Poster #17

How to Choose a Suit for a BSL4 Laboratory – The Approach Taken at SPIEZ LABORATORY

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Choosing the appropriate suit for a BSL4 laboratory is of vital importance for creating a safe work environment within such a facility. The suit has to provide protection for the wearer, be compatible with the infrastructure at the facility, while still providing some level of comfort. There have been a number of manufacturers on the market and with the increased number of new BSL4 facilities worldwide, new manufacturers are entering this market. Unfortunately, apart from the information provided by the manufacturers, there is not a lot of data in the literature on what to look for in a BSL4 suit. Thus, we decided to develop a test program in order to compare the different suit models and to guarantee that the chosen suit can be used in the specific conditions encountered at our new facility. Tests ranged from studies on material compatibility and determination of protection factors to questionnaires on wearer comfort. Results as well as some conclusions that could be drawn from the tests will be presented.

Fig. 1: Suit Models Used in the Study and Tests Performed
Three suits by different manufacturers were tested. The suits will be differentiated by their colours (i. e. blue, white and yellow) and not their manufacturers' names.
Tests in the following areas were performed:

- Material compatibility: performance in 2.5% per-acetic acid
- Protection factor: leak tightness (data not shown) and chemical protection factors
- Wearer comfort: user feedback (data not shown).

Step	Time [min]	Activity	Comments
1	10	Enter lab and sit on chair	Start injection of methyl-salicylate and adapt to local environment
2	10	Walk on treadmill (5 km/h)	Simulation of "normal" movement inside laboratory.
3	10	Sit on chair	Rest
4	5	Crawl underneath a 1 m tall board	Deflating and inflating suit.
5	10	Sit on chair	Rest
6	5	Climb up and down a ladder	Increased physical exercise.
7	10	Sit on chair	Rest
8	10	Fill bucket with rocks and tip back into container	Deflating and inflating suit and increased physical exercise.
9	10	Sit on chair	Rest
10	10	Walk on treadmill (5 km/h)	Simulation of "normal" movement inside laboratory.
11	10	Sit on chair	Rest
12	5	Crawl underneath a 1 m tall board	Deflating and inflating suit.
13	10	Sit on chair	Rest
14	5	Climb up and down a ladder	Increased physical exercise.
15	10	Sit on chair	Rest
16	10	Fill bucket with rocks and tip back into container	Deflating and inflating suit and increased physical exercise.
17	10	Sit on chair	Rest
18	10	Walk on treadmill (5 km/h)	Simulation of "normal" movement inside laboratory.
19	15	Sit on chair	Rest and stop injection of methyl-salicylate
20	15	Move outside and sit on chair	Vent excess methyl-salicylate

Fig. 3: Test Program for Integrated Tests on Chemical Protection Suits
In order to compare the suits' protection factors a program was designed to simulate situations which may also occur while working in a BSL4 suit laboratory. Briefly, we wanted to see what happens when the suit is for example deflated and quickly re-inflated again (e.g. while bending down and standing up again) or during strenuous exercises when a lot of breathing air is needed.
Additionally, the program offered the unique possibility to thoroughly experience working in a BSL4 suit. Since wearer comfort is an important factor when attempting to implement biosafety measures at a facility, we wanted to profit from the test program. A questionnaire (not shown) was developed to gauge people's impressions while running through the 3 h test program.

Fig. 2: Material Compatibility towards 2.5% Per-Acetic Acid
BSL4 suit laboratories require a chemical shower process when leaving the laboratory. At the new facility at SPIEZ LABORATORY decontamination in the chemical shower is performed using per-acetic acid at a maximum concentration of 2.5%. A number of standard tests were performed in order to gain some insights into the material properties (data not shown). Material samples were immersed in 2.5% per-acetic acid for 7, 14 and 28 days and changes in the performance noted in comparison to non-incubated samples. Visually, differences in material compatibility could be clearly demonstrated with the blue suit giving the best results, followed by the yellow suit and finally the white one. Measurement results obtained from tensile, tear resistance and puncture tests, however, revealed that the yellow suit's material proofed to be best suited for exposure to per-acetic acid, followed by the blue suit. Throughout the tests, the white suit showed the lowest performance (data not shown).

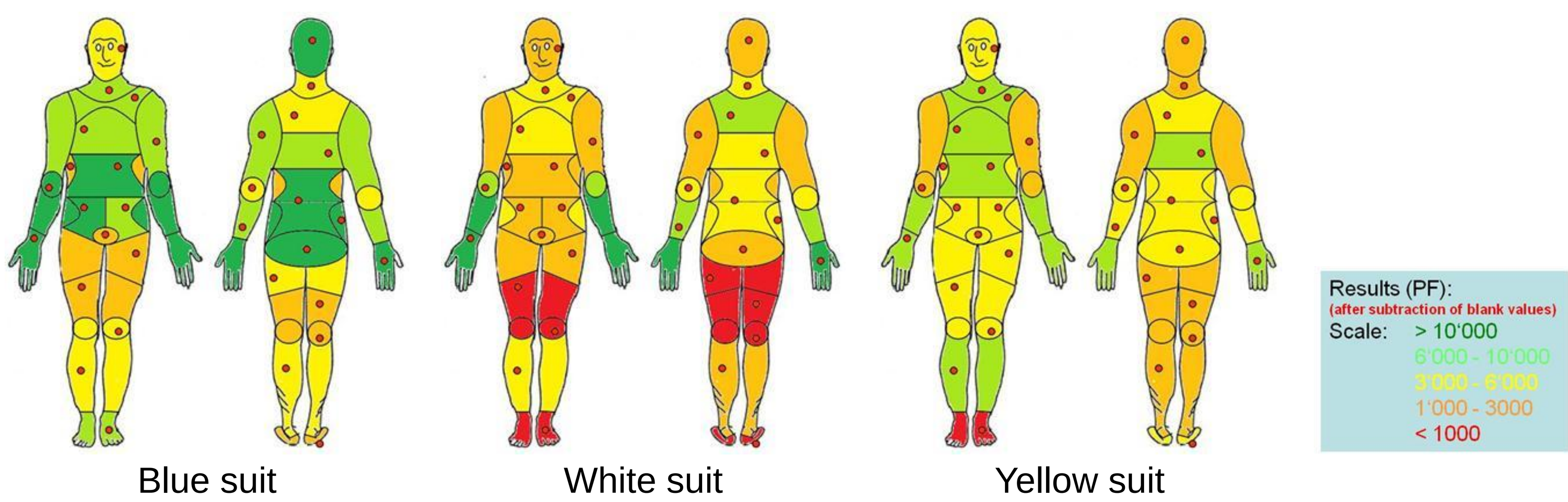

Fig. 4: Determination of Protection Factors Using an Integrated Test for Chemical Protection Suits
The method is based on the MIST Program [Technical Assessment of the Man-In-Simulant Test Program] (Standing Committee on Program and Technical Review of the U.S. Army, 1997) and can be performed either with gas (methyl salicylate, MeS) or aerosol (di-ethyl-hexyil-sebacat, DEHS). Gas instead of the aerosol was used, since the detection limit for aerosols is lower (local protection factor max. 1000) than the expected protection factors for BSL4 suits. The test chamber was filled with 55 mg/m^3 MeS and the test person had to perform a defined motion sequence (Fig. 3) for 3 hours (total dosage 9900 mg/m^3/min). The overall protection factor against VX gas was calculated according to the BRHA (body region hazard analysis, MIST Program) over 33 positions.
Results clearly pointed towards one suit model with the blue suit giving the best protection followed by the yellow and white suit. However, user feedback (not shown) also demonstrated, that the way this higher protection was achieved strongly limited wearer comfort. For example, the blue suit blows air from the back of the head towards the front and the face shield. This decreases the amount of contaminant that may blow past the face (and may potentially be inhaled). However, the constant noise of the air being blown past the head is almost unbearable.

Conclusion

Initially, we intended to base our decision of which suit to buy on objective comparisons between different models. The data obtained pointed towards one model. However, this particular model could not win over the future users of our facility. This clearly proved that user feedback is still of primary importance, especially as we could show that all suits offered comparable protection levels. Importantly though, with the test program used it was possible to thoroughly experience working in a BSL4 suit for extended periods of time. This being especially important for the future users at our facility who have no previous experience of working at BSL4.
Generally, the tests performed and the program used during this study may certainly be adapted to specific needs and maybe even facilitated. However, we have been able to point out certain short-comings in the suits' design based not only on people's feedback, but on scientific data and we are now working together with one of the manufacturers to further improve the suit.

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