# Microbiological safety cabinets - Protective functions and their limits

Thomas Hinrichs ▪ Berner International GmbH ▪ Elmshorn Germany

**Key words:** Microbiological safety cabinet, personal protection, product protection, DIN EN 12469, NSF 49, performance envelope testing, downflow, inflow

## Introduction

**The effect of airflow (s. fig. 1) on the protective functions of safety cabinets will be described. [1] The protective functions in terms of personal and product protection have been tested using the microbiological test method in accordance with DIN EN 12469 [2]. The optimum performance in the form of a „Performance Envelope" has been determined for a BERNER** Flow**Safe**® **safety cabinet. The variation in airflow conditions for safety cabinets reduces the performance and can lead to the loss of protective functions. Comparisons show that every safety cabinet, due to design differences, has its own PE and therefore different performance limits.**

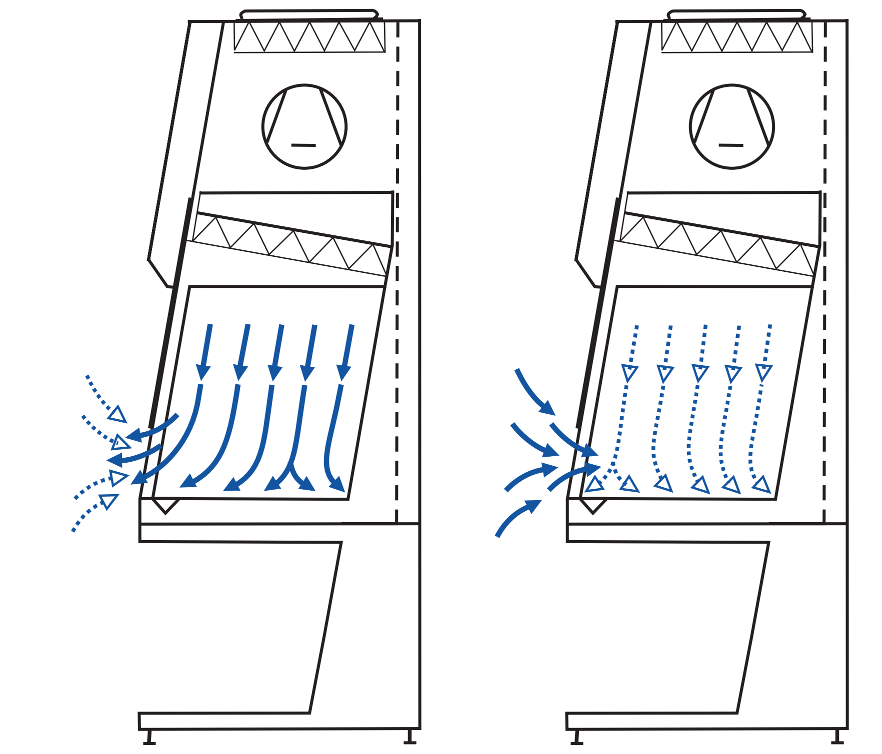


Fig. 1: Interaction inflow and downflow within SC

## Materials and methods

Table 1 presents the results relating to the airflow conditions and microbiological tests of personal and product protection in accordance with DIN EN 12469. Initially the Safety Cabinet (SC) was set to the specific operating point of 0,35m/s for a low turbulence downflow and to 0,44m/s for air inflow. Subsequently the flow conditions were changed gradually by 0,05 m/s in accordance with NSF 49 [3], until one or more of the limit values for personal and/or product protection had been exceeded, or if the SC's limits in terms of flow dynamics were reached, arising from design-dependent reasons.

## Results

**Table 1:** Detection reg. the performance limits of safety cabinets against airflow variation

**Test subject**: Microbiological safety cabinet class 2, **BERNER** Flow**Safe**® B-[**MaxPro**]²-130, $h_A$ = 180 mm; **Test specifications**: DIN EN 12469 (09.2000); DIN 12980 (06.2005), NSF/ANSI 49 (01.2007); **Location**: BERNER R&D laboratory, Elmshorn, Germany.

**Test Materials:** Nebulizer: collision nebulizer, model CN 31, $\overline{V}_n$ = 0,51 ± 0,05 m/s, Δ p = 1,4 bar; Cylinder: stainless steel; d = 63 mm; Spore suspension: B. subtilis var. niger, ATCC 9372; Agar plates: trypticase soy agar, d = 90 and 150 mm; Thermal anemometer: Testo AG, model 454; Air capture hood: TSI GmbH model Accubalance®.
**Test Materials personal protection:** $N_n \geq 5\text{-}8x10^8$ cfu; $N_c \geq 300$ cfu; Six impinger: model AGI 30, $\dot{V}_i$ = 12,5 l/min, $N_i \leq 10$ cfu; Two slit samplers: model FH 5, $\dot{V}_s$ = 30 l/min, $N_s \leq 5$ cfu.
**Test Materials product protection:** $N_n \geq 5\text{-}8x10^6$ cfu; $N_c \geq 300$ cfu; 25 agar plates: $N_a \leq 5$ cfu

| **Tested protective function** | | | **Personal protection** | | **Product protection** | |
|---|---|---|---|---|---|---|
| **Replicates each single airflow combination** | | | 5 | | 3 | |
| **Airflow combinations** | | | 42 | | | |
| **Total number of tests** | | | 210 | | 126 | |
| **Variable** | | | **Airflow** | | **Protective function** | |
| **No.** | **Downflow** | **Inflow** | $\overline{V}_D$ in [m/s] | $\overline{V}_I$ in [m/s] | Personal | Product |
| 0 | Operating point | | 0,35 | 0,44 | Yes | Yes |
| 1 | Reduced | Reduced | 0,11 - 0,32 | 0,19 - 0,40 | Yes | Yes |
| 2 | Reduced | Reduced | ≤ 0,08 | ≤ 0,18 | **No** | Yes |
| 3 | Reduced | Raised | 0,21 - 0,33 | 0,43 - 0,86 | Yes | Yes |
| 4 | Reduced | Constant | 0,08 - 0,27 | 0,83 | Yes | **No** |
| 5 | Raised | Reduced | 0,40 - 0,63 | 0,14 - 0,40 | Yes | Yes |
| 6 | Constant | Reduced | 0,64 | ≤ 0,13 | **No** | Yes |
| 7 | Raised | Raised | 0,37 - 0,50 | 0,44 - 0,89 | Yes | Yes |

**Glossary:** $h_A$: Height of the front aperture in [mm]; $\overline{V}_n$: Average discharge air flow velocity of the nebulizer in [m/s]; ATCC: American Type Culture Collection, Rockville, MD, USA; $N_n$: Minimum number of spores delivered by the nebulizer per test in [cfu]; cfu: Colony forming unit; $N_c$: Minimum number of spores on the control plate per test in [cfu]; $N_i$: Limit of spores collected by six impinger per test in [cfu]; $N_s$: Limit of spores collected by two slit sampler's per test in [cfu]; $N_a$: Limit of spores collected with all agar plates per test in [cfu]; $\dot{V}_i$: Volume flow of each impinger in [l/min]; $\dot{V}_s$: Volume flow of each slit sampler in [l/min]; $\overline{v}_D$: Average downflow velocity in the work room in [m/s]; $\overline{v}_I$: Average inflow velocity in the work aperture in [m/s]

## Discussion

The performance limits of the protective functions are very important for determining the optimum specific operating point for every model, to guarantee the highest possible safety functions. A reduction of the airflow volume inside the SC to minimise vibration, noise level or extension of filter life results in the specific operating point being very close to the performance limit of the protective functions [4, 5]. If the airflow volume is too low, then personal as well as product safety can no longer be guaranteed (fig. 2). If the air inflow is increased and at the same time the downflow is greatly reduced, then particles from the laboratory will pass into the workspace (s. fig.1, right). If downflow is significantly higher then the inflow, then particles from the workspace will enter the laboratory (s. fig. 1, left).
In addition the data of the **BERNER** Flow**Safe**® SC was compared with the data from other manufacturers [4, 6] (fig. 3). The performance limits of the safety functions varied strongly between the six compared models. It shows very clearly that every model has a unique „Performance Envelope" which is dependent on the geometry, the work aperture height, shape and size of the work surface and positioning of the specific working point.

**Fig. 2: Results of the microbiol. test of personal and product protection based on inflow and downflow.**

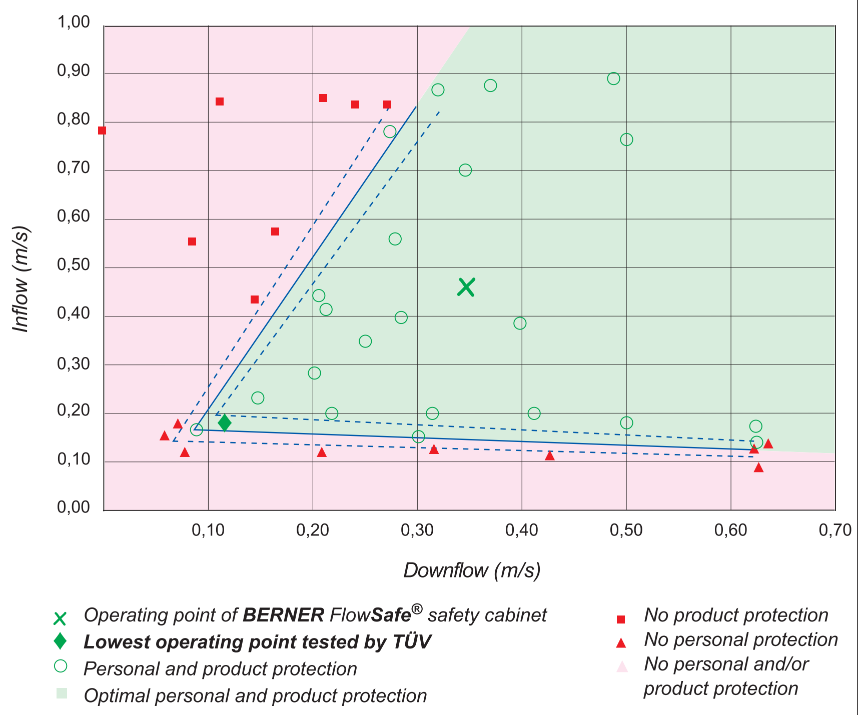
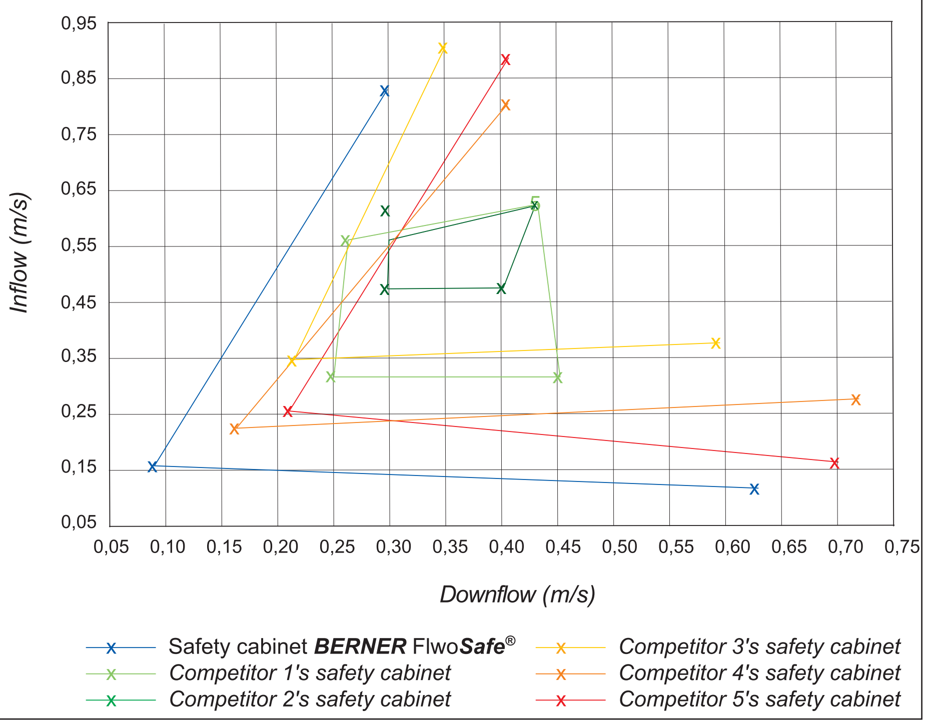



**Fig. 3: Comparison of Performance Envelope of different safety cabinets.**




## Summary

The performance limits of the protective functions were determined using the microbiological test method under extreme airflow velocities for a **BERNER** Flow**Safe**® SC. For two SC, for example, the air flow velocities could be set the same, but due to differences in their design the level of protection would not be equal. The protective functions are dependent on a multitude of design-dependent factors [6]. Summarising it could be said that the **BERNER** Flow**Safe**® SC, in comparison to other SC, has the widest „Performance Envelope" and therefore guarantees the highest level of safety functions.

### Bibliography

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