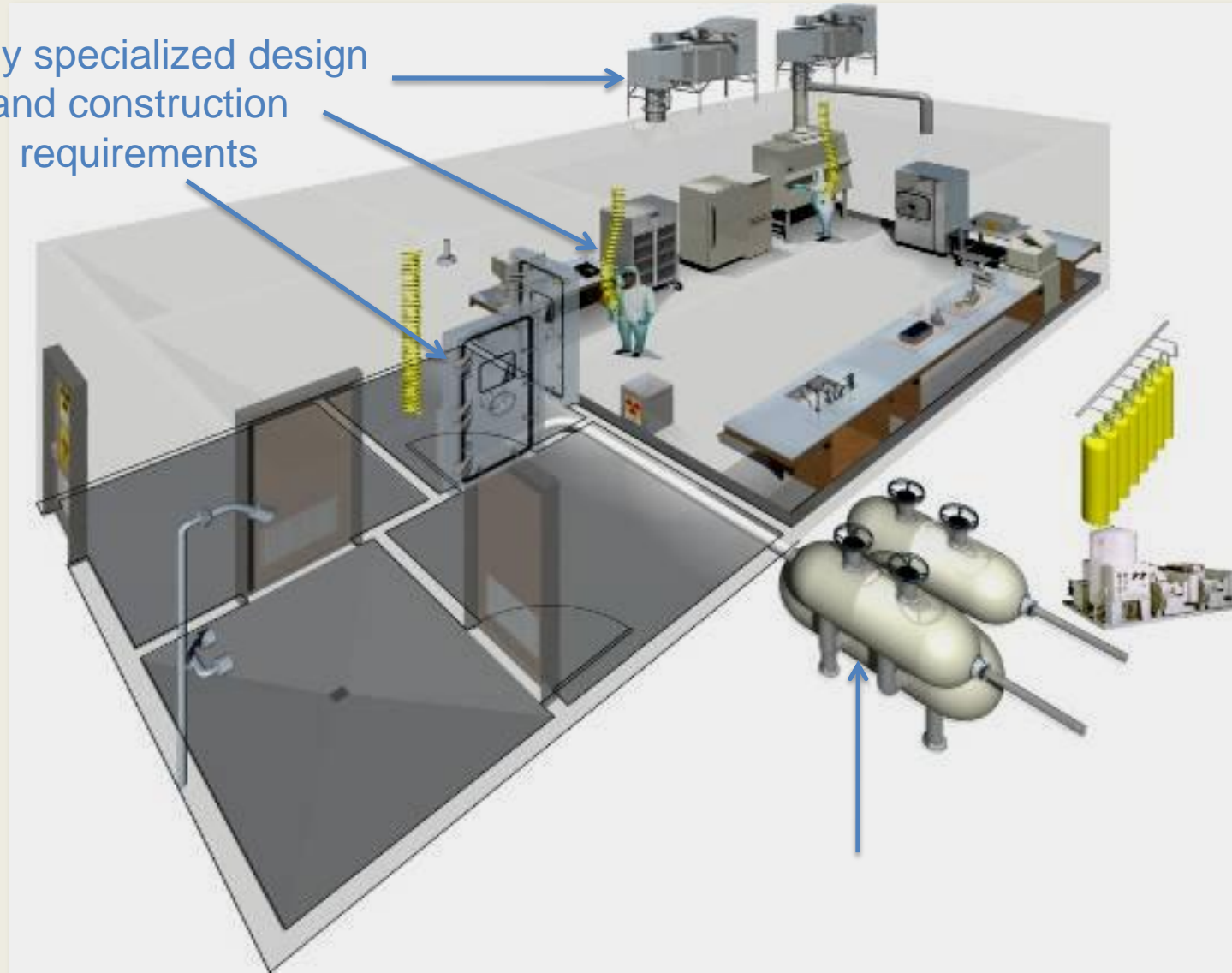
# **BSL-4 USER SURVEY RESULTS AIDING THE DESIGN OF THE NEXT GENERATION OF POSITIVE PRESSURE SUITS**

**Dave Harbourt, PhD  
NBBTP Fellow**

- **Discuss the different types of BSL-4 suits currently available**
- **Examine increasing needs of the expanding BSL-4 community**
- **Discuss the development of the BSL-4 suit survey**
- **Evaluate the results of the survey in regard to both past experiences and design suggestions**
- **Conclusions and recommendations**

# Biosafety Level 4 (BSL-4) Suit Lab

Highly specialized design  
and construction  
requirements





## Delta (French) suit

- Manufactured by Sperian Protection (Honeywell)
- Lighter than the Dover suit with a quieter air supply line
- Clear headpiece enhances peripheral vision
- Internal HEPA filter for supply air



## ILC Dover (Blue) suit

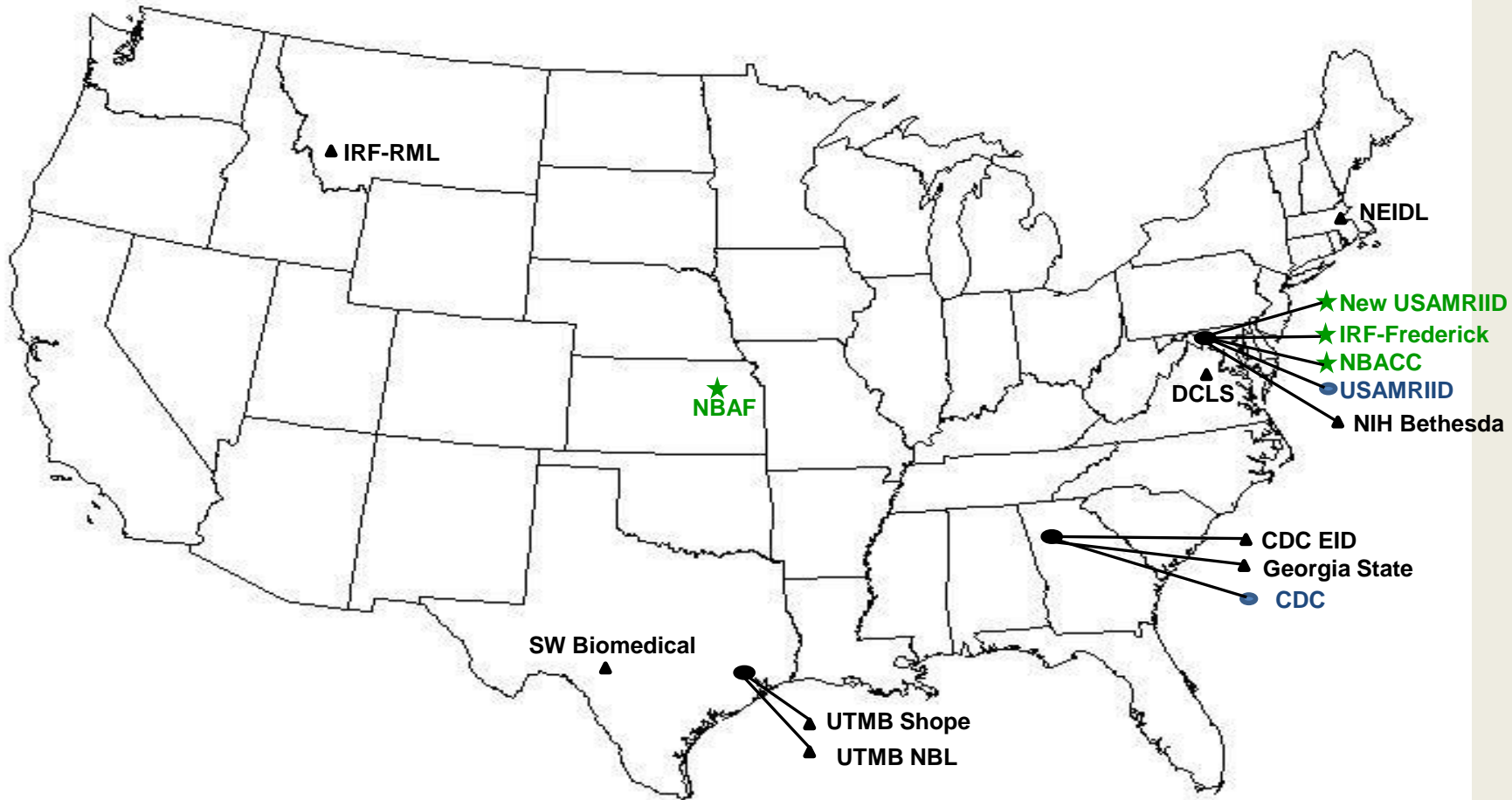
- Used in BSL-4 facilities since 1979
- Chemturlon material gives strong sense of protection
- Lacks some flexibility, requires hearing protection
- External HEPA filter for supply air



## HvO (German) suit

- All exhaust valves are located on the back of headpiece
- 180° visibility around the headpiece
- Lightweight/flexible material construction

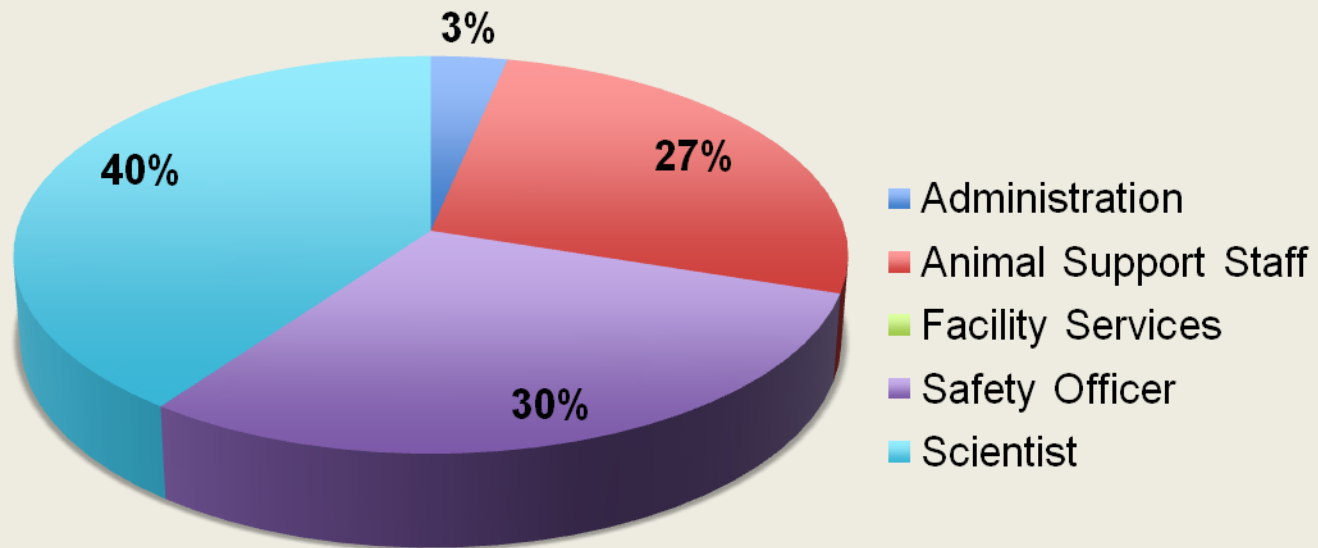
# Biosafety Level 4 Facilities planned or under construction



- **Average tenure of BSL-4 worker is between 4-6 years**
- **Extensive training and background checks limit turnaround time**
- **Lack of transferrable Select Agent clearance between facilities**
- **Sharp divide in experience in the BSL-4 user community**
- **Divide in experience coupled with larger facilities increasing the size of the BSL-4 work force could lead to more accidents**
- **Important for safety and management staff to maximize worker comfort in the BSL-4 environment**

- **A 38 question suit survey was developed with consultation from the BSL-4 community**
- **Survey was separated into two parts:**
  - Previous experiences with suits
  - Design suggestions for new suits
- **Surveys were distributed to the NIH user community in March 2011**
  - 52 surveys were distributed
  - 30 total responses
  - 58% response rate

# Survey Results: Current Position



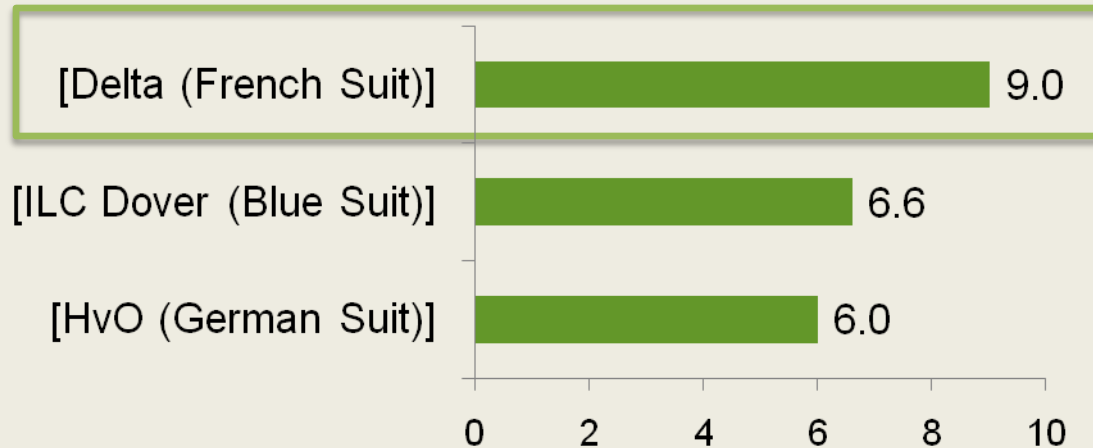
N = 30



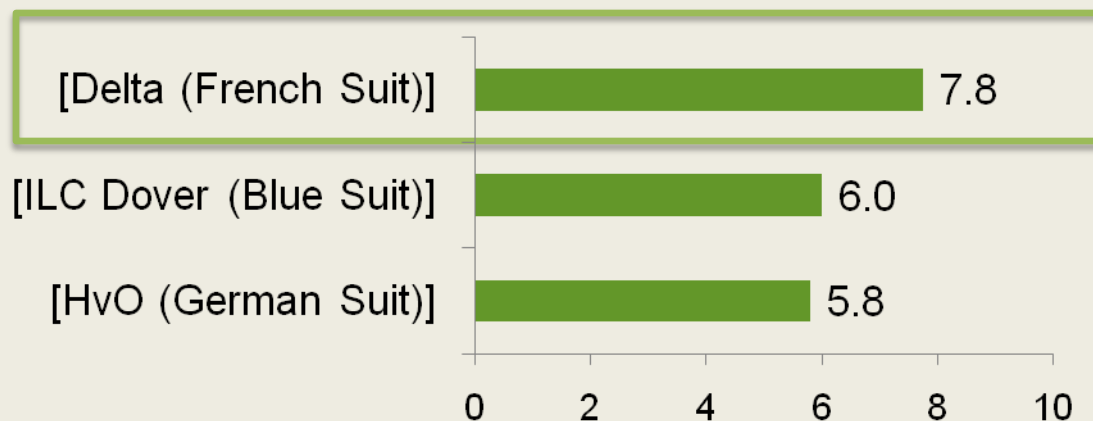
# Survey Results: Current BSL-4 Suits



## FIELD OF VISION



## RANGE OF MOTION WHILE SITTING OR STANDING

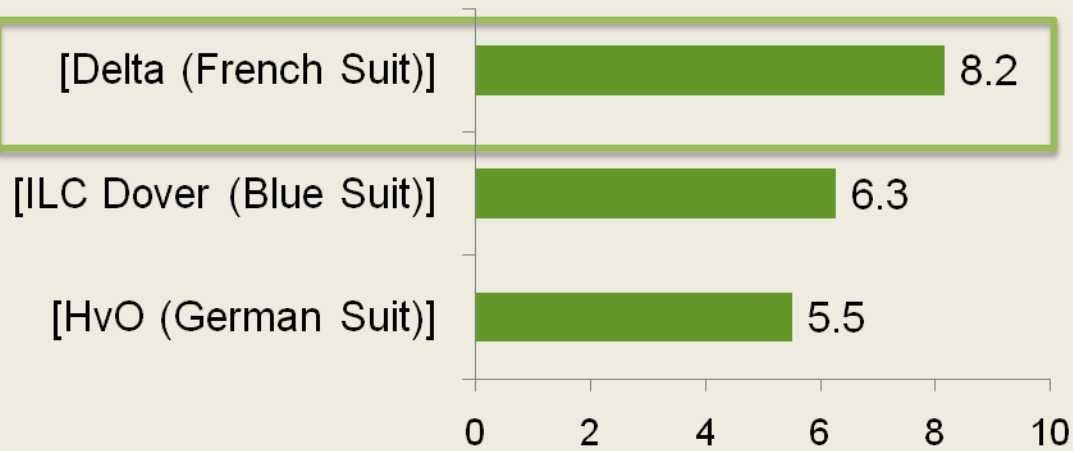


**CONCLUSION:** The Delta Suit offered the best field of vision and comfort in a set position

# Survey Results: Current BSL-4 Suits

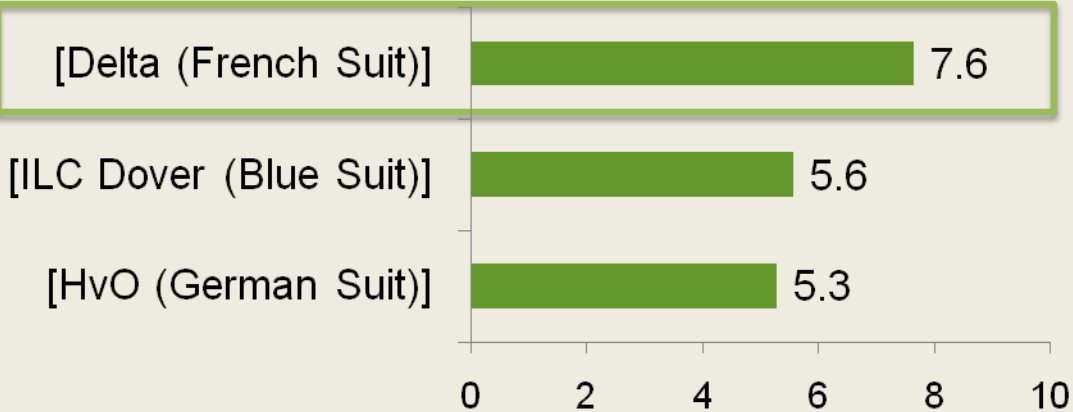


## RANGE OF MOTION WHILE WALKING



**CONCLUSION:** The Delta Suit offered the best range of motion while moving

## RANGE OF MOTION WHILE BENDING OVER



## ILC Dover Suit Comments

- Suit is durable and holes are easily sealed once recognized, environment within the suit is comfortable
- I like the flexibility of the Dover, but constant use (twice daily, for instance) over a short period of time causes failures in the fabric and the seams
- Plastic is thick, but does not overly impede movement. I also like the wide field of view in the Dover suit.
- I like the ILC Dover because it is a thicker suit. The visibility on the visor could be better though. It is also noisier than the Delta/Sperian suit.
- Durable, doesn't overinflate while sitting
- Keeping all the dangers that I can't see outside of the suit.

## Delta Suit Comments

- light weight, relatively quiet (X2)
- Light, good visibility, internal HEPA
- Ability to return air quickly, air temperature, ability of visor to clear up, foot/feet durability
- The Sperian is easy to get in/out of, more flexible and not as noisy as the Dover.

## ILC Dover Suit Comments

- Suit is not flexible and any movement is difficult while in the suit. Suit does not fit well. Suit difficult to get into and remove Gloves lack good manual dexterity
- It is difficult to ensure a solid seal at the base of the zipper when closed. It also is very loud when the air is on. Seams tend to split rather easily.
- Poor workmanship and quality control, poor design of the foot
- Heavy, loud, generally uncomfortable, little interest from the company in making the suits better
- Feet on Dover suit and stiffness/thickness of material all around
- Not made for everybody type. Lacks flexibility
- The Dover suits are way too stiff and heavy.

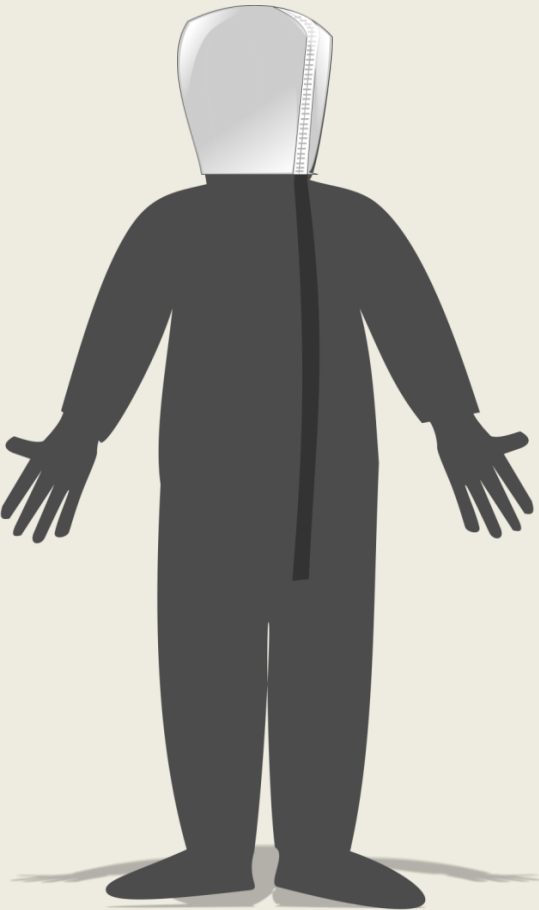
## Delta Suit Comments

- Less durable, inconsistent/poor quality control
- The design of the air hose and its area of attachment are terrible and have been the cause of many suit failures.
- Lack of mobility, large shield preventing maneuvering
- The Sperion suits just don't last long - even with lighter (BSC vs animal) use.

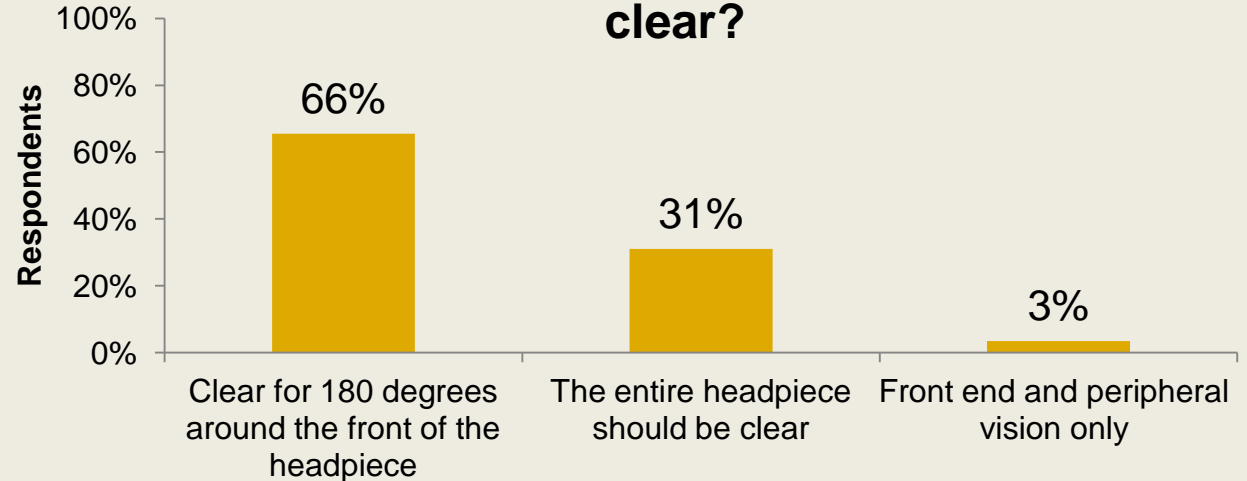
# Survey Results: BSL-4 Suit Design



# BSL-4 Suit Headpiece

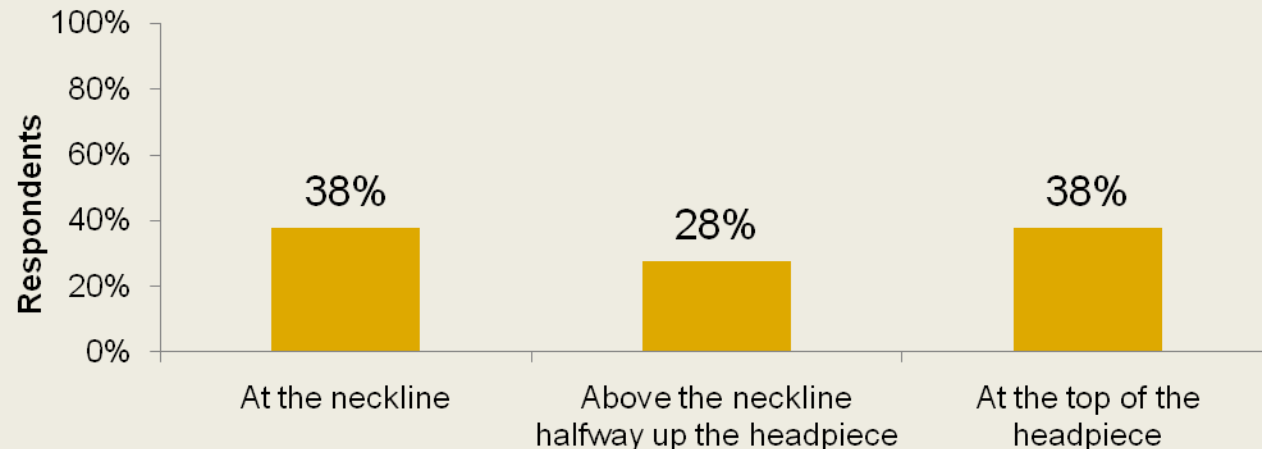


## What proportion of the headpiece should be clear?



**N = 30**

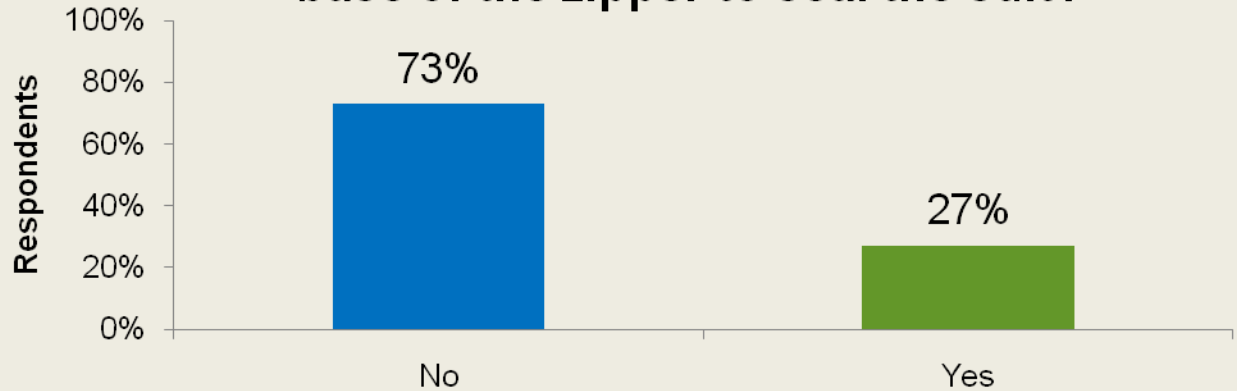
## Where should the zipper on the suit open?



**N = 29**

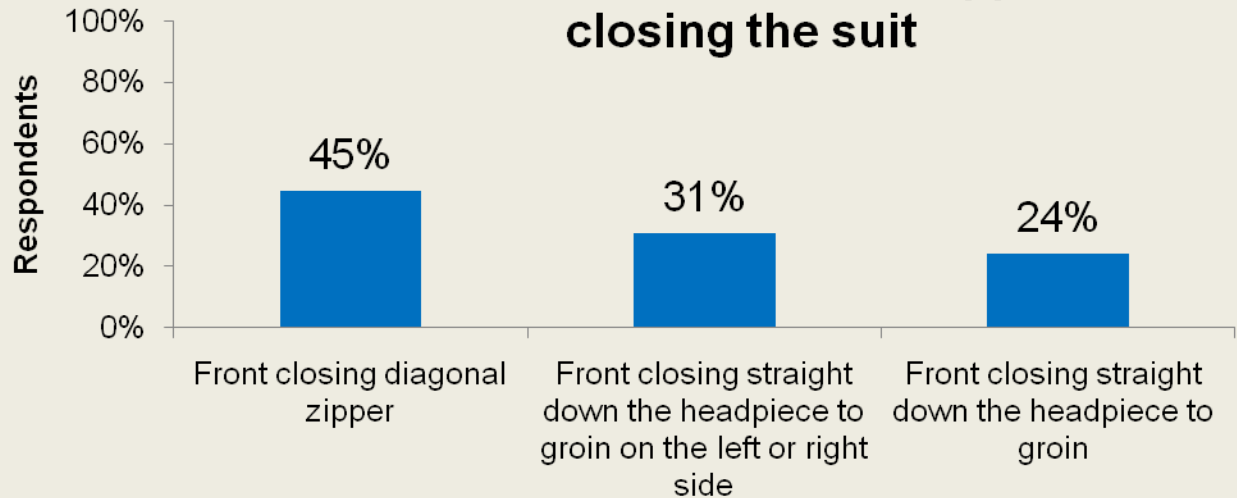
# BSL-4 Suit Body

Should there be an additional fastener at the base of the zipper to seal the suit?



N = 30

Preference for orientation of the zipper when closing the suit



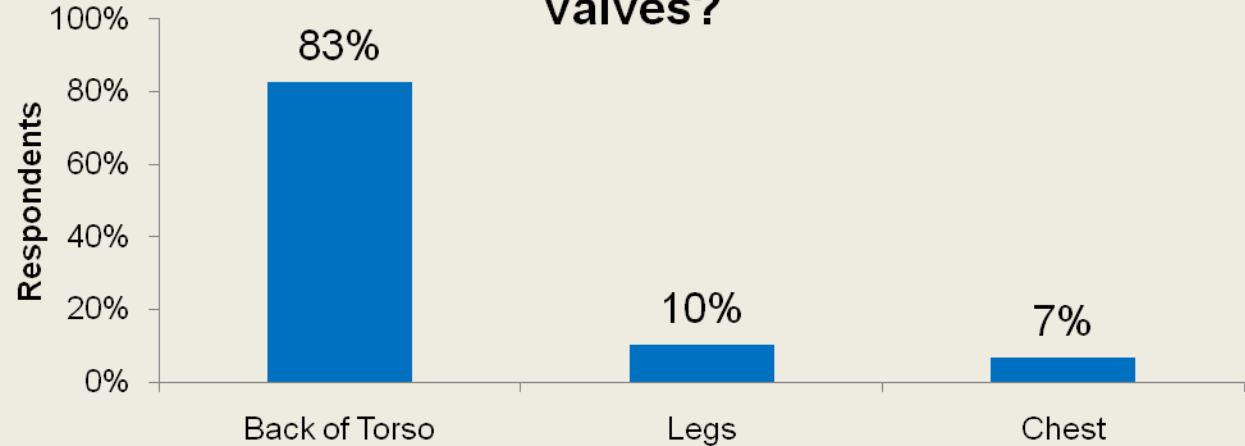
N = 29



# BSL-4 Suit Body

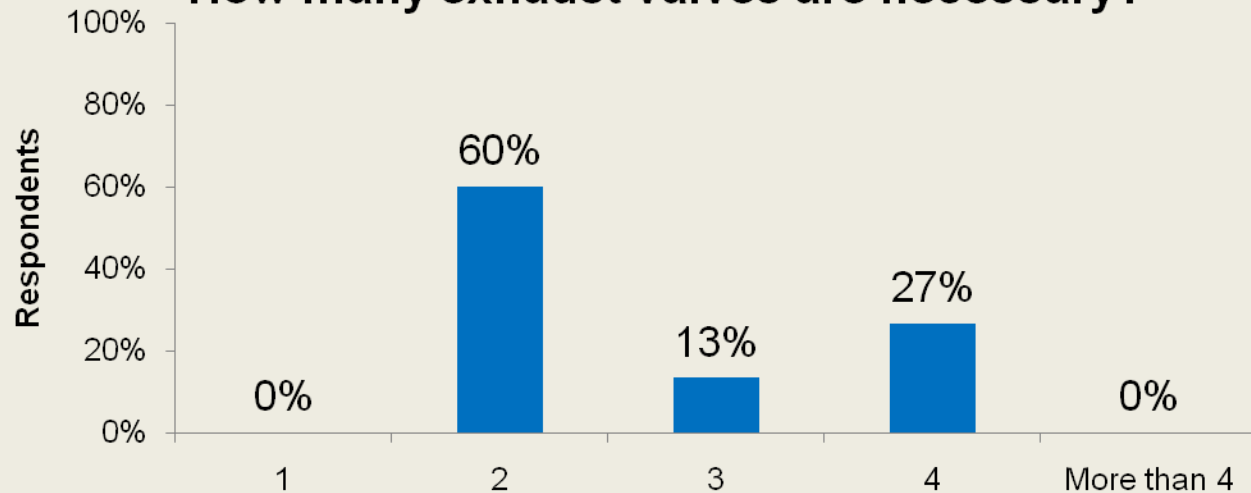


## What is the best location for the exhaust valves?



N = 29

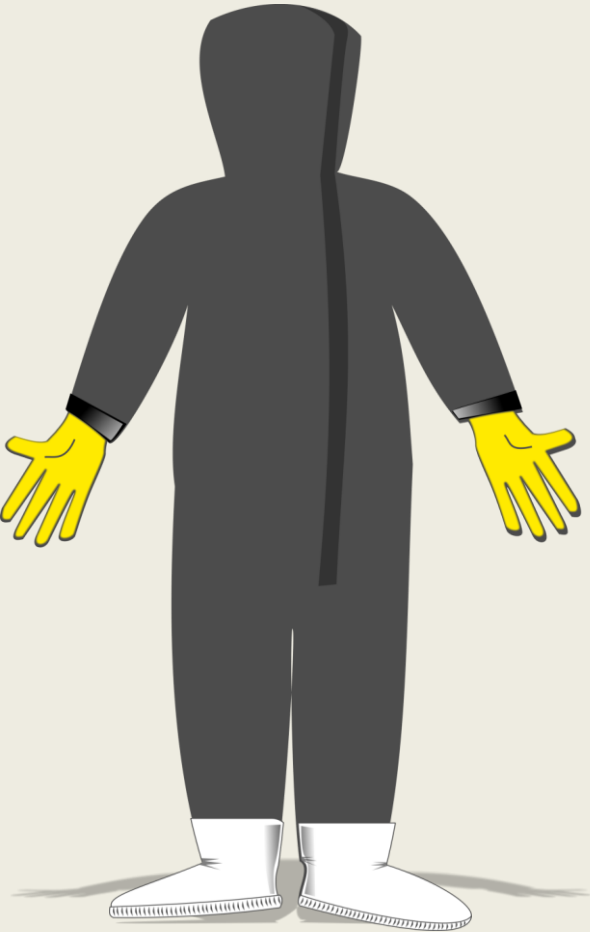
## How many exhaust valves are necessary?



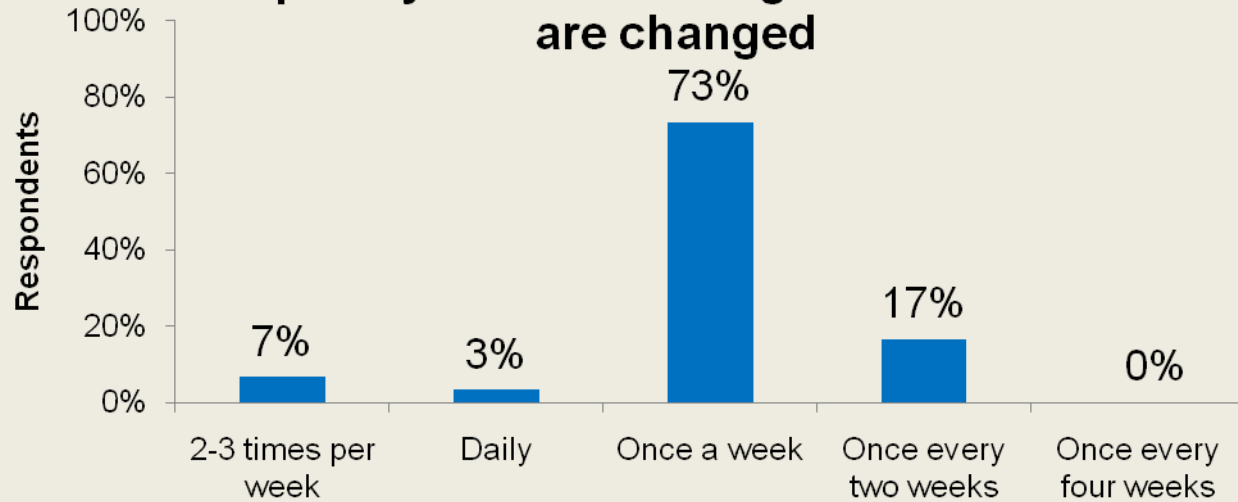
N = 30



# BSL-4 Suit Appendages

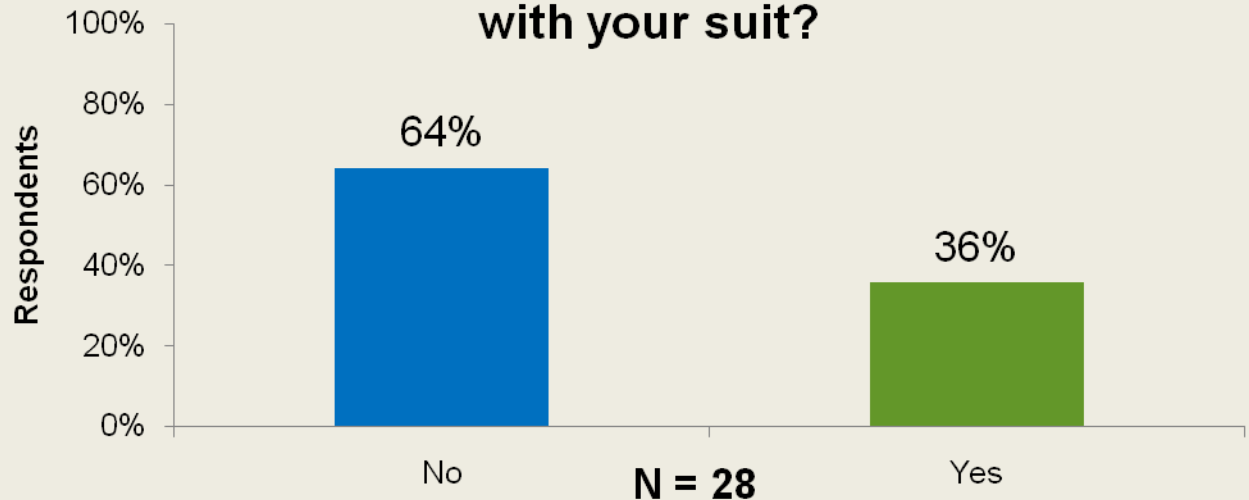


## Frequency that the outer gloves on the suit are changed



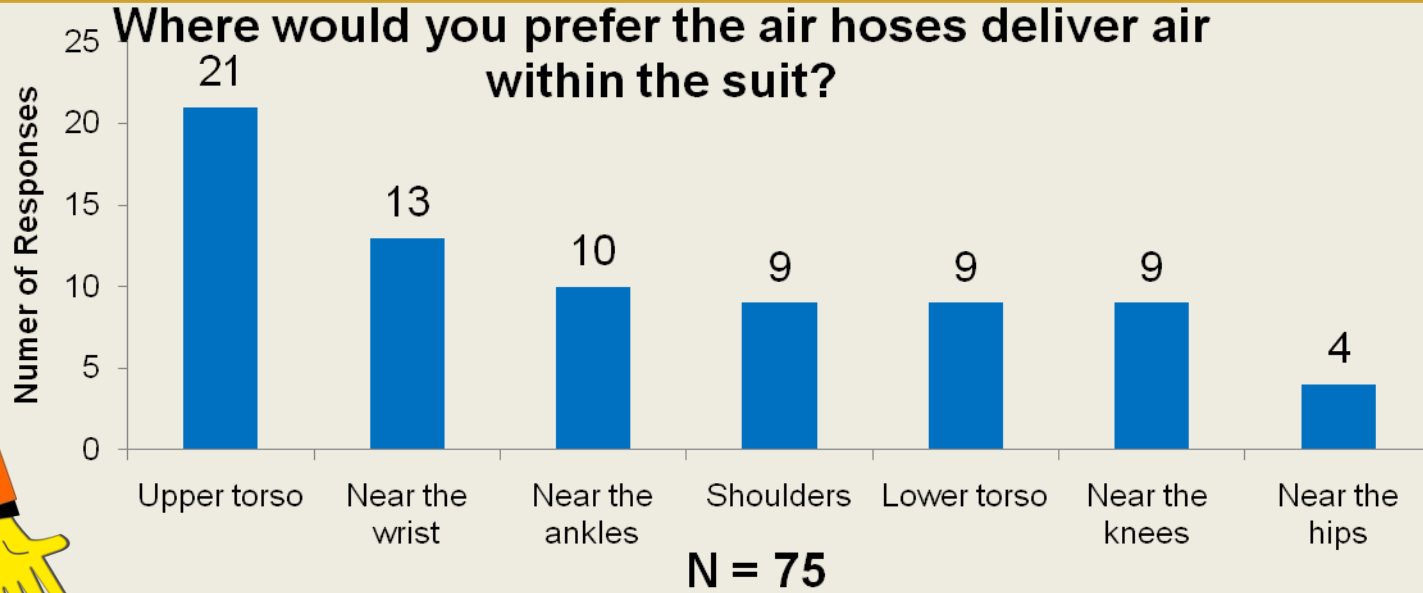
N = 30

## Do you wear an extra pair of outer gloves with your suit?

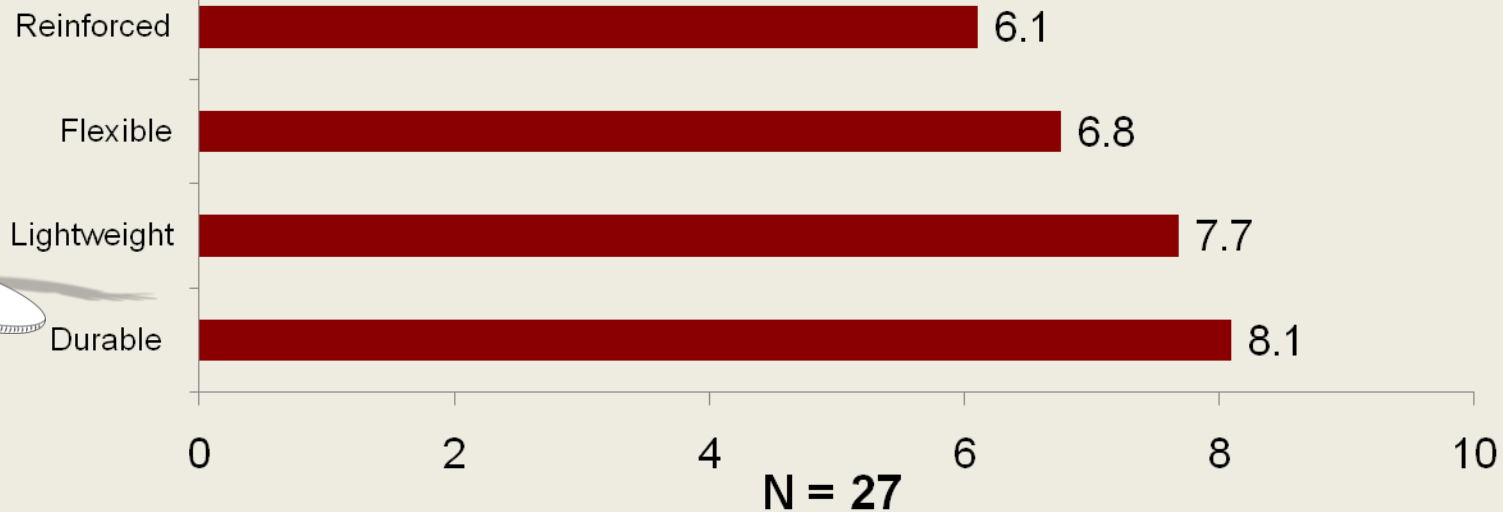


N = 28

# BSL-4 Suit Suggestions



### Prioritization ranking of suit material characteristics



- Try to reinforce the suit seams, particularly at the tip of the toes.
- I think in general suit design needs to look at better material, longevity of the suit, user comfort
- No matter what you design, people will complain. Dover and Delta have their positive and negative attributes and I don't mind wearing either. **The most consistent flaw with both manufacturers is not reinforcing stress point and routine points of failure. Dover doesn't care and, while Delta has made a number of significant improvements over the past 3 years, their quality control stinks. A good suit would have the positive attributes on both manufacturers, be light, durable and quiet.**
- A different material for the visor so it doesn't scratch so easily. The metal fittings for the Sperian suits are great and make suit checks MUCH easier than the Dover (that requires taping all exhaust valves).

- **New suit designs are needed to meet the demand of the new BSL-4 workforce that will be both much larger and less experienced**
- **Both the ILC Dover and Delta BSL-4 suits do an adequate job of providing for the user community**
- **Ideally the next generation of suits would encompass the best qualities of both suits**
- **In order to provide for different environments, manufacturers should consider offering multiple models**
- **Any new suit design should be enhanced by a stringent quality control process to minimize defects**

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## **Participating BSL-4 Users**

# QUESTIONS?



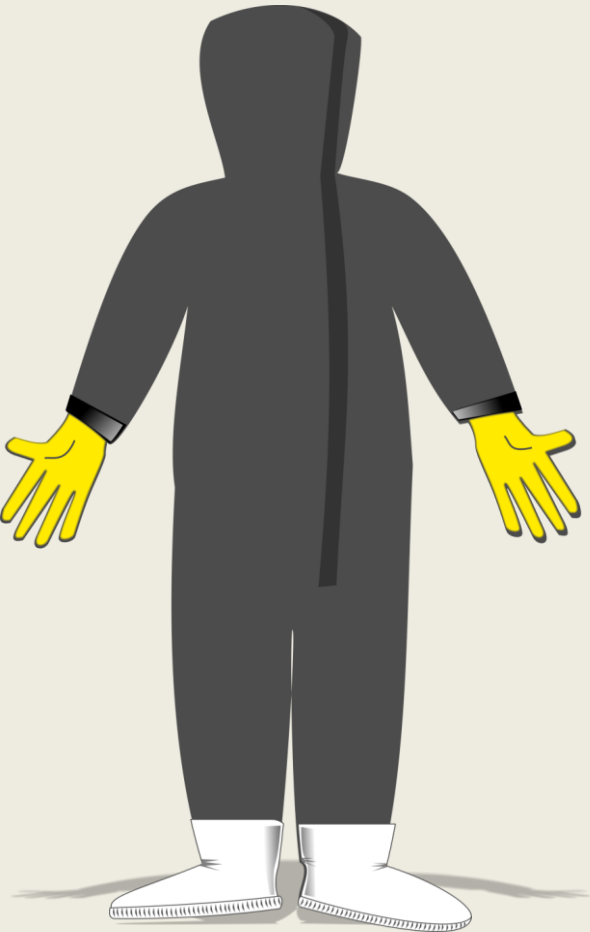


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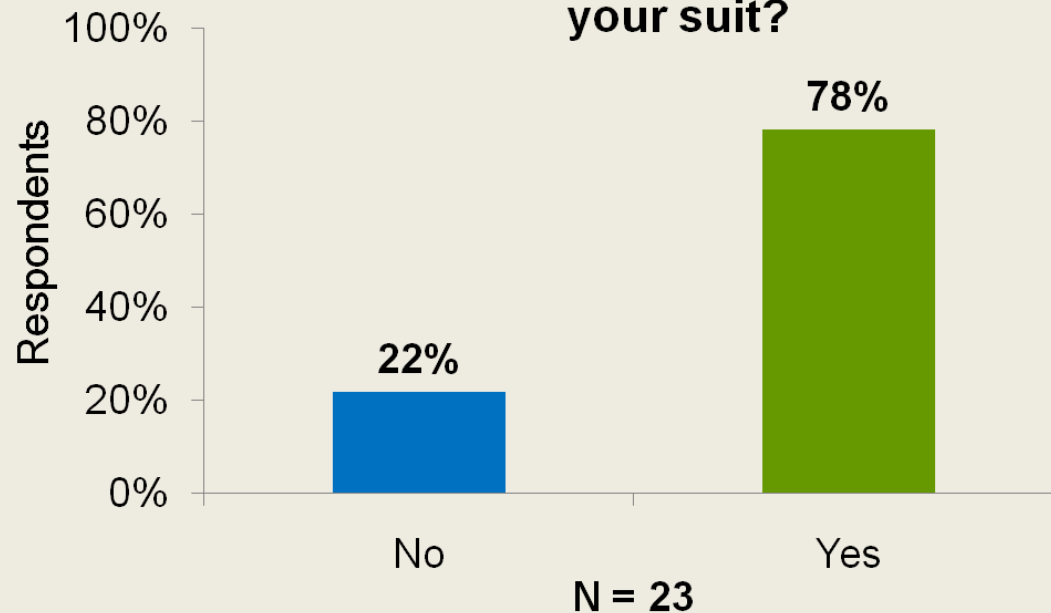
- **Long hours in an enclosed environment**
- **Workers are deprived of air for periods of time moving between suites**
- **Small network of workers and sensitive nature of experiments**
- **Fatigue and stress compound each other**
- **Suit conditions are further complicated by potential lethal consequences if a mistake is made**



# BSL-4 Suit Appendages



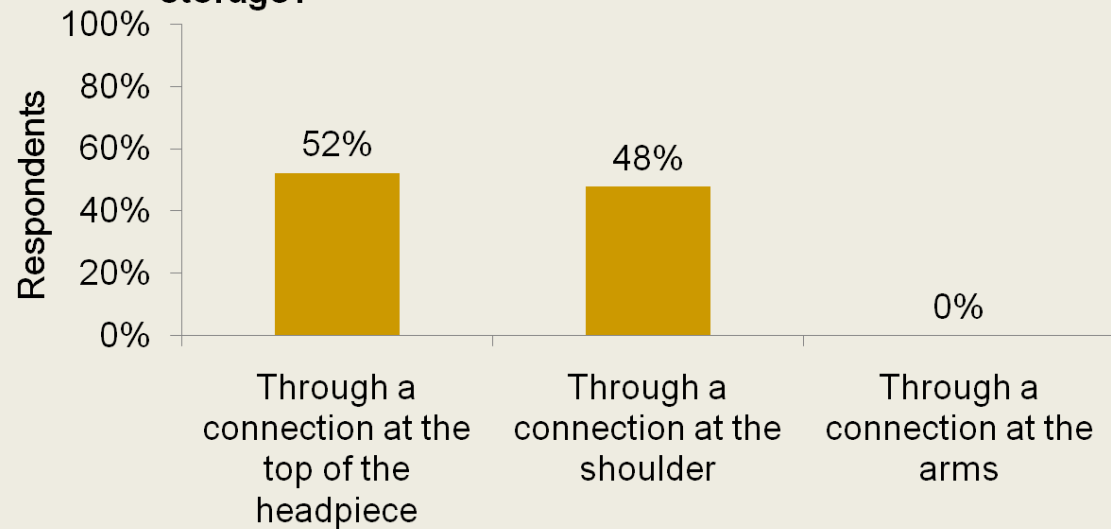
Do you wear an extra pair of outer boots with your suit?



# BSL-4 Suit Body



How would you prefer to hang your BSL-4 suit for drying and storage?



N = 23

- **An option to get a special made suit if the standard does not fit.**
- A different material for the visor so it doesn't scratch so easily. The metal fittings for the Spearian suits are great and make suit checks MUCH easier than the Dover (that requires taping all exhaust valves).
- noise control
- I had suit failures at the hands and zippers in the ILC Dover suit. I have heard that the "peter pan feet" Delta suit have ripped easier than the ILC Dover suit.
- I think in general suit design needs to look at better material, longevity of the suit, user comfort
- I think the connector valve is a very important point. It needs to be easily manipulated with one hand.