

Skill Development in the Water Sector Guidelines



German Water
Partnership

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“No investment without qualification”

This key strategy principle of the German Water Partnership for Capacity Development in the international water sector finds concrete, practice-oriented support in these guidelines for vocational education and training (VET), based on the belief that a functioning infrastructure cannot endure without skilled workers. The necessary measures to overcome the need for in-depth training and practical implementation in the international water sector have not been forthcoming to this day. The reasons are varied and ranging from a lack of appreciation to a lack of financial resources.



But commitment to training and qualification pays off. This is demonstrated impressively by the German catch-up process following reunification. Stadtentwässerung Dresden (Dresden Sewage Works), for example, achieved its current successful status by means of clear legislative frameworks and investment in systems and networks. Further major contributions were also **made (?)** by targeted personnel development and commitment to vocational training. The essential foundation is the wastewater treatment specialist. These are the employees who ensure that the plant is operated professionally by quickly identifying faults and expertly repair damage, and who take the necessary protective measures in the event of flooding. These are also the people who, with their knowledge and skills, are responsible for the efficiency of processes – from energy consumption and the use of chemicals to operating the plant with care to ensure a long service life.

Dresden is just one of many members of the German Water Partnership taking responsibility for developing good vocational and education training opportunities for young people. This brochure is designed to facilitate the establishment of appropriate VET opportunities in the water sector, based on the very practical job profiles within the drinking water and wastewater sector.

We at German Water Partnership are looking forward to a strong cooperation in vocational training as well as to successful collaboration in the field of capacity development.

Gunda Röstel
Deputy Chair
German Water Partnership

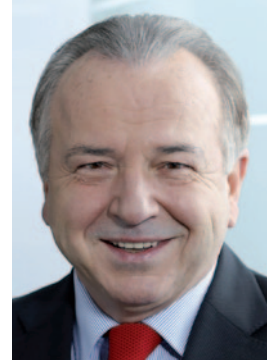
German Environmental Skills

Both, the protection of the global food supply and the right to safe drinking water are inseparable, huge challenges of today and tomorrow.

The increasing number of reports about the scarcity of water has raised the question: "How long will the reserves last?" The available water is limited (only 0.03 percent¹ of the resources worldwide can be reached relatively easily) and water consumption is growing rapidly. Between 1930 and 2000 it increased sixfold. The UNESCO expects that the demand will increase by more than 55 percent until the year 2050. Agriculture consumes about 70 percent. For example the production of 100 kilograms of cotton needs 11,000 liters of water which results in shrinking lakes such as the Aral Sea. The world's increasing energy consumption makes the situation even worse (water-intensive power generation and biofuel production).

Outdated processes and technologies for water catchment, treatment, supply and use (e. g. irrigation technology) have to be modernized and replaced by efficient and sustainable technologies and methods. A worldwide network is needed to impart knowledge and exchange the experiences of German research and water management as well as initial and

also further training. GWP and Wilo are committed to do so. They are focused on future-oriented water technology, considering the local needs and capabilities. Training and job qualification are critical success factors for a future-oriented development of sustainable water management.



As a founding member of German Water Partnership, WILO is represented on the board and the steering committee. Our financial and personal contributions by far exceed a normal membership. It is our pleasure to also promote these guidelines as well.

Peter Stamm
Hier fehlt die Position
WILO SE

¹ Source: wasser.de

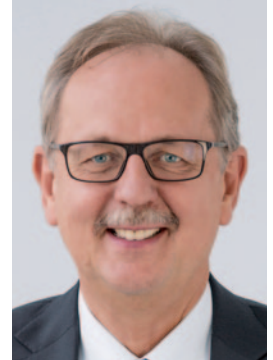
Practical learning for a better water supply

Today, already over 900 million people live in regions where they have no access to safe drinking water. According to a study by the OECD, this could increase to 47 percent of the world population by 2030.

The use of technologies for water supply and treatment as well as the qualification of specialized personnel in this sector are subject to very different standards worldwide, as are education and training in these areas. In many countries, a large proportion of non-industrial sewage flows untreated into rivers, lakes and seas. In regions with inadequate technical education in this sector, even simple water supply and treatment utilities cannot be properly planned and existing plant and equipment cannot be maintained, analyzed and optimized in an adequate way. High water losses during transport as well as deficiencies in treatment cannot be rectified and affect the economy and the health of the local population.

In view of these challenges, access to technical education in the water and wastewater sector provides important leverage for improving and securing the quality of water supply and wastewater disposal in a sustainable way. Here, technicians need both, basic technical knowledge and local exper-

tise. Festo Didactic, in cooperation with universities and international experts, develops technical training courses based on modular training rigs that allow practical, activity-oriented learning about water supply and wastewater treatment processes.



This publication is the result of successful collaboration within the Vocational Training Working Group which, as part of the GWP Capacity Development Task Force, has brought together diverse expertise and undertaken intensive efforts for the promotion of VET in the water and wastewater sector.

Dr. Theodor Niehaus
Managing Director
Festo Didactic GmbH & Co. KG

1 The hydrologic cycle and jobs in water technology

According to DWA estimates, some 250,000 people are employed in the water resources management sector in Germany. There are also numerous plumbers and manufacturers who install apartments with bathrooms. These people work in ministries and authorities, universities and research institutions, planning offices and construction companies, manufacturing companies and service providers, laboratories, and testing institutes, emergency organizations, at trade fairs, trade associations, in international development cooperation and in some 10,000 plants for water supply and wastewater disposal.

Numerous academic engineers and scientists have their roles in these areas. Vocational education and training (non-academic) is described below in more detail. This segment employs the majority of people in this sector. These individuals work in waterworks, wastewater treatment plants, dams, on levees and operate locks. They build fish ladders and repair levees, provide services during flood events and carry out rodent extermination measures in sewer systems. They plan, build, operate and maintain these different water management facilities. They live next to the sea and maintain marine navigation signage, work in harbours, in the chemi-

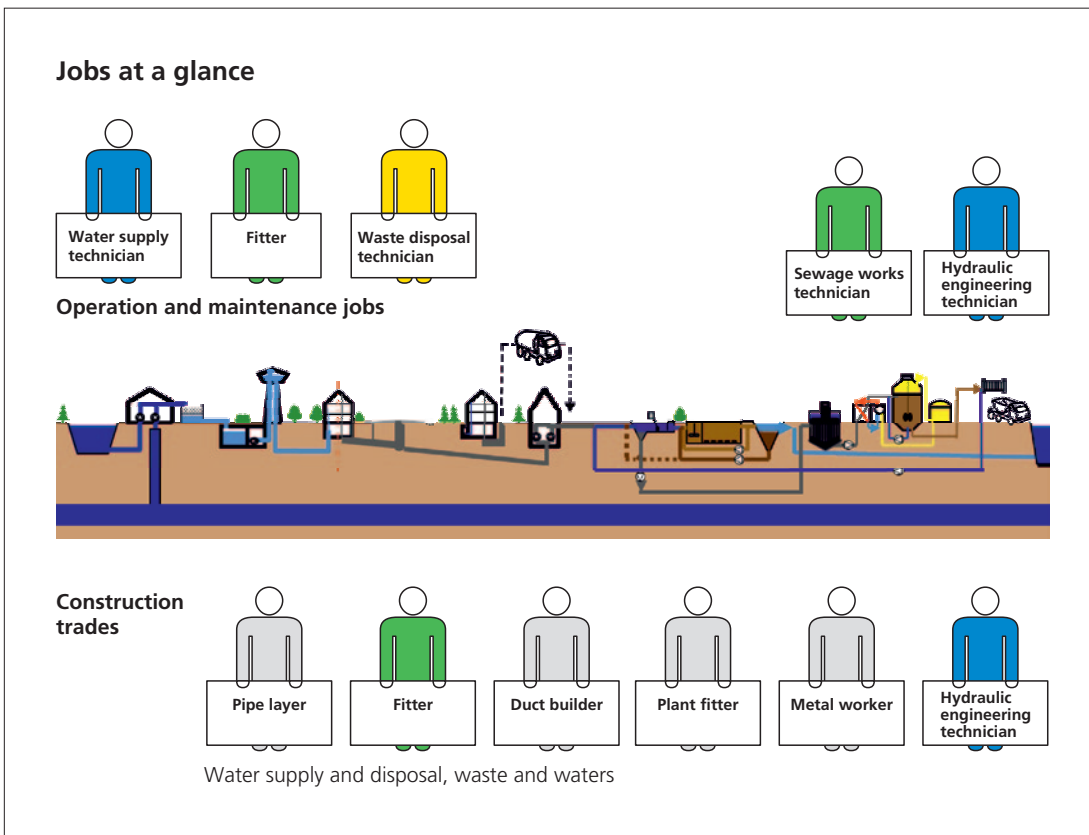


Figure 1: Professions in water technology (DWA)

cal industry or on reservoirs. They build, clean and renovate sewers and water supply networks under roads with dense traffic and maintain small wastewater treatment systems next to mountain huts in the Alps. Water resources management employees work in a great variety of locations at many different companies and service providers, but mainly in public facilities and utilities. This distinguishes this industry from others.

In Germany, about 80,000 people are employed by water supply utilities (water catchment, treatment and distribution) and sanitation utilities (sewer networks, wastewater treatment plants, sludge utilization). Of these, approximately 60,000 are estimated to be skilled workers and master technicians of various skills. Half of them are in environmental technology (ET) professions, especially specialists for water supply technology, master technicians for water resources, specialists and master technicians for wastewater treatment. The four environmental technology professions (specialist for water supply engineering, specialist for wastewater treatment, specialist for pipe, sewer and industrial services, specialist for recycling and waste management) were reorganized by the Federal Institute for Vocational Education and Training (BIBB) with social partners in 2002. It is now a three-year sandwich course ending with a state examination. Part-time external courses offer other employees the possibility to acquire advanced qualifications.

These professions originated in the 1970s. On July 23, 1979, ATV (predecessor of today's DWA), the DVGW (German Technical and Scientific Association for Gas and Water) and the Board of Trustees for Water Resources Management at the Federal Ministry of the Interior requested a training regulation for the staff of wastewater treatment plants and waterworks. On May 30, 1984, the Ordinance for the Regulation

for the Profession of Supply & Waste Disposal Technician, was published with the three disciplines of water supply, wastewater and waste. This was followed in 1987 by advanced training for master technician for water resources, master technician for wastewater treatment and master technician for urban sanitation. These were then updated in 2004.

As a result, today Germany has over 30 years' experience in these environmental technology professions. In addition to these core professions, numerous other important technical professionals are required in the water resources management sector. Here we distinguish between the traditional construction trades and those that ensure the continuous operation and maintenance of plant and machinery.

1. **Planning:**
Water resources management specialist
2. **Construction:**
Pipeline builder, sewer builder, metalworker, electronics technician, plant mechanic
3. **Construction, operation and maintenance:**
Hydraulic engineering technician, plumber, fitter (heating, air conditioning)
4. **Operation and maintenance:**
Water resources management technician, Wastewater treatment technician, specialist for pipe, sewer and industrial services, chemistry lab assistant

It must also not be forgotten that in addition to technical professions, operators also require commercial, administrative and organizational (IT) professions.

2 Water technology – past, present and future

2.1 History

The cities of Europe grew drastically during industrialization (mid 19th century until the turn of the century). The high population density combined with poor hygienic conditions led to frequent cholera and typhoid epidemics.

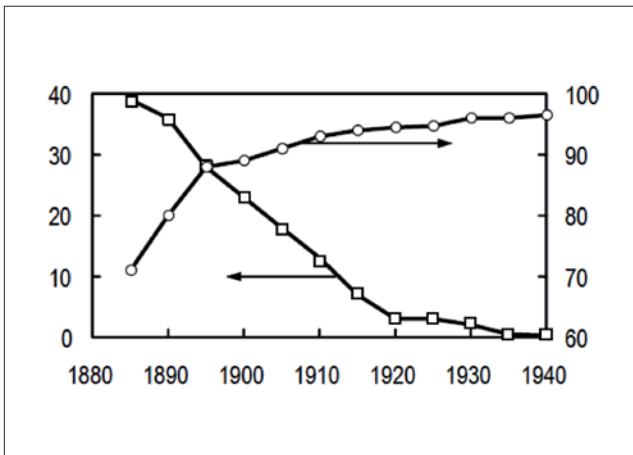


Figure 2: Influence of public water supply on cases of typhoid (Massachusetts, USA, Gujer 2007)

This resulted in the construction of a central water supply and wastewater plant after the Great Fire in Hamburg (1850). This sewage system ensured that faeces, urine and rainwater from all over the city were discharged into the River Elbe within an hour. The Hamburg type of sewage plant became the model for Danzig, Berlin, Vienna, Warsaw, Frankfurt, New York and Chicago.

As figure 3 shows, in pre-industrial times sewage – that is, liquid waste – was discharged directly into rivers.

The principle of the modern sewer was to pipe the water outside the gates of the city to raise the level of comfort within the city. This modernization of the sewage system required intercepting sewers to divert sewage outside the city (figure 4).

Blockages frequently occurred at the intersections of the intercepting sewers with the transverse sewers. The pioneering work of the Hamburg sewer system resulted in two innovations: The intersections are replaced by tangential bypasses (figure 5), allowing unhindered gravity flow of water into rivers. The water flows through hydrodynamically shaped channels (figures 6 and 7). Sedimentation tanks located upstream of the outfall allow the wastewater to ‘come to rest’ and solid matter to precipitate. At intervals, the sludge is then removed and utilized.

Another method adopted in the early days of wastewater treatment was sewage farms, the irrigation of fields outside the city with sewage. The sewers radiate from a central point (figure 8), with the sewer cross-section expanding like a telescope as the city increases in size.

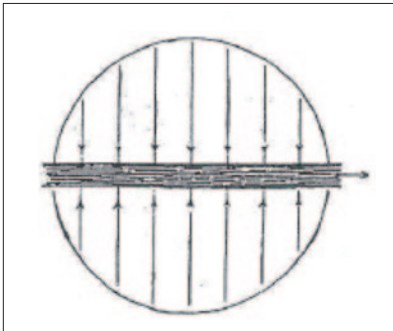


Figure 3: A sewage canal system discharging into a river (Hobrecht 1884, in Kluge 2000: p. 58)

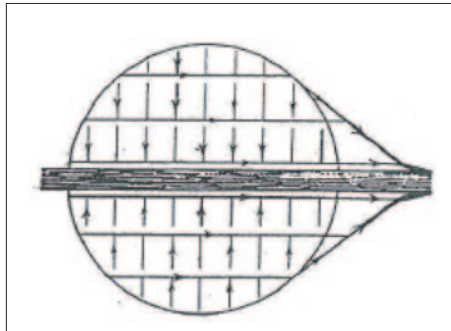


Figure 4: Sewage being piped outside the city by means of intercepting sewers (Hobrecht 1884, in Kluge 2000: p. 58)

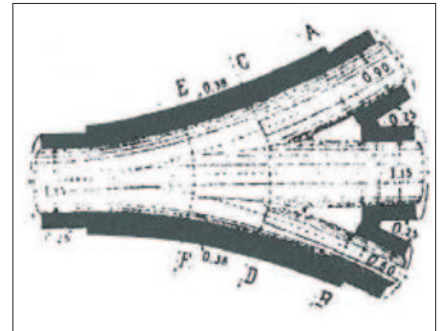


Figure 5: Sewer junctions reflecting the pattern of railroad junctions (Lindley 1886, in Kluge 2000: p. 48)



Figure 7: Egg-shaped hydrodynamic sewer cross-section (Lindley 1886, in Kluge 2000: p. 45)

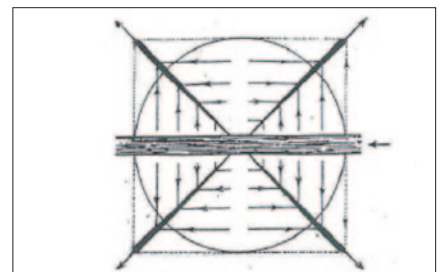


Figure 8: Intercepting sewers radiating from the center to the periphery (Lindley 1886, in Kluge 2000: p. 58)

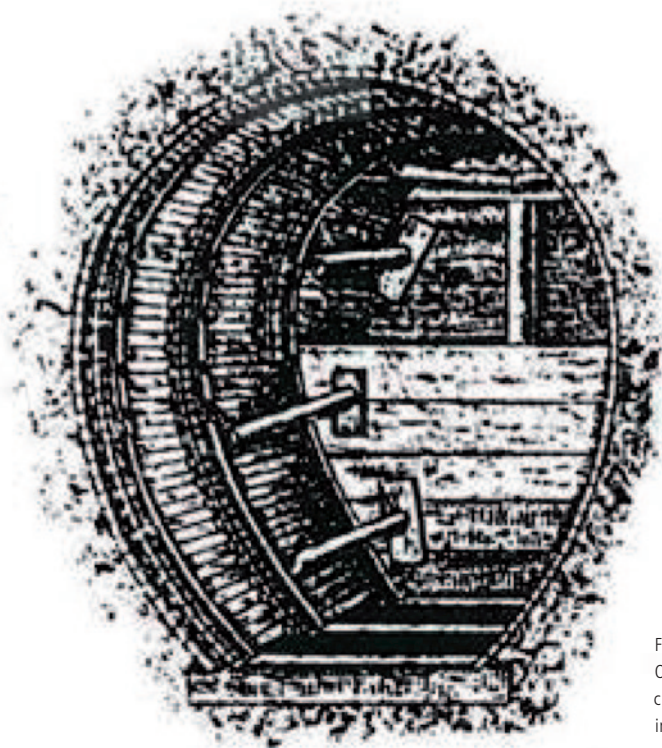


Figure 6: Oval hydrodynamic sewer cross-section (Lindley 1886, in Kluge 2000: p. 45)

Besser "archimedes screw"?

2.2 Present

The first purely biological wastewater treatment plant was commissioned in England in 1892. Today, modern sewage plants are an effective combination of mechanical, biological and chemo-physical processes.

- › The first steps in wastewater treatment in a municipal sewage plant are purely mechanical. After raising the water to the required height by means of raw water pumps, initial cleaning is done by a screening chamber and a grit chamber. Coarse and fine screens remove coarse matter of different sizes from the untreated wastewater. The grit chamber promotes the sedimentation of sand and other heavy matter by reducing the flow rate. Solid matter settles to the

bottom and can be removed. At the same time, air is injected at the bottom of the basin to transport oil and fat to the top by flotation, thus allowing separation. The flow comes to an almost complete standstill in the preliminary sedimentation tank. Suspended and floating matter has time to precipitate or rise to the top. Scrapers on the water surface and floor of the basin permit controlled removal of this matter.

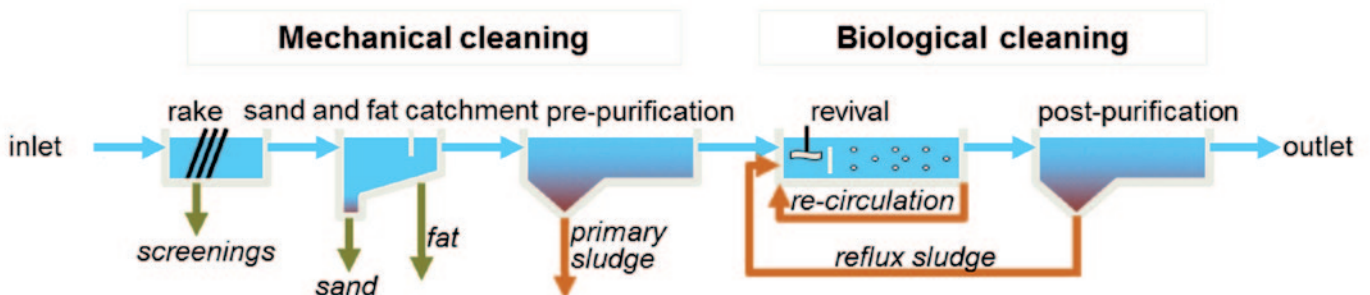


Figure 9: Modern municipal wastewater treatment plant (Technical University of Darmstadt, IWAR)

Two biological purification stages are used for the breakdown of organic matter and to prevent increased discharge of nutrients into the ecosystem of the receiving body of water (the water into which the water is pumped after treatment).

- › The first stage of biological treatment – denitrification – involves the use of heterotrophic and autotrophic bacteria that are able to break down organic substances (carbon reduction).
- › The second biological stage – nitrification – converts the ammonia dissolved in the water by means of bacterial oxidation. With the oxygen supply carefully controlled, it is first converted into nitrite and then to nitrate. The nitrate is returned to the denitrification stage as return sludge, where it is broken down. The removed sludge can be used as a source of energy, either through biogas production or incineration. Following these energy production processes, the sludge can then either be applied to agricultural land or landfilled.
- › Chemo-physical processes (tertiary purification stage, advanced wastewater treatment) treat contaminants directly, disinfecting and allowing later partial use in the household or in food (domestic use). These processes specifically target groups of contaminants.

2.3 Future: sewage as a resource

The wastewater purification processes described above require a high input of energy and chemicals. The ultimate goal is the destruction of nutrients such as nitrate and phosphate.

- › There are new semi-central wastewater treatment systems, which treat wastewater as a resource and – in addition to mechanical and biological process steps – produce energy in the form of methane gas in an anaerobic fermentation unit, processing the sewage in such a way that it can be used as irrigation water, thus recycling the dissolved nutrients such as nitrate and phosphate. The treatment of wastewater for reuse can be carried out to different quality standards for different purposes such as agricultural irrigation, artificial groundwater replenishment and water for eco-flow.
- › The recovery of finite resources – in particular phosphorus recovery – is of ecological and economic importance. Linked to the biological stage, phosphate-accumulating micro-organisms ensure the removal of phosphate. Numerous processes can be used downstream of sludge digestion to separate matter suitable for use as fertilizer from heavy metals and other substances. This purification stage is not yet a standard element of municipal systems and therefore has high market and upgrade potential.

3 Dual professional training for a high employability

If you tell visitors from other countries about the dual VET (vocational education and training) system in Germany you can expect very different emotional responses: from enthusiasm about the practical relevance of the training and the resulting employability of graduates to astonishment that young people are paid during their training and horror that the dual system systematises child labor.

But the German VET system is by no means unusual – there are similar systems in Austria and Switzerland. Dual vocational education and training has both academic and vocational elements. The former results in the attainment of the higher education entrance qualification, allowing study at universities and colleges and leading to academic degrees, such as bachelor’s and master’s.

The initial vocational training, on the other hand, results in the attainment of a medium-level qualification. The dual principle applies to the initial training in most skills. Currently, the Federal Institute for Vocational Education and Training lists 344 occupations from agent in marketing communication to wood-processing mechanic.

When people talk about the characteristics of the German vocational training system, they normally mean the dual vocational training system, which has its roots in the medieval system of handicrafts regulation and estates of the realm. “Dual” indicates both the shared responsibility of companies and the state and the combination of practical and theoretical elements that are cleverly dovetailed. This leads to some special legal stipulations:

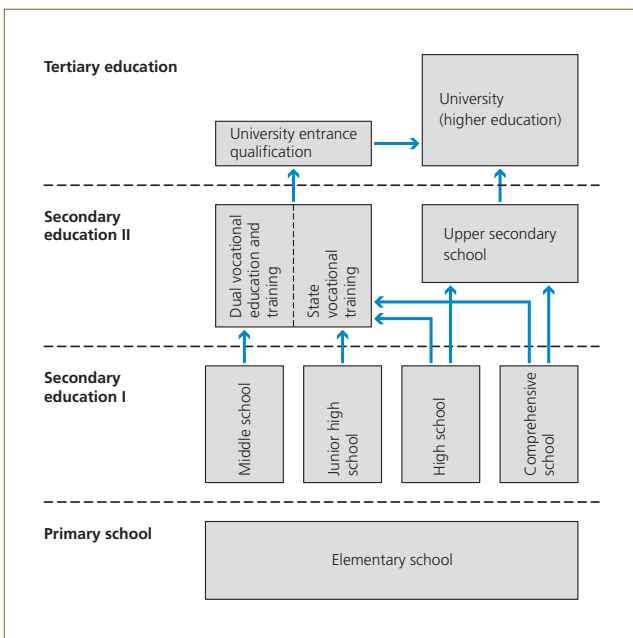


Figure 10: Structure of the German vocational education and training system (Festo Didactic)

- › Young people who want to start an apprenticeship in the dual system after secondary school apply to a company for a place in a way similar to job applicants. They don’t sign an employment contract, but a training contract.
- › Their status is not of a school or a university student, but of an apprentice. This gives them special protection as employees under German labor law.
- › During their training, they receive a monthly training allowance as determined by the two partners (union for collective agreements and employees association)
- › They have all the rights and obligations of employees, but they also have the right to receive optimal preparation for the demands of their job from the company providing the apprenticeship position.

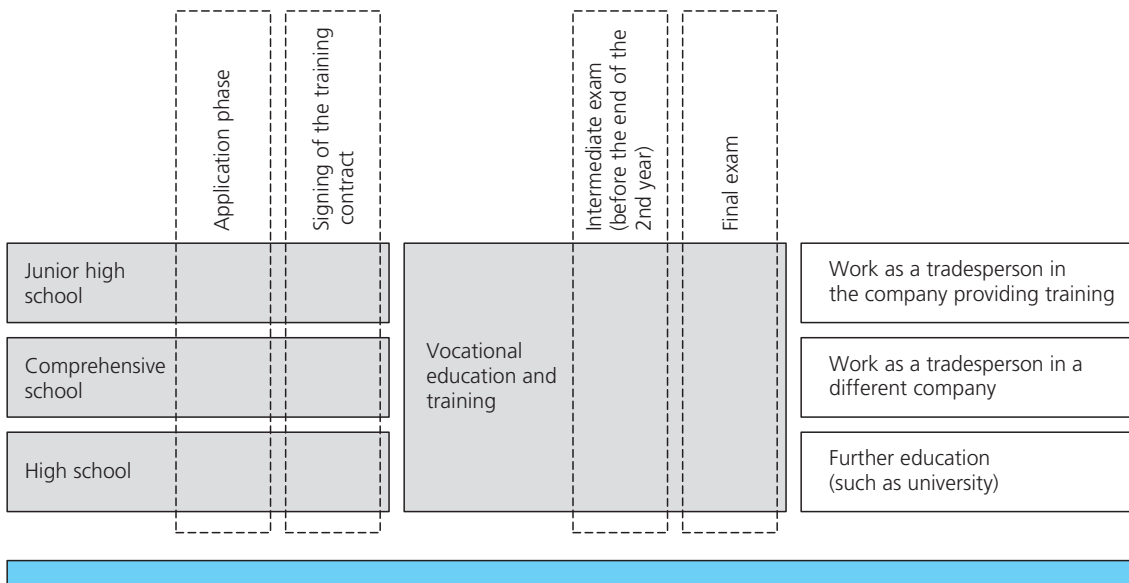


Figure 11:
The dual vocational training process (Festo Didactic)

- › Finally, at the end of their training, the company ensures that apprentices demonstrate their acquired knowledge and skills in a central examination conducted by the appropriate professional association. In a multi-part examination – a combination of theoretical exam and practical work – the apprentices demonstrate that they meet the requirements of the qualification. Then, after three years of training and the final exam, they attain level 4 in the German and European qualifications framework.

To ensure a balance between professional and enterprise-specific requirements, the dual system is based on both practical and theoretical training.

The predominantly practical skills training is the responsibility of the company providing the apprenticeship program and is conducted there. It is based on skill-specific training curricula drawn up by joint committees with equal employers' association and trade union representation. The instructors hired

by the companies design and deliver the practical vocational training based on these curricula. These establish which parts of the training take place in the training workshop and which involve practical work in the company itself. The goal of the practical training is action-oriented learning and the development of comprehensive vocational competences. From the second year of training, apprentices are introduced to their future tasks. This ensures that at the end of their apprenticeship they are able to meet the requirements of their chosen occupation.

In parallel to this, the apprentices attend a vocational school. The schools are the responsibility of the respective state as, under the German federal system, education is the responsibility of Germany's sixteen states. The states lay down the curricula for each qualification, based on which state-trained vocational school teachers teach general and skill-related knowledge. General education comprises familiar subjects such as German, English and mathematics. The skill-specific content, on the other hand, is divided into typical tasks such as "Operating pipe systems", "Mechanical treatment of



Figure 12: Dual vocational training in practice (Festo Didactic)

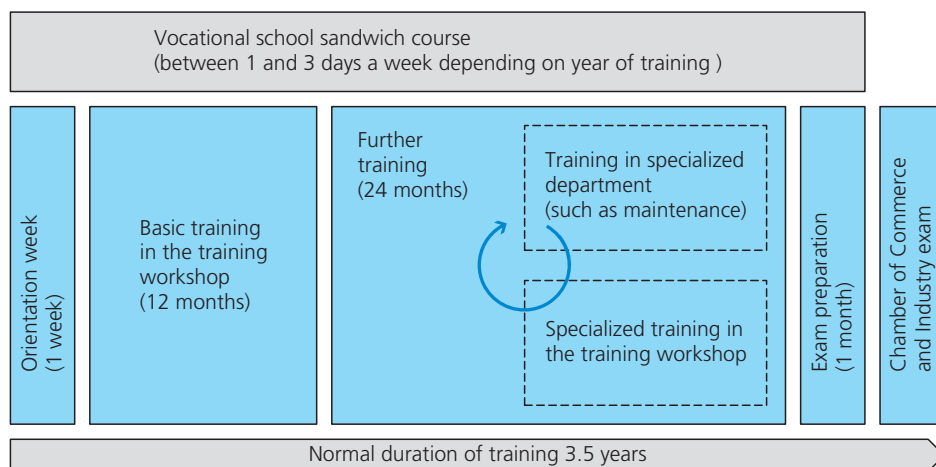


Figure 13:
Example of the structure
of vocational training
(Festo Didactic)

wastewater” and “Control and regulation of wastewater treatment plants”. In this way, conventional subject-focused education (what) is complemented by elements with an action-oriented focus (how). This combination ensures the high practical relevance of the acquired knowledge.

The vocational school classes from part of a sandwich course (between one and three days a week) or are conducted in blocks lasting four to six weeks. The timetable is developed collaboratively by the school and the company.

In addition to the high practical relevance of the dual system described above, the flexibility of the German vocational training system is regarded as a key factor contributing to the high employability of young people following their training. The “Curricular framework for theoretical vocational training” and the “Practical training curriculum framework” provide a content framework explicitly allowing companies and vocational schools to coordinate details. This results in the parties involved having a high degree of freedom of discretion, enabling them to respond rapidly to technical or organizational developments.

Let us assume, for example, that several water utilities integrate membrane filtration into their systems. The partners then ensure – in collaboration with the body that conducts the examination – that the topic of membrane filtration is added to the syllabus or that its scope is expanded. Or if analog electronic circuits lose importance in the company, the scope of analog circuit design is limited to the extent that is required for later knowledge or skill modules, perhaps in favor of digital circuit design.

This flexibility is permitted both in vocational theory and with regard to priorities for vocational practice. Indeed, legislation explicitly calls for this: “Deviation from the training curriculum framework in content or time is in particular permitted when required by industrial practice.”

The German dual vocational training system is based on centuries-long tradition, and may thus be considered to be old, but outdated it is certainly not. This is demonstrated by its capacity for constant renewal and low youth unemployment in Germany, as well as the high employability of those it trains.

4 Personnel requirements and qualifications as a function of plant technology and size

Depending on the level of qualification, the technical operating personnel of a wastewater treatment plant is made up of:

- › Unskilled and semi-skilled workers
- › Skilled workers, such as wastewater technicians, and/or other skilled workers (electricians, industrial electronics technicians or similar)
- › Engineers, such as a civil engineer specializing in hydraulic design, or an environmental engineer

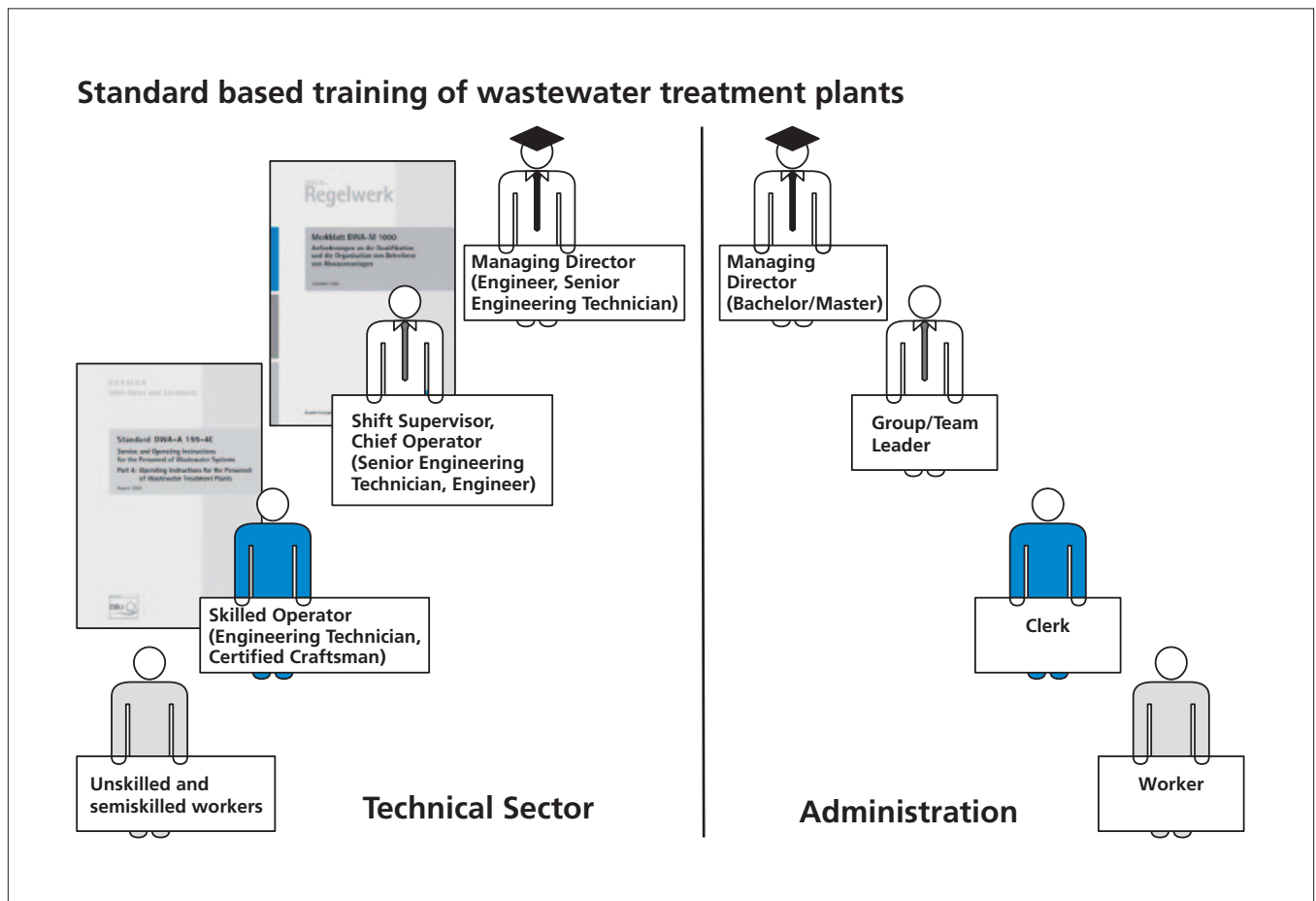


Figure 14: Standard-based operations of wastewater treatment plants (DWA)

The tasks of the technical manager, the shift supervisor and machine operator and the required qualification depend on the plant size as classified in the DWA-M 1000 regulation and defined in detail in DWA-A 199. The DWA-M 1000 regulation specifies, for example, that an engineer is not required as operations manager for a plant serving less than 100,000 PE (table 1). Of the 10,000 German wastewater treatment plants, the vast majority is of this size. Only 230 are size classification 5 (PE >100,000).

A wastewater treatment plant is expensive for the local authority, costing 2.50 euros per cubic meter of treated wastewater. The requirements for the operation of wastewater treatment plants are clear: efficiency, quality and safety – around the clock – with minimal staff. Every person counts. Under these circumstances, absolute reliability and the capacity to act independently are essential.

Plant Size Classification SC	SC 1 up to 1,000 PE	SC 2 up to 5,000 PE	SC 3 up to 10,000 PE	SC 4 up to 100,000 PE	SC 5 >100,000 PE
Operation sewer networks	A1	A2	A2/B	B/C	C
Operation WWTP	A2	A2	A2/B	B/C	C
Operation WWTP + networks	A2	A2	A2/B	B/C	C
Planning, design networks	C	C	C	C	C
Planning, design WWTP	C	C	C	C	C
Planning, design WWTP + networks	C	C	C	C	C

PE: Total number of inhabitants and population equivalents

A1: Crafts skills (metalworkers, electricians or comparable qualification with wastewater-related knowledge, such as a basic DWA course)

A2: Wastewater engineering technician; environmental engineering professions

B: Certified senior wastewater engineering technician or comparable

C: Staff with engineering degree (TC, university, UAS) or comparable

Table 1: Requirements for technical staff depending on size classification and scope of the task (DWA-M 1000)

Trainees generally work under close supervision, because they acquire most of their professional knowledge and skills in the plant. Training activities are defined in a training plan and monitored in a report book, which is checked by the vocational school. The dual system of vocational education and training (VET) has proven to be effective. In 1984, the profession of “Supply and waste disposal specialist” was created by the German Government in cooperation with water sector operators and associations. Three years of training for environmental professions have been required for metalworkers, cooks and power electronics technicians for a long time.

The job description was revised and made more specific in 2002. A single skill was no longer sufficient to meet the increased requirements. So, the Federal Institute for Vocational Education and Training (BIBB) – again in close cooperation with the water sector – decided that the field of supply and waste disposal technician with three specializations should have four environmental skills with common core competences. As a result, two thirds of the training content can be taught jointly at vocational schools for the four specializations: water supply engineering technician, sewage engineering technician, pipe layer, pipeline fitter and duct builder, and recycling and waste management engineering technician. This means that more classes can be provided at the seven training centers in Germany, where full-time block instruction is held over 13 weeks per year. Class size is important as merely 1,700 trainees in environmental technology complete their training each year. Only training in the specialization – which takes up one third of a vocational school – has to take place in smaller classes. Generally, a good 0.2 percent of school-leavers choose this occupation. The wastewater treatment plants regularly hold open days for recruitment purposes and to promote understanding of

their role. Every student should have the opportunity to visit a wastewater treatment plant while they are attending school.

Many wastewater treatment plants look back on a 100-year history. However, the service life of equipment is only 10 to 25 years. Despite good maintenance, higher cleaning requirements and increased energy efficiency due to new technology, equipment has to be replaced sooner or later because of wear. The new cogeneration plant allows thirty to forty percent of the energy required for a plant to be generated on site from digester gas, solar energy and wind turbines. Thus, local authority’s biggest user of power can even generate an energy surplus.

More extensive treatment of wastewater with ultraviolet light and activated carbon might be needed to meet local requirements for water at a bathing site. These developments imply that all staff have to continuously update their knowledge and skills – through regular training courses, the neighborhood partnerships for lifelong learning (a form of peer-to-peer learning) or continuing training for junior management staff.

At the large plants – out of a total of 10,000 sewage plants and 6,600 drinking water treatment plants – a team of engineers works hand in hand with environmental professionals. But most plants are smaller. Only in this way can a high level of connection to the central sewage network (96 percent) be achieved. The DWA-M 1000 regulation even indicates that a skilled wastewater worker with three year’s training is suitable as a technical manager for plants smaller than 10,000 PE. Small local authorities cannot afford to pay more. In the case of very small teams, the examination subject “Electrical specialist with limited duties” was also integrated into the train-

ing. This allows the specialist not only to decommission electrical systems such as pumps, but also to isolate them from the power supply and replace them without an electrician. The wastewater treatment specialist must understand science and technology of all the processes in the water treatment plant and in the sewer system so that they are able to control, maintain and repair the plant in practice. The results are to be documented in accordance with regulations and operating instructions. DWA-A 199 provides good draft examples for this (see info box, right).

The wastewater treatment manager plays a central role in the smooth organization of the process and practical management tasks. In addition, he is responsible for the monitoring of activities of third parties working on the plant. Here, for example, all tasks associated with the maintenance of equipment for gas extraction from sewage sludge and the use of gas in the cogeneration plant are awarded to contractors for safety reasons.

Given their qualifications and constantly updated expertise, the wastewater treatment manager and his staff can easily assigned to municipal and industrial sewage treatment plants of all sizes. Strong competent teams can make the impossible possible.

DWA-A 199: Service and operating instructions

Service instructions:

The service instructions cover operation with details concerning organization, remit and responsibilities of the staff. They also contain rules for behavior during operation to prevent accidents and health hazards.

Operating instructions:

The operating instructions contain guidelines for regular operation and for managing special operating conditions, in particular:

- › Description of functional processes in the overall plant and its individual parts
- › Instructions for normal operation and special modes of operation
- › Instructions for behavior in the event of operational problems, including corrective measures
- › Requirements for waste disposal
- › Scope of monitoring with the necessary checks, sampling and measurements
- › Organization of maintenance and materials management
- › Operations management and regulations on scope and maintenance of regulatory and compliance documentation

(DWA-A 199-1)

DWA-M 1000

DWA-M 1000: Regulations regarding the qualification and organization of wastewater treatment plant operators

The key conditions for compliance with legal and technical requirements and for meeting the customer's quality requirements for wastewater disposal are:

- › Appropriately dimensioned facilities and sewage systems
- › Socially competent and far-sighted leadership
- › Professional and compliant operation
- › Properly qualified personnel
- › Effective quality assurance measures
- › Economic action
- › Continuous further development

This advisory guideline contains requirements for the qualification and the organization of wastewater treatment plant operators. It aims to provide a basis for safe, reliable, environmentally friendly and economical wastewater disposal in compliance with legal and technical regulations.

Guidelines are available for the implementation of requirements as part of technical safety management. (online at: www.dwa.de/Technisches_Sicherheitsmanagement.html)

Advisory Guideline DWA-M 1000: August 2012

ATV-M 271

ATV-M 271: Personnel requirements for the operation of municipal sewage treatment plants

The purification capacity of a sewage treatment plant is significantly affected by the work of the sewage treatment plant staff. The areas of responsibility of the wastewater treatment plant staff range from process control and the inspection and maintenance of operational facilities to repair work. Cleanliness is essential at a sewage treatment plant to ensure work hygiene and maintain outward appearance. At the same time, it enhances staff efficiency, motivation and commitment. For this reason, sufficient time must be available for maintaining outward appearance.

ATV-M 271 determines the time requirements for the operation of sewage treatment plants to provide planners and operators with an indication of what level of staffing is required for existing, expanded or newly built municipal sewage treatment plants. The results of an extensive questionnaire with targeted follow-up questions established the time required for the operation of various components of a wastewater treatment plant depending on plant size are presented in chart form. Using these dimensioning guidelines, the appropriate time required for each operating unit was determined dependent on the number of system components and the level of equipment of a wastewater treatment plant and converted into personnel requirements.

Advisory Guideline ATV-M 271, September 1998

DWA-A 199

Worksheet DWA-A 199: Service and operating instructions for the personnel of wastewater systems

To ensure the proper functioning and smooth operation of wastewater treatment facilities, personnel must undergo initial and advanced training to acquire detailed knowledge of the plant and the technical processes and allowing them to undertake their duties in a competent way. Economical and safe operation also requires a precise delimitation of tasks and responsibilities of the staff.

This worksheet provides wastewater treatment system operators with a model and guide to preparing their own service instructions for staff. A sample text is attached in the appendix for reference.

- › Part 1: Service instructions for the personnel of wastewater systems
- › Part 2: Operating instructions for the personnel of sewerage systems and stormwater treatment systems
- › Part 3: Operating instructions for the personnel of wastewater pumping stations
- › Part 4: Operating instructions for the personnel of wastewater treatment plants

The introduction of service instructions, combined with a clear regulation of responsibilities and the organization of the operator, results in streamlined work processes, reduced internal interface problems and the avoidance of additional costs. Transparent organization improves customer focus. If there is a technical safety management system or a quality and environmental management system, these service instructions form an integral part of that system.



5 Efficient skill development for high productivity

How does the manager of a water utility cope with the rapid changes in his sector, the accelerated development of technologies, the release of new regulations, and the changing environment regarding the quality of wastewater to be treated? Even though he and his staff members have a sound vocational qualification, they constantly need to update and renew their knowledge and skills in a process of lifelong learning to guarantee the productivity of their plant.

Many countries worldwide do not have job profiles and vocational qualifications for the water and sanitation sector. In countries where there is no specialized training for professionals in the water industry, skilled or semi-skilled people from related fields, such as plumbers and electricians, are often trained and upskilled for employment in the water industry.

In order to create efficient training schemes, the Vocational Training Working Group of GWP, as part of the GWP Capacity Development Task Force, has worked on the definition of fundamental job profiles for the Water and Sanitation Sector (WASS). As a first step, around thirty occupations were identified that are necessary to cover all technical functions of the industrial water cycle.

They were grouped into the following core processes:

- › Water collection and purification
- › Water supply
- › Wastewater transport
- › Wastewater treatment
- › Cross-functional process quality assurance

The job profile “Leak detection”, for example, belongs to the core process “water supply”, as do the following job profiles:

- › Operation & maintenance (O&M) of pump systems
- › O&M of water storage tanks/reservoirs
- › O&M of water distribution systems
- › Service connection management
- › Water meter management
- › Mobile water distribution

As explained in the former chapter, depending on the size of the utility and the population served, a job is carried out by one or more employees. In a smaller utility, one staff member may be responsible for various jobs combined into one. In a larger utility each job might be executed by one or more specialists.

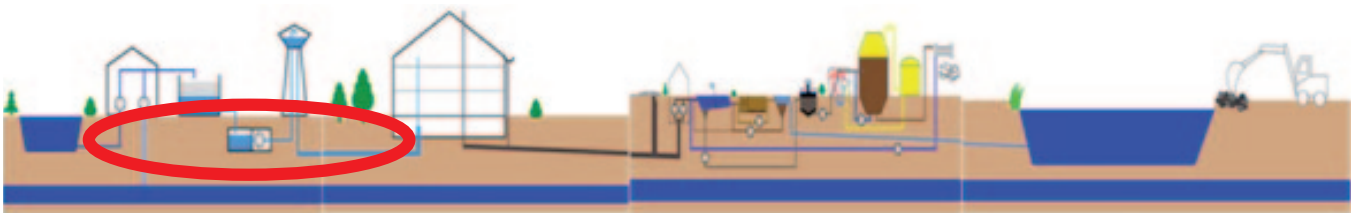


Figure 15: The industrial water cycle – the red oval in the graphic indicates the job profile leak detection as belonging to the core process “water supply” (DWA)

5.1 Targeting professional competence

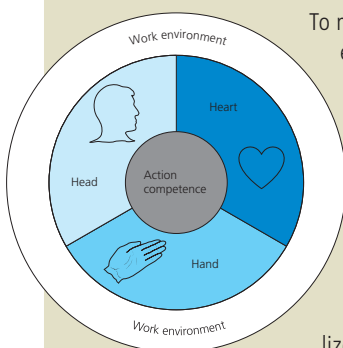
Intensive learning is needed in the WASS to guarantee safe water supply and the proper discharge and treatment of wastewater. To synchronize the learning content and skills relevant for the workplace, the “Vocational Training Working Group of GWP Capacity Development” has adopted a competence-based training approach. This ensures that training is pertinent and focuses on concrete activities. This sets it apart from assessment for the relevant qualification. Assessment takes place in standardized testing situations away from the workplace, and is not evaluated in the context of self-managed activity.

Here is an example to illustrate: during a training course, sewage system inspectors learn new regulations and visual inspection methods. The knowledge acquired by them is assessed in an examination and certified by the appropriate qualification. However, the qualification says nothing about whether they will use the new knowledge and skills in every-

day work and whether they can improve the procedures for sewage system inspection and increase their efficiency.

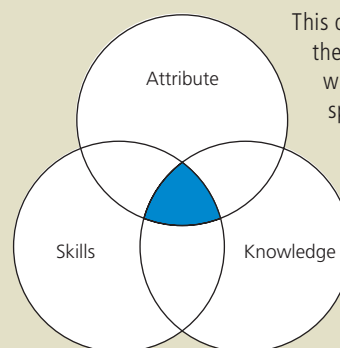
Only in a specific work process will it become clear whether the acquired knowledge and skills are applied, and whether it is a static qualification or results in professional competence. So in other words, qualifications describe the knowledge and skills that a person has. Whether these can be used in a result-oriented and productive way only becomes clear “in action”. Professional competence is therefore defined as the ability of people to work in a self-managed manner in open, complex and dynamic situations (Erpenbeck/Rosenstiel 2004). Or according to the definition by Cinterfor, the Inter-American Center for Knowledge Development in Vocational Training, an institution of the ILO (International Labour Organization), it is the proven ability to successfully complete a task in the sense of a complete activity.

Working with head, heart and hand



To master a job, staff not only need expertise, but also the willingness to act (attitude, motivation) and the capacity (knowledge and skills). It can also be said that being professionally competent requires head, heart and hand. Here, the head stands for the knowledge, the heart symbolizes desire, commitment and motivation, while the hand symbolizes dexterity and manual skills.

Figure 16: Professional competence (Festo Didactic)



This definition corresponds to the Anglo-Saxon approach which, in the same context, speaks of professional competence comprising the elements attitude (and behavior), skills (and abilities), and knowledge. The acronym ASK is a good way to remember this approach.

Figure 17: Professional competence (Festo Didactic)

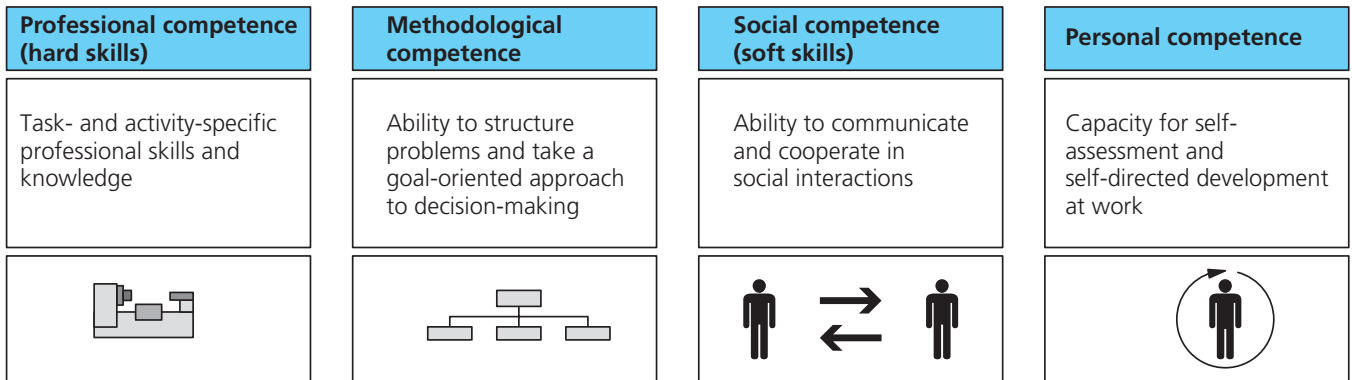


Figure 18: Competence types (Festo Didactic)

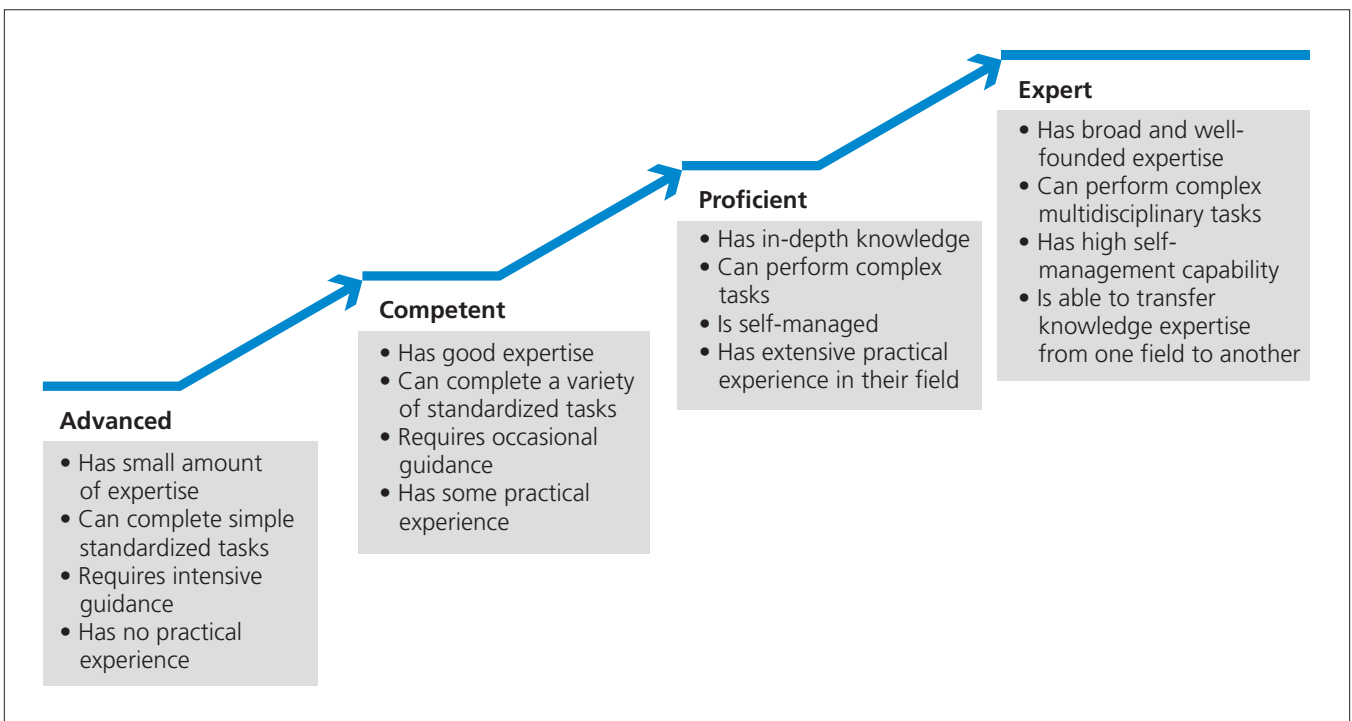


Figure 19: Example of a four-level model: advanced, competent, proficient and expert (Festo Didactic)

5.2 Defining competence profiles

Based on the description of job duties as shown in the examples of the job profiles “Leak detection” and “Process control” in the following chapter, competences are deduced that are needed to execute these duties and to fulfil the requirements of the job. The different competences are structured and differentiated by competence types. The categories as shown in figure 18 are commonly used.

Based on these individual competences, a competence profile can now be created depending on the tasks and the resulting requirements. This involves the need to assess different levels of competence, such as novice or expert, as different activities do not require the same level of mastery.

The best-known competence scale in German-speaking countries is the three-tier scale established by North/Reinhardt (2005): “Advanced, Professional, and Expert”. It can be expanded to four, five or more levels. For competence profiles in the water industry, a four-tier scale was chosen, which consists of the levels Advanced, Competent, Proficient and Expert (figure 19).

A crucial challenge in the formulation of levels for the individual competences is a clear delineation of the different levels and requirements. The definition and scaling of the methodological competence “self-management” is shown as an example in table 2:

Self-management		
... means planning and arranging schedules and work processes in such a way as to make efficient and effective use of one’s equipment. This requires a careful, systematic and goal-oriented approach and the execution of tasks by setting priorities and, where appropriate, the use of available tools (such as to-do lists, electronic calendar, etc.).		
The employee ...	Level name	Scale
... plans and arranges their capacity based on instructions ... requires regular support and guidance	Advanced	1
... plans and arranges their capacity independently in a goal-oriented way ... separates significant from insignificant and sets priorities	Competent	2
... plans and arranges even complex activities for their own work area independently in a goal-oriented way ... applies available methods for control, evaluation and measurement of success	Proficient	3
... plans and arranges complex activities even across work areas and sets priorities even if there are conflicting demands ... optimizes their personal work style and proactively eliminates timewasters ... can adapt their work organization to unforeseen requirements	Expert	4

Table 2: Scale of methodological competence “self-management” (Festo Didactic)

5.3 Assessing competences and training for them

If we want to develop trainings for the personnel working at a utility or to determine what competence is required of recruits, they have to be evaluated. The aim is to know their level of competence, their strengths and weaknesses, and their development potential.

As we have mentioned before, competences cannot be tested in the conventional way, but they can be assessed. Competence assessment is based on performance and executed by observing tasks that require a wide range of activities and which therefore have a relatively open and complex structure. Such tasks take, for example, the form of problem-solving, troubleshooting, and improvement of processes or similar complex situations and allow evaluation according to the following criteria: how do the employees approach the task? What hypotheses do they develop and what plans do they derive from these? How do they communicate with others? How persistently do they apply themselves to the task? How do the employees behave in the event of failure?

Competence assessment can be carried out by self-assessment and/or third-party assessment, 360-degree feedback or standardized knowledge tests in combination with practical tests. How to run an examination is described in detail in chapter 7.

Knowing the gap between the requirements of the competence profile and the existing competences of the target group allows the design of tailor-made trainings, addressing exactly the knowledge and skills needed for the job profile. Thus, waste of work time and other resources are avoided, and the motivation of learners is increased because they learn precisely what they need for their job.

The use of standardized job and competence profiles makes it easy to establish the staffing requirements for a municipal utility or sewage treatment plant or to quickly and effectively identify and plan the necessary trainings.

The around thirty job and competence profiles developed by the Vocational Training Working Group of GWP deliver a blueprint that can be easily adapted to local conditions and requirements.

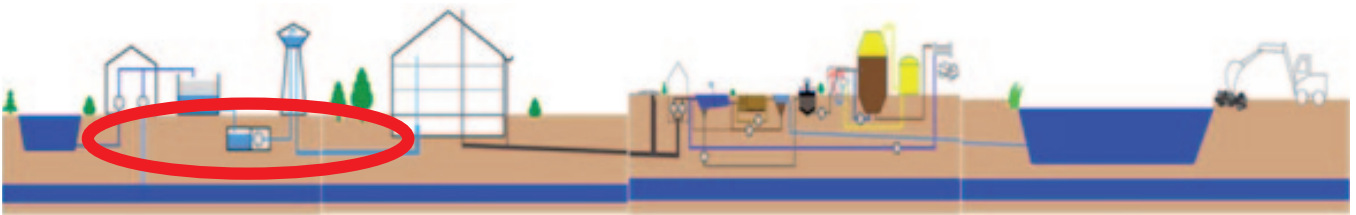


Figure 20: Water leak detection (Hermann Sewerin GmbH)

6 Example job profiles

6.1 Leak detection

Core process: water supply



Job duties

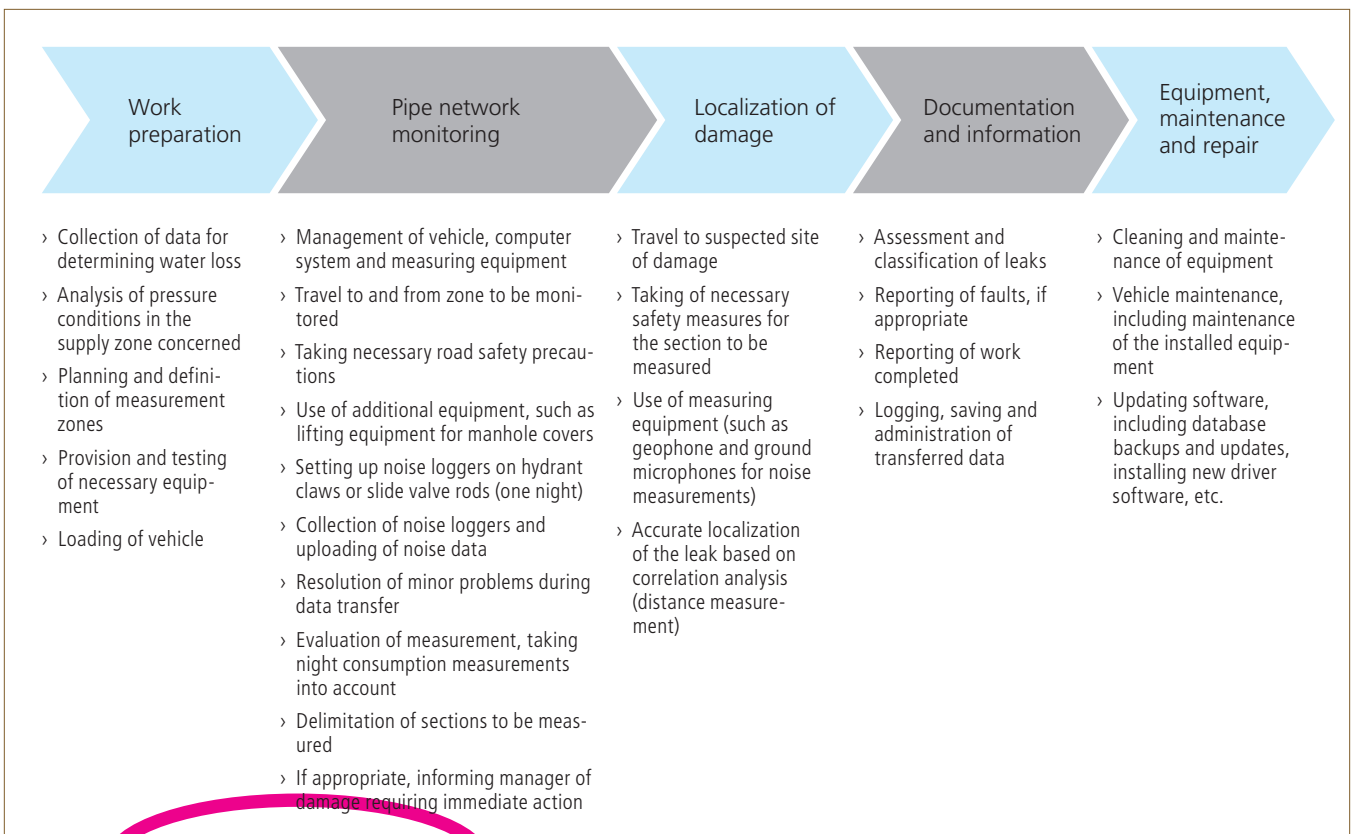


Figure 21: Job duties – Quellenangabe fehlt

Requirements profile (the right person for the job)

Enjoys troubleshooting, likes technology, steadfast, weatherproof

Competence profile	A Advanced	B Competent	C Proficient	D Expert
Occupational health and safety	X			
GIS data		X		
Water supply and network technology		X		
Legal action	X			
IT applications		X		
Standards and regulations		X		
Measuring technology		X		
Work organization		X		
Problem-solving	X			
Systematic approach		X		
Communication	X			
Capacity for teamwork	X			Grading: B
Customer orientation	X			EQF: 2-3

Table 3: Competence profile: Leak detection – Quellenangabe fehlt

Sample exam questions:

What procedure can be used to localize a leak within a certain zone of a supply network?

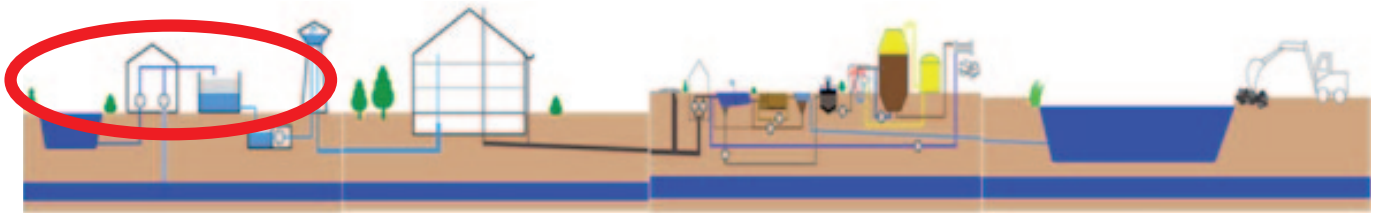
» Zero consumption measurement

At what time of day are they usually carried out?

» At night, between 2:00 am and 4:00 am

6.2 Process control (control room)

Core process: water supply



Job duties

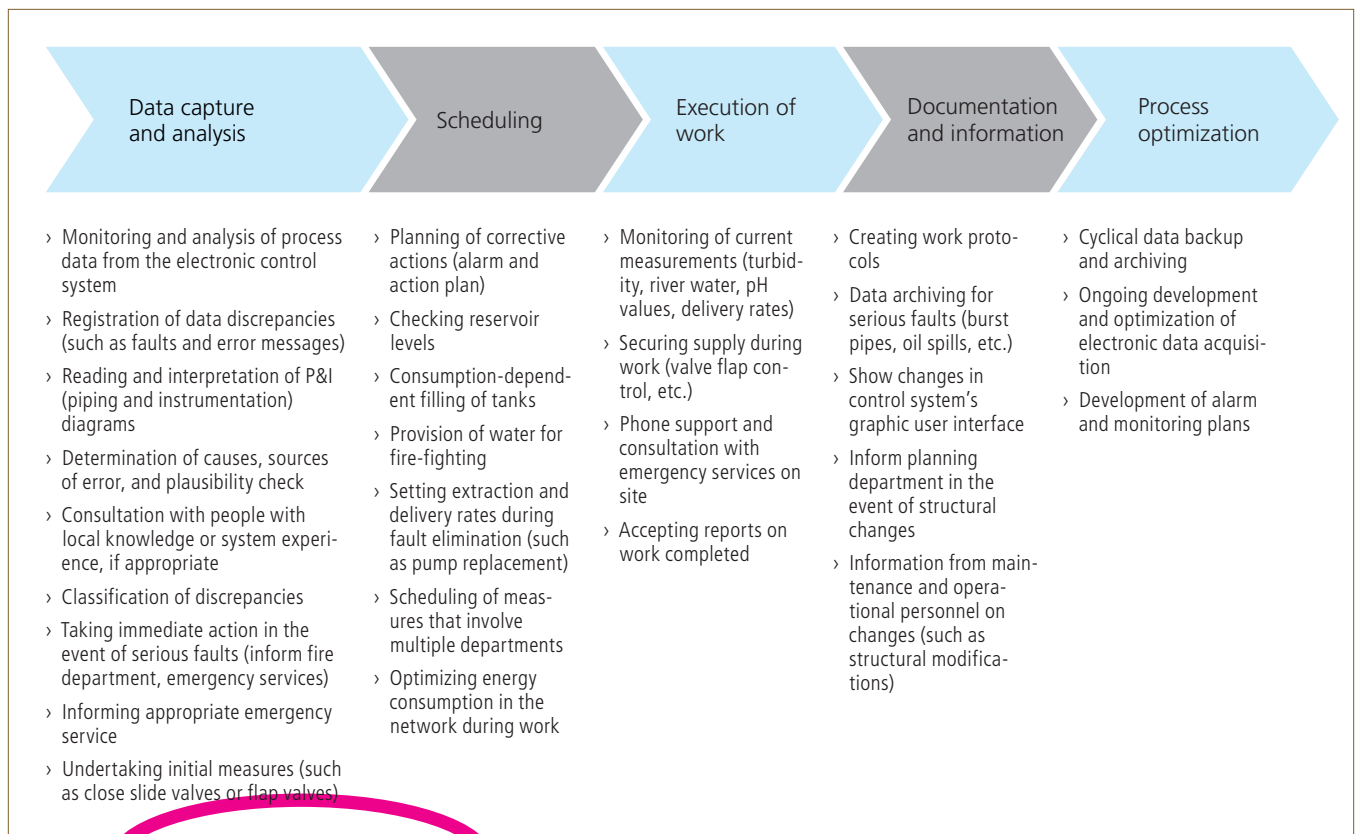


Figure 22: Job duties – Quellenangabe fehlt

Requirements profile (the right person for the job)

Capacity for fast and correct interpretation of data, technical mind, ability to concentrate

Competence profile	A Advanced	B Competent	C Proficient	D Expert
GIS data		X		
Legal action				X
Standards and regulations			X	
IT applications			X	
Water supply engineering		X		
Pipeline technology			X	
Measuring and control technology				X
Systematic approach			X	
Analytical skills			X	
Communication			X	
Capacity for teamwork			X	Level: C
Ability to cope with pressure			X	EQF: 4

Table 4: Competence profile: process control – *Quellenangabe fehlt*

Sample exam questions:

Name four types of faults that could occur in a water supply system.

- » Pump failure
- » Low water level in elevated tank
- » External influence (such as theft, fire)
- » Pressure drop in line system



Figure 23: Water leak in Lima (Hermann Sewerin GmbH)



Figure 24: A water utility control room (Festo Didactic)

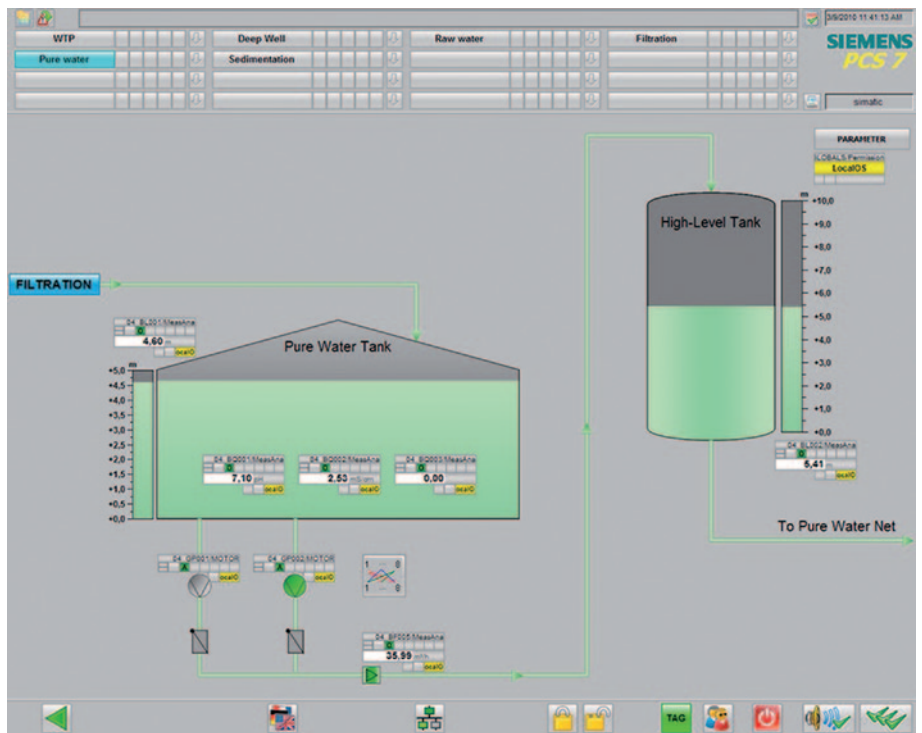


Figure 25: Pure Water Tank (Siemens AG Industry Sector)

7 How to run an examination

An examination is a procedure in which knowledge or performance is evaluated through oral, written or practical tasks.

Examinations are contrived situations in which specific performance is required of the examinees to determine by measurement – or where this is not possible, to assess as objectively as possible – the underlying skills, knowledge, and aptitudes and to recognize these with certification.

The problem with examinations is the predictive value of a performance that has been achieved at a given moment and is subject to standardized evaluation by more or less subjective assessment. The stress occurring under exam conditions also has to be taken into account. This applies particularly to the determination of athletic performance in competitions. Otherwise, sports betting would be not so interesting. To increase the predictive value of exams, entry requirements often have to be met.

7.1 Exams in the field of education

Exams are frequently used in the field of education. These include entrance, intermediate, final or masters exams. Here, too, the question of the validity of the exam comes up and their predictive value arises. Examinations for determining knowledge, performance, and skills are generally governed by examination regulations to ensure comparability between examinees. For this reason, examinations are centrally organized and conducted by independent state authorities.

There are three types of examination in the education sector:

- › Written exams
- › Oral exams
- › Practical exams

These test methods are used to receive an assessment of the current competences of the examinee based on a contrived situation. This method is also known as diagnostic examination. Selective examinations are relatively rare and usually only used for candidate selection.

In practice it is usually a written and oral examination to test for a specific level of knowledge. In the case of university exams, the written exams normally comprise subject-related proctored exams and a dissertation or thesis (such as diploma thesis, master's or bachelor's dissertation). Written dissertations and theses for regular courses of study are routinely assigned, supervised and assessed by a university lecturer.

Examinations in vocational training

In the area of vocational education and training, examinations can be found in initial vocational training (such as intermediate and final exams) and in advanced training (such as master craftsman's examinations) as well as in continuing training. The examinations conducted by the German vocational training system enjoy a high degree of recognition worldwide and the associated certificates are recognized by employers and institutions of secondary education in many non-European countries as proof of qualification.

The examinations in initial vocational training and advanced training certify the achievement of a certain level in the German and European qualifications framework. The final examination in a three-year apprenticeship certifies a level 4 of the European Qualifications Framework (EQF) and the advanced training examination for master craftsman certifies EQF level 6, which is equivalent to a bachelor's degree at university. These exams are conducted centrally by an independent body.

The degree of responsibility and the scope for discretion for vocational schools has become ever greater. Increasingly, training centers have developed their own profiles and priorities, which nevertheless comply with the legal requirements. This makes it all the more important to provide the same requirements for graduation and certification. For this reason, examination tasks are set centrally.

Central examinations ensure the comparability of requirements, thus also ensuring the comparability of results. They establish the performance that is actually achieved and compliance with prescribed standards. Central exams also result in greater transparency and ensure greater fairness. They

offer partners in the dual system of VET the opportunity to evaluate the quality of training and to formulate approaches to improvement. By evaluating exam results, the examining body can establish the efficacy of the system, as well as its strengths and weaknesses. In other words: passing a final examination or master craftsman's examination certifies the achievement of a uniform standard.

Two different approaches are used for assessing the quality of exams (see Reetz/Hewlett 2008: pp. 43). Objectivity, reliability and validity are regarded as diagnostic criteria. Economy, justiciability and equal opportunity are additional quality criteria.

The following conceptual quality criteria are differentiated from the above:

- › Action orientation and practical relevance
- › Process orientation
- › Individualization (recording individual competences and experiences)
- › Authenticity

There is no such thing as an ideal examination that meets all quality criteria. A trade-off between the quality criteria is always required. Internationally, conceptual quality criteria are often subordinated to diagnostic quality criteria. In particular, this impairs the predictive value with regard to the examinees' readiness to the professional practice. Often, examinations fail to accurately reflect the job and requirement profile.

The goal with the entire examination process, however, is to accurately determine the examinees' professional capacity.

7.2 Evaluation of existing competences through testing in the water sector

As already described in chapters 5 and 6, the Vocational Training Working Group of GWP, has worked on the definition of fundamental job profiles for the water and sanitation sector. One can fall back on these job profiles and thereby test the required competences. This is possible not only in initial vocational training and advanced training, but also for individual modules in continuing training. The examination covers the activities undertaken during the operation of a water supply or wastewater disposal utility and the associ-

ated competences insofar as these are essential for performing the activities. This content, which is tightly regulated, corresponds to the minimum level in compliance with German quality standards.

This requires examinations that make use of all three test methods, as not all areas of competence can be equally well examined with each method. For this reason, the examinations are quite different to those in universities.

Written exams and oral exams

These are practical tasks related to the work organization with technological, mathematical and scientific content in accordance with the technical regulations and the statutory sources. Occupational health and safety measures as well as quality assurance measures should also be involved.

Example: Which of the following conditions in the activated sludge tank damages the nitrification process?

- (a) O₂ content = 1.5 mg/l
- (b) O₂ content = 5.0 mg/l
- (c) No O₂ injection
- (d) High turbulence
- (e) Return sludge flow RSF = 1.2

Practical exams

Practical exams are ideally executed using a real system. Where this is not possible, subsystems, equipment or components used in real systems should be used in the examination to establish professional capacity.

Example: Modifying a compressed air installation

Due to a warranty claim, a recently installed new gate valve with electropneumatic control is to be removed and the old hand-operated valve reinstalled. The original compressed air line and the corresponding components are shown in the attached drawing.



Figure 26: Practical exam in a World Skills competition (Festo Didactic)

8 About the authors



Janosch Birkert (born 1986) specializes in environmental engineering, water and soil protection and is currently completing his master studies at the Technical University of Darmstadt. He is working at the ISOE – Institute for Social-Ecological Research as a graduate assistant in the research unit Water Resources and Land Use.



Rüdiger Heidebrecht (born 1956) studied civil engineering, specializing in water resources management and tropical technology. Following professional positions in water resources management and the German Development Service (DED), since 1992 he has worked on national and European standardization for the German Association for Water, Wastewater and Waste (DWA). Since 1997, he has headed up the Education and International Cooperation Department and has developed national and international education offerings. He is federal government expert at the BIBB (Federal Institute for Vocational Education and Training) for the environmental technology professions and has been active as a short-term expert for international water projects in various countries since 1994.



Dr. Thomas Kluge (born 1948) is a co-founder of ISOE – Institute for Social-Ecological Research. Until April 1, 2014 he was a member of the Executive Board. He is senior scientist in the Water Resources and Land Use research unit. Thomas Kluge studied Law (second state examination in law) and Sociology at the Goethe University Frankfurt and received his doctorate there in 1984 for his

thesis on “Society, Technology, Nature – A Life-Philosophical Critique of Technology and Society”. Following post-doctoral work, in 1999 he was appointed “Privatdozent” (private lecturer) from the University of Kassel, with a thesis on “Water and Society – From Hydraulic Machinery to Sustainable Development”. Since his post-doctoral qualification he has been teaching at the University of Kassel.



Dipl.-Ing. Peter Köstner (born 1958) is an expert in the field of hydraulic engineering, wastewater management, hydro-technical constructions and EU-environmental Management. Currently he is head of the department “International Co-operation and Know-How-Transfer” of Munich Municipal Wastewater Treatment. Mr. Köstner is also leader of the German Water Association-Working Group for South-East Europe (Romania and Bulgaria) and head of German Water Partnership-Countries Forum Romania. He is also the German Board member of the German-Romanien Environmental-Foundation “Aquademica”.



Roland Knitschky (born 1964) studied geology, specializing in hydrogeology, and completed advanced training in human resources and organizational development. Following professional positions in state authorities, engineering firms and the German Development Service (DED), since 2003 he has worked for the German Association for Water, Wastewater and Waste (DWA). As a consultant, he is responsible for international cooperation activities and the transfer of German water resources sector concepts to the area of development cooperation, particularly as part of DWA cooperation with the German Society for Interna-

tional Cooperation (GIZ). Today he supports international water projects in the fields of vocational training, standardization and certification in water resources management as well as cooperation with associations as a short-term expert.



Dr. Andreas Lenz (born 1963)

After studying chemistry in Munich he specialized in analytical and environmental chemistry. He was working in different professional positions at the university and in private companies out of the environmental sector. He is member of several committees of experts in the field of technical and vocational education and training predominantly in the water sector.

He has been active as a short term expert for national and international environment, water, and capacity development projects. Today he is head of the Department Environment and Technology at BVS, an authority in Bavaria. He is responsible for vocational education and training in the environmental technology professions.



Holger Regber (born 1961)

Following completion of his initial vocational training as an electrical fitter, Holger Regber studied vocational education, electrical engineering/electronics and business management. Since 1990 he has been a trainer, consultant and project leader at Festo Didactic GmbH & Co. KG in Denkendorf, Germany, focusing on production and production-related processes.

He supports companies with the implementation of lean and efficient value-added systems. The key issue for him is the promotion and development of the company's employees to active designers of their own value-added process.



Gunda Röstel (born 1962)

After studying special needs education in Rostock, she was a school teacher and principal in Flöha from 1990 to 1996. Her political engagement began in 1990 with Bündnis 90/Die Grünen, and she was elected Federal Chairperson in 1996 and

1998. Today she is commercial manager of Stadtentwässerung Dresden GmbH (municipal sewerage) and authorized signatory of Gelsenwasser AG. Her other duties include Deputy Chair of German Water Partnership, Chair of the Economic Committee and the Extended Water and Wastewater Management Board at BDEW, Chair of the Board of Trustees of Dresden Technical University, and member of the Supervisory Board of EnBW, Burg Municipal Utilities and the Dresden University Clinic.



Yvonne Salazar (born 1950)

holds master degrees in Latin American studies and adult education. During her career, she has concentrated on improving learning efficiency and learning transfer. During international projects she has worked on the development of job profiles, as well as on the design of practical learning in the water sector.

Key milestones in her career were advising the Argentinean government on the implementation of a vocational training reform, the management of continuing education and training at the Berlin City Cleaning Service, as well as the management of an education and consulting company. Today she works as a project manager in the Global Training Business Development department at Festo Didactic GmbH & Co. KG, where she is responsible for international qualification and certification programs.

Abbreviations

ASK	Attitude Skills Knowledge
ATV	Abwassertechnische Vereinigung e. V. (Association for Wastewater Technology)
BDEW	Bundesverband der Energie- und Wasserwirtschaft e. V. (German Association of Energy and Water Industries)
BIBB	Bundesinstitut für Berufsbildung (Federal Institute for Vocational Education and Training)
BVS	Bayerische Verwaltungsschule (Management School of Bavaria)
DED	Deutscher Entwicklungsdienst (German Development Service)
DVGW	Deutscher Verein des Gas- und Wasserfaches e. V. (German Technical and Scientific Association for Gas and Water)
DWA	Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V. (German Association for Water, Wastewater and Waste)
EnBW	Energie Baden-Württemberg AG (Utility Company Baden-Württemberg)
EQF	European Qualification Framework
ET	Environmental Technologies
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (German Society for International Cooperation)
ILO	International Labour Organization
ISOE	Institut für sozial-ökologische Forschung gGmbH (Institute for Social-Ecological Research)
IT	Information Technology
IWAR	Institute for Water, Wastewater and Recycling at the Technical University of Darmstadt
O&M	Operation & Maintenance
PE	Population Equivalent
SC	Size Classification
SWE	Stadtwerke Esslingen (Municipal Utilities Esslingen)
TC	Training Center
UAS	University of Applied Sciences
VET	Vocational Education and Training
WASS	Water and Sanitation Sector
WWTP	Wastewater Treatment Plant

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