



**The most important Thing
is the Health of the People
in the Laboratory.**

Preserving this is an essential part of our mission.

Perfect materials and simple, but absolutely safe handling are the requirements for safety.

Introduction

- ✓ SCAT Europe - A Success Story
- ✓ Safety Solutions Made in Germany
- ✓ Articles, Reviews and Useful Information

Safety Solutions

Make your Lab a safer Place



Why do we protect HIM...



... but not HER?

We at SCAT cannot understand why, for example, employees in a paint shop are consistently protected from toxic fumes, while laboratory workers are often exposed to the highly toxic solvent fumes from an HPLC system without any occupational safety at all.

Let's take a look at the processes on the supply and disposal side of an HPLC system:

The process on the supply side of an HPLC system:

An HPLC system extracts solvents from an open or leaky closed supply container (often a 1 litre laboratory bottle, with GL 45 thread). Solvent vapours escape through leaks in the storage bottle.

This has consequences: on one hand, there is a permanent health hazard for the laboratory staff, and on the other hand, the mixing ratio of the eluents can change, which leads to falsified analysis results. Air, dust and dirt particles can be sucked in through loose capillaries and thus get into the highly sensitive analysis devices, which in turn entails impairment of the analysis and time-consuming troubleshooting and corrective measures.

A hermetically sealing Safety Cap can provide a simple and quick solution. Solvents should only come in contact with the highly inert PTFE of the cap to avoid contamination of the eluent. The capillaries are firmly fixed, using fittings with an integrated ferrule (see also **page 156**). A suction filter should be placed at the end of the capillary in the storage bottle (see **page 169**). This is to avoid

Safety Solutions

Make your Lab a safer Place

possible micro-contamination of the eluent. It is important that the inner diameter of the fitting is identical to the outer diameter of the capillary.

The same applies here: the smallest leaks unnecessarily endanger work safety in everyday laboratory work and lead to falsified analysis results. Because measuring the diameter of the capillary is very time-consuming, all our Safety Caps are fully equipped with the possible fittings (1.6 mm = green; 2.3 mm = purple and 3.2 mm = blue, see also **page 156**). This saves you a lot of work and the reordering of individual parts. Unused connections must be sealed with blind plugs. Of course, these are also included in the scope of delivery.

Basically, we at SCAT represent the plug-and-play philosophy: We want to make sure that you get all the necessary connections in the scope of delivery. That's why you always have a few fittings left after using the Safety Cap, but you can always be sure that the right ones are included. Safety First!

The freely rotatable core of the Safety Cap enables replacement or change of the storage container without "twisted tubes".

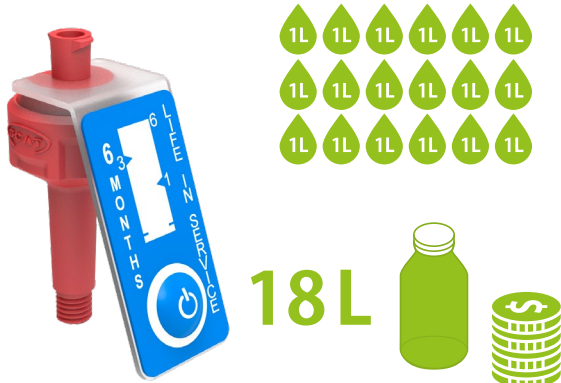
The HPLC extracts the eluent from the supply bottle. If a hermetically sealing Safety Cap is used, the removal creates a negative pressure. If there is no ventilation valve (see **page 53**) on the cap, that cap will not be hermetically sealed - and you will be unnecessarily exposed to a toxic solvent.

To achieve pressure equalization, you always need a ventilation valve. It is important that the ventilation is only conducted towards the inside of the container, otherwise solvents can escape. To ensure that the eluent is not contaminated during pressure equalization, the ventilation valve is also equipped with a PTFE filter that filters the smallest particles from the ambient air. As each filter becomes clogged over time, we recommend changing the vent valves every 6 months. You can either ensure the time measurement on the ventilation valve yourself by making a note, or by activating the supplied time strip, which shows the elapsed time. For the professionals: the Luer Lock adapter on the ventilation valve can be used to gas the eluent or to remove moisture from the air.



Worldwide trust

Over 80% of HPLC users in Europe trust the developer and market leader of SCAT Safety Caps. In more than 150 countries, our products contribute to more safety at work and in production.




Air valves

A SCAT Europe air valve prevents the evaporation of up to 750 ml of solvent during its life cycle of 6 months.

With an HPLC system equipped with 4 storage bottles, this makes a volume of 3 litres per half year. In a laboratory equipped with 6 HPLC systems, the ventilation valves prevent the evaporation of approx. 18 litres in 6 months.

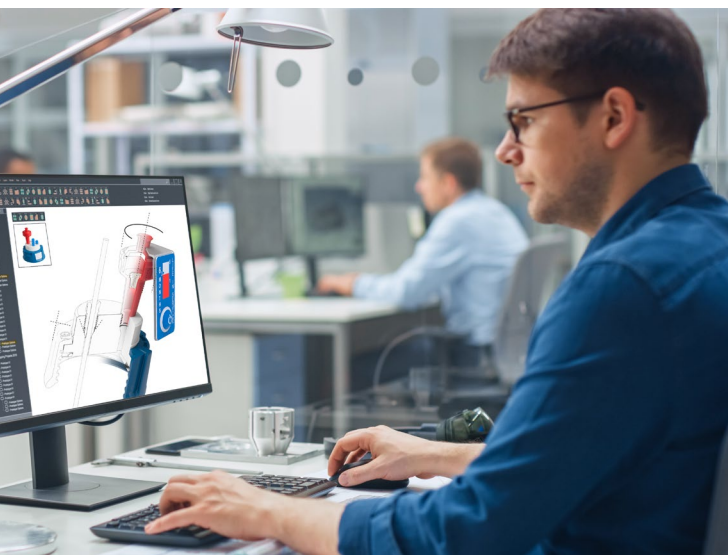
Safety Solutions

Make your Lab a safer Place



Exhaust filter

A SCAT Europe Safety Waste Cap with exhaust air filter, on a 10 litre waste canister, blocks approximately 28 litres of solvent waste, compared to an open canister in the vented laboratory, which can be fed back into the disposal cycle.



In house development: our team of specialists constructs each product according to the latest safety standards.

Safety Caps with a shut-off valve correspond to the highest level of development (see **page 46**). The shut-off valve prevents air intake into the HPLC system to avoid malfunctions or interruptions. Another advantage is that the storage container can be changed almost without dripping.

The process at the disposal side of an HPLC system:

After passing the HPLC system, the eluent must be disposed of safely. The structure of a Safety Waste Cap is similar to that of a Safety Cap: both are hermetically sealed, but in contrast to the Safety Cap, the Safety Waste Cap (see **page 68**) does not have a ventilation valve, but rather an exhaust air filter.

Since the rising solvent vapours must somehow escape from the container, an exhaust air filter also has the function of a pressure relief valve. It is extremely important that escaping solvent vapours are reliably bound, strictly speaking, adsorbed by the activated carbon. The performance of the activated carbon is the most important factor for workplace safety in the laboratory. Please take a look at the safety-related explanations on **page 66**.

Important to know: Activated carbon for solvent vapours does not sufficiently bind acidic or alkaline vapours. Since acids or bases are used to adjust the pH of the eluent to neutral, they can also occur in HPLC waste, especially as residues from overdosing. Therefore SCAT uses two additional layers of specially developed activated carbon for acid and caustic vapours. This three-layer model is unique and reflects our motto "Safety First!"

The service life of an active carbon filter depends on many influencing factors, e.g. flow rate, temperature, pressure, design of the activated carbon, solvents used, and many more. The most precise method of measuring the loading of the filter would be a comparative, permanent weight measurement. Since this is impractical in everyday laboratory work, we assumed a worst-case scenario with 24-hour operation of the HPLC and high flow rates for the runtime of our activated carbon.

Safety Solutions

Make your Lab a safer Place

We offer Safety Waste Caps in significantly more variants than Safety Caps. This is because there are significantly more disposal containers with different threads and capacities (see also the overview from **page 130**).

If you collect solvents in a container with a capacity of more than 5 litres, the use of electrostatic conductive canisters is recommended according to TRGS 727. The electrical conductivity is achieved by adding an additive, in this case carbon, to the base material PE-HD.

This makes the canister electrostatic conductive, but unfortunately also opaque due to the black color of the carbon. To be able to still keep an eye on the filling level, we offer Safety Waste Caps with level control (see **page 62** onwards).

A closer look at the processes on the supply and disposal side of an HPLC makes it clear that there are a number of weak points where toxic solvents can escape.

We at SCAT are driven to identify these weak points, to sensitize the user and to show ways to eliminate these risks - so that your laboratory remains an all-round safe workplace.



Modern CNC production with our own machinery.



High-quality materials, the latest equipment and precise workmanship: this is our quality standard.



SCAT headquarters near Frankfurt Airport: development, production and logistics in one complex.



Safety Solutions

Specialised Articles, Test Reports and Useful Information

Everything revolves around Safety

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■ Herbert Heidfeldt. Consultant for Environment, Health & Safety, Darmstadt, Germany.

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■ Test report. SGS Institut Fresenius was commissioned to investigate reduction of emissions achieved by use of SCAT Safety Caps.

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■ Kurt Moritz. Specialist in charge of electrostatics and mechanical explosion protection for the technical plant safety of Merck KGaA, Darmstadt.

Protect your Health Key Regulations & Laws

Page 28

■ Important key regulations & laws. SCAT Europe supports enterprises with consultation and can offer standard as well as customized solutions for all areas.

Laboratory Safety with Passion

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■ Article of LABORPRAXIS, Online, October 2022.

Safety Solutions Product-Catalogue

HPLC-Supply

- Safety Caps
- Air Valves
- Sets

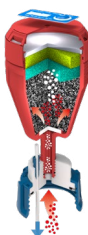


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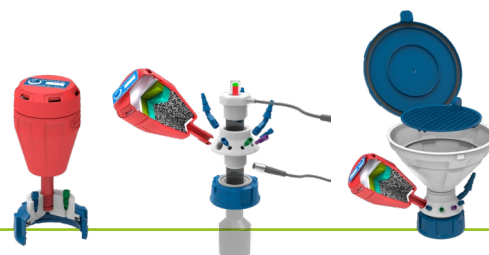


HPLC-Disposal

- Safety Waste Caps
- Safety Waste Cap LISA
- Universal Waste Hub JAN



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Safety Funnels

- MARCO
- ARNOLD
- Funnels for Barrels



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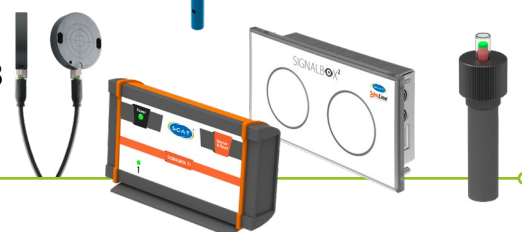


Level Control

- Sensors
- Signalboxes
- Mechanical



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Containers

- Laboratory Glass Bottles
- Canisters
- Collection Trays



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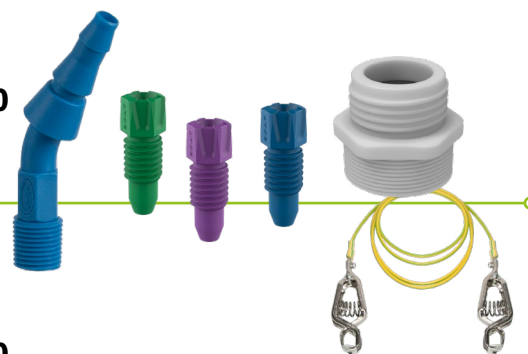


Accessory

- Air Valves
- Exhaust Filters
- Adapters and more

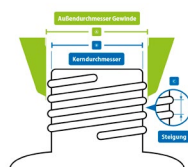


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Addendum

- Thread Determination
- Chemical Resistance Table
- Useful Informations



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Everything revolves around Safety

“In the chemical laboratory, safety isn’t self-evident. SCAT Europe helps its customers to achieve and maintain a very high degree of safety.”



Herbert Heidfeldt

Consultant for Environment, Health & Safety.

Herbert Heidfeldt began his career over 40 years ago in Research & Development at Merck KGaA. Since 2006, he has worked as a certified auditor, trainer and consultant for Corporate Environment, Health & Safety.

Working in the laboratory means managing complex tasks routinely and reliably. Therefore, this work demands placing a great deal of confidence in the facilities and in their own competence. More and more, supervisors and employees of chemical laboratories have to struggle with the growing occupational safety and legal requirements.

Along with the abundance of requirements, the need for professional help in order to provide competent and practical solutions for the user is also increasing.

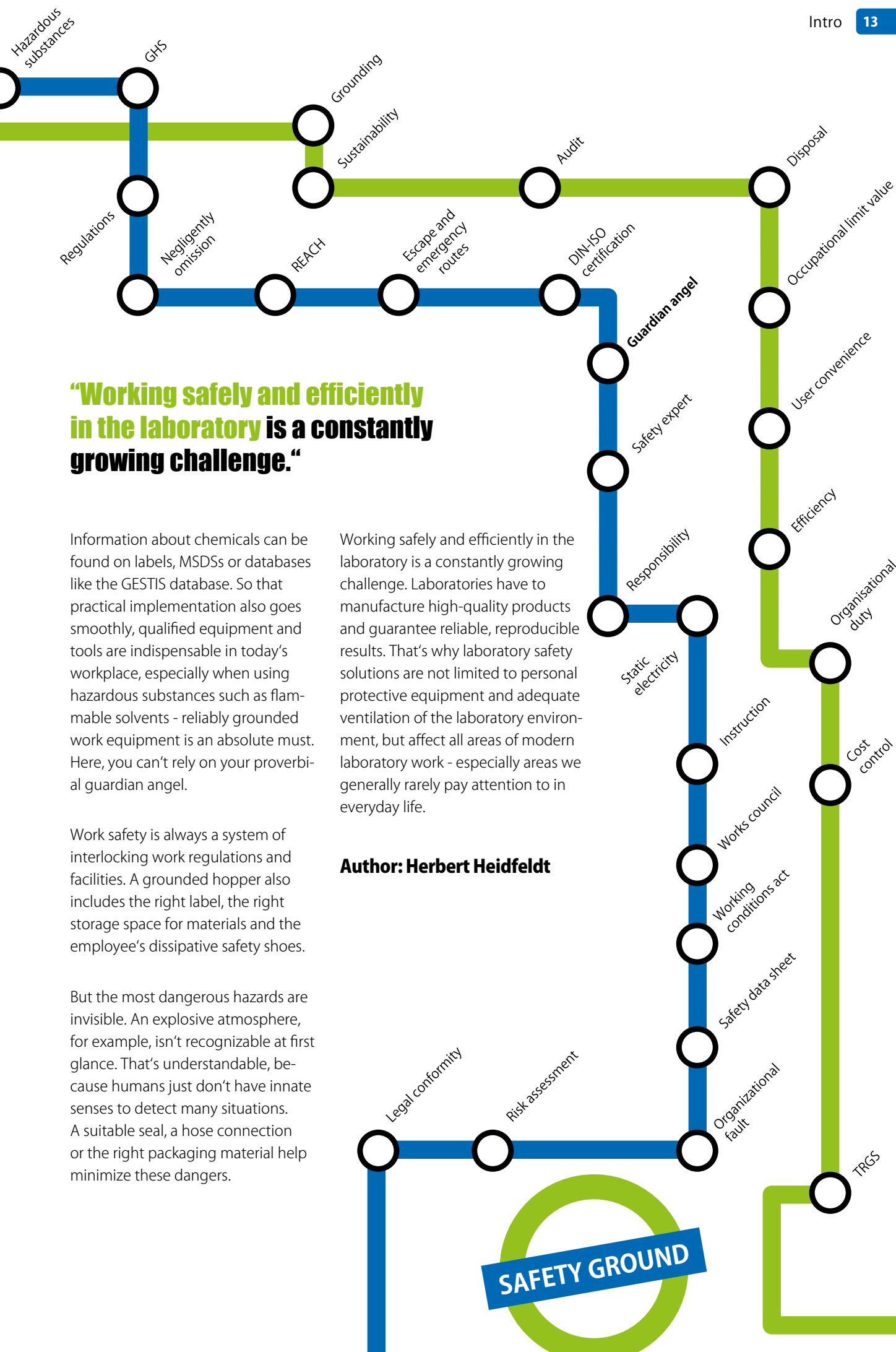
Even as early as planning a laboratory, future risks can be reduced to a minimum by, for example, properly collecting hazardous materials that must be properly disposed of after use. Here, planners, managers and employees often focus on known safety facilities such as emergency exits and routes, signage, emergency showers and eye washes and fire fighting.

However, these are only designed for facilities to limit damages in an emergency. What about preventing these same emergencies from happening in the first place? The entire process chain of using chemicals is replete with dangers, especially their disposal.

Do you know how to handle all your materials properly and safely? Have you planned and tested emergency measures? Do employees receive regular training instruction? Is each next job (or the next upcoming experiment) thoroughly discussed and approved? Have you thought of everything? Or have you just been lucky so far?

Only one thing is certain: safety has many faces.

Especially in our workplaces in chemical laboratories, many sensible solutions help us handle materials properly.



Safe handling of Solvents in the Laboratory



“Avoiding contamination in the laboratory is absolutely necessary to protect employees against health hazards.”



Michael Baldus

Product Manager, NOVIA Chromatographie- und Messverfahren GmbH.

NOVIA is a company owned by Proadis Partner für Bildung und Beratung GmbH.

Does this situation sound familiar?

You're in the laboratory preparing your samples, but you're still thinking about the parallel analysis you just ran and also have to remember to equilibrate your HPLC system. You lose focus for a moment and you've spilled the solvent you wanted to pour straight into the flask.

In my own experience, that's part of a normal workday in the laboratory.

This loss of attention is followed by contamination with hazardous chemicals, particularly solvents. But it isn't just inattention like this; it's also incorrect handling by insufficiently qualified and thus unsuitable laboratory equipment that leads to health and environmental hazards.

Avoiding contamination in the laboratory is absolutely necessary to protect employees against health hazards. The greatest danger for employees is to be unknowingly exposed to risk.

In order to avoid undesired physical contact with hazardous materials, laboratory personnel should observe the basic safety rules for working in the laboratory.

But they can only do so if suitable technical solutions for handling solvents are available and can be implemented.

In our experience, both the Safety Caps for solvent extraction and the Safety Waste Caps for safe disposal fulfil these requirements ideally.



“SCAT Europe systems are demonstrably easy and safe to use“

Responsible activities in the laboratory require well-trained personnel. In doing so, the pure knowledge of occupational health and safety plays a role, especially so-called “awareness”. Only employees who are familiar with the contexts and risks contained in their work and have developed an awareness of security can act appropriately - but only if they know the necessary correct technical solutions and are able to use them.

As a company engaged in the education and training of laboratory staff, we have a high responsibility towards people to inform them about correct practices, necessary expertise and the correct, optimum technical solutions in theory and in practice.

We realize this by making health, safety and environmental protection an integral part of our qualification measures - whether in training, continuing education or programs of study.

All the SCAT Europe systems we implement have proven themselves to be easy and safe to use - whether it's the simple replacement of ventilation valves, the secure closure of the safety funnel with a ball valve or the flexibility provided by the multiple sizes of threaded connections and additional components.

Maximum security is always combined with user-friendliness and easy handling.

Conclusion:

In order to ensure the safe handling of solvents in the laboratory, facilities must include easily usable and reliable tools and systems, as these contribute significantly to occupational health and safety - all systems by SCAT Europe meet these requirements. They also ensure that “clean”, reproducible analysis results are obtained, since the systems avoid contamination of the solvent, even with outside impurities.

Author: Michael Baldus

Ensuring Safety - Every Day in the Lab

“This clearly documents that with the SCAT Safety Cap an evident reduction in the methanol concentration in the test chamber to nearly 0 was achieved, so the workplace limit value of 270 mg/m³ specified by TRGS 900 was fallen well below.”



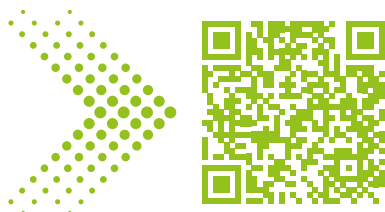
SGS Institut Fresenius was commissioned to investigate reduction of emissions achieved by use of SCAT Safety Caps.

In this respect, 1000 ml solvent bottles with and without Safety Caps were used and the emissions over a period of 28 days compared.

Then test chamber tests were conducted over a period of 7 days, during which the level of emissions in atmosphere were regularly monitored.

The solvent components tested as examples were the tested compounds methanol/water (ratio: 80/20), acetonitrile and methanol.

**Articles and test reports
also available as download:**



No change in the mixture ratio was found with SCAT Europe Safety Caps

Determining the changes in density and volume

SGS Institut Fresenius GmbH was commissioned by SCAT Europe GmbH to evaluate the effectiveness of their SCAT Safety Caps in comparison to a solvent bottle without SCAT Safety Caps. Changes in density of a methanol/water mixture were examined to determine if use of the SCAT Safety Cap could prevent a change in the mixture over an longer time of 8 days.

A comparison of the measured results shows that in a bottle fitted with the SCAT Safety Cap no change in density occurs, the initial density of $0,855 \text{ g/cm}^3$ stayed constant throughout the entire 8 days of the test. In contrast to this, the solvent bottle without a SCAT Safety Cap displayed a demonstrable change in density so that the initial value of $0,855 \text{ g/cm}^3$ of the solvent mixture rose to a density of $0,858 \text{ g/cm}^3$ (Fig.1). An increase in density indicates that there has been a greater loss of methanol than of water from the mixture. This loss did not occur in the same mixture ratio.

Therefore a change in the composition of the methanol/water mixture can be assumed, which then could result in errors in measured values under laboratory conditions. In contrast to this, in the solvent bottle with the SCAT Safety Cap, no change in the mixture ratio was found so that errors in measured values due to a change in the solvent mixture can be excluded.

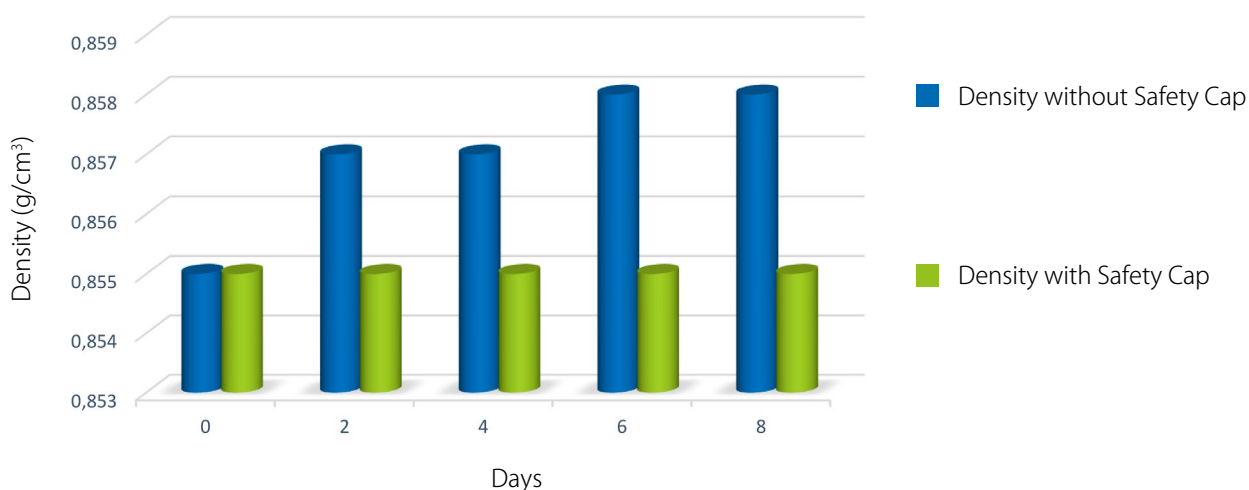


Fig. 1 Changes in the density of a methanol/water mixture

Continued on the next page



Quality Assurance Measures

SCAT Europe Safety Caps

Characterization of the change in volume in methanol and acetonitrile

The first step in this test was to determine change in volume by means of differential weighing over the 28 day pilot study in which both acetonitrile and methanol were specified as solvents. These two solvents were used to generate the best possible comparison with real on-site conditions in a HPLC laboratory. Based on the measurement results it is evident that in both series of trials with the SCAT Safety Cap, scarcely any change in volume over the period of 28 days was observed. In comparison to this, without the SCAT Safety Cap, a significant reduction in the given volume of 1 litre was found within the period of the trial (Fig. 2).

In the acetonitrile bottle without a Safety Cap, a reduction in volume of almost 10% occurred so that after 28 days, only 90% of the initial volume remained in the solvent bottle. Consequently, after 4 weeks, almost 10% of the solvent quantity was lost, having escaped unfiltered into the atmosphere.

During differential weighting to determine the change in volume of methanol, it was evident that an even more significant reduction had occurred in the solvent bottle not fitted with a SCAT Safety Cap: After 28 days, only 87.8% of the initial volume remained in the open solvent bottle, compared with 100% of the initial volume remaining in the solvent bottle equipped with the SCAT Safety Cap. It is obvious that almost 13% of the solvent quantity used are lost, having escaped into the atmosphere from the solvent bottle not fitted with a SCAT Safety Cap.

Characterization of the atmospheric concentration by test chamber investigations

In order to investigate the atmospheric emissions caused by open solvent bottles in comparison to a solvent bottle with SCAT Safety Cap, one of each solvent bottles were placed in a test chamber and their respective methanol or acetonitrile emissions were tested after 1, 3 and 7 days (fig. 3).

It was evident that within the test chamber, despite continuous air exchange a methanol concentration of 630–660 mg/m³ could be determined for the solvent bottle without Safety Cap, whereas a concentration of 1–2 mg/m³ was analyzed for a solvent bottle with SCAT Safety Cap.

This clearly documents that with the SCAT Safety Cap an evident reduction in the methanol concentration in the test chamber to nearly 0 was achieved, so the workplace limit value of 270 mg/m³ specified by TRGS 900 was fallen well below.

In contrast to this, without Safety Cap the concentration of 630–660 mg/m³ clearly exceeds the workplace limit value to constitute a background exposure which can lead to impairment of employees' health in the laboratory.

A similar picture also results from the test chamber investigation with acetonitrile, in which a concentration of 1–5 mg/m³ was determined with Safety Cap, as opposed to an atmospheric concentration of 730–800 mg/m³ without the SCAT Safety Cap, despite continuous air exchange (Fig. 3).

Comparison of the detected test chamber emissions with the acetonitrile limit values of 34 mg/m³ specified by TRGS 900 showed that without the SCAT Safety Cap, the workplace limit value was evidently exceeded. In contrast to this, with the SCAT on the bottle a distinct minimization of the acetonitrile concentration was determined, which was well below the workplace limit value of 34 mg/m³ specified by TRGS 900 (fig. 4).

Test Report Conclusion

Conclusion

In conclusion, it is evident that solvent emissions could be significantly reduced by the SCAT Safety Caps. In this respect, the use of SCAT Safety Caps can be expected to lead to a clear reduction of the exposure to solvents in the air in a laboratory.

In this connection the reduction in the solvent concentration in the air can be assumed to be of a similar proportion as was described previously, leading to significantly lower health risk for the employees concerned.

Furthermore, SCAT technology significantly minimizes the risk of contamination of solvent-free blank samples in laboratories, so the use of SCAT Safety Caps can also be considered a measure of quality assurance.

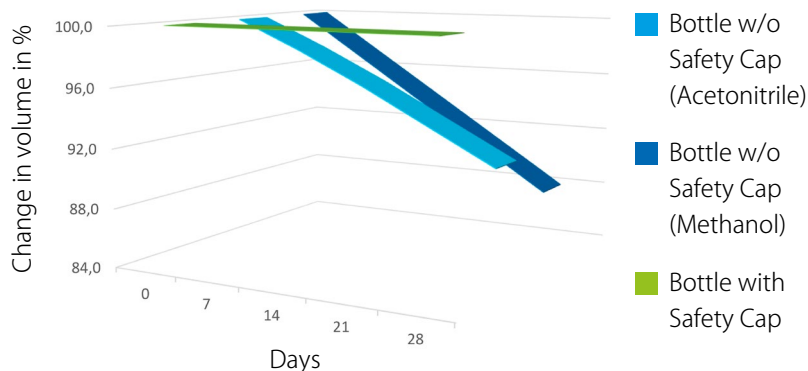


Fig. 2 Changes in volume of methanol and acetonitrile

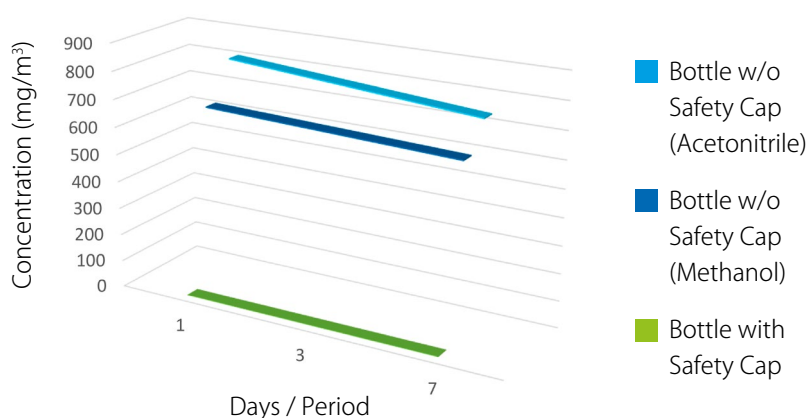


Fig. 3 Methanol emissions and acetonitrile emissions in the test chamber

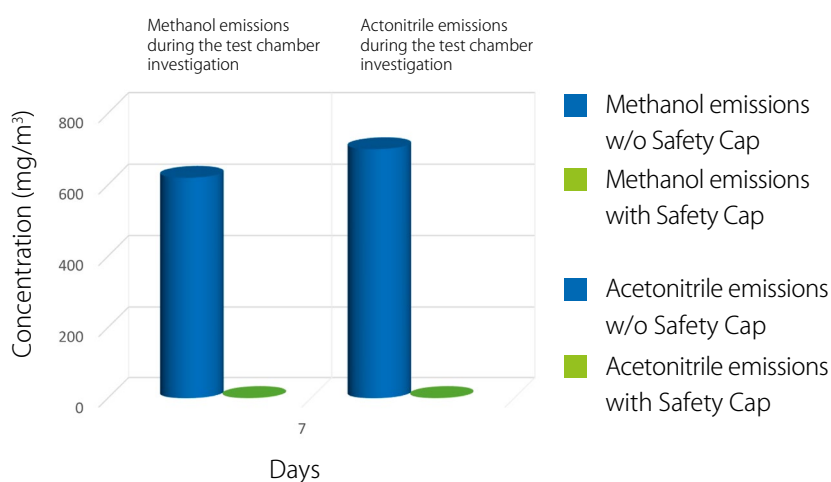


Fig. 4 Methanol emissions and acetonitrile emissions in the test chamber

The Underestimated Cost of Laboratory Air

Source: LABORPRAXIS / October Edition 2020

Air Exchange in the Laboratory // Some ten olympic swimming pools full of air must be pumped through a laboratory of size 120 m² - every eight hours. This ensures for the safety of the personnel, but it is expensive and detrimental to the environment. However, if even small measures are undertaken, this can serve to save on the costs involved in air exchange.



Peter Rebehn

Managing Partner
of SCAT Europe GmbH.

Everyday work with cancer-causing or toxic materials is unavoidable in many laboratories. There exists a corresponding danger that the workers involved can become sick as a result of respiratory illnesses they might contract. An important protective measure is therefore an efficient exchange of air in the laboratory. The German Federal Institute for Occupational Safety and Medicine (BAUA) demands fundamentally that

for every square metre of floor space, 25 cubic metres of air are exchanged every hour. As a result, laboratories in Germany must be equipped with correspondingly large ventilation systems. Because a human being only breathes in around half a cubic metre of air per hour, a high dilution, and therefore a correspondingly high degree of safety, is thereby provided for, even when toxic materials are being released into it. If it is possible to prove that there is no resulting increase in risk, the BAUA will also allow for a reduced - or even just a natural - level of air ventilation. This brings short-term benefits and saves thousands of Euros.

Eightfold exchange standard!

Conventionally, the rate of air exchange is used as a measure for gauging and evaluating air exchange. It compares the amount of air entering or leaving a room (over an hour) with the volume of air space physically located there. The Air Exchange Rate (AER) is then the resulting given ratio. An AER of 8 therefore means that all the air in a room is fully exchanged some 8 times, during the space of one hour. Exactly how much air per hour and square metre that represents, is dependent

upon the ceiling height of the room. If a room has a ceiling height of 3 metres - as is the case in many laboratories - it results, approximately, in an air exchange of 25 m³/m²h, as demanded by the BAUA. Therefore, an AER of 8 (more exactly, 8.33) is often used as the general yardstick for laboratories. To clarify further: if the ceiling height is only 2 metres, the total spatial room volume of air would have to be exchanged some 12.5 times per hour, in order to achieve the required 25m³/m²h.

What does laboratory air cost?

Usually, there is of course a basic wish to keep the amount of air exchanged as low as possible, without correspondingly endangering the health of personnel. This, because the annual costs of exchanging all the air in a laboratory are quite considerable, as the following example involving a laboratory with a floor space of 120 m², that is running around the clock, shows:

- **Air Exchange Rate (AER):**
25 m³ / m²h
- **Laboratory Area: 120 m²**
- **Daily Time for Air Exchange: 24h**
- **Annual Time for Air Exchange:**
365 d

The Underestimated Cost of Laboratory Air

If these 4 parameters are multiplied by each other, the result is a total overall air exchange volume of 26,280,000 m³ / year. If an average air cost of 2 Euros per 1,000 m³ and year is assumed, it results in a total overall annual cost involved of 52,560 Euros

- an amount which surely offers some good potential for savings!

Safe reduced air exchange

But what possibilities are there to reduce the AER, yet at the same time fulfilling the technical obligations for hazardous substances, as described in TRGS 526 and as demanded by the BAUA? As mentioned before, the TRGS allows - as described under Para. 6.2.5. - for a reduction of the AER, using various methods, provided the subsequent obligatory assessment of the hazards involved still allows for "the method used to be permanently and sufficiently sustainable and effective." An effective method for reducing the AER is, for instance, to use hermetically sealed caps on laboratory supply bottles. Similarly effective is the use of exhaust filters on canisters at the

waste collection side. By means of such simple methods, it is actually easily possible - in conjunction with an assessment of resulting safety - to reduce the AER from a factor of 8 to one of just 5, corresponding to a reduction of 38%.

15 HPLC units must first undertake a corresponding investment of about 10,000 Euros in the first year (see Table 1). During the following years, there will be further annual costs of some 4,650 Euros, for the required

six-monthly exchange of exhaust filters and air valves. Summing everything up, however, these additional "hardware-related" operating costs will be very much more than compensated for by thereby achieving lower and more cost-effective rates of air exchange. Overall, the annual resultant savings enjoyed every year, as of the second year, are no less than around 15,000 Euros (see Table 2).

Table 1: Cost calculation for a laboratory with 120 m² and 15 HPLC units


Costs for initial equipping Price/set, comprising: 4x Safety Caps (Extraction) 4x Air valves 1x Waste Cap (Disposal) 1x Exhaust filter 4x Laboratory bottles 1x Waste canister	Running costs half-yearly exchange of (a) Exhaust filter & (b) Air valves
15 x 500 €	(a) 15 x 1 x 75 € (b) 15 x 4 x 20 €
Resultant total cost: 7,500 €	Resultant total cost: 2,325 €
Overall total investment costs in the first year: 9,825 €	

Taking the a.m. annual total overall costs of 52,560 Euros, this corresponds to a savings potential of some 20,000 Euros - for air exchange, there then remain substantially reduced costs of only 32,587 Euros p.a. This cost saving is of course not equivalent to the final direct cost saving involved, as the laboratory must first be equipped with the corresponding hermetically sealed caps. As an example, a laboratory with

This calculation example proves that by implementing such simple measures, every laboratory can save significantly, namely some 15,000 Euros p.a. - and without having to compromise in any way on safety!

Table 2: Example of amortization with an AER of 5 (basic costs: € 32,587 p.a.), as compared to an AER of 8 (basic costs: € 52,560 p.a.)

Point in time	Cost of initial equipping	Cost of consumables	Total costs incl. basic costs, with an air exchange rate of 5	Overall summed savings potential since purchase
Year of purchase	7,500 €	2,325 €*	42,712 €	10,148 €
1st Year after purchase	-	4,650 €**	42,712 €	25,471 €
2nd Year after purchase	-	4,650 €**	42,712 €	40,794 €
3rd Year after purchase	-	4,650 €**	42,712 €	56,117 €
		**	= 1x Exchange of exhaust filter & air valve necessary = 2x Exchange of exhaust filter & air valve necessary	



Risks of Electrostatic ignition in the Laboratory

When handling flammable Liquids

“Alternatively, the use of conductive or dissipative materials is recommended, as they discharge safely when grounded. In this way the prerequisite for brush discharge, namely charged insulation surfaces, is not given.”

Author: Kurt Moritz

Kurt Moritz is the expert for electrostatics and mechanical explosion protection in the Technical Plant Safety department of Merck KGaA, Darmstadt.

Electrostatics, commonly known as static electricity, is not produced through friction of two surfaces as per popular belief. It is generated by separating surfaces which have previously been in intensive contact. In this context, intensive contact refers to a surface having a dwell time, even if short, and a maximum distance of 10 mm to the other contact surface.

Depending on the conductivity and position in the triboelectric series, materials tend to pick up charged particles on their surfaces or transmit charged particles to the adjacent

surface. In this case, conductive materials serve as electron suppliers (donator), while insulating materials absorb charged particles (acceptor).

If the surfaces are separated quickly after such a charge transfer, and if at least one of these materials is a poor conductor of electricity, the electrical charge can no longer be transferred back to its origin. Consequently, this inability for charged particles to be transferred back results in an excess charge on one surface, while a charge deficiency is created on the other surface. During separation a voltage is generated, reaching up to the magnitude of kV.

Therefore, electrostatics is always a surface effect and occurs on the surface on a molecular or atomic level.

When working with solids, it is easy to recognize separation processes that may lead to chargers, as these are generally visible movements. In general, visible movements are always present. Removing film layers, decanting material from a container or removing a synthetic piece of clothing from the body (fleece, polyester) are all examples that can lead to noticeable and sometimes visible static charge transfers.

As previously explained, for charge separation to occur at least one of the materials involved requires to be a poor conductor. Poor conductors (or “insulators”) include most plastics like PE, PVC, PVDF, PTFE, etc. However, solids are not measured in units of conductivity (unit: S/m) but in terms of their resistance (unit: Ωm). Siemens/ meter being the reciprocal of ohmmeter, the values are directly comparable, i.e. low conductivity corresponds to high resistance.

Most common Type Discharge by Spark

Surface roughness, flow-inhibiting installations and cross-sectional changes favour these effects, increasing the charge of the system.

Of course, a certain volume of liquid as well as flow velocities are required in order to generate a charge.

In a closed system a flow velocity of typically < 1 m/s is regarded as uncritical, as up to this point an equilibrium of charge transfer and charge reflow exists. However, this limit does not apply to pipe-exit conditions or decanting, since here different volume/surface ratios are given. Furthermore, stopping the liquid flow will not allow for a charge reflow.

For the given reasons, filling a test tube from a laboratory wash bottle does not meet the criteria that lead to critical electrostatic charges, even though the wash bottle is also made of insulating material (generally LDPE or HDPE).

However, charges quantity is transferred at increasing velocities. **This situation may occur in capillaries and tubes of HPLC systems**, particularly when multiple tubes are combined, thus increasing the flow of waste solvents through a single tube. The associated separation or charging processes can be sufficiently strong to result in an electrostatic field being formed around the transfer tubes. If there are components inside the affected charge area which are conductive (such as metal parts) as well as non-grounded, they will become subject to a charge polarisation.

This means that the opposing polarity increases towards the field; the same polarity is repelled. This polarisation effect of charged particles in non-grounded, conductive components can be so strong that a discharge of the excess charge or - depending on polarity - an equalisation of the charge deficit to the next grounded point takes place. Both generally manifest themselves in form of sparks.

A typical example of building up a charge through induction are metallic components such as couplings or brackets connected to a transfer tube made from insulating material.

Even when pouring liquids flowing over surfaces and are, subsequently, collected in containers (e.g. waste solvents that are poured through a funnel into a collection container), charges may accumulate. Initially, the funnel may take on one polarity due to the separation process between liquid and funnel. The oppositely charged liquid collects in the container and transmits its charge to the container. If the funnel and container are not electrically/electrostatically connected to each other, a different electric potential forms on both components, i.e. a charge that can be discharged in the form of sparks. This creates an ignition risk.

Incidents with damaging effects due to electrostatic charges and discharges when transferring liquids and waste solvents are well-known and documented.

How do you avoid electrostatic ignition risks when handling solvents in laboratories?

There are three different types of electrostatic discharge that apply to laboratory conditions.

A risk assessment taking into account the three types is used to evaluate the risk as well as to specify safeguards, and by this mitigates electrostatic hazards.

The most common type is the discharge by spark which always occurs when conductive materials are charged by separating their surfaces from insulating materials or by "induction".

These charged, conductive objects may include

- packaging materials such as canisters, alloy bottles,
- metal containers
- persons
- tools such as funnels, pipe components, sieves and filters
- as well as flammable solvents with high conductivity (alcohols, ketones)

if their charges cannot be discharged.

The charge accumulates in the same way as in a capacitor. If the potential is high enough, the charge is equalized with another conductive object to another potential (generally to the grounded point).

Avoid Ignition Risks

The use of conductive or dissipative earthing materials prevents spark discharges.

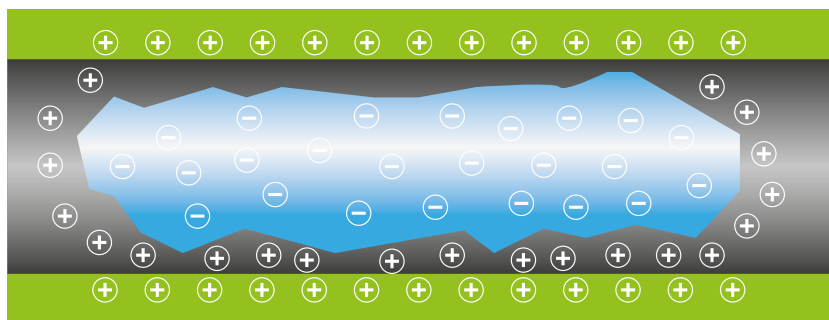
The charge is equalised via the ground connection and a possible charge is harmlessly discharged. At the same time, conductive, grounded containers are capable of grounding the conductive liquids they hold.

The second relevant type of discharge is the brush discharge.

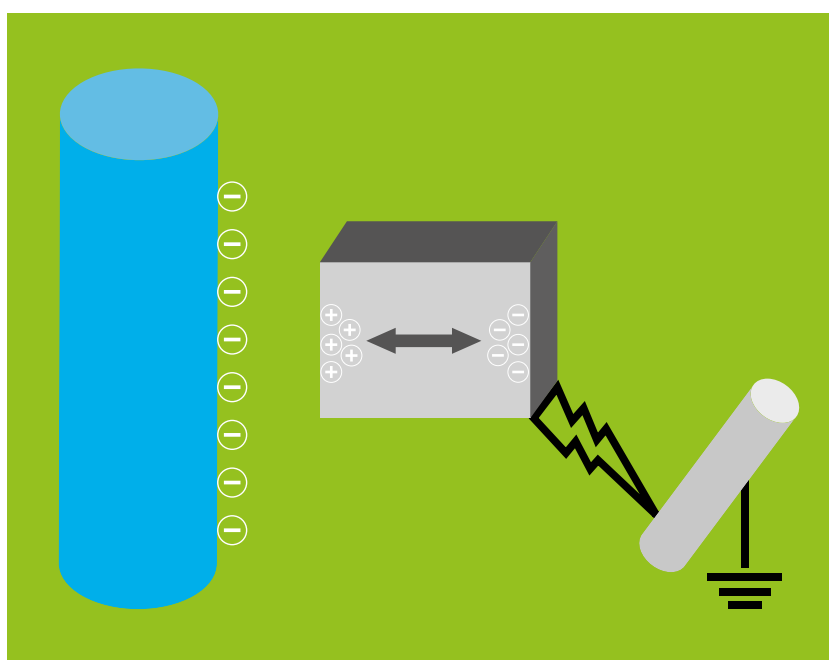
This occurs on surfaces made of insulating material which have been charged by separating operations such as rubbing, wiping, the removal of protective films, etc., or by spraying.

Insulating solid surfaces can only be charged by such surface processes. Charging via induction does not occur in insulating materials, as the poor conductivity does not allow the charged particles in the material to be moved/polarised.

If a charged insulating surface is given a grounded conductor, such as by the approach of a metal object or a person, the electrostatic field concentrates towards this grounding point and develops into a spark manifesting on the surface - the brush discharge.

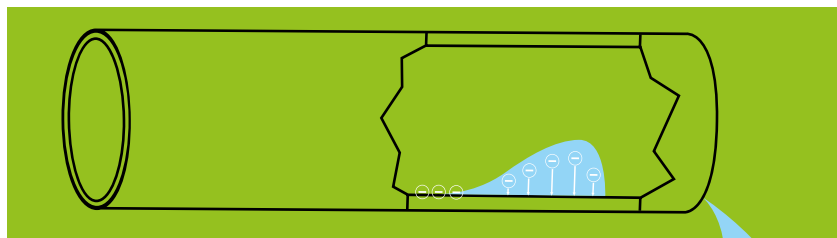


Charge separation on a molecular basis during transfer.



Polarisation of conductive, non-grounded parts through "induction". This may lead to a charge equalisation in form of a spark.

Prevent Spark Discharge Use of dissipative Materials



Charge separation when pouring a liquid with high conductivity (such as methanol, THF, acetonitrile) and a body of insulating material (such as PE/PTFE/etc.). Charges can also accumulate with reversed properties (conductive body and insulating liquid).



The safe grounding of conductive components prevents spark discharges. Dissipative materials must also be grounded.

Brush discharges are lower in energy than spark discharges and cannot ignite flammable dust-air mixtures with a minimum ignition energy of > 1 mJ. However, the energy of the brush discharge is sufficient to ignite flammable solvent vapours or combustible gases.

Depending on the combustible material (e.g. belonging to the explosion group IIC) and how likely ignitable solvent vapour-air mixtures are (e.g. "occasional" (zone 1), an insulating material surfaces > 20 cm² made of insulating material may be evaluated as critical.

In certain conditions, containers such as canisters, bottles etc or tools made of insulating material are supplied with a manufacturer release for use with flammable solvents. However, the operator must observe the manufacturer specifications and conditions of use (such as "Dry wiping prohibited", "...only for designated use", etc.).

To protect against brush discharges, surfaces made of insulating material must not be charged by rubbing, wiping, or similar operations in the simultaneous presence of flammable vapours.

Using conductive or dissipative grounding materials avoids insulation surfaces being present. This means that the prerequisite for brush discharges is no longer given.

Technical Regulations for hazardous Substances

TRGS 727

The third type of discharge observed in laboratories is the propagating bush discharge.

This mainly occurs inside plants and on surfaces made of insulating material if so-called “strong charge-generating processes” take place simultaneously.

For example, these conditions are present in insulating tubes through which aerosols or solid particles are transferred at high velocities.

A tube exposed to the conditions of propagating brush discharge is generally recognisable by a dark mark, with a length of several centimetres. At the centre of the mark perforation of the wall due the discharge can be seen. A propagating brush discharge contains enough energy to ignite fuel-air mixtures of any kind. However, as several conditions are required for the generation of this type of discharge, the probability of occurrence is relatively low. If in doubt, seek an expert opinion.

Since propagating brush discharges only occur on surfaces made of insulating material, the use of conductive or dissipative transport or conveyor systems is also an adequate safeguard in this situation.

Electrostatics and its ignition risks is a very complex issue. The requirements for components and parts used in so-called hazardous areas, i.e. zones in which flammable atmospheres occur frequently and to a great extent, are effectively regulated.

But even in areas with high air exchange and lower solvent volumes which are not defined as hazardous zones, care must be taken to avoid creating electrostatic ignition sources near emission points or in areas of handling solvents. An electrostatic discharge occurring in this area would inevitably cause the mixture to ignite and, in a worst-case scenario, would cause the container to explode.

Instead, this emission should initially be avoided by using suitable filtration systems. If this is not possible, care must be taken to ensure that no electrostatic hazards can be created near solvent emission points or in areas where these substances are handled (i.e. waste solvent collection points).

In order to do so, it must be ensured that not only the previously specified safeguards for solvent systems are applied, but also additional mitigations such as grounding of operators through dissipating floor mats and appropriate footwear are considered. Electrostatic requirements for the hazardous areas listed above are regulated differently depending on national regulations.

In Germany, the “Technische Regel für Gefahrstoffe” (“Technical Regulations for Hazardous Substances”), or TRGS 727 (formerly TRBS 2153), stipulates electrostatic requirements in hazardous areas under the title “Prevention of ignition hazards due to electrostatic charge”.

At European level, CENELEC (EUROPEAN COMMITTEE FOR ELECTRO-TECHNICAL STANDARDIZATION) CLC/TR 50404:2003 superseded by CLC/TR 60079-32-1:2015 Electrostatics - Code of practice for the avoidance of hazards due to static electricity, is applied.

These regulations describe hazards and specify safety measures. Therefore, this source can also be used as reference or for specific questions.

Author: Kurt Moritz

Kurt Moritz is the expert for electrostatics and mechanical explosion protection in the Technical Plant Safety department of Merck KGaA, Darmstadt.

Protect your Health

Key regulations & Laws

Hazardous vapours may arise while working with solvents and other hazardous liquids. Inadequate sealing of supply or waste containers creates health risks. Numerous statutory guidelines apply. Always put your own health first.

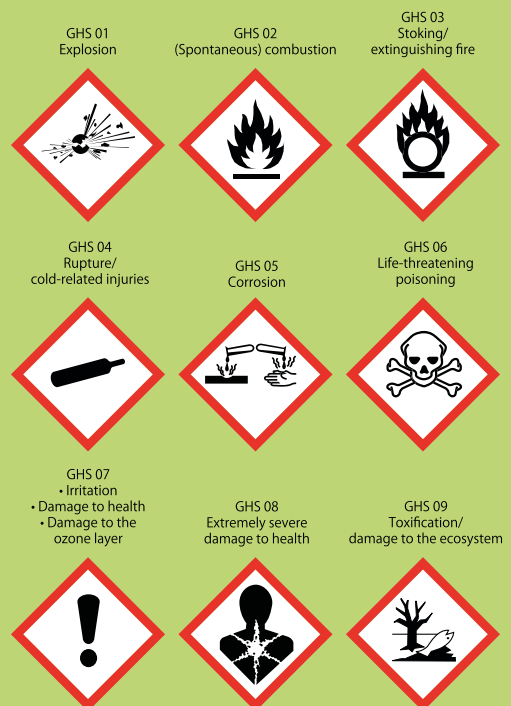
In addition to the Chemicals Act, the Hazardous Substances Act is based on the Occupational Health and Safety Act. The employer is responsible for protecting all workers against risks to health through inhalation, skin contact and the physico-chemical effects of hazardous substances.

In January 2009, regulation (EC) no. 1272/2008 - the CLP Regulation - entered into effect.

It regulates the classification, labelling and packaging of substances and mixtures (Regulation on classification, labelling and packaging of substances and mixtures, or CLP) and replaced the European Dangerous Substances Directive and the Dangerous Preparations Directive in 2015.

The CLP Regulation is based on a UN recommendation to introduce a uniform system for the classification and labelling of chemicals (Globally Harmonised System, UN GHS), which dates back to the 1992 Sustainability Conference in Rio de Janeiro. This represents a compromise between established systems, primarily between North America, the EU and the regulations on hazardous goods.

Source: Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA). For more information, please visit: www.unece.org



European list of agents that trigger (occupational) diseases (Extract from BKV Annex 1, December 2014. Source: BAuA)

Lead or its compounds • mercury or its compounds • chromium or its compounds • cadmium or its compounds • manganese or its compounds • thallium or its compounds • vanadium or its compounds • arsenic or its compounds • phosphorus or its inorganic compounds • beryllium or its compounds • carbon monoxide • hydrogen sulphide • mucosal lesions, cancer or other neoplasms of the urinary tract by aromatic amines • halocarbons • benzene, its homologues or styrene • nitro or amino compounds of benzene or its homologues • carbon disulfide • methyl alcohol (methanol) • organic phosphorus compounds • fluorine or its compounds • nitric esters • halogenated alkyl, aryl or alkylaryl oxide • halogenated alkyl, aryl or alkyl aryl sulphide • diseases of the teeth by acids • corneal damage to the eye by benzoquinone • para-tertiary butyl phenol • isocyanate • liver disease by dimethylformamide • polyneuropathy or encephalopathy caused by organic solvents or mixtures thereof • diseases of the blood, the blood-forming and the lymphatic system by benzene • cancer of the larynx by sulphuric acid-containing aerosols (...)

Protect your Health

Key Regulations & Laws

TTRGS 526 “Laboratories“ (Technical regulations for hazardous substances)

2 / General information:

Laboratories must (...) be designed and operated according to prior art standards.

3.1 / Risk assessment - Procedure:

Measures to protect against hazardous substances shall be set so that (...) the employees are not exposed to any hazards or loads. If this is not possible, the activity should be designed so that the overall risk to workers is minimized after reviewing alternate measures.

3.3.1 / Exposure assessment:

The employer can generally assume that no unacceptably high exposure to hazardous substances is present if expert (...) personnel is acting in accordance with relevant regulations and prior art (...).

3.7 / Employment restrictions:

Employment restrictions for minors, women of childbearing age, and pregnant and lactating women must be observed (Young Persons Employment Act, Maternity Protection Act and the regulation for the protection of mothers in the workplace).

4.3.1 / Avoiding hazards:

The employer shall design the workplace to avoid hazards or reduce them to a minimum. The duration and extent of exposure to hazardous substances must be limited, (...).

4.11.1 / Release of gases and vapours:

Outside of fume hoods, activities in which gases and vapours may form in hazardous concentrations or quantities may only be performed if suitable safeguards (...) ensure that a threat (...) is excluded.

4.16.1 / Handling waste:

When preparing and filling storage tanks (of waste), no hazardous gases or vapours (...) may leak or otherwise enter into the laboratory air.

5.2.23 / Chromatography (HPLC):

If the system cannot be operated with a fume hood, the released solvent vapours must be vented/dissipated safely.

6.1 / Technical protective measures:

Hazards in laboratories are primarily avoided by ensuring that workplaces are appropriately designed and equipped. These include (...) the nature of the equipment, instruments and (...).

TRBS 2153 - Avoiding ignition hazards due to electrostatic charges (Technical regulations for operating safety) (See also TRGS 727)

4.5 Electrostatic charges when handling liquids - small containers

(...) Dangerous charges can be generated by friction, fluid flow or ungrounded persons. In these cases, hazardous discharges to insulated metal components, such as handles, locks, barrel pumps or solid/liquid surfaces, should be expected.

4.5.1 Conductive or dissipative containers

While filling and emptying the container, all conductive or dissipative parts of the system must be electrically connected and grounded.

4.5.5 (3) Isolating containers

In zone 1, the maximum permissible flow velocity is 1 m/s. The maximum permissible volume is 5 l.



Laboratory Safety with Passion

Source: LABORPRAXIS / ONLINE / October 2022

If a cartoon character sniffs a solvent bottle too much, he becomes a mad professor. In real life, solvent fumes have less entertaining consequences and are therefore to be avoided at all costs. The SCAT company has made this its mission - and thus made laboratory safety its main task.



Fig.1: Laboratory safety can also be done with humor: Jan Rittgasser, director of marketing at SCAT, impersonates the "mad professor" at an exhibition - the company's trademark. An early model of the Safety Caps can be seen in the foreground.

Laboratory Safety with Passion

In the beginning there was caution, maybe even a bit of fear when you stand in the laboratory for the first time during your training or studies and are confronted with various toxic solvents and carcinogenic chromates. Every move is carefully considered, every test setup is checked twice and three times. Then, over the years, comes practice. The processes become familiar, the safety precautions become known and the handling of hazardous substances becomes routine and safe. From here, it is important to maintain awareness of the potential dangers in the laboratory. Because otherwise, there is a risk of stepping into the next trap: carefree habit. Even the best lab workers, after years of routine, become lax about personal protective equipment or other safety precautions in the lab.

This dilemma is also known to the team at SCAT, the "Safety Center for Analytical Technologies". The company has set itself the goal of supporting users in the analytical laboratory in protecting themselves from harmful substances in the working environment. For almost 25 years, the experts have been developing new technical devices that are intended to make the handling of solvents in wet-chemical laboratories and in HPLC applications safer. The team is there with creative ideas and full commitment and passion. One employee quickly tested his idea of sealing a filling funnel with a rubber lip for practicality: fill the Tupperware container with vinegar water, add a rubber seal and then put it under the bed overnight to do the smell test. This commitment has not only led to SCAT using just such rubber seals on the funnels since then, but also made the committed employee in the company virtually immortal.

Since then, the funnels have been named after him: MARCO. Other team members have also immortalized themselves in product names, for example in the ARNOLD funnel or in the Universal Waste Hub JAN.

"All of us at SCAT are driven by the idea of making the laboratory a safe place to work," says Managing Partner Peter Rebehn, summing up the corporate philosophy. In an interview with LABORPRAXIS, he admits that the only exception was the name of the LISA Safety Waste Caps. "It's an artificial name. We already had so many men's names, so it was just about time to include a product with a woman's name."

The company SCAT

The "Safety Center for Analytical Technologies" SCAT was founded in 1998 to protect users in analytical laboratories from harmful substances in the working environment. The reason was the initial requirement of a large German chemical company to reduce the concentration of pollutants that was too high in a laboratory in which organic solvents were used. SCAT developed its Safety Caps for solvent bottles so that no major conversion work was necessary - the starting point for the success of the almost 25-year-old company. Since June 2020, the developers at the new location of the SCAT headquarters near Frankfurt Airport have been providing improved and new safety solutions for handling solvents in the laboratory.

The mission: safety – and saving money as a side effect

Peter Rebehn has been Managing Partner at SCAT since 2018, and knows the challenges of everyday laboratory work. "We prefer to visit our customers on site and advise them directly in the laboratory. Since it is our daily bread, we immediately recognize where there are still gaps in occupational safety," he says. A typical picture, which is still far too common in the university context, are HPLC systems whose solvent supply is provided by more or less creative self-sealed storage bottles: sometimes the bottle opening is covered with aluminum foil, sometimes with glass wool, often the hose also stuck through parafilm and sometimes even simply placed in the open neck of the bottle without any further covering.

Even a simple cap is not enough. All of this is more or less insufficient, since the solvent can be so easily dispersed in the air and there is a risk that employees will inhale the noxious fumes. After all, despite increasing efforts to replace toxic substances in the laboratory with less dangerous ones, hazardous substances such as methanol and acetonitrile are still frequently used eluents in HPLC.

In its "Safety Solutions" division, SCAT has therefore specialized, among other things, in safe, hermetically sealing caps for solvent containers, both on the supply and disposal side, for storage bottles as well as for waste containers - and thus apparently hit the right nerve. "I've never met anyone in the lab who said: No, I don't need that," says Peter Rebehn. The Safety Caps are equipped with a ventilation valve, which allows emission-free pressure

Laboratory Safety with Passion

equalization in the solvent bottle. In addition, an exhaust air filter is screwed on, which adsorbs the solvent vapours and binds vapours from alkalis and acids. The inner surface of the activated carbon achieves a top value of 1,500 m²/g, as the expert points out. In this way, workplace limit values for toxic solvents such as methanol or acetonitrile are easily complied with, and the occupational safety of employees is guaranteed.



Fig. 2: The Safety Waste Caps contain three different types of activated carbon for additional safety: 1st layer adsorbs solvent vapours, 2nd layer binds alkalis, 3rd layer binds acids.

Hermetically sealed Safety Caps have another advantage in addition to the safety aspect, emphasizes Rebehn: "Hermetically sealed caps have fewer emissions and therefore less consumption. This is currently becoming more important again, because the prices for solvents are also rising." In addition, thanks to the better sealed

"Laboratory safety is not limited to products, it also involves a lot of persuasion and educational work."

Peter Rebehn, Managing Partner of SCAT

solvent containers, the air exchange rate in the laboratory can be reduced from 8 to 5 times without compromising safety, which in turn saves costs in the laboratory, how Security expert Rebehn added. According to a sample calculation for an HPLC laboratory with 15 systems on 120 m², 10,000 to 15,000 euros can be saved every year (you can read more about this in the article "The underestimated value of laboratory air").

SCAT-Connect-Box for automation in large HPLC laboratories

The latest development by the SCAT team is intended to further improve safety in the HPLC laboratory and also increase user-friendliness. In the spirit of increasing digitization and automation, the product developers have launched a system that can be used to control and monitor the filling level of the storage bottles and waste containers: SCAT-Connect. The heart of this is the SCAT Connect Box. Silicone tubes lead from the central control unit to the individual storage containers. Oxygen is pumped through the tubes and escapes at the tubing's end. The required amount of pressure changes depending on the filling level of the vessel. This relationship allows the fill level to be calculated after a one-off calibration for the solvent used and the associated vessel. "This hydrostatic measuring principle is not new, but it has never been used in our industry in a laboratory context," says Peter Rebehn.

The filling levels determined in this way can then be conveniently viewed in real time via an app on a computer, tablet or smartphone. Another advantage: The system



Fig. 3: With the app for SCAT-Connect, users in the laboratory always have an eye on the fill levels of their solvents.

Laboratory Safety with Passion

automatically refills the storage bottles from a larger storage tank via pumps, so that it is not necessary to top up with solvent as often. The managing director promises that supply and disposal systems can be fully digitized in the future. This not only saves work, but also reduces the risk of exposure because there is less direct interaction with the solvents. Especially for large analytical laboratories with many HPLC systems, more freedom is created for the laboratory technicians, because sample runs are automated over a longer period of time and work without intervention by the staff. When the waste container is full, the employee receives a message via app to empty or change the container. An audible alarm can also be turned on to indicate critical levels. "We are investing a lot of money here in the future," says Peter Rebehn and is confident that this investment is worthwhile - not only for his own company, but also for the large HPLC laboratories that should benefit from the new technology. Two pilot systems with the SCAT Connect Box are already in use, and more will follow.

A "Mad Professor" becomes the brand image

The Safety Caps and the SCAT Connect Box are just two examples of how SCAT wants to make work in the laboratory more efficient and above all safer. However, the more than 1,600 items developed in-house for the safe handling of hazardous liquids are not the only part of improving laboratory safety. "It also requires a lot of persuasion and educational work," emphasizes Rebehn.

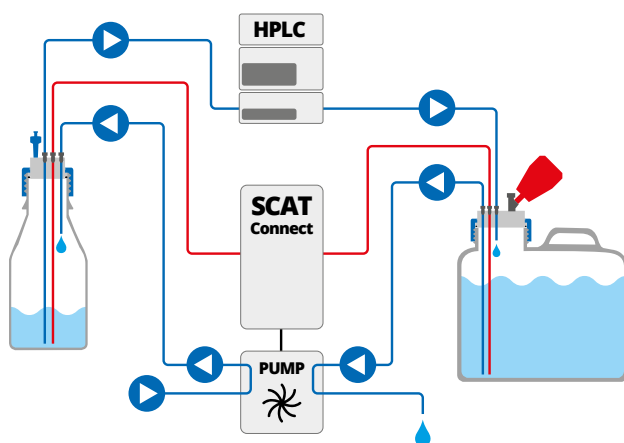


Fig.4: Functional diagram for SCAT-Connect: The system continuously measures the fill levels of solvent and waste containers with millimetre precision using a hydrostatic measurement method. External devices such as pumps can be controlled.

"We are often at trade fairs to sensitize users to the topic and to train them with lectures." This is the only way to counteract the downside of too much routine and avoid careless handling in the laboratory in the long term.

Finally, the comic-like "Mad Professor" of SCAT's branding shows what happens when you don't take laboratory safety seriously. "It was originally intended as a deterrent example," reveals the application specialist. "Because if you inhale too much solvent, it will eventually soften your head."

However, it does not seem to have a real deterrent effect, but rather attracts interested and curious looks, e.g. at trade fairs. The face of the maniacally laughing character now adorns SCAT bags, presentation slides and product packaging and has ensured a high recognition value for the brand. And those who regularly sensitize themselves to the dangers in the laboratory and take appropriate precautionary measures do not have to fear becoming a "Mad Professor" themselves, due to too much inhaled solvent vapour.

