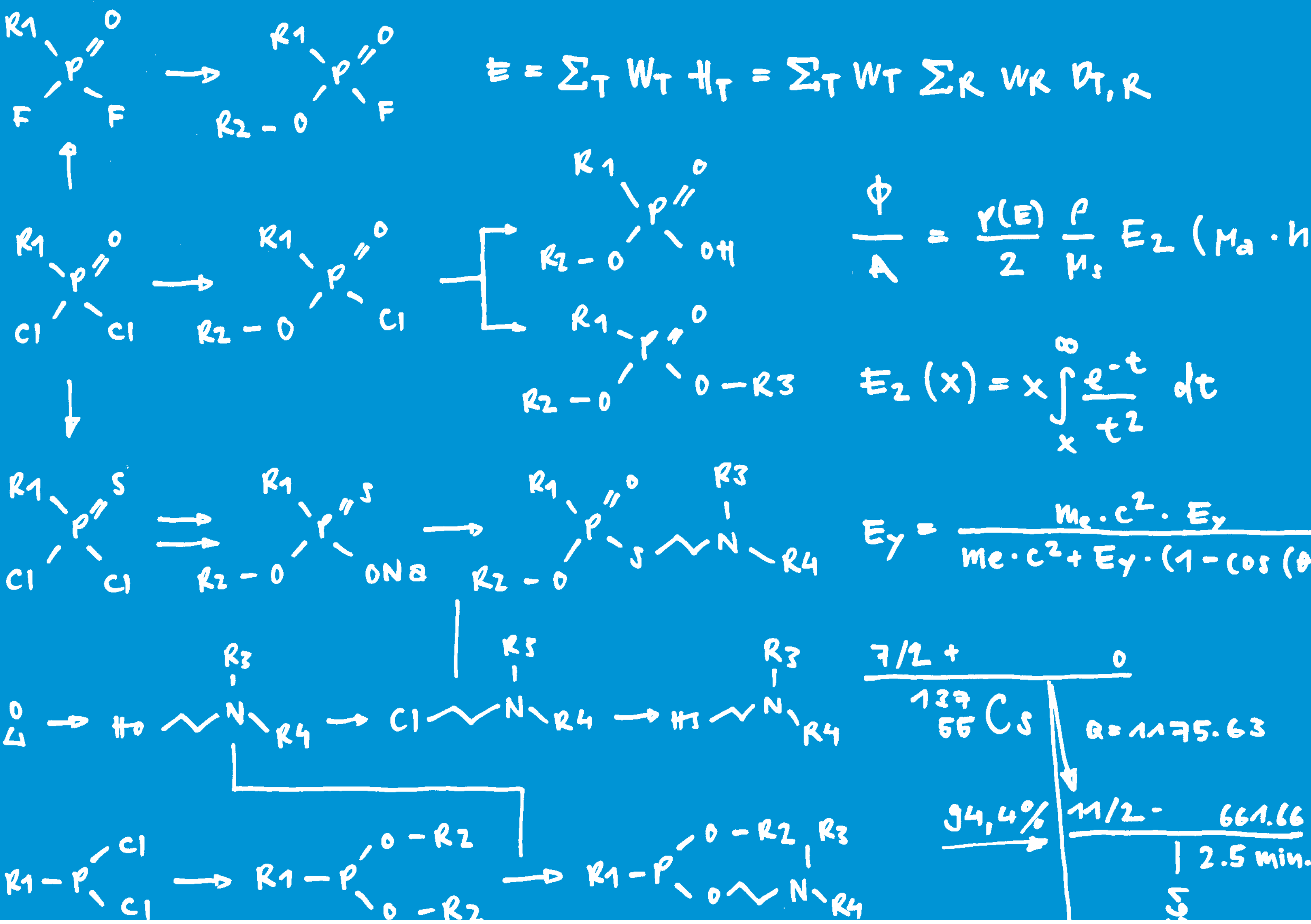
Annual Report 2023

Spiez Laboratory



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Federal Department of Defence,
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Federal Office for Civil Protection FOCP
SPIEZ LABORATORY

Imprint

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This Annual Report is also available in a German/French version.

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Editorial

Dear Reader,

Marc Cadisch
Director Spiez Laboratory

Russia has been waging a war of aggression against Ukraine for more than two years and has repeatedly threatened to use nuclear weapons. Both warring parties have accused each other of using chemical warfare agents and of preparing for the use of biological weapons. There is also increasing evidence that the Russian side is using riot control agents in combat. In Syria, repeated use of chemical weapons by various parties of the conflict has been demonstrated over the last ten years. It should also be remembered that chemical warfare agents from the Novichok group were used to poison the Skripals and Navalny.

However, successes in the area of disarmament and control of weapons of mass destruction have undoubtedly been achieved in recent decades. Last year, the Organisation for the Prohibition of Chemical Weapons (OPCW) announced that the destruction of over 70 000 tonnes of declared chemical weapons had been completed. The OPCW was awarded the Nobel Peace Prize in 2013 in recognition of its work and the progress it had so far made in eliminating chemical weapons. Together with the City of The Hague, the OPCW established the "OPCW-The Hague Award". Since 2014, this award has been given to individuals and institutions that have made an outstanding contribution to the realisation of a world free of chemical weapons. We are honoured that Spiez Laboratory was presented with the OPCW-The Hague Award last year. This is the result of extensive and multifaceted work by the entire team at Spiez Laboratory, and in particular its uninterrupted status as an OPCW Designated Laboratory for 25 years (p. 10). Furthermore, in the field of nuclear weapons arms control we participated in important international initiatives within the framework of the UN (p. 16).

We must not allow ourselves to be blinded by these successes: Global security policy developments are anything but positive, also with regard to NBC threats. The importance of NBC protection is therefore also increasing for Switzerland. The protection of the Swiss population and the army against NBC threats must be ensured. For us at Spiez Laboratory, this means that in addition to arms control, we must step up our efforts to prepare for NBC incidents. This has been the focus of our work in all divisions. During 2023, we commissioned, for example, a new facility for measuring radioactivity in humans (p. 31), further developed the detection methods for toxins (p. 35), supported the Swiss Armed Forces in the evaluation of a new chemical warfare agent detector (p. 20), and used our in-house engineering expertise to build inspection and test facilities for NBC protection (p. 23). However, we cannot ensure the required NBC protection on our own. That is why we regularly organise operational exercises with part-

On 27 November 2023, Stefan Mogl, Deputy Director Spiez Laboratory and Head of the Chemistry Division, was presented with the OPCW-The Hague Award on behalf of Spiez Laboratory, in a festive ceremony during the OPCW Conference of the States Parties.

ners, in 2023 also at international level (p. 6). In addition, we cooperate closely with other federal laboratories (p. 43) and with our military specialist partner in Spiez, the NBC-EOD Centre of Excellence (p. 47).

When it comes to security policy, we must continue to keep an eye on long-term developments. With this in mind, we are ensuring that NBC protection in Switzerland can also be guaranteed in the coming decades, with the publicly announced construction project for the modernisation of Spiez Laboratory (p. 40). I wish you a stimulating read.

C-Scenario
Dispersion of a nerve agent in a train in a tunnel

01

Germany and Switzerland train for NBC emergencies in Spiez

Germany and Switzerland are comparatively well prepared for NBC incidents. With the Analytical Task Force CBRN (ATF CBRN), Germany has specialists at several locations, supported by the Federal Office of Civil Protection and Disaster Assistance (BBK). In Switzerland, three highly specialised task forces (EEVBS) are stationed in Spiez. In order to improve their capabilities, the units from the two countries regularly practise emergency response and cooperation together.

César Metzger

B-Scenario
Members of the B-EEVBS during sampling

A member of Bern's professional fire brigade (yellow) cuts a B-EEVBS employee out of her protective suit after decontamination.

Such exercises, known as ATFEX, have been carried out every two years since 2011. The Swiss C-EEVBS has been able to take part in these exercises in Germany for years. In 2023, this extensive exercise took place for the first time in Switzerland and was organised by Spiez Laboratory. The aim was to provide the German colleagues with a variety of training facilities. Spiez Laboratory devised a total of six scenarios with different challenges at various locations. In addition to the Spiez NBC Centre, the Spiez Regional Competence Centre for Civil Protection (RKZ Stygli), the Thun military training range and an old railway tunnel near Spiez were also used.

On the Sunday before the exercise began, some 60 emergency personnel travelled from their respective locations in Hamburg, Berlin, Dortmund, Essen, Leipzig, Cologne, Mannheim and Munich to assemble at a meeting point near the Swiss border. On Monday morning, they set off for Spiez and crossed the Swiss border in Weil am Rhein. The convoy of numerous vehicles with flashing blue-lights and German number plates caused quite a stir on the Swiss motorways. However, the police and other authorities in the cantons they were travelling through had been informed in advance and this helped to ensure a smooth journey.

On arrival in Spiez, the German emergency forces were welcomed by their Swiss colleagues and immediately familiarised with the local conditions as well as the specific Swiss radio technology. This was followed by preparation of the equipment for the first day of the exercise and checking into the accommodation. From Tuesday to Thursday, the participants then experienced three intensive days of exercises. Using the scenarios prepared in advance, the ATF were challenged in all three hazard areas of chemistry, biology and radioactivity.

The first four scenarios conducted focussed on the ATF's central area of responsibility: the management of chemical hazards. They all presented a variety of demanding challenges for detection and sampling. In a mock car accident, the leakage of an unknown, powdery chemical substance had to

N-Scenario
Detection and securing of a radioactive source

be detected, sampled and analysed. In a fabricated illegal home laboratory, the ATF's attentiveness and skills were tested in dealing with a criminal or terrorist incident. Another scenario was modelled on the 1995 terrorist attack in the Tokyo subway by the Aum Shinrikyo sect, in which a nerve agent was released inside a public transport vehicle. Due to the variety of scenarios and incident sites, not only was technical expertise in the area of chemical defence required, participants were also able to practise efficient organisation at the incident site. All chemical scenarios were repeated twice so that all members of the ATF could experience each exercise situation.

On Thursday, the ATF members were challenged with biological and radioactivity scenarios. To this end, the participants were divided into two teams: One team was tasked with unearthing a terrorist cell and discovering highly radioactive sources in a small house on the Thun military training range. The other team was confronted with the occurrence of an unusually high number of people and animals infected with rabbit plague (tularaemia). The ATF team was tasked with searching the affected area and suspicious premises. Sampling had to be carried out whilst observing strict biosafety regulations. The professional fire brigade of the city of Bern took part in the exercise by demonstrating and testing its new decontamination container.

Cooperation and interoperability are regularly trained and reviewed at international level and in various disciplines in the form of such large-scale exercises. This allows the alignment of operational processes, methodology, expertise, material and equipment. In this case, the members of the ATF successfully mastered all scenarios. For their part, the Emergency response teams of Spiez Laboratory successfully organised a major exercise and were able to gain valuable experience in the process.

ATFEX 2023 has shown how valuable international exercises are – especially for highly specialised units such as the

ATF and EEVBS, which have no comparable partners in their own country. For neighbouring countries such as Germany and Switzerland, the knowledge and experience gained from joint exercises can also be put to good use in a real cross-border operational situation and improve tangible cooperation in the event of an incident.

Delay due to the pandemic
The conduct of the first ATFEX in Switzerland was originally planned for 2020. Due to the SARS-CoV-2 pandemic, these plans had to be postponed. Planning could only be resumed in 2022 after the precautionary measures were lifted.

The OPCW Centre for Chemistry and Technology
in Pijnacker-Nootdorp, Netherlands

02

Spiez Laboratory receives the OPCW-The Hague Award

In 2023, the Organisation for the Prohibition of Chemical Weapons (OPCW) in The Hague was able to announce the destruction of all chemical weapons stockpiles declared worldwide. This demonstrates that the Chemical Weapons Convention (CWC) is a success story of multilateral disarmament. Unlike other disarmament treaties, it includes a comprehensive verification regime. The OPCW is responsible for the implementation of the CWC in 193 States Parties and was awarded the Nobel Peace Prize in 2013 for its work. Since the CWC entered into force in 1997, Switzerland, and Spiez Laboratory in particular, has always actively supported the OPCW. In 2003, Spiez Laboratory received the OPCW-The Hague Award for their extensive and diverse work over the past decades.

Stefan Mogl, Peter Siegenthaler,
Christophe Curty, Beat Schmidt

UN/OPCW chemical weapons inspectors taking samples in Damascus, Syria

OPCW-The Hague Award
The OPCW-The Hague Award was created in 2014 by the Director-General, after the OPCW had been awarded the Nobel Peace Prize in 2013. The award is given to individuals and organisations that have rendered outstanding services to the implementation of the Chemical Weapons Convention.

OPCW Designated Laboratory for 25 years

The analysis of authentic samples collected in inspections is an important part of the OPCW verification regime. The OPCW may take samples as part of its inspection activities and analyse them on-site. To do this, the organisation needs to have transportable analytical equipment at its disposal. Even before 1997, Spiez Laboratory tested mass spectrometric systems for the OPCW for their suitability for use in the field.

If the OPCW cannot or does not wish to analyse samples on site, or if the OPCW wishes to verify measurements from inspections, it sends samples to laboratories in States Parties that have been designated in advance by the OPCW for this task. As early as 1989, the Organic Analysis Branch at Spiez Laboratory, together with partner laboratories, began developing methods for testing a wide variety of samples for the presence of chemical warfare agents (CWAs) and validating them in interlaboratory comparison tests. The aim was to ensure the quality of the analyses using standardised methods.

Spiez Laboratory was one of the first five institutes worldwide to be designated after the first series of interlaboratory comparison tests in 1998. Since then, it has regularly taken part in the Official OPCW Proficiency Tests and also regularly supports the OPCW in carrying them out. Spiez Laboratory has now held the status of OPCW Designated Laboratory for 25 years without interruption, something that worldwide only very few laboratories have achieved.

OPCW investigations into chemical weapons uses

In order for OPCW inspectors and Designated Laboratories to identify relevant substances, they need databases with reference data: the “fingerprints” of the chemical warfare agents (CWAs), so to speak. For good reasons, however, CWA databases are not publicly accessible and not commercially available. The OPCW therefore set up the OPCW Central Analytical Database (OCAD) specifically for this purpose. Since 1996, Spiez Laboratory has supplied the OPCW with more than 7700 data

Samples from Syria in Spiez Laboratory

sets for various analytical techniques for inclusion in the OCAD. This corresponded to more than half of all OCAD datasets in 2023. Spiez Laboratory has also been involved for many years in the work of the Validation Group, the OPCW's expert group for ensuring the quality of submitted OCAD data.

In connection with the Syrian civil war, Spiez Laboratory was given an additional role in 2013. As a Designated Laboratory, its analysts have since then been repeatedly entrusted with the analysis of suspicious samples, allowing the OPCW to confirm various cases of chemical weapons use in Syria.

Methods for sample analysis

In a complex, multilateral disarmament treaty such as the CWC, not all points are resolved in detail at the conclusion of negotiations and must therefore be clarified by the States Parties in consultations. The analysis of authentic verification samples by Designated Laboratories was one such issue. The CWC stipulates that the OPCW Director-General is responsible for the integrity and quality of offsite analyses by Designated Laboratories and that he selects at least two Designated Laboratories for this purpose. The States Parties have been negotiating for several years since 2000 how this should be implemented in practice. The issues involved included transport, securing the chain of evidence, anonymisation of samples and quality control of the analyses by supplementing inspection samples with control samples (negative and positive controls).

Representatives of Spiez Laboratory have presented the Swiss position at OPCW consultations in The Hague. Only chemicals that do not change chemically during transport to the Designated Laboratories are suitable for use as OPCW control samples. Already during the negotiations, the Organic Analysis Branch at Spiez Laboratory carried out laboratory tests on the stability of CWAs and related chemicals in order to evaluate chemicals that are suitable as control samples. Subsequently, the Organic Chemistry Branch became a supplier of reference chemicals for the OPCW laboratory and has since supplied the OPCW with several hundred solutions of high-purity reference standards for the preparation of control samples and other purposes.

Training of OPCW Inspectors

Routine inspections to verify the declarations of States Parties are a central part of the CWC verification regime. For this purpose, the OPCW has a pool of chemical weapons inspectors who carry out inspections at industrial plants as well as at civilian and military government facilities. During the early years of the CWC, individual States Parties, including Switzerland, provided basic training for OPCW inspectors. After the CWC entered into force in 1997, Spiez Laboratory, together with the chemical industry, organised part of the basic training for over 100 new OPCW inspectors for two years and offered advanced courses in phosphorus chemistry in 2003. After a few years, the OPCW was able to take over the basic training of its inspectors itself. Spiez Laboratory again supported the OPCW by organising mock inspections in Spiez. Between 2007 and 2011, a total of 68 new OPCW inspectors visited Spiez Laboratory for training purposes.

In the everyday work of OPCW inspectors, the focus is on routine inspections. However, the CWC also provides for other types of inspections: If a State Party has compelling information that another State may have violated the prohibition of chemical weapons, it can request a challenge inspection from the OPCW Director-General. Compared to a routine inspection, a challenge inspection is very complex and its conduct is much more demanding. In 2004, Switzerland and Spiez Laboratory organised a challenge inspection exercise lasting several days, during which the OPCW inspectors were able to demonstrate their skills and test their procedures.

Scientific expertise for the OPCW

Scientific and technological developments play a central role in the CWC. These include, for example, new developments in the production of chemicals and in the chemical industry, improved methods of protection against toxic chemicals, developments of new instruments for the detection and identification of chemicals, or developments that could make it easier to circumvent the prohibition of chemical weapons. To enable the OPCW to take account of the latest scientific discoveries, the OPCW Director-General is assisted by the OPCW Scientific Advisory Board (SAB). The SAB consists of 25 experts who are appointed by the Director-General for a maximum of six years. Spiez Laboratory has been represented by an SAB member for more than 15 years since the board was established in 1998, and has chaired it twice.

On behalf of the Director-General, the SAB also directs Temporary Working Groups (TWGs) that address specific technical issues such as the optimisation of OPCW verification, sampling and analysis, biotoxins or forensic sciences. In addition to members of the SAB, other specialists are involved in the work of the TWG. Technical experts from Spiez Laboratory have regularly participated in SAB TWGs. After the TWG on Convergence in Chemistry and Biology recommended in 2014 that the impact of convergence between biology and chemistry on the CWC should be regularly assessed, Spiez Laboratory launched the Spiez CONVERGENCE conference series. Organised since 2014 in collaboration with ETH Zurich, the International Security Division, part of the State Secretariat of the Federal Department of Foreign Affairs (FDFA), and the Strategy and Cooperation Division, part of the State Secretariat for Security Policy (SEPOS) of the Federal Department of Defence, Civil Protection and Sport (DDPS), experts from research, industry and policy have been discussing the latest scientific developments and their impact on the conventions banning biological and chemical weapons in Spiez every two years.

Interpretation of the CWC Treaty Text

Occasionally, events lead to treaty provisions having to be subsequently clarified by the States Parties. The hostage rescue by Russian security forces in the Dubrovka Theatre in Moscow in October 2002 was such an event: Chechen rebels held more than 800 visitors hostage there. The security forces released an aerosol into the theatre's air conditioning system, which anaesthetised the Chechen hostage-takers and the hostages. More than 100 hostages died as a result of an overdose of the aerosol, the composition of which was unknown at the time. Non-governmental organisations and in particular the International Committee of the Red Cross (ICRC) warned that the development and use of narcotic chemicals for law enforcement / police operations could undermine the Chemical Weapons Convention.

As early as 2003, the Swiss delegation took up this issue in order to find a policy solution with the States Parties within the framework of the OPCW. Negotiations proved difficult over many years and there were repeated setbacks. In 2021, however, the States Parties reached a ground-breaking decision in a vote called for by Switzerland, Australia and the USA: since then, the use of aerosolised chemicals that affect the central nervous system has been prohibited for police operations or for law enforcement and is considered a violation of the provisions of the CWC.

With its experts in chemical weapons arms control, Spiez Laboratory has helped to shape the Swiss position from the outset and explained the issues in policy papers, countless bilateral meetings and information events. It has thus made a significant contribution to this important further development of the CWC.

Support among OPCW States Parties

In addition to banning chemical weapons, the CWC aims to promote the peaceful use of chemistry and mutual cooperation between the States Parties. Spiez Laboratory has played a key role in Switzerland's initiatives in this area. For example, it developed the first electronic application for submitting OPCW declarations, made it available to interested States Parties and trained them in its use. It also designed a training programme in chemical synthesis to which the OPCW invited candidates from less developed States Parties. Since 2000, 18 candidates each completed a three-month internship in the Organic Chemistry Group and were trained in good laboratory practice.

Direct intergovernmental support is another option: in the VETOXA project, Spiez Laboratory, together with a Swiss company, has been helping Albania to properly dispose of chloropicrin stocks since 2001. It was involved in the development of methods and then also in the destruction on site. And when chemical weapons stockpiles in Albania belonging to the old government were disclosed in 2004, it helped to sample the stockpiles and characterise the CWAs with a view to ensuring their correct destruction.

Outlook: Chemical Forensics as a new priority area

In 2023, the OPCW moved into a new laboratory building in Nootdorp outside The Hague: the Centre for Chemistry and Technology (ChemTech Centre), which was financed entirely by voluntary contributions from States Parties including Switzerland. At the request of the OPCW, Spiez Laboratory advised the laboratory planners on the design of

National Authorities CWC

In accordance with Article VII, paragraph 4, the CWC requires each State Party to establish a "CWC National Authority" as the national contact point for the Organisation for the Prohibition of Chemical Weapons (OPCW). In Switzerland, the International Security Division (ISD) of the FDFA holds the chairmanship. In addition, the national authority includes representatives from the State Secretariat for Economic Affairs (SECO) of the Federal Department of Economic Affairs, Education and Research (EAER), the Strategy and Cooperation Division in the State Secretariat for Security Policy (SEPOS), and Spiez Laboratory in the Federal Office for Civil Protection (FOCP) of the DDPS.

the synthesis laboratory for highly toxic chemicals at the ChemTech Centre.

After the OPCW was able to confirm the destruction of all declared chemical weapons in 2023 – 26 years after the entry into force of the CWC – the OPCW is now focussing on preventing new chemical weapons programmes. Multilateral projects in the ChemTech Centre should allow the OPCW to expand the scientific capabilities required to this end.

One example is the development of forensic methods to help the OPCW trace the origin of CWAs and thus identify those responsible for their use. This task will be challenging and Spiez Laboratory will continue to support the OPCW in the development of technical capabilities and, as part of the Swiss delegation, with contributions to the political bodies.

Satellite image of the inspection exercise location in Menzingen

03

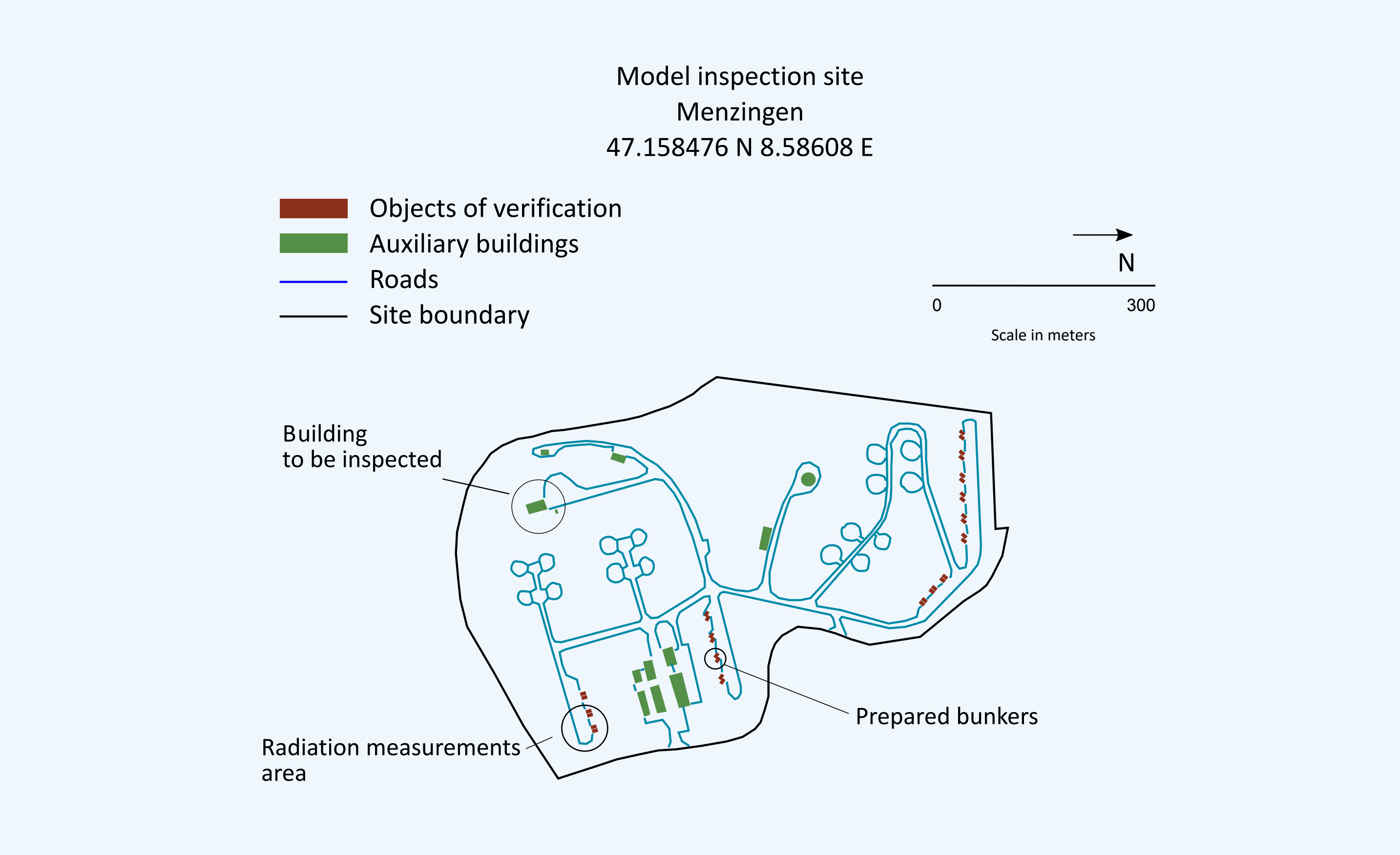
UNIDIR exercise: Menzingen Verification Experiment

Verification mechanisms that enable the parties to confirm the absence of nuclear weapons in certain stockpiles are crucial for nuclear disarmament and arms control. The Menzingen Verification Experiment of March 2023 served to test practical procedures to verify the absence of nuclear weapons.

Christoph Wirz

General framework

The United Nations Institute for Disarmament Research (UNIDIR) developed the concept for the experiment, which took place in cooperation with the FDFA, the DDPS (Spiez Laboratory and the International Relations Defence Branch of the Armed Forces Staff), the Princeton University Program on Science and Global Security and the Open Nuclear Network. In addition to Switzerland, the Netherlands and Norway also provided financial support. The venue was the site of the former Bloodhound anti-aircraft position on the Gubel near



Inspection exercise plan in Menzigen

Menzingen (Canton Zug) – today a museum.

The scenario developed for the experiment was based on the assumption that the inspection would be carried out as part of an agreement that obliges the parties to remove all nuclear weapons from storage sites at military bases that host nuclear-capable delivery systems. The inspection procedures applied were modelled on those of the Treaty on Conventional Forces in Europe (CFE) and those of the New START treaty.

Conduct of the Inspection Exercise

The inspected party submitted a site diagram showing the boundaries, entrances, roads and all buildings. All buildings suitable for the permanent or temporary storage of nuclear weapons were liable to inspection and had to be labelled as verification objects. This included special storage bunkers as well as garages, hangars or similar facilities. In the first phase of the inspection, the inspectors examined the terrain of the site and identified buildings that were not listed on the site diagram, after which they proposed an update of the plan.

Inspection of selected bunkers

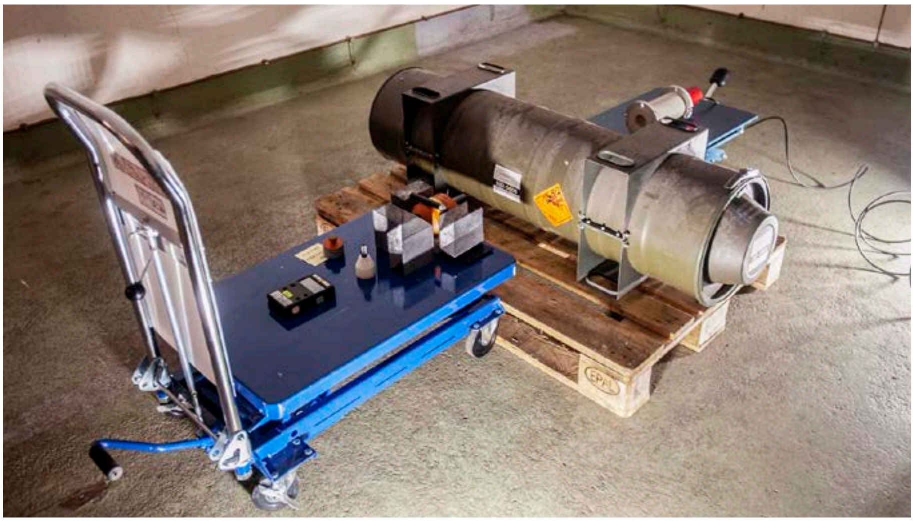
After checking the accuracy of the site diagram, the inspectors selected objects for closer inspection. For the experiment, these bunkers had been prepared in advance. The inspectors examined the bunkers and the objects inside. They took measurements to ensure that there were no hidden volumes or false walls and that the objects had been categorised correctly. The inspectors then carried out a visual inspection of the items that allowed such inspection, by opening the containers, reading the markings or weighing the items. Objects were then selected for radiation measurements.

Radiation measurements

The radiation measurements took place in a separate area of the site to ensure safe handling of the radioactive sources used in the experiment. There is no weapons-grade fissile ma-

Evaluation unit of the Princeton University device

One of the containers examined by the inspection team



Measuring set-up for gamma measurement

terial in Switzerland. In order to be able to prepare individual objects for the exercise, Spiez Laboratory had assessed in advance which “normal” radioactive sources could be used to simulate a nuclear weapon in terms of radiation. Two different sources were provided by Spiez Laboratory, one to simulate a plutonium-based nuclear weapon and one for a uranium-based nuclear weapon. Both were installed in prepared containers placed in bunkers. An empty, otherwise identical container for each type was placed in the neighbouring bunker.

Neutron measurements successfully identified a plutonium warhead simulated by such a source. Gamma measurements made it possible to detect uranium. However, the challenge was greater when it came to proving the absence of uranium. Even if no uranium is detected, well-shielded uranium might still be present. This problem was effectively addressed by employing a special device developed by the Laboratory for Science and Global Security at Princeton University. Using a Cs-137 reference source and a Na-22 calibration source as well as a specific combination of measurements, the device was able to determine the wall thickness of the containers. These precision measurements clearly verified that there was no uranium and no significant shielding in the empty container, and they identified an anomaly in the depleted uranium container.

The Menzingen Verification Experiment demonstrated in practice the feasibility of an approach to nuclear disarmament based on the removal of nuclear weapons from their delivery systems.

A full report on the experiment has been published by UNIDIR[1]. A publication in Science & Global Security[2] provides the details of the radioactivity measurements.

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1 https ://unidir.org/publication/menzingen-verification-experiment-verifying-absence-nuclear-weapons-field

2 Eric Lepowsky, Manuel Kreutle, Christoph Wirz & Alexander Glaser, Ceci N’est Pas Une Bombe : Lessons from a Field Experiment Using Neutron and Gamma Measurements to Confirm the Absence of Nuclear Weapons, Science & Global Security 31, no3, 2023 https ://scienceandglobalsecurity.org/archive/2023/09/ceci_nest_pas_une_bombe_lesson.html

Sensitivity measurements of the LCD 3.3 using the KAA13.
The gas phase is generated using the permeation principle. For this purpose, a polyethylene cell is filled with a chemical warfare agent and sealed airtight. The chemical warfare agent then permeates through the cell for several months and is diluted by a stream of air. The temperature is controlled by the water bath and the addition of humidity by another air stream.

04 Evaluation of a new chemical warfare agent detector for the Swiss Armed Forces

The tried and tested chemical warfare agent detector 97 (CNG 97) adopted by the Swiss Armed Forces reached the end of its service life in 2023. Spiez Laboratory supported armasuisse and the Armed Forces in the selection process for a successor system (CNG 23) by evaluating technical and mission-specific properties. The CNG 23 must be capable of detecting chemical warfare agents and selected toxic industrial chemicals in the ambient air quickly and accurately.

Josha Albrecht, Fausto Guidetti

The CNG 97 is based on an ion mobility spectrometer (IMS), the Chemical Agent Monitor (CAM) of Smiths Detection. The CNG 97 was further developed by Spiez Laboratory together with Smiths Detection for the needs of the Swiss Armed Forces before it was introduced in 1997 as the first spectrometric measuring device for the detection of nerve agents and blister agents in the army. IMS devices allow the selective detection in real time of chemical warfare agents and toxic industrial chemicals in local ambient air. They thus warn soldiers in the field of potential hazards in the air. For the CNG 23, a device was again to be identified that best fulfils the technical and mission-specific requirements of today's army. To this end, Spiez Laboratory provided armasuisse with technical support during the evaluation process.

Systematic approach in the evaluation

An evaluation depends on many factors. The key factor is always to define the requirements based on the specific applications of the user – in this case the army. The evaluation of the device types available on the market is then based on these requirements.

Since the introduction of the CNG 97 in the 1990s, the technology for chemical warfare agent detection devices has advanced. At the same time, military requirements have also changed and with them the user-specific demands. New toxic chemicals, including chemicals with industrial applications, have been incorporated into military requirements. Taking the various factors into account, the project team defined 23 selection criteria in consultation with the user, the test laboratory, the Armed Forces Command Support Organisation and the Federal Office for Defence Procurement armasuisse.

Sniff test for Sarin using the LCD 3.3. The test checks whether the device can detect chemical warfare agents and toxic industrial chemicals. For example, 5 µL of sarin (GB) is pipetted onto a filter paper in a 120 mL test vessel and allowed to evaporate for 12 hours. At the same time, the alarm and recovery times are checked.

Once the list of criteria had been drawn up, Spiez Laboratory was commissioned to draw up a longlist of a possible selection of chemical warfare agent detection devices. Based on this longlist, the project team then drew up a shortlist of devices to be evaluated in more detail, taking into account the tender criteria. The final shortlist consisted of three IMS devices from three different companies. These three devices were then evaluated according to the 23 criteria.

Tests with numerous substances

Spiez Laboratory is the only institute in Switzerland that is able to carry out measurements with chemical warfare agents and has various methods at its disposal for testing technical and application-specific selection criteria.

In order to test the measurement behaviour of the three devices, a list of chemicals with approx. 30 test substances was compiled, consisting of nerve agents, blister agents, irritants and toxic industrial chemicals. This selection also purposefully included certain chemicals that are known to frequently trigger false positive alarms in IMS devices due to cross-sensitivities.

The ability of the devices to recognise a test substance was tested using the sniff test developed by Spiez Laboratory. This involves generating a concentrated atmosphere with the respective test substance, which is measured directly with the detection device. If the device sounds an alarm, it has basically recognised the hazard. In a next step, it is checked whether the device has correctly identified the test substance.

The CNG 23 is a field measuring device for the troops. Hence, the device will be exposed to changing measurement and weather conditions and must function correctly across a broad spectrum of conditions. In order to test the influence of variations in chemical warfare agent concentrations and humidity, Spiez Laboratory employs a chemical warfare agent enrichment system (KAA13) with which the concentration and humidity can be modified for measurements. Furthermore, temperature affects battery life. The influence of low temperatures was tested in a climate chamber.

For field use of the detector, additional factors must be taken into account: the weight, the start-up time after switching on, the response time when a chemical is present, and the recovery time – the time until the device is operational again after a positive measurement. The various times that were tested are relevant because IMS field detection devices have an alarm cycle of a few seconds. If the response time or the recovery time is too long, for example, sources of danger may be overlooked or the alarm may be triggered too late. If a chemical warfare agent has been measured with a detection device in the field, it must be decontaminated; the ability to decontaminate is therefore also an important requirement. All these deployment-specific criteria were tested in parallel to the measurements with the chemicals at Spiez Laboratory.

Good results for chemical warfare agents

As part of the evaluation process for the CNG 23, Spiez Laboratory carried out a total of around 300 tests. All three IMS field detection devices on the final shortlist performed well in the detection of chemical warfare agents. However, as expected, the differences were greater in the sniff tests with toxic industrial chemicals. In the tests with the chemical warfare agent enrichment system, all three devices were able to detect the respective substances at similar concentrations, with the blister agents having a higher detection limit than the nerve agents. The sensitivity of IMS detection devices is often reduced at high humidity (e.g., 80 %). This phenomenon was observed in two of the three devices. Major differences were found with regard to the operational criteria, particularly in terms of battery life.

Taking all criteria into account, the LCD 3.3 from Smiths Detection ultimately achieved the best evaluation result. The device impressed with its wide range of detectable chemicals and easy handling. A long battery life despite a small number of batteries also guaranteed a long field deployment. With the selection of this model as the new CNG 23 by armasuisse, a good and reliable successor model to the CNG 97 has been procured.

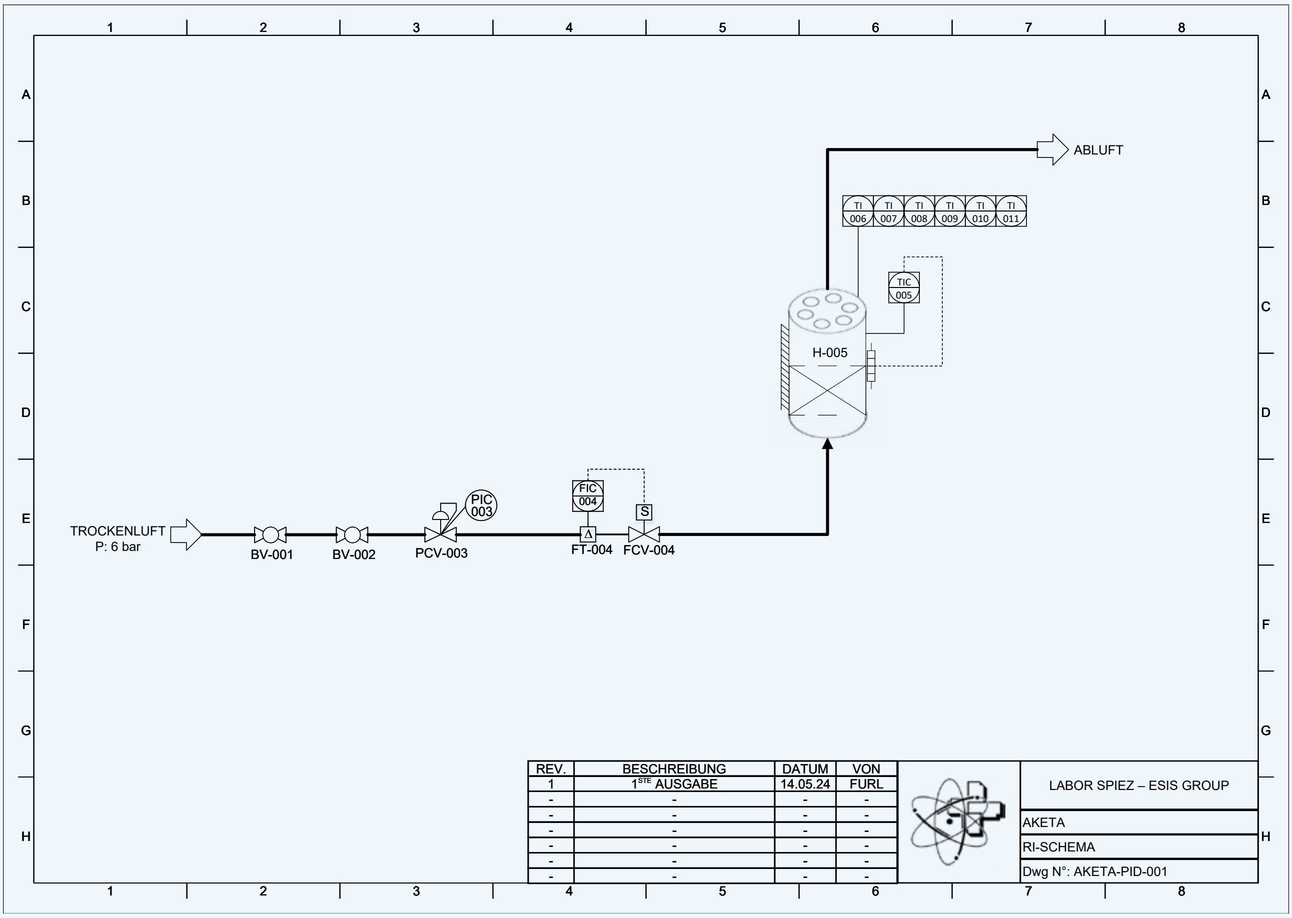
05 Chemical engineering: development of test benches

Based on current threat analyses, Spiez Laboratory ensures that appropriate protective measures are in place against NBC events. The corresponding NBC protection equipment must guarantee both effective and adequate protection. Test benches, which are generally not available on the market as finished products, are in particular needed to measure the protective performance of equipment against harmful toxic substances. Over the past few years, the CBRNe Protection Systems Division has therefore developed expertise in the development, production and validation of such test facilities.

Gilles Richner, Marco Furlan, Thomas Friedrich

At the start of a project, the requirements for the test bench as well as the general conditions and operating parameters need to be defined. This process, which ultimately leads to the development of the specifications, is an iterative process carried out in multiple stages jointly with the end user of the test bench. The specifications include experimental conditions such as temperature and pressure, but also the chemical resistance of the materials used, as well as maintenance, calibration, transportability of the test bench and various safety aspects. A cost estimate determines the procurement process to be followed. Depending on the complexity and cost of the project, one or more stages may have to be carried out with external partners.

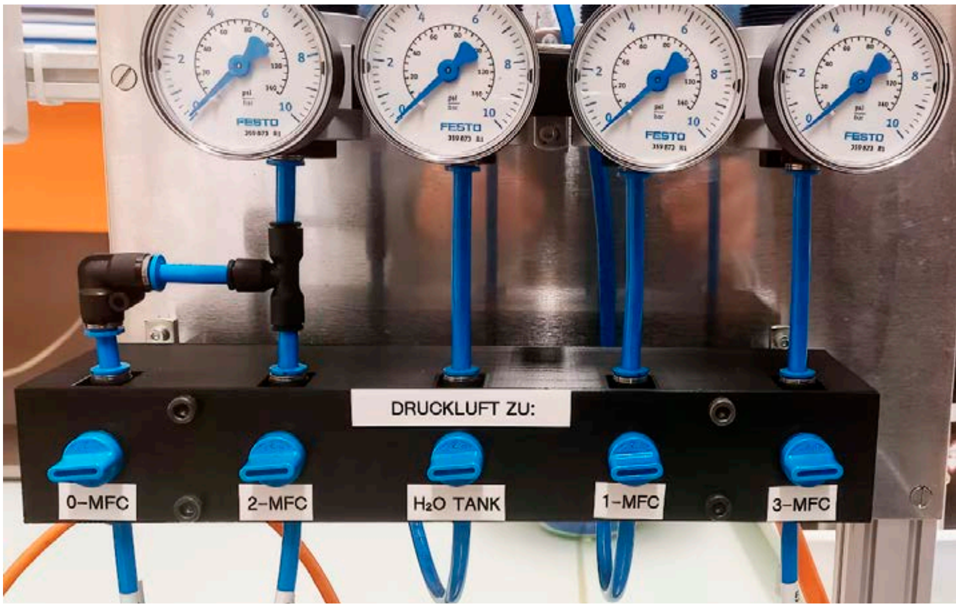
The P&ID diagram (Piping and instrumentation diagram) is the detailed diagram of the test bench, showing the piping and instrumentation such as pumps, measuring devices, valves and control devices. The various components (equipment, fittings, heat exchanger, etc.) are represented symbolically rather than to scale. The P&ID diagram, together with the material and energy balances, is used to determine the equipment needed to build the test bench. The P&ID diagram is an important part of the assembly, commissioning, maintenance and decommissioning of the test bench.

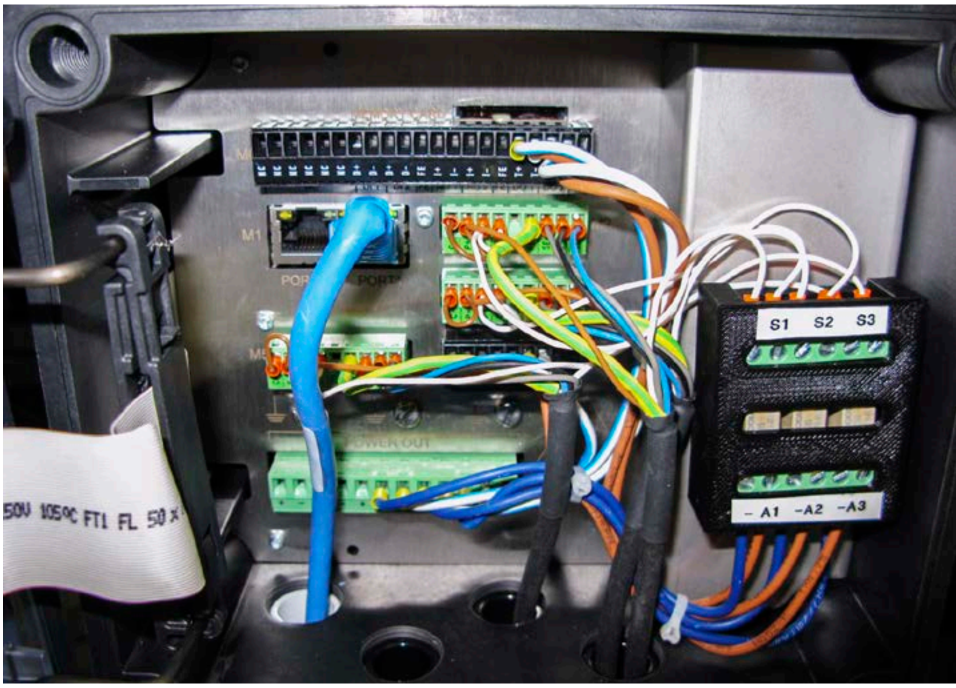


P&ID diagram of a test bench for measuring the auto-ignition temperature of activated carbon

Test cells of the test bench for real-time measurement of the resistance of protective clothing against chemical warfare agents (liquid mustard).

3D printed support system for the compressed air valves of the warfare agent dosing installation for the testing of detection devices





Wiring of the 2022 (LEMA 22) conductivity test bench transmitter for the liquid mustard agent resistance test

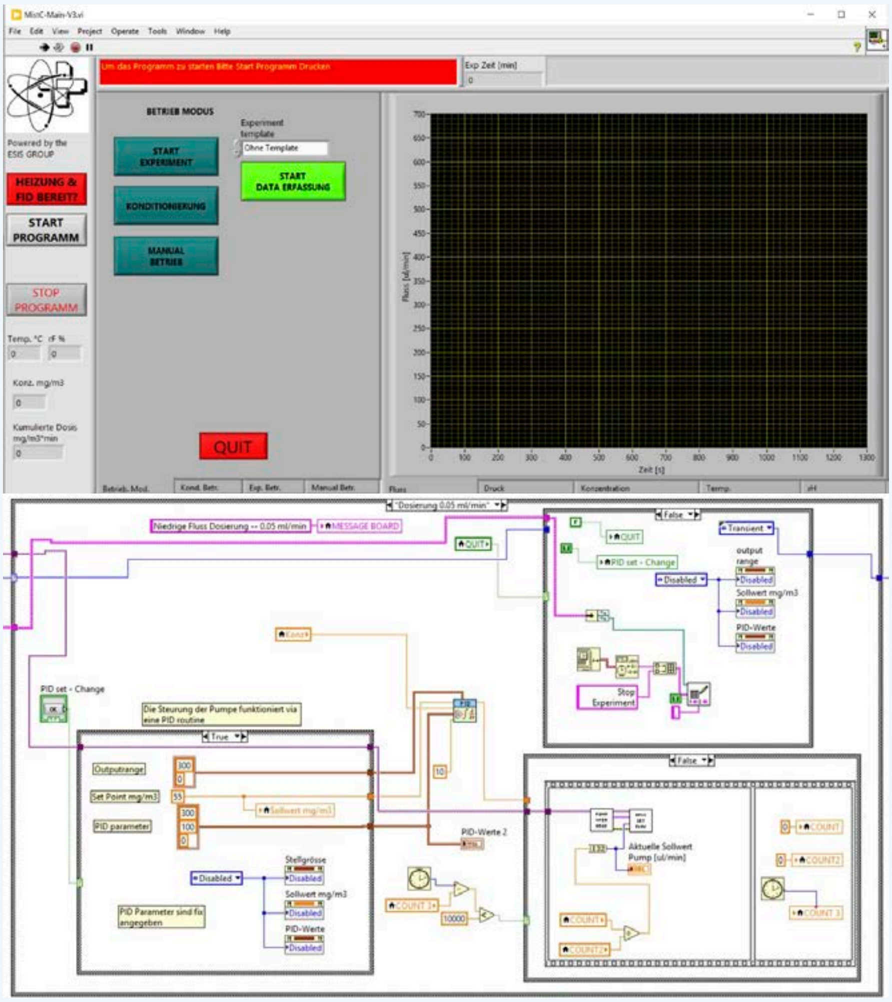
Test benches often incorporate commercially available measurement devices, such as sensors and transducers. When various potentially suitable products are considered, it makes sense to evaluate the measurement technology of each of them. To do this, the most suitable measurement technology is purchased in a simple version and preliminary tests are carried out using it in a provisional test set-up close to actual conditions. If the components prove suitable, they are purchased in sufficient numbers, otherwise the same procedure is repeated with other products.

For special mechanical parts such as measuring cells, a design concept is first drawn up. This concept takes into account all the requirements of the technical specifications, such as the materials to be used, the sealing concept and the adaptation of the sensors evaluated beforehand. The detailed construction of the entire module and the manufacturing drawings can then be carried out by external companies. The individual parts are then precision-manufactured by external mechanical workshops. Special thermoplastic parts can also be manufactured using the department's own 3D printer.

Technical components such as taps, valves and sensors are combined with fittings and pipes to form a complete system (installation) using the P&ID diagram. Fittings and piping must be carefully selected and installed in a manner that prevents leakage of hazardous substances. If the leak test of the complete installation is inconclusive, a localised leak search is carried out using a leak detection liquid or helium. The components are fixed using steel brackets or aluminium profiles.

Test benches usually contain various electronic and electrical systems, such as computers, measurement technology, flow rate controllers and solenoid valves. Such components need to be professionally powered and electrically connected in conformity with the wiring diagrams. Electrical signals, typically 4–20 mA or 0–10 V, are connected to the data recording system.

The tests must be carried out under controlled experimental conditions in a reproducible and safe manner. The test parameters are adjusted and the data from the various measurement sensors and analysis devices is automatically recorded using specially developed data acquisition and control software. The operator can follow the progress of each test in real time. A measurement



Top: User interface of the control software for the Man-in-simulation-test (MIST) test facility for systemic testing of personal protective equipment. Bottom: Part of the corresponding graphical programming in Labview®.

protocol is drawn up at the end of the test. The design of the man-machine interface is important here, not only to ensure that the system works efficiently, but also to avoid operating errors. These skills are known as software engineering. Depending on the complexity of the system, this software is either programmed in-house using, for example, VBA® or the Labview® graphical programming system, or delegated to external partners.

Once a new test bench has been assembled and commissioned, all the functions defined in the technical specifications are checked. Before measurements are carried out for a customer, the test bench must be fully validated. Numerous tests are used to determine properties and parameters such as the accuracy of the measured value, the repeatability and laboratory precision, the detection limit and the determination of the measurement error. In addition, reference materials must be determined for periodic control of the test method. Wherever possible, comparison measurements are carried out with international partner laboratories.

Today, Spiez Laboratory has the engineering skills needed to develop semi-automatic test benches. As a result, it can implement independently, flexibly and in a short space of time new control and test methods that are reproducible, stable and safe.

View of the storage tank area on the Fukushima Daiichi site

06 Fukushima: dealing with contaminated water

More than a decade after the accident at the Fukushima Daiichi nuclear power plant, the global community is using innovative technologies and international cooperation to deal with the long-term consequences. With the Advanced Liquid Processing System (ALPS), the operating company TEPCO is ensuring that contaminated water is treated before being released into the sea. The process is monitored by the IAEA to ensure transparency and safety of this release. Spiez Laboratory supports the IAEA with extensive measurements.

Cédric von Gunten

Water Discharge

6 CPS

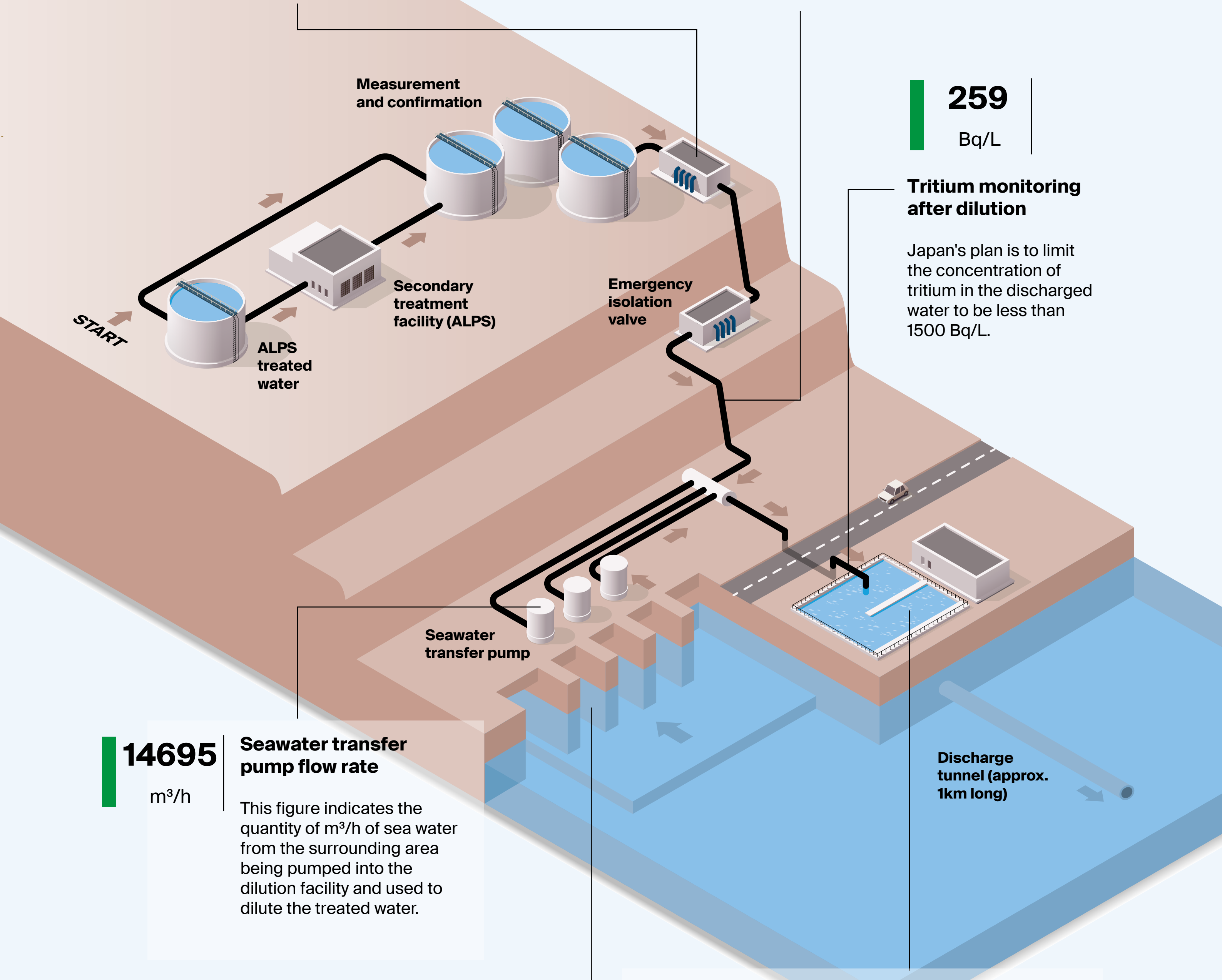
ALPS treated water transfer line radiation monitor

This figure shows the measurement value monitored by the radiation detector placed at the transfer pumps.

18.97 m³/h

ALPS treated water transfer line flow rate

This figure shows the quantity of m³/h of the ALPS treated water flowing through the pipes at this point for dilution further downstream and is based on pump status and capacity.



259 Bq/L

Tritium monitoring after dilution

Japan's plan is to limit the concentration of tritium in the discharged water to be less than 1500 Bq/L.

14695 m³/h

Seawater transfer pump flow rate

This figure indicates the quantity of m³/h of sea water from the surrounding area being pumped into the dilution facility and used to dilute the treated water.

5.2 CPS

Seawater intake radiation monitor

This figure shows the measurement value monitored by the radiation detector placed at the seawater intake pumps.

5 CPS

Vertical shaft radiation monitor - gamma

This figure shows the measurement value monitored by the radiation detector placed at the vertical shaft.

A numerical value and a green bar indicate that this aspect of the discharge system is operating currently and that the data being reported from TEPCO to the IAEA is within the expected levels.

A grey bar indicates that this aspect of the discharge system is not currently operating. This does not indicate a problem, but rather that some aspect of the system is not currently "online."

A numerical value and a red bar indicate that the data being reported from TEPCO to the IAEA is at an abnormal level which has required TEPCO action.

CPS: Counts per second
Measurement values according to IAEA data from 05.03.2024

13 years after the accident at the Fukushima Daiichi nuclear power plant, the world is still dealing with its consequences. Water is continuously pumped through the three damaged reactor units. The main purpose of the water is to prevent the nuclear fuel from heating up again. It also shields the strong gamma radiation emitted by the reactors. As a result, every day around 275 cubic metres of water absorb radioactive substances such as strontium-90 and caesium-137. Together with the inflowing groundwater and precipitation, around 375 cubic metres of contaminated water are produced every day.

The contaminated water is processed and temporarily stored on site using an Advanced Liquid Processing System (ALPS). The ALPS filters all radioactive nuclides except tritium and carbon-14 out of the water. This is accomplished with the help of pump and filter systems as well as a series of chemical reactions. The temporary storage of the treated water requires a lot of space and capacity limits were reached in 2023. For this reason, the Japanese government decided to release the water into the Pacific Ocean in compliance with regulatory emission limits. Therefore, the IAEA was requested to provide technical assistance in 2019. Spiez Laboratory was already available to the IAEA as a Collaborating Centre for marine monitoring at the time (see the annual reports of Spiez Laboratory from 2017 and 2019). The ALPS water must be released in a safe and transparent manner. The IAEA achieves this goal through independent monitoring of the data published by Japan and Tokyo Electric Power Company (TEPCO).

As one of seven selected laboratories, Spiez Laboratory took part in the first independent monitoring of ALPS water by the IAEA. The concentrations of several radioactive nuclides were measured in Spiez, including cobalt-60, strontium-90, caesium-137, tritium, iron-55, nickel-63 and the radionuclides of plutonium, uranium and americium. The seven independent laboratories confirmed the results of the Japanese government and TEPCO with their measurements. With the exception of tritium, the concentrations measured were several orders of magnitude below the emission limits. For tritium, a discharge limit of 1500 Bq/L and 22 TBq per year was set by the Japanese government in agreement with the IAEA. To ensure that this limit can also be adhered to, the ALPS water is diluted with seawater by a factor of 1000 before being released. In addition, TEPCO must ensure that tritium in the discharge is analysed and monitored. This and other data can be consulted on the corresponding IAEA website (www.iaea.org/alps). The seawater is discharged into the Pacific via a discharge pipe within the no-fishing zone, about one kilometre from the coast.

For a better understanding of the tritium release limits, they can be compared with other established emission limits and radioactive sources. The World Health Organization (WHO) defines a limit of 10 000 Bq/L for tritium in drinking water. Consequently, the water treated using ALPS could theoretically be consumed without any health risks with regard to tritium, before being discharged into the Pacific. By way of comparison, the Gösgen nuclear power plant is authorised to release up to 70 TBq of tritium per year, and the Leibstadt nuclear power plant up to 20 TBq. In practice, Swiss nuclear power plants discharged a total of 20 TBq of tritium into rivers in 2022. In a global context, the La Hague reprocessing plant stands out with an annual tritium discharge of up to 15 000 TBq, which accounts for a significant proportion of the global emissions of around 20 000 TBq.

Tritium is also produced naturally in the atmosphere. Every year, around 72 000 TBq of tritium is created by the reaction of air with secondary neutrons from cosmic radiation. This tritium then finds its way into the world's water systems in the form of precipitation. Although the release from ALPS makes only a minimal contribution to the total amount of naturally and artificially produced tritium in the environment, it emphasises the importance of careful monitoring and transparency in nuclear safety.

Exterior view of the measuring facility

07 Whole-body counter: measuring radioactivity in humans

The inauguration of the new building for the whole-body counter marked an important milestone in the measurement of radioactivity in humans (incorporation measurement). The nuclear disasters at Chernobyl and Fukushima have shown that the need for whole-body measurements increases dramatically in the aftermath of accidents. The operation of the incorporation measurement facility at Spiez Laboratory increases the measurement capacity in Switzerland. It also enables the necessary expertise to be both maintained and secured.

Rolf Althaus

At the beginning of April 2023, armasuisse handed over the new GZ[1] building to Spiez Laboratory for use. The inauguration ceremony took place in August with guests from all over Switzerland.

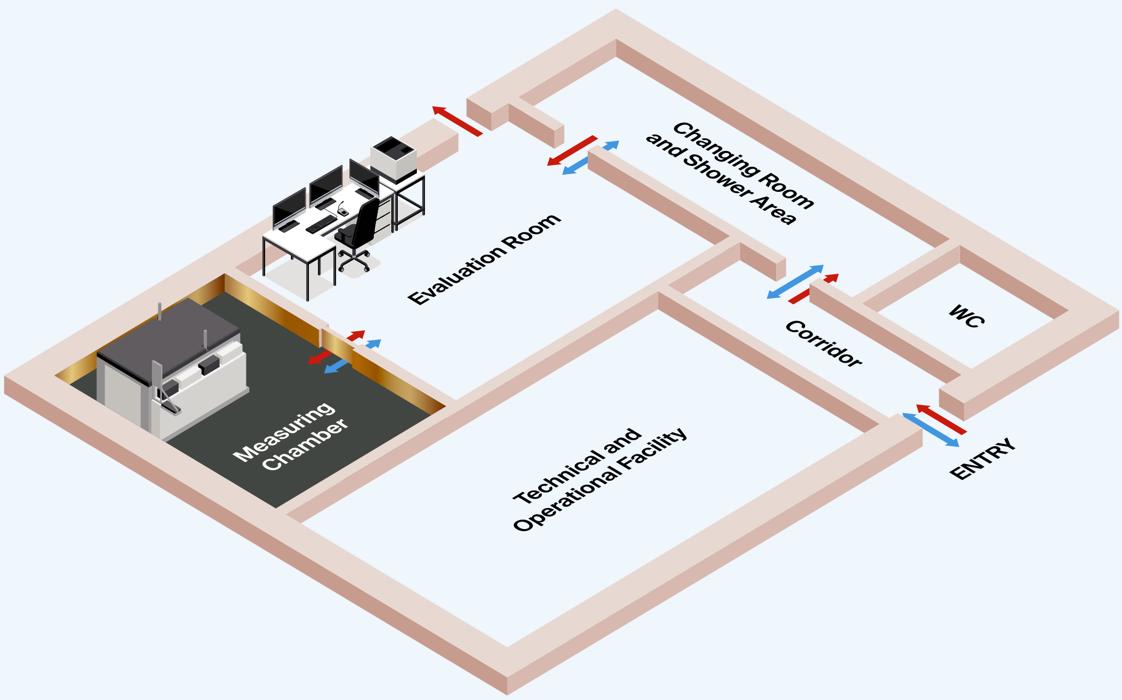
The background of the new facility at Spiez Laboratory dates back to the 1960s. The measurement of radioactivity in the human body – so-called incorporation measurements, as radioactivity is absorbed into the body via the respiratory tract or digestion – has its origins in the spread of nuclear energy and above-ground nuclear weapons tests. The increasing exposure of the environment and humans to the man-made fission products of weapons tests led to the installation of modern measurement technology at university hospitals and research institutes, such as the University Hospital Basel in 1968. With a purchase price of CHF 300 000, the procurement of the whole-body counter was a significant investment in the cutting-edge technology of the time.

The counter was operated successfully in Basel over the following decades and the measurement technology was updated several times. However, costly maintenance and the declining demand for measurements – given that the situation was assessed as normal – led to the whole-body counter being decommissioned and dismantled in 2012. In order to maintain the measuring capacity in Switzerland, the Federal Office of Public Health (FOPH) searched for an institution that could take over the unique measuring chamber made of low-radioactivity steel plates and continue to operate it with modern measurement technology.

Given its experience with mobile whole-body counters and its involvement in the follow-up to the Fukushima nuclear disaster, Spiez Laboratory agreed to take on the task. The management of the Federal Office for Civil Protection (FOCP) supported the project and authorised the corresponding project to take over and operate a stationary

1 Ganzkörperzähler (GZ) – in English whole-body counter.

Schematic floor plan of the building with room functionalities. The blue area is entered by visitors following the arrows (blue arrows: normal situation, red arrows: incident).



Centrepiece of the new building: The steel chamber with new copper panelling and state-of-the-art technology. The person lies down on the upholstered surface to take measurements. The blue reflections on the wall indicate the positions of the two ultra-pure germanium detectors below the bed surface. These are positioned according to the size and weight of the person to be measured.

whole-body counter with the measuring chamber from Basel.

Preliminary studies quickly revealed that the 55-tonne measuring chamber could not be integrated easily into the existing building structures of Spiez Laboratory. Based on the utilisation concept, the structural measures required to operate the whole-body counter under various utilisation scenarios were defined. The resulting feasibility studies were evaluated in terms of financing, location and benefits. In August 2018, a building structure designed for a normal situation with minimal infrastructure was selected from the variants. At the same time, the extended usage concept envisages using the existing infrastructure of the nearby NBC centre's multi-purpose gymnasium in the event of a major incident.

The new GZ building is located on the perimeter of the site and is integrated into the outer fence, as it were. As a result, the full-body counter is accessible from public grounds: externe persons can be admitted directly without having to register first at Spiez Laboratory's front desk. Normally, persons enter the building through the main entrance. If contamination is suspected, they will be instructed to take a shower and put on disposable clothing. They pass through the shower and changing area into the evaluation room and on into the measuring chamber. This chamber has a very special feel to it, as all the walls are clad in copper panelling. The copper provides an additional shielding effect; in addition, the warm metallic colour in the narrow chamber creates a pleasant atmosphere. The measuring time is between 3 and 30 minutes. The measurement is started and monitored from the evaluation room.

The aim of a measurement is to determine an effective dose for the individual based on the activity of the radionuclides in the body. This effective dose

The measuring chamber was assembled using a heavy-duty crane. The image shows a steel element of the chamber ceiling being hoisted into place.

and the identification of the radionuclides form the basis for possible further medical treatment steps.

In addition to employees from the Nuclear Chemistry Division, the N-lab specialists of the NBC Defence Battalions 10 and 20 of the Swiss Armed Forces also attend refresher training courses in the operation of the measurement technology and the evaluation of the spectra. This ensures that in the event of a major incident, both the mobile and the stationary whole-body counter can be operated for an extended period of time.

In 2024, two further project milestones will be reached with the testing of the utilisation concept and the further approval of the incorporation measurement facility by the FOPH.

The inauguration of the GZ building took place on 28 August 2023 with invited guests from numerous institutions in Switzerland.

Seeds of the ricin plant

08 Detection of biotoxins using ion mobility spectrometry

The detection and identification of high molecular weight biotoxins such as ricin is one of Spiez Laboratory's core competences. With the nano-LC-IMS-QTOF, it has a sophisticated analytical instrument that combines several powerful analytical techniques. It enables the detailed analysis and identification of complex biological samples.

Michel Moser, Matthias Wittwer,
Christian Müller

The nano-LC-IMS-QTOF for the detection and identification of toxins

Biotoxins can generally be detected and quantified with high sensitivity using enzyme-linked immunosorbent assays (ELISA). However, unambiguous identification is not always possible, as mutations in the toxin can interfere with the binding of the detection antibodies. For this reason, complementary mass spectrometry and proteomics approaches are increasingly being used. For this reason, Spiez Laboratory has a nano-liquid-chromatography ion-mobility tandem mass spectrometer (nano-LC-IMS-QTOF), which is used for the identification of high molecular weight biotoxins.

A broadly applicable protein extraction method is used to analyse a wide range of environmental samples. It is based on the fact that proteins bind to carboxylate-coated magnetic beads and are extracted due to their hydrophilic properties. In parallel, antibodies coupled to magnetic beads can be used to search for specific biotoxins. The extracted biotoxins (proteins) are trypsine-digested and their peptides are separated and detected in the nano-LC-IMS-QTOF using three properties: firstly by interaction of the peptides with the stationary phase (retention time), secondly by the charge and collision surface of the peptides (ion mobility), and thirdly by the flight time of the peptides and their fragments through the flight tube (TOF).

Together with the signal intensity of the detected peptides and their fragments, this results in a high-resolution four-dimensional data set for each analysis cycle. Using Deep Neural Networks (DNNs), the recorded data is compared against spectral databases, analysed and statistically weighted. Data-independent acquisitions (DIA) are carried out to ensure that large numbers of samples can be analysed systematically and reproducibly. In contrast to data-dependent acquisition (DDA), which only selects peptides with high fragmentation intensity, all peptides and their fragments can be detected. This allows the recovery of peptides with very low concentrations (1 ppb). Spectral libraries are then used to interpret the complex, superimposed fragment patterns. The relevant data originate either from calibrated and annotated fragment spectra or they have been calculated by pre-trained neural networks from protein sequences (library-free approach). This method can also be used to reliably detect proteins and peptides that have never been measured and annotated as pure substances in a spectral library.

In autumn 2023, the Biology Division was able to put these flexible yet highly accurate detection methods to a demanding test by participating in the UNSGM round robin test. The task was to detect and quantify the plant toxins abrin and ricin in complex environmental and food samples. Using the highly sensitive ELISA and the nano-LC-IMS-QTOF, the correct toxin isoforms could be assigned to all samples. By analysing the non-specific protein extraction, it was also possible to characterise the background matrix of the samples, which provided important forensic information.

Spiez Laboratory is currently developing, testing and optimising various additional methods using the nano-LC-IMS-QTOF with the aim of ensuring biotoxin identification using ion mobility spectrometry at even lower substance concentrations. From 2024, the detection of toxins with the nano-LC-IMS-QTOF will also be introduced as a military training module: The biology laboratory specialists of the Swiss Armed Forces' NBC Defence Battalions 10 and 20 will receive dedicated training in the use of this method as part of their refresher courses.

09

Standardised method for chemical inactivation of Risk Group 4 viruses

Proper disinfection and inactivation of highly pathogenic viruses is an essential component of public health and infectious disease prevention. Depending on environment, surfaces, and type of contaminant, various methods of disinfection can be applied. During infectious disease outbreaks, these methods must not only be efficient but also easy to use and readily available. With these aspects in mind, Spiez Laboratory has developed a standardised method for in-house testing of chemical disinfectants against highly pathogenic viruses.

Hulda R. Jonsdottir, Daniel Zysset, Benjamin Weber

Zaire Ebola virus is a filovirus with zoonotic potential. It causes severe hemorrhagic fever in humans and can present with a mortality rate of up to 90 %. According to WHO estimates, nearly 30 000 people were affected during the 2014–2016 West-African Ebola epidemic, with more than 10 000 deaths.

The West African Ebola virus disease outbreak of 2014–16 highlighted the importance of effective disinfectants against viral pathogens. Safe and efficacious disinfection of treatment centres and hospital rooms, as well as vehicles used to transport infected persons. Disinfection of such a complex mixture of different materials, such as textiles, plastics, rubbers, and metals, is extremely challenging. Additionally, the diverse composition of infectious bodily fluids, the primary transmission route of Ebola virus, complicates disinfection procedures.

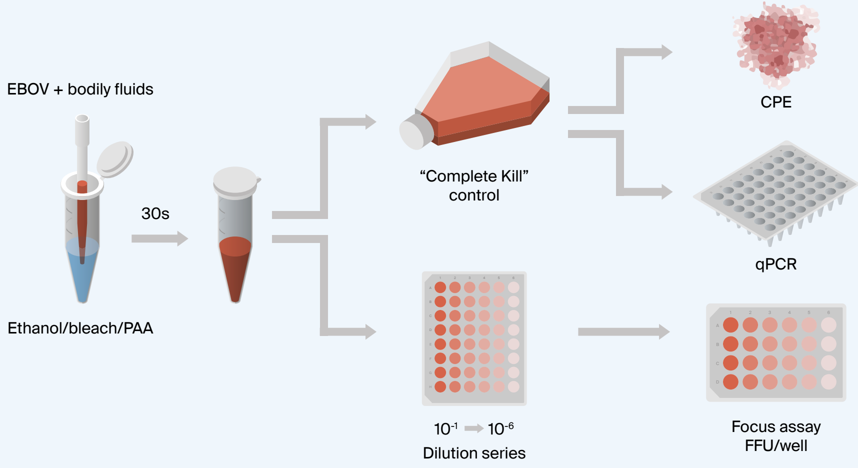
Based on ISO standards and guidelines from the German Robert Koch Institute (RKI), Spiez Laboratory has developed a new, standardised in-house testing procedure[1] in which the inactivation of Ebola virus in various bodily fluids (e.g., blood or mucus) is assessed. This procedure, conducted in the Biosafety Laboratory Level–4 (BSL-4), allows for the evaluation of both established and novel chemical disinfectants against highly pathogenic risk group 4 viruses.

The developed and implemented testing procedure enables the assessment of virus inactivation using various disinfectants using the same standardised workflow, thereby improving reproducibility and minimising experimental deviations. Strict controls must be conducted to ensure experimental validity. For an experiment to be considered valid, controls must not deviate more than 10 % from the positive control, thus limiting experimental uncertainties.

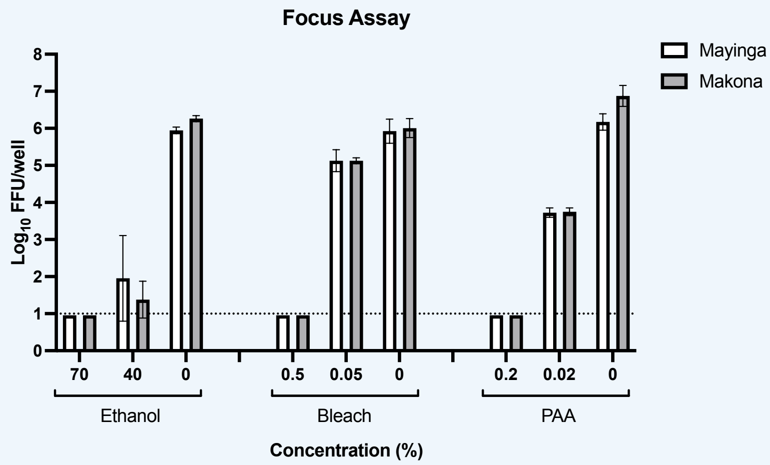
Building on this standardised testing procedure, we can easily test other chemical disinfectants against Ebola and other viruses. On this note, we are currently evaluating the effect of simple homemade soap against Lassa virus, another haemorrhagic fever virus, both in suspension and additionally in simulated hand wash experiments. Lassa virus is endemic in Nigeria and causes

1 Jonsdottir, H.R., Zysset, D., Lenz, N. et al. Virucidal activity of three standard chemical disinfectants against Ebola virus suspended in tripartite soil and whole blood. Scientific Reports, 2023 13(1), 15718

When evaluating the inactivation capacity of chemical disinfectants, a standardised workflow is essential to minimise experimental variation and complete inactivation of highly pathogenic organisms must be validated. Before making any recommendations on the use of disinfectants, it must be ensured that the infectivity of deadly viruses is eliminated.



Inactivation efficacy against Ebola virus depends on the concentration of the applied decontamination solution. For ethanol, bleach, and PAA, low and intermediate concentrations are not sufficient to fully inactivate the Ebola virus. It is therefore essential to use the appropriate concentration for field decontamination.



both asymptomatic and severe symptomatic infections in humans. Viral transmission between people in hospitals with poor infection prevention and control is frequent. Therefore, we believe that by assessing how simple soap inactivates Lassa virus, we might be able to make handwashing and cleaning recommendations to reduce such transmission of the virus. Preliminary results indicate that biological soil load has a large influence on the inactivation capacity of low concentration of soap and that the traditional 20 second handwash might not be enough for inactivation of virus mixed with certain biological materials.

Continued vigilance and optimisation of current disinfection protocols is extremely important due to the continuous presence of the Ebola virus on the African continent and increased zoonotic spillover of novel viral pathogens. Furthermore, to facilitate general pandemic preparedness, the availability of reliable chemical disinfection protocols is a very important element of general pandemic preparedness and infection prevention. To this end, the established procedure will serve as a valuable testing tool for evaluating the chemical inactivation of existing and emerging risk group 4 viruses.

1. **Main building Spiez Laboratory: will be replaced by a new building**
2. **Maintenance and storage building: will be renovated**
3. **Chemical Safety Laboratory: will be renovated**
4. **Energy centre: will be renovated**
5. **Biosafety Laboratory: no renovation necessary**
6. **Sample Reception Unit (SRU): no renovation necessary**

10 Planning the modernisation of Spiez Laboratory

After four decades of intensive use, the buildings and technical infrastructure of Spiez Laboratory are in need of refurbishment. A feasibility study has shown that a new construction on the existing site in Spiez is the most favourable option.

Mauro Zanni, Kurt Münger

Brochure for the inauguration of the NC Laboratory in 1981

On 22 May 1981 at the inauguration of the then known NC Laboratory Spiez, the head of the Federal Military Department, Federal Councillor Georges-André Chevallaz, stated that the construction of the new centre in Spiez would “ensure the infrastructure essential for continuous progress in all AC matters”.[1] Today, it is clear that the expectations of Federal Councillor Chevallaz have been more than met. Spiez has become the central hub for Swiss NBC protection.

Intensive use – major need for refurbishment

After more than 40 years of use, the buildings of Spiez Laboratory and various technical installations are dated and will no longer be state of the art in the long term. The stable climatic conditions required for high-precision analytical work can only be ensured with difficulty within the existing building shell and technical installations. The service ducts (water, compressed air, electricity) and other technical infrastructure are in need of renovation due to many years of intensive use. In addition, capacity limits have been reached in various areas and conversions or extensions are barely possible. Most of the laboratory equipment (fume hoods, laboratory furniture) is also more than 40 years old and needs to be replaced. Finally, the building no longer fulfils today’s requirements in terms of energy efficiency and earthquake safety.

The best option: new construction at the existing location

Various options were thoroughly analysed as part of a feasibility study. The main aim was to assess the options of complete refurbishment and a new replacement building – with a clear result: the utility value analysis clearly showed that, taking into account the operational aspects, a new construction of the main building is the most efficient and also the most cost-effective option.

1 AC-Laboratorium Spiez. Einweihung 22. Mai 1981 (Festschrift), Spiez 1981, S. 3. (NC Laboratory Spiez, Inauguration 22 May 1981 (Commemorative Bulletin), p.3)

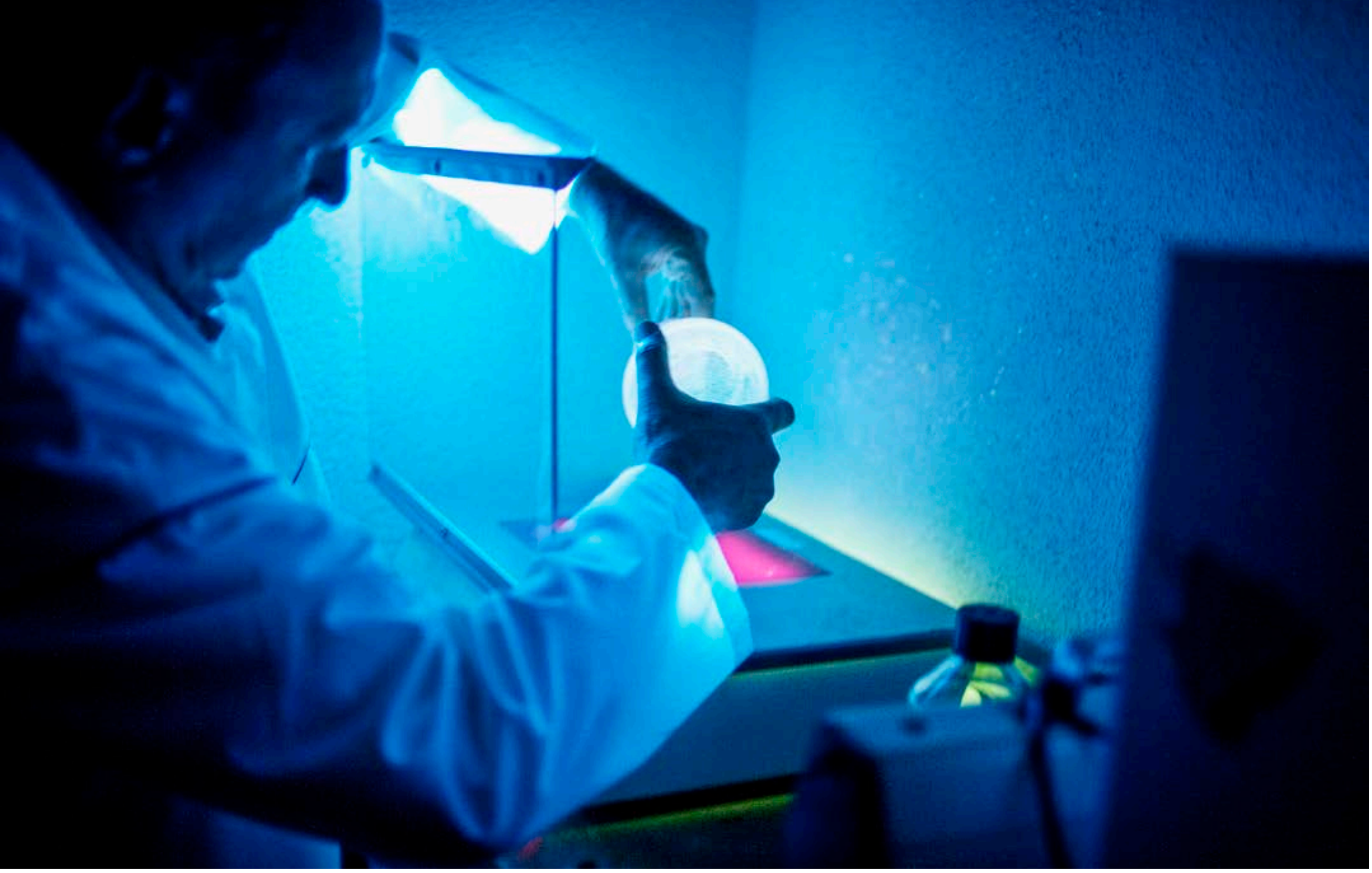
The new building must fit in with the existing facilities. In particular, this includes the Chemical Safety Laboratory, the Biosafety Laboratory, the Sample Reception Unit and the army's facilities. The army's NBC-EOD Centre of Excellence, which is located at the same site, works closely with Spiez Laboratory. Together, Spiez Laboratory and the NBC-EOD Centre of Excellence provide the necessary resources for dealing with NBC incidents in Switzerland.

Ultimately, the renovation project is intended to utilise the opportunity to render the infrastructure of Spiez Laboratory fit for development and therefore fit for the future. The individual laboratories should be able to be rebuilt or adapted quickly and easily. With this in mind, a new building clearly offers the best conditions.

Commissioning earliest in 2030

After intensive preparatory work, the project was put out to public tender at the end of 2023. The exact specifications, implementation planning and costs will be worked out in detail in a two-stage process and the best project will be selected in mid-2025. According to current planning, the construction project is to be included in the DDPS 2026 real estate programme and thus in the Federal Council's 2026 Armed Forces Dispatch. The final political decision on the necessary funding will then be made by parliament. In the best-case scenario, realisation of the construction project can begin in 2027.

Numerous partners are involved in Spiez Laboratory's modernisation project: The construction project is being managed by armasuisse Real Estate. The FOCP / Spiez Laboratory is represented as tenant, user and operator. The project management coordinates the contributions of numerous service providers such as laboratory planners, architects, engineers, safety experts, etc. Good co-operation between the partners is a key prerequisite for the success of the project. The expertise and experience of the armasuisse Real Estate specialists is indispensable for this.



An employee of the Agroscope Research Station uses UV light to visualise the food ingredient isocoumarin.

11 The federal laboratories: diverse tasks and common interests

Spiez Laboratory is intensifying the exchange of expertise and the collaboration with other federal laboratories, such as Agroscope and the Institute of Virology and Immunology (IVI). Scientific expertise and resources are to be pooled through joint research projects and the exchange of expertise. The aim is to utilise synergies in order to increase the efficiency and effectiveness of the research work of all participating institutions.

Marc Cadisch, Director Spiez Laboratory
Corinne Jud Khan, Head Competence Area Methods Development and Analysis, Agroscope

In addition to Spiez Laboratory – responsible for NBC protection – the federal government operates a number of other specialised laboratories. In organisational terms, these belong to various federal offices or are independent institutes such as Swissmedic or METAS.

There are many contacts between the experts from these different laboratories; the professional exchange works well. There are also agreements at management level to support and systematically promote further opportunities for these collaborations. For example, Spiez Laboratory has long-standing agreements with the **Institute of Virology and Immunology (IVI),** the Swiss reference laboratory for the diagnosis and research of highly infectious and other important viral animal diseases, as well as with **Agroscope,** the federal centre of excellence for research and development in agriculture and the food sector.

An IVI employee looks after pigs in a research project for a vaccination against African swine fever.

New committee: Heads of Federal Laboratories

In addition to these bilateral contacts and agreements, a systematic exchange between all heads of the federal laboratories is also key. The authors of this article therefore took the initiative and organised an initial meeting in 2019 with the heads of the other federal laboratories. Over time, this first meeting developed into the standing working group “Heads of Federal Laboratories”.

In addition to Spiez Laboratory, Agroscope ad IVI, the following institutions actively participate in the working group:

- **Swiss Federal Institute of Metrology METAS,** the competence centre for all issues relating to measurement, measuring instruments and measuring methods
- **Swissmedic,** the Swiss regulatory authority for therapeutic products
- **armasuisse Science and Technology S+T** with various laboratories in the fields of cyber security and data science, communication and electromagnetic compatibility, ammunition monitoring and test centres for system and component testing
- **Federal Office for Customs and Border Security (FOCBS)** with a laboratory in the field of precious metal control
- **Armed Forces Pharmacy,** the army’s centre of expertise and distribution and production hub for therapeutic products
- **Federal Office of Public Health (FOPH),** Radiation Protection Division
- **Federal Office of Communications (OFCOM)** with test facilities in the area of market surveillance for radio equipment and electromagnetic compatibility of electrical equipment

An employee from Spiez Laboratory works at a biosafety cabinet in the level-3 biosafety laboratory.

– **EAWAG,** the water research institute of the ETH Domain

Definition of common tasks and interests

The above list shows: The federal laboratories form a heterogeneous group; they have completely different tasks and require very different scientific methods and infrastructures to fulfil them. Nevertheless, there are similarities and points of contact. During the first meeting of the federal laboratory heads, these areas of common interest first had to be identified. These include, for example, laboratory-specific ICT applications, special conditions and requirements for procurements, instruments and processes for knowledge management in laboratory work, the recruitment of international specialists, and cooperation between federal laboratories in crisis situations. In a further step, concrete structures, processes and instruments of cooperation are now to be developed and established for these areas of responsibility.

Cooperation in the event of a crisis

The core mission of Spiez Laboratory extends beyond research and testing; it is also a central federal measurement organisation for the management of NBC incidents and is supported in this by specialised companies of the armed forces (p. 47). In addition to this long-established cooperation with the army, the targeted use of the capabilities and infrastructure of the other federal laboratories would also be of great benefit in a crisis situation. This was already demonstrated in 2020, when the newly formed network of laboratory heads was able to make a contribution to managing the coronavirus crisis: On 3 April 2020, the Federal Council entrusted Spiez Laboratory with the coordination of all laboratories to build up the necessary measurement capacities for SARS-CoV-19 in Switzerland. In order to fulfil this task, Spiez Laboratory was significantly supported by contributions from other federal laboratories, arranged through the network of laboratory heads.

The federal laboratory heads now want to be even better prepared for their co-operation in future crises. On behalf of the working group, Spiez Laboratory has therefore conducted a survey among the federal laboratories in order to record existing structures and instruments of bilateral cooperation and to ascertain whether there are additional opportunities for mutual support. Technical aspects are also being clarified, such as the general conditions for the secondment of personnel or the loan of equipment. The aim is to develop in advance the necessary instruments and processes for rapid, efficient and therefore successful federal crisis management in the laboratory sector. If necessary, they can then be activated immediately and valuable time can be saved.

Support during the pandemic

At the beginning of the COVID-19-pandemic, the worldwide demand for consumables (sampling material, test kits, solutions, plastic goods, etc.) for medical microbiology laboratories increased rapidly. Existing stocks were quickly depleted and supply chains collapsed. The number of analysers and staffing levels also had to be expanded rapidly and extensively. During the chaos phase, short-term interim solutions had to be found to ensure that the bare essentials were available. The network of federal laboratories also played a role here. Coordinated by Corinne Jud from Agroscope, a detailed inventory of available resources was drawn up in a very short space of time: All relevant materials and equipment available in the federal laboratories and their material stores were recorded. A list of human resources with transferable skills was also compiled. As part of “COVID-19 Laboratory Coordination Switzerland”, these lists were aligned with the requests for support from medical microbiology laboratories and material deliveries were arranged where possible. An open internet platform (ARC[1]) developed ad hoc with EPFL and ETH was used for this resource management. As a result, Spiez Laboratory, with the support of other federal laboratories, was able to make a significant contribution to bridging an acute shortage.

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1 Courcol et al. (2021) ARC: An Open Web-Platform for Request/Supply Matching for a Prioritized and Controlled COVID-19 Response. Front. Public Health 9:607677.

Military training refresher courses in Spiez Laboratory: Training of B-specialists

12 Civil-military cooperation in NBC protection: a Swiss success model

In addition to Spiez Laboratory, the Spiez NBC Centre is also home to the military NBC-EOD Centre of Excellence. The two institutions operate independently of each other in organisational terms and pursue different missions. However, they deal with the same hazards and threats and work closely together on a technical level.

Kurt Münger, Head of Management Tasks, Spiez Laboratory
Colonel Matthias Schmid, Head of Doctrine and Deputy Chief of Staff, NBC-EOD Centre of Excellence

Joint exercise with a chemical warfare agent detection device

The NBC-EOD Centre of Excellence of the Swiss Armed Forces, which is part of the Engineer/Rescue/CBRN Training Unit within the Training and Education Command, is responsible for NBC defence and explosive ordnance disposal in the Swiss Armed Forces. In cooperation with various partners, it develops the principles and specifications for NBC defence and explosive ordnance disposal of the armed forces, coordinates the training of the NBC defence troops and ensures the deployment of the armed forces in NBC defence and explosive ordnance disposal.

Two recruit schools are held in the NBC-EOD Centre of Excellence every year. All NBC specialists of the Armed Forces and members of the militia formations of the NBC defence troops complete their basic and specialist training at the NBC Defence School 77. In addition, the NBC readiness detachment – a formation of long-term service personnel – is stationed in Spiez, and the laboratory companies of the two NBC Defence Battalions 10 and 20 usually carry out their refresher courses in Spiez Laboratory.

Scientific expertise for the Armed Forces – additional staff for Spiez Laboratory

As the Federal Institute for NBC Protection, Spiez Laboratory develops the scientific and technological basis required for the protection of the population, the emergency organisations, and for NBC arms control. Located within the Federal Office for Civil Protection (FOCP), it makes its expertise available to various partners. The NBC-EOD Centre of Excellence in particular benefits from this partnership. Thanks to the shared location, the exchange of expertise between scientific experts at Spiez Laboratory and their colleagues in the military sector is easily embedded in everyday working life. The chains of communication are literally short.

As a result, support is provided in both directions: In order to fulfil its tasks in the event of a major NBC incident, Spiez Laboratory is dependent on the NBC defence forces. If a large number of samples have to be analysed in a short space of time, Spiez Laboratory quickly reaches the limits of its own personnel resources. In such cases, the two NBC Defence Battalions each have a laboratory company that can be activated instantly in the event of an incident to support Spiez Laboratory with personnel. The militia soldiers have civilian qualifications in laboratory work and are trained and instructed in the use of the equipment and measurement methods of Spiez Laboratory during refresher courses. This military support enables Spiez Laboratory to maintain continuous 24/7 operations if required.

Joint exercises and joint committees

Some time ago, on behalf of the DDPS departmental management, the two organisations drew up a joint concept of operations for the Spiez NBC Centre. This comprehensively and systematically harmonises the civilian and military resources for managing NBC incidents in Switzerland and their planned further development. Implementation is constantly reviewed and improved through regular joint exercises. The EOD command (explosive ordnance disposal and mine clearance) is also involved in this process and is supported by NBC specialists from Spiez Laboratory when required. Various institutionalised committees and processes exist at both command and specialist levels to coordinate the extensive civil-military cooperation.

Spiez Laboratory and NBC-EOD Centre of Excellence do not only work closely together on a technical level. In order to utilise synergies, Spiez Laboratory provides various operational services (energy and water supply, building services, building maintenance, IT services, etc.) for the entire Spiez NBC Centre, including the NBC-EOD Centre of Excellence. The Kantine 77 provides catering for the troops on behalf of NBC-EOD Centre of Excellence. Both organisations also use it as a staff restaurant and for events with visiting groups.

Despite their differences, the two specialist partners at the Spiez NBC Centre, the civilian Spiez Laboratory and the military NBC-EOD Centre of Excellence, complement each other perfectly. Their specific skills and competences are essential for their joint success.

Training of N-specialists on a mobile measuring device for thyroid measurement

13 Scientific publications 2023

Brackmann Maximilian, Zysset Daniel, Liechti Nicole, Hunger-Glaser Isabel, Engler Olivier

The WHO BioHub system: experiences from the pilot phase

BMJ Glob Health 2023 Aug;8(8):e013421

Ekins S, Brackmann M, Invernizzi C, Lentzos F

Generative Artificial Intelligence-Assisted Protein Design Must Consider Repurposing Potential

GEN Biotechnol, 2023 Aug 1;2(4):296–300

Ekins S, Lentzos F, Brackmann M, Invernizzi C

There's a 'ChatGPT' for biology. What could go wrong?

Bulletin of the Atomic Scientist, March 24, 2023

Corcho-Alvarado J A, Röllin S, Sahli H

Determination of transuranium elements produced by the Castle Bravo explosion

Environmental Radiochemical Analysis VII, ed. N. Evans, Royal Society of Chemistry, 2023, vol. 357, ch. 2, pp. 19–27

Meyzonnat G, Musy S, Corcho-Alvarado J A et al.

Age distribution of groundwater in fractured aquifers of the St. Lawrence Lowlands (Canada) determined by environmental tracers ($^3H/^3He$, ^{85}Kr, SF_6, CFC-12, ^{14}C)

Hydrogeol J 31, 2139–2157 (2023)

Kamdee K, Corcho-Alvarado J A, Yongprawat M, Occarach O, Hunyek V, Wongsit A et al.

Using ^{81}Kr and isotopic tracers to characterise old groundwater in the Bangkok metropolitan and vicinity areas

Isotopes in Environmental and Health Studies, Vol. 59, No. 4–6, 426–453

Dutoit Jean-Claude, Meier Urs, Schär Martin, Siegenthaler Peter

various contributions

in P. Vanninen (ed): Recommended operating procedures for analysis in the verification of chemical disarmament ("Blue Book"), 2023 Edition, University of Helsinki, Finland, 2023. ISBN 978-951-51-9958-4 (paperback); ISBN 978-951-51-9959-1 (PDF)

Huttner A, Agnandji ST, Engler O, Hooper JW, Kwilas S, Ricks K, Clements TL, Jonsdottir HR, Nakka SS, Rothenberger S, Kremsner P, Züst R, Medaglini D, Ottenhoff T, Harandi AM, Siegrist CA; VEBCON; VSV-EBOVAC; VSV-EBOPLUS Consortia

Antibody responses to recombinant vesicular stomatitis virus-Zaire Ebolavirus vaccination for Ebola virus disease across doses and continents: 5-year durability

Clin Microbiol Infect. 2023 Dec;29(12):1587–1594

Urbina F, Lentzos F, Invernizzi C, Ekins S

AI in drug discovery: A wake-up call

Drug Discov Today, 2023 Jan;28(1):103410

Urbina F, Lentzos F, Invernizzi C, Ekins S

Preventing AI From Creating Biochemical Threats

J Chem Inf Model, 2023 Feb 13;63(3):691–694

Jonsdottir Hulda, Zysset Daniel, Lenz Nicole, Siegrist Denise, Züst Roland, Geissmann Yannick, Engler Olivier, Weber Benjamin

Virucidal activity of three standard chemical disinfectants against Ebola virus suspended in tripartite soil and whole blood

Scientific Reports, 2023 13(1), 15718

Brigger D, Guntern P, Jonsdottir HR, Pennington LF, Weber B, Taddeo A, Zimmer G, Leborgne NGF, Benarafa C, Jardetzky TS, Eggel A

Sex-specific differences in immune response to SARS-CoV-2 vaccination vanish with age

Allergy, 2023 Jun;78(6):1683–1686

Bauer G, Wildauer A, Povoden G, Menzi B, Curty C

Crime Scene Novichok – Optical Detection of Fourth-Generation Agents (FGAs) Using Handheld Forensic Light Sources

Forensic Sciences, 2023; 3(2):231–244

Röllin Stefan, Sahli Hans, Corcho José, Hofstetter Michael

Messungen von Alpha- und Beta-Strahlern im Erdboden mittels ICP-MS

Strahlenschutz PRAXIS 3/2023, S. 37–39

Kalthoff O, Wirz C, Groß-Alltag F, Stetter F, Bücherl T

Determination of uranium-enrichment from gamma-spectra by linear least-squares

Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 1057, 2023, 168750

Lepowsky E, Kreutle M, Wirz C, Glaser A

Ceci N'est Pas Une Bombe: Lessons from a Field Experiment Using Neutron and Gamma Measurements to Confirm the Absence of Nuclear Weapons

Science and Global Security, 2023/09

Lepowsky E, Kreutle M, Wirz C, Glaser A

Confirming the Absence of Nuclear Weapons. Neutron and Gamma Measurements During a Verification Experiment in Switzerland

INMM & ESARDA Joint Annual Meeting, Vienna, May 2023.

Lepowsky E, Kreutle M, Wirz C, Glaser A

Radiation Measurements

in: P. Podvig (ed.), Menzingen Verification Experiment: Verifying the Absence of Nuclear Weapons in the Field, United Nations Institute for Disarmament Verification (UNIDIR), Geneva, Switzerland, July 2023 (Chapter 4)

Jenni C, Altorfer T, Düzel S, Ganz M, Denzler D, Tillenkamp F, Zahnd A, Brenner L

Numerical procedure to determine the performance and structural response of passive shock wave safety valves under blast loading

International Journal of Protective Structures, 2023;0(0)

Meier P, Clement P, Altenried S, Reina G, Ren Q, Züst R, Engler O, Choi F, Nestle N, Deisenroth T, Neubauer P, Wick P

Quaternary ammonium-based coating of textiles is effective against bacteria and viruses with a low risk to human health

Scientific Reports, Nov 23;13(1):20556

Züst R, Ackermann-Gäumann R, Liechti N, Siegrist D, Ryter S, Portmann J, Lenz N, Beuret C, Koller R, Staehelin C, Kuenzli AB, Marschall J, Rothenberger S, Engler O

Presence and Persistence of Andes Virus RNA in Human Semen

Viruses, 2023 Nov 17;15(11):2266.

14 Accredited laboratories

Participation in External Quality Assurance (EQA) Exercises
October 2022 – September 2023

Nuclear Chemistry Division

STS 0028	Testing laboratory for the determination of radionuclides and elemental analysis		
	1	University of Wageningen (NL)	– International Soil Exchange (ISE)
	4	ielab (ESP)	– Potable water – Sea water
	2	International Atomic Energy Agency (IAEA)	– PT ALMERA – PT IRSIN
	1	Institut de radiophysique (IRA) / Federal Office of Public Health (FOPH)	– Round Robin Test Gamma Spectrometry

Biology Division

STS 0054	Testing laboratory for the detection of biological agents		
	10	QCMD (UK)	– Molecular biological detection methods Round Robin Test Bacteriology: F. tularensis – Molecular biological detection methods Round Robin Test Virology: Arboviruses, YFV, DENV, WNV, Pox viruses
	5	INSTAND (GER)	– Molecular biological detection methods Round Robin Test Bacteriology: B. anthracis, F. tularensis, C. burnetti, Brucella spp
	2	United Nations Secretary-General's Mechanism (UNSGM)	– Molecular biological detection methods Round Robin Test Bacteriology: Burkholderia species – Molecular biological detection methods Round Robin Test Virology: Haemorrhagic Fever Viruses

Chemistry Division

STS 0019	Testing laboratory for the analysis of samples for the presence of chemical warfare agents and related compounds		
	0	Organisation for the Prohibition of Chemical Weapons (OPCW)	The test centre was exempted from participation in the OPCW Proficiency Tests in 2023. The OPCW designation for 2023–2024 was granted on the basis of successfully completed off-site analyses and other support services.

CBRNe Protection Systems Division

STS 0022	Testing laboratory for adsorbents and breathing apparatus filters		
	0	No Round Robin Tests	

STS 0036	Testing laboratory for Plastics and Rubber, and for the Protection Performance of Polymers, Rubber and Textiles against Chemical Warfare Agents		
	5	German Reference Bureau for Interlaboratory Tests and Reference Materials (Deutsches Referenzbüro für Ringversuche und Referenzmaterialien GmbH, DRRR) (GER)	– Tear Resistance Test, Elmendorf-Method – Melt flow rate MFR/MVR – Izod-Notch impact resistance PP-TPO und Izod-Impact resistance PP-GF – Specimen milling and tensile test – Foam tensile test
	1	OFI Technologie & Innovation GmbH	– Charpy-Impact resistance test
	1	Armasuisse Land Systems	– Round robin test training suit fabric

STS 0055	Testing laboratory for NBC protection material, shelter equipment and shelter installations		
	0	No Round Robin Tests	

15 Organigram

SPIEZ LABORATORY
Dr Marc Cadisch[2]

- **MANAGEMENT TASKS** – Dr Kurt Münger[2]
- **NBC ARMS CONTROL** – Dr Cédric Invernizzi[2]

NUCLEAR CHEMISTRY – Marc Stauffer[2]
- **RADIOACTIVITY** – Dr Stefan Kradolfer
- **RADIOCHEMISTRY AND INORGANIC ANALYSIS** – Cédric von Gunten
- **RADIATION PROTECTION AND MOBILE DETECTION** – Markus Zürcher

BIOLOGY – Dr Isabel Hunger-Glaser[2]
- **BIOSAFETY AND ENGINEERING CONTAINMENT LABORATORY** – Dr Benjamin Weber
- **DIAGNOSTICS AND REFERENCE FUNCTIONS** – Dr Kristina Schmidt
- **RESEARCH AND ANALYSIS OF HIGHLY PATHOGENIC AGENTS** – Dr Olivier Engler
- **PROTEOMICS, BIOINFORMATICS AND TOXINS** – Dr Matthias Wittwer

CHEMISTRY – Stefan Mogl[1,2]
- **DETECTION AND DECONTAMINATION** – Josha Albrecht
- **ANALYTICAL CHEMISTRY** – Dr Peter Siegenthaler
- **ORGANIC CHEMISTRY** – Dr Christophe Curty

CBRNe PROTECTION SYSTEMS – Dr César Metzger[2]
- **INCIDENT RESPONSE AND INDIVIDUAL PROTECTION** – Dr Gilles Richner
- **COLLECTIVE PROTECTION** – André Zahnd
- **MATERIAL TESTING** – Thomas Friedrich

LOGISTICS, QUALITY, SAFETY AND SECURITY – Mauro Zanni[2]
- **MANAGEMENT SUPPORT** – Felicitas Jegher
- **MATERIAL MANAGEMENT, FINANCES, CONTROLLING** – Alexander Werlen
- **MEASUREMENT TECHNOLOGY AND LABORATORY IT** – Matthias Indermühle
- **TECHNICAL SERVICES** – Daniel Gurtner

1) Deputy Director Spiez Laboratory
2) Management Board Spiez Laboratory

01. 01. 2024

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Civil Protection and Sport DDPS
Federal Office for Civil Protection FOCP
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