# UV-Disinfection of Drinking Water – the new DVGW Work Sheet 94 Parts 1–3

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## ABSTRACT

The new DVGW work sheet (DVGW 2006), which is a well known German standard for the operation of UV systems for drinking water, was published (in German) last year after a long-term review process. This updates the first DVGW UV Regulations published in 1997 (DVGW 1997). The structure and content of the work sheet has changed quite substantially from the 1997 version. The following review summarizes these changes and explains how to use the revised version with a focus on operators and engineering consulting companies as an effective working tool.

## BACKGROUND

Ultraviolet (UV) Systems for the disinfection of drinking water have gained increasing popularity as an alternative to chemical disinfectants on a worldwide basis. Following recent market data the annual growth rate of the technology is more than 10% per year and thus the use of UV is one of the fastest growing water treatment technologies.

In the 1990's, the process still had the image of being an option for small and medium sized water supplies, but projects in Canada and the United States have shown that UV can be the technology of choice for water supplies with flow rates more than 10,000 m3/h (240 ML per day or 63 MGD). One of the main drivers for UV, besides its environmental friendliness and economic application, is the large amount of available operational and research data, which makes UV disinfection one of the best documented of any disinfection process.

However, in the phase of early applications of UV at beginning of the 20th century, UV seemed not to be a success story. After the first technical use of UV for water disinfection in France, the technology was forgotten for the next 60 years. But then it was 'reinvented' in the early 1980's, when research looked for alternatives to chemical disinfectants, which had been shown to form carcinogenic byproducts, which are known to affect human health. Being an alternative at that stage, it became quite clear that the technical UV process had to be improved in terms of its robustness and cost. Standards were missing at that time and the transparency of the process made it difficult to find some early adapters using the technology.

## DEVELOPMENT OF THE DVGW WORK SHEET

The potential of UV for the disinfection of drinking water was clearly identified in Europe in the middle 1980's, when a group of researchers and companies from Germany, Austria and The Netherlands collected data to establish a standard for a secured operation of UV systems in drinking water. This work was first published by the German Gas and Water Association in 1994 (DVGW 1994) as work sheet W 293. The content mainly focused on very substantial requirements for UV systems and its applications, and this first set of regulations are still valid in this form today.

Three years later, the DVGW published the first W 294 version (DVGW 1997) with more detailed descriptions of the main technology requirements and even more important the first standardized concept for a full size equipment performance test for UV systems based on a bioassay standard using Bacillus subtilis spores. The main hurdle for a UV system was and still is the requirement to deliver a bioassay proven UV fluence of 400 J/m$^2$ (40 mJ/cm$^2$) continuously as a minimum over time and under all circumstances, such as transmittance changes or variances of flow. Parallel to the DVGW work sheet, a similar standard was established in Austria (ÖNorm 2001), which was subsequently expanded to cover medium pressure UV systems (ÖNorm 2003).

For the first time it was now possible for engineers, operators and authorities to compare different UV systems from different vendors on a neutral and transparent base.

Now ten years after the first publication, it was considered necessary to revise the work sheet on the basis of new experience which has been gathered.

## INTERNATIONAL RELEVANCE OF THE WORK SHEET

Both the German and the Austrian standards were rapidly recognized and adapted on a worldwide basis. Meanwhile many countries accept UV systems compliant to one of the standards (e.g., Switzerland, Norway and Sweden). Other countries (e.g., The Netherlands, Australia, New Zealand and the USA) have created their own standards, which grandfather the German and Austrian requirements. Especially in the US, it is interesting to see how fast the largest drinking water market for UV systems has developed with the background of new regulations for chemical disinfectant by-product and *Cryptosporidium* control requirements. The US Environmental Protection agency (USEPA) has reacted to the explosive need for UV systems with a new and recently published UV Disinfection Guidance Manual (USEPA 2006), which adapts German and Austrian UV performance concepts to a wide extent.

## REGULATIVE BACKGROUND

In contrast to the older version of the work sheet (DVGW 1997), the new version (DVGW 2006) has been implemented as part of the German Drinking Water Regulations. Thus it is a *legal requirement* for operators to use UV systems that are compliant to the W 294 work sheet. At present, it is under discussion as to how and to what extent older systems can be grandfathered or become subject to additional performance tests.

## STRUCTURE AND CONTENT OF THE NEW WORK SHEET

The most obvious change in comparison to the 1997 version is a new structure, dividing into three parts:

- Part 1 Requirements on quality, function and operation
- Part 2 Testing of quality, function and operation
- Part 3 Measurement ports and sensors for the radiometric monitoring of UV disinfection systems, requirements, testing and calibration

By using this new structure, it was possible to focus on different target groups, each of them using only a part of the whole work sheet. This results in a more user friendly way for readers to get the information that is important. Part 1 targets operators and engineers; while Parts 2 and 3 are more focused on vendors and performance test laboratories.

Beyond the structural changes, several content changes have occurred. One of the most prominent is represented by Chapter 5: "Criteria for Choosing a UV system". This chapter guides potential operators through the different sets of water quality parameters that affect the performance of a UV system and thus are important when choosing one. While the old version provided almost no real help with respect to this matter, now there are several parameters mentioned together with recommendations on how to handle them, such as iron and manganese, hardness, and UV transmittance. There are also measurement regimes described on how to gather the information if applicable. Furthermore, this chapter also provides some details about dimensioning a UV system on the basis of transmittance, flow rate, head loss and installation considerations. This was also missing in the old version.

A high relevance feature in the new work sheet is the provision of details for operators and engineers about economic factors to be used to compare different systems from different vendors. The following topics are mentioned:

- Capital investment for the UV system
- Capital investment for the installation
- Lifetime of UV lamps
- Lifetime of ballasts/power supplies
- Spare part costs (UV lamps)
- Operational procedures for cleaning, changing lamps, and general maintenance
- Operational procedures for determining the energy consumption of the UV system
- Operational procedures for determining head loss generated by the UV system

These topics provide useful and important help for the inexperienced operator to easily generate an operating procedure and economic calculations.

However, when going into further detail, the list may not provide enough depth when comparing, for example, the service and spare part packages from different vendors. The list should more be seen more as a useful tool when specifying small or medium sized installations. Larger installations usually have sophisticated control and monitoring systems with different control algorithms, which influence the operational part substantially.

## MONITORING OF UV SYSTEMS

The new and revised part for the monitoring of UV systems with sensors is probably the most comprehensive part and provides a lot of detailed and new information. Probably the most interesting new information is:

- The designer of a UV system has the choice between two different kinds of UV sensors. One has a very small acceptance angle and the other one a broad one. While the small angle represents the concept of the old work sheet (DVGW 1997), broad one takes into account that the Austrian ÖNorm regulation (ÖNorm 2001) follows this concept. This put the two associations in the position to harmonize their efforts when regulating and standardizing UV systems. It also helps UV designers to control the systems better using the two allowed sensor configurations in different transmittance ranges. However, for an operator or engineer this would only be of low relevance, since they can only rely on the fact that the system is safe independent from the choice of the monitor, if the system is compliant.

- In comparison to the old version, UV systems now have the requirement to operate with multiple sensors depending on the number of lamps or the energy consumption per lamp (whichever criterion is the stronger is the one that counts). This provides additional safety, since, in the past, it was possible to run very large UV systems with only one sensor. For operators and engineers the details provided may not be very relevant because they can again be sure that the system is safe if compliant to the new standard, respectively if the UV system has enough sensors.
- Sensors have to be recalibrated after a period of 2 years. In order to provide a common calibration service, DVGW is in the planning phase to establish an official calibration laboratory.

**Picture:** *DVGW compliant UV Sensor (Courtesy of Dr. Gröbel UV-Elektronik GmbH, Germany)*

One of the principal improvements in the new standard, in conjunction with sensors, is the possibility to generate performance curves and matrices. This enables operators to run their system in an optimal manner according to flow and water parameter changes, without risking dropping below the minimum fluence to be applied, but also without wasting energy through overdosing. To achieve this, the new standard gives guidance on how to create a test performance protocol in such a way that a performance curve can be generated in contrast to various single performance point tests. This is the case when a minimum of three test points have been successfully proven for a minimum fluence of 400 J/m$^2$ (40 mJ/cm$^2$) with different combinations of flow rate and UV transmittance.

**Graph:** *Example for Performance Curve (see right)*

Last, but not least, it should be mentioned that the new version gives some helpful details concerning quality, technical and functional requirements that the operator should expect as a minimum from a vendor's equipment. It also provides information about general control functions that are helpful when creating specifications especially for an inexperienced operator or engineer. Under the chapter: "Installation and Operation", the reader can also find useful information about general safety and installation requirements. There is also information about how to create a daily log book, the cleaning of a UV systems and some considerations about spare parts, especially UV lamps.

## SUMMARY

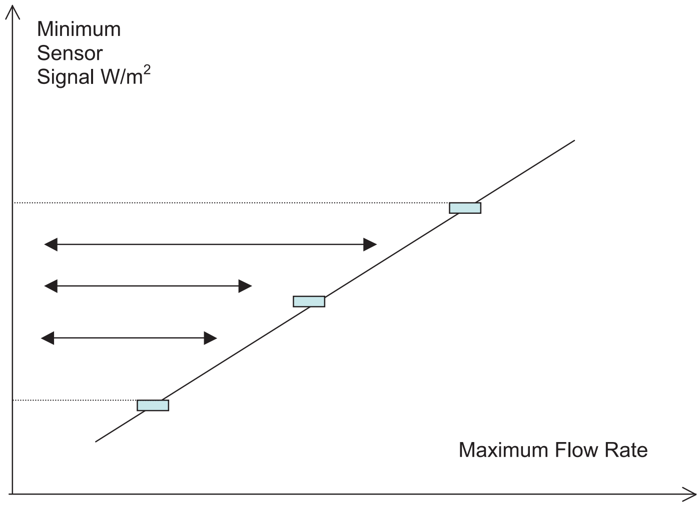
The new DVGW work sheet W 294 (DVGW 2006) has been successfully revised in comparison to the old version (DVGW 1997) by delivering more relevant planning and operational information, together with a more readable structure for different kinds of stakeholders. The fundamental requirements however remain unchanged, for example, a minimum fluence of 400 J/m$^2$ (40 mJ/cm$^2$).

One of the principal improvements is given in Part 1, where engineers and operators find useful and more detailed information about how to operate a UV system and how to compare different systems on the basis of economic factors.

The new version provides more flexibility for all stakeholders through the implementation of a performance test curve concept and the possibility to use different sensor types. This should also have a considerable impact on international acceptance of the new version, which is important for vendors operating in a globalized business environment.

In summary the revision can be seen as a success. However, one drawback is still exists, which is the lack of clarity concerning the process of recalibration, which is a preposition in order to be fully compliant to the standard.

*Example for operational set points resulting to a performance curve. A UV system can operate in th esector beyond the line (marked with arrows).*




*The square points on the line mark the bioassay tested flow vs. transmittance (respectively sensor signal) combinations which deliver the target fluence of 400 J/m$^2$.*

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[1]Together with his business partner Mr. Christoph Dicks, HYTECON was founded in May 2007 and is providing consulting services in the field of new and innovative environmentally friendly water treatment solutions.