DVS GERMAN WELDING SOCIETY

RESEARCH | TECHNOLOGY | EDUCATION

IN FOCUS

Arc Welding in the DVS

www.dvs-ev.de

The technical-scientific collaboration in the DVS

As a technical-scientific association the DVS is fully committed to joining technology. To that end DVS initiates and supports research activities for example, captures and documents the latest state-of-the-art technology and ensures that training and development programs offered by the DVS meet current requirements. This close network of research, technology and education is the core element of the technical-scientific collaboration work in the DVS. With this interdisciplinary approach, the association guarantees that its diverse work results are always based on current knowledge and are compatible with each other.

An impressive example of this successful work philosophy is the DVS technical code, consisting of more than 500 DVS technical bulletins and guidelines. The DVS technical code also sets high training standards and comparable qualifications in training and ongoing training, creating the basis for the highest level of uniform national and international acceptance and procedures.

The results of the DVS work are reflected in DVS events and are supported by DVS Media GmbH inter for example in specialist magazines, specialist books and other publications and made accessible to the professional world.

The booklet “In Focus” presents specific examples to illustrate the practical results of the scientific and technical community work in the DVS and invites you to participate in the various activities in the DVS. Each booklet is devoted to one topic and shows how the entire business location Germany benefits from the close linking in the DVS of research, technology and education to the respective industry.

Dipl.-Ing. Jens Jerzembeck
Head of Research and Technology

Source: ©aerogondo /Fotolia.com

Contents

Publisher:
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Title image: Michael Krone, DVS photo contest, “Minitesla”

Arc Welding guarantees jobs in Germany

In order to join individual parts to create one complete work piece, there are numerous welding procedures which can be used. One must be selected for each specific instance. When selecting a procedure, the following aspects should be taken into consideration: From the perspective of technological processes, the material, component geometry, access to the point which needs to be welded and the potential welding position all play a part, as well as the quality requirements for the welded product. From an economic perspective, the quantity of the work pieces needing to be manufactured and the costs for the welding equipment required, as well as those manufacturing costs during process selection, should all be taken into consideration.

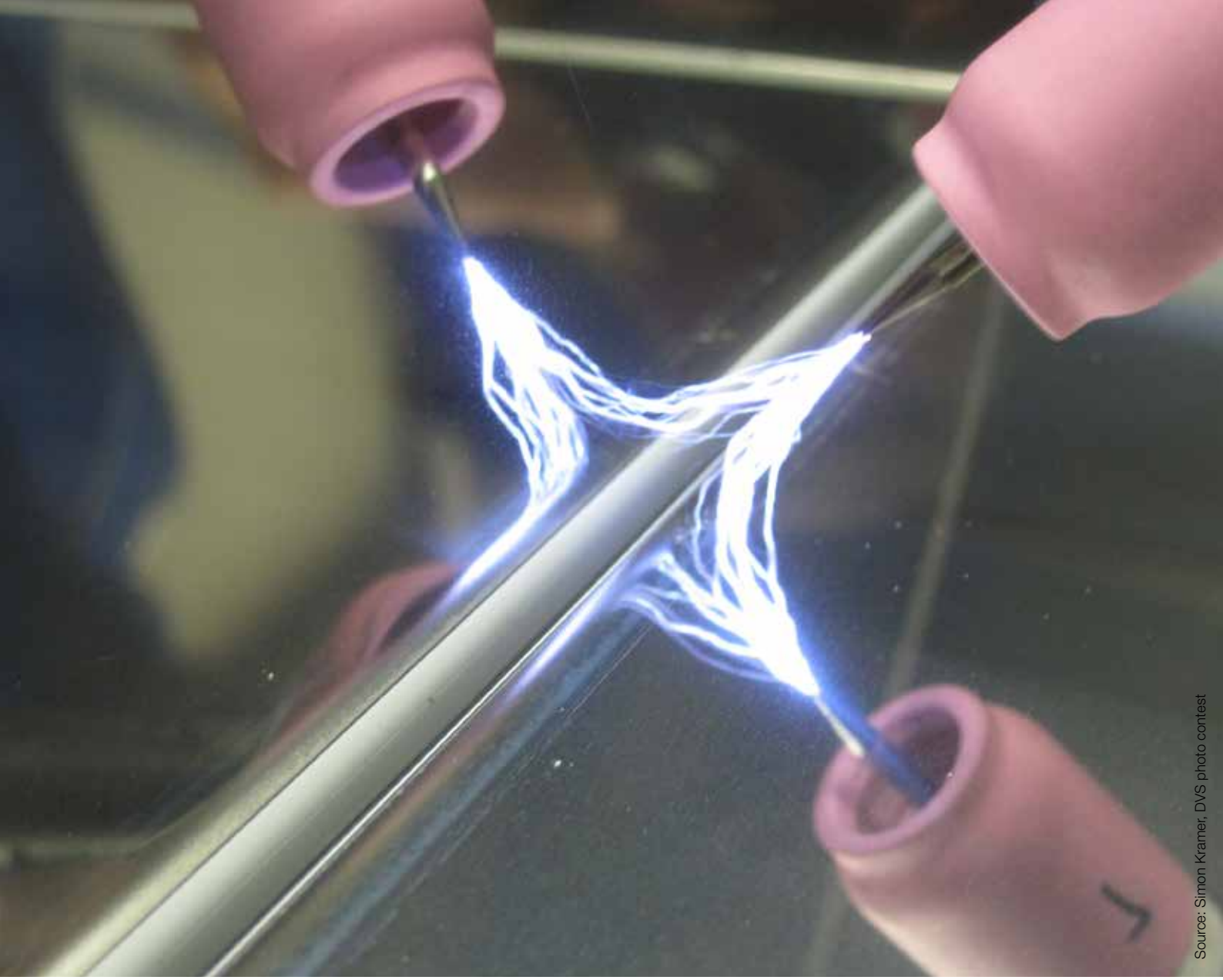
The production site plays yet another important role in terms of economics. Production processes undertaken in Germany incur high costs. As such, in the past, some companies chose to relocate their production plants to more cost-effective countries/regions, such as China. Even though Europe and Germany are somewhat more expensive locations to manufacture products, the both outstanding and secure infrastructure provides a strong argument in favour of production sites in the Federal Republic of Germany. Germany still plays an important role when it comes to welding technology thanks to their high standards of staff training, certified quality management systems that have been tried and tested, as well as their advanced knowledge due to the close connection between research and industry.

The DVS also makes some contributions to this high level of welding technology in Germany. DVS educational institutes have long since been the top choice for training welders, welding specialists, welding technicians and welding engineers. Standardised training is also required in the domain of automated welding technology. The DVS will be able to offer a comprehensive training course for robotic operators thanks to the prospective collaboration of robot manufacturers and DVS educational institutes. Those robot manufacturers who work together with the DVS provide pioneering work in order to set the standard for preparing operator examinations.

The phrase “Industry 4.0” is often being used, especially in the domain of automated welding technology. At the moment, many companies are still unable to estimate the outlay versus benefits of interlinking welding processes and making them digital. As such, they are unknowingly giving up the possibility to make use of the potential advantages. The DVS is currently developing the first guidelines on the best way to employ data in robot-aided welding technology in order to provide support for getting start in the domain.

In all areas of Arc Welding, the DVS is helping to quickly and effectively have current knowledge employed both on training courses and within the industry through the close relationship fostered between their Research Association on Welding and Allied Processes e. V. of DVS and their Technical Committee. It is only possible to benefit from the potential offered by welding and material technology, and in turn guarantee jobs within the welding technology sector in the future, if advancements are made in current knowledge from welding engineers to welders or operators.

Dipl.-Ing. Jens Jerzembeck
Head of the Technical Committee



Igniting an electric arc in a mirror metal tub.

The DVS technical code

The DVS technical code for "Arc Welding" offers extensive, application-oriented information on procedures, quality assurance, testing, design, training, materials, etc. and also defines the special requirements that are required of skilled workers in the area of Arc Welding.

The interdisciplinary cooperation between the Research Association on Welding and Allied Processes e. V. of DVS, the Technical Committee (AfT) and the Education Committee (AfB), has resulted in a worldwide established and recognised set of DVS technical code, which represents a self-contained system.

DVS members have free access under: www.dvs-regelwerk.de

Source: Hubert Dunstheimer, DVS photo contest

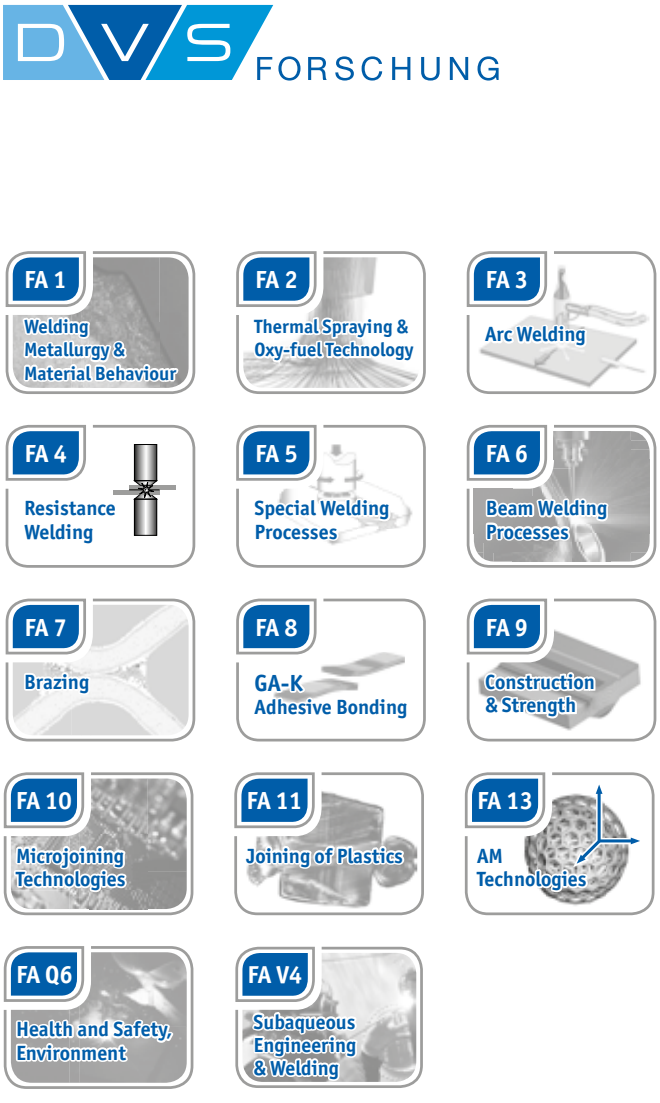
Pipe coupling with TIG welding.

Research in the DVS

The Research Association on Welding and Allied Processes e. V. of DVS

The research into joining technology in the DVS is a successful partnership between industry, research and the state. The Research Association on Welding and Allied Processes e. V. of DVS represents as a modern, professional and service-oriented institution for joining technology. As a research-promoting institution in the form of a non-profit association, it offers materials, process and industry-specific research focussing on joining, cutting and coating through its specialist committees in the professional world and the interested public. The specialist committees cover the entire value added and process chain of joining technology.

More than 500 experts from industry and science are successfully involved in the research association's network. More than 100 ongoing research projects are guided and supported annually. The research group is interdisciplinary oriented and open to different cross-industry research collaborations.



The Expert Committees of the Research Association of DVS.

Further and up-to-date information on the work of the Research Association of DVS is available at: www.dvs-forschung.de

The Expert Committee 3 “Arc Welding”

The general objective of the research undertaken by the Expert Committee (FA) 3 “Arc Welding” is to further develop the effectiveness and profitability of arc welding processes in industrial practice. In particular, the needs of small and medium-sized businesses will be addressed. During research, the following limiting and environmental conditions should be taken into consideration: preconditioning, post-treatment, tolerances, distortion, emissions, contaminants and quality criteria typical in practice.

Joining processes must be made understandable. Economic feasibility and assessments of profitability are also part of the research work. Within the scope of the projects, potential solutions will be devised and documented. It should be made possible to compare the findings of different research projects and practical tasks using parameter specifications relating to welding activities. It must be possible to plan, simulate, monitor and qualitatively determine arc welding processes, as well as to make them free of emissions, economical and reliable.

Current fields of research and focus topics include arc welding processes for modern types of materials and material compounds, additive manufacturing using Arc Welding, modelling, simulation, visualisation and evaluation of arc welding processes, adapting process variants and hybrid processes to joining tasks, developing device and equipment technology and finally sensor technology and quality assurance procedures in the domain of Arc Welding.

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Please visit the following link to find an overview of any current or completed research projects:
www.dvs-forschung.de

How application-oriented research works

Research balance – transfer of findings and implementing them in projects:

“Sensor-assisted GMA narrow-gap welding for thick sheets of fine grain steels with modified process management”
(IGF-no.: 17.923N / DVS-no.: 03.111)
Duration: 1st January 2014 – 31st July 2016
BAM Berlin, FB 9.3: Welding manufacturing procedures

Different control algorithms for automated GMA narrow-gap welding of sheets measuring over 30 mm in thickness were developed within the scope of this research project by employing process-oriented (electricity and voltage measurement) and optical sensor technology (light section methods). The objective of this research was to make it possible for process management procedures to be secure and joints to be filled in evenly during multilayer welding for gap widths varying from 18 to 24 mm by adapting process parameters online.

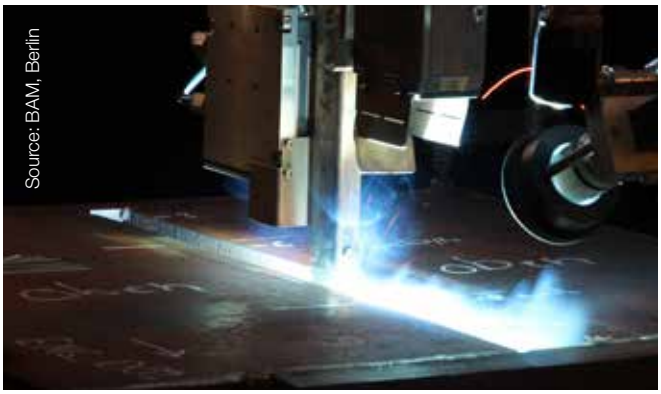
It is particularly important to correctly align the oscillation width to the width of the narrow gap joint in order to ensure that edges are connected securely. The strategy developed during the research project makes it possible to independently control the oscillation of the electrode just by using their self-devised arc sensor. This not only enables the gap width to be adjusted automatically, but it also means that differing contact pipe spacing can be evened out and if the torch position strays from the welding centre, it can be resolved. In addition to the main application

for impulse welding processes considered during the project, it was possible to show the function of the control system for spray arc processes without any need for the user to change or add settings. This significantly enhances the system's flexibility.

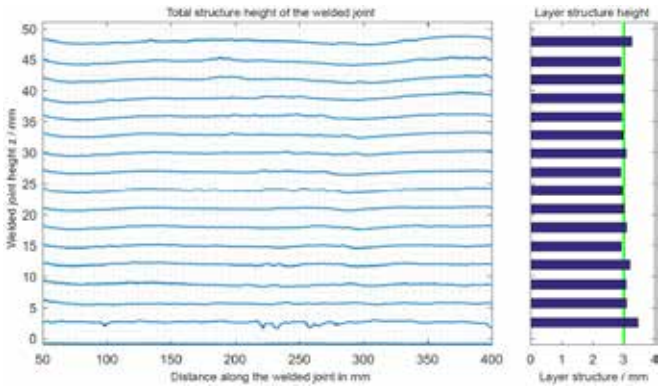
The filling ratio control system developed adjusts both the necessary welding speed, as well as the speed of the wire feed, to the gap width measured on the basis of the target structure height set by the user. A final welding demonstration was performed on a component 50 mm thick with variations in gap width between 18-24 mm. In this case, despite huge discrepancies in the cross-sectional area of the welded seam, it was possible to keep the structure height along the welded seam constant to a few tenths of a mm across 17 welding layers.

Furthermore, researchers developed a method to reconstruct the real gap width from a combination of process-oriented measurement data and the dynamic data from the narrow-gap blade by using optical and process-oriented data recorded during the welding process. In this way, optical sensors can be completely replaced with light arc sensor technology. This enables the filling ratio control system that has been developed to be put to use for applications with even higher sheet thicknesses for which it is not possible to use an optical sensor, for example.

Users of GMA narrow-gap technology can employ findings from the research project in various ways: For applications that can be used with optical sensor technology, findings can be directly integrated into the control system and used to help design light arc sensor technology which enables operation without optical sensors. If there is no optical sensor technology available, oscillation controls can be used, independent of the process. After equipment has been calibrated, light arc sensor technology can also be used for the filling ratio control system.



GMA narrow-gap welding on the demonstrator with 50 mm sheet thickness



Consistent layer structure with variable gap widths by using adaptive welding processes (laser measurement results, target structure height 3mm / layer)

Company opinions

Andreas Förster, Borsig PHE, Berlin:
From our perspective, the solution developed within the scope of the project represents a milestone on the journey to achieving fully-automated GMA narrow-gap welding. It is particularly noteworthy to mention how the oscillation width is assessed using an electric arc, as controlling the oscillation width makes it possible to resolve even the tiniest defects in the process of preparing the welded joint. As such, the system is extremely suitable for practical use within the industry. It is now possible to achieve secure welding despite weld preparation using flame cutting. Furthermore, the operator/welder is no longer forced to constantly observe the welded joint, as such exposure to the very intensive electric arc is significantly reduced.

Dr.-Ing. Birger Jaeschke (graduate engineer), Lorch Schweißtechnik GmbH, Auenwald:
In terms of research, the concept of a self-learning system is actually nothing new, however this project has enriched the concept with new and refreshing ideas. The detailed solutions and methods developed over the course of the project show that achieving a sensible balance between expanding storage capacity and processing power and carefully selected output and input channels with model-based signal pre-processing plays a key role. I would like to thank those involved for having developed an excellent sense of what the industry needs, so that we can be excited about the future.

Technology in the DVS

The Technical Committee (AfT)

Considering the currently more than 250 established joining processes, the technical-scientific collaboration work in the DVS can and must be systematic. This is guaranteed by the Technical Committee, which has more than 200 work councils. The AfT brings together more than 2,300 experts from business, academia, organisations and corporations who work together to capture and continually advance the state of the art. The fact that the DVS with this bundled expertise is also acknowledged on the international stage as a confident and competent partner in all assembly engineering issues is clear.

DVS is a major contributor to the international joining technology network through its involvement in the International Institute of Welding (IIW) and the EWF – European Federation for Welding, Joining and Cutting. The work results originating from the AfT are published as DVS technical bulletins and guidelines.

At the national level, the AfT works very closely with the Normenausschuss Schweißen und verwandte Verfahren (NAS) des DIN e. V., in particular in the numerous community committees. The constructive cooperation with NAS enables optimum coordination of the DVS technical code with the normative requirements. The DVS technical code provides valuable application notes for practical application.

DVS members benefit from free access to the DVS technical code under www.dvs-regelwerk.de.
All the DVS technical bulletins and guidelines are available electronically.

Afterglowing – TIG.

Source: Gerhard Frühsammer, DVS photo contest

Structure of the Technical Committee (AfT)

consultation

AfT-Conference

V: Prof. Dr.-Ing. U. Reisgen
GF: Dipl.-Ing. J. Jerzembeck

AfT-Board

Main Division W

Basic materials, filler materials and auxiliary materials

AG W 1 Technical Gases	**AG W 2 **** Welding of Cast Materials	**AG W 3 **** Joining of Metal, Ceramic and Glass	**AG W 4 *** Joining of Plastics	**AG W 5 *** Welding Consumables	**AG W 6 *** Welding of Aluminium and other Light Metals

Main Division V

Processes and equipment

AG V 1 * Gas Welding	**AG V 2 *** Arc Welding	**AG V 3 *** Resistance Welding	**AG V 4** Underwater Engineering	**AG V 5 *** (Thermal) Cutting	
AG V 6.1 * Brazing **AG V 6.2 *** Soldering	**AG V 7 *** Thermal Spraying and Thermal Sprayed Layers	**AG V 8** Adhesive Bonding	**AG V 9.1 *** Electron Beam Welding **AG V 9.2 *** Laser Beam Welding and Allied Processes	**AG V 10 **** Mechanical Joining	**AG V 11** Friction Welding

Main Division Q

Quality management, design, calculation, health and safety

AG Q 1 Design and Calculation	**AG Q 2*** Quality Assurance of Welding	**AG Q 4*** Testing of Welds	**AG Q 5*** Qualification Requirements for Welding and Allied Processes Personnel	**AG Q 6** Health and Safety and Enviromental Protection

Main Division I

Information

AG I 1 Information and Communication Technology	**AG I 2*** Application Oriented Welding Simulation	**AG I 3** History of Welding Technology	**AG I 4 *** Illustration, Terms and Definitions

Main Division A

Applications

AG A 1 Welding in Turbo Machine Building	**AG A 2** Joining in Electronics and Precision Engineering	**AG A 3** Welding in Plant-Tank and Pipeline Construction	**AG A 5** Welding in Construction Settings	**AG A 6** Welding in Shipbuild and Marine Engineering
AG A 7 Welding in Railway Vehicle Manufacturing	**AG A 8** Joining in Vehicle Manufacturing	**AG A 9 *** Welding in Aviation and Aerospace Engineering		

Specialist Societies

Specialist Society for "Brazing/Soldering"	**Specialist Society SEMFIRA/EMF *****

AG: Working Group, * Joint Working Group with NAS (Standardisation Committee Welding and Allied Processes of DIN e. V.),
** Joint Working Group with other Societies, ***SEMFIRA = Safety in ElectroMagnetic Fields, EMF = ElectroMagnetic Fields.

Working Groups on the topic of “Arc Welding”

More than 400 specialists are involved in process-oriented working groups within the domain of Arc Welding. Those represented include manufacturers of welding power sources and welding fillers, users from various sectors and research employees. Furthermore, experts in training and certification provide support in the drafting of technical codes. Working groups from the domains of MMA, inert gas, stud and flux-cored wire welding are currently working to produce a system of technical bulletins on the topic of “Welding heat-resistant steels” which include information on various processes.

Another task undertaken by the working groups is to organise educational events, such as the “Electric arc physics” workshop, the “Arc brazing” workshop and the ROBOT conference. These events provide an opportunity for interested specialists to get informed about the latest technology, current research and development projects, as well as any new technical codes.

Ad-hoc working groups were established in order to address current questions on topics such as “Efficient preparation of welded joints for GMA welding”, or “Industry 4.0 – putting welding data to good use”.

Furthermore, the working groups are involved in standardisation processes within the group DKE 361 “Arc welding equipment” at the Deutschen Kommission Elektrotechnik Elektronik Informationstechnik in DIN und VDI.

Working Groups and Working Committees in the domain of “Arc Welding”

AG V 2.2 “Stud Welding”

In this Working Group (AG) V 2.2 “Stud Welding”, specialists from device and accessory manufacturing companies, circles of users and institutes all work together to undertake tasks involving arc and stud welding processes, procedures and devices. Some examples of current topics are issues regarding exposure due to electromagnetic fields and the drafting of DVS technical bulletins on Stud Welding of individual groups of materials, as well as issues concerning equipment technology, the evaluation of stud welding connections and automation.

AG V 2.3 “Inert Gas Welding with non-consumable electrodes”

Device and accessory manufacturers, users and institutes deal with technical tasks which involve Tungsten Inert Gas Fusion Welding, Tungsten Inert Gas Welding and Tungsten Plasma Welding. One of the projects currently being undertaken involves drafting DVS technical bulletins on welding materials, equipment technology and procedures which are subject to specific requirements. Technical codes on assessing and handling annealing colours in chemical plants and in food production facilities, as well as regarding how to handle tungsten electrodes and on the topic of formation, are produced and regularly updated.

AG V 2.4 “Inert Gas Welding with consumable electrodes”

Activities focus on topics from the domains of Metal Inert Gas Welding (MIG) and Metal Active Gas Welding (MAG). The observation of research from the area of arc physics and the corresponding investigative methods for electric arcs, as well as the development of process and equipment technology are being used to form advice for practice, that is to say, the user. Impulse technology is currently the principle factor being considered in this regard. A user-oriented compilation of various, modern process regulations for GMAW is updated at regular intervals. User-oriented DVS technical bulletins on regular GMA variants are currently in progress. Furthermore, a method for measuring the hydrogen content in welding fillers is being developed. The Working Group V 2.4 is also working to draft DVS technical bulletins on how to weld individual materials.

AG V 2.5 “Submerged and Electroslag Welding”

Submerged Welding with wire electrodes, strip electrodes, several wire electrodes, metal powder additive, cored wire electrodes, as well as electroslag welding are all topics covered by manufacturers of fillers and welding power sources, users and specialists in research and education. At present, in addition to applications for new materials, new procedural variants and new wire/powder combinations, there is an increasing amount of work which concentrates on providing users with guidance in the area of welding heat-resistant steels.

AG V 2.6 “Mechanisation, automation and the use of robots in Arc Welding”

This committee deals with topics including automation in welding technology, the use of robots and sensors and operator training. The Working Group V 2.6 also deals with quality assurance in automated welding productions and automated testing procedures for welded joints or welded joint preparation. There is currently a DVS training guideline 1184 entitled “Operators of fully-mechanical and automated welding equipment in Metal Inert Gas Welding”. User guidance is currently being drafted for the outlay and benefits of using robots, as well as sensor tech-

nology and quality management in automated welding technology. This information provides the user with an initial overview of what should be taken into consideration when changing over from manual to automated welding production. Furthermore, the Working Group V 2.6 organises ROBOT conferences which take place on a regular basis.

AG V 2.7 “Welding with cored wires”

When using cored wires to weld, users can find support and guidance in technical bulletins and training resources provided by the working group. The group are currently undertaking a project to develop user-oriented technical bulletins on the topics of welding with heat-resistant steels and welded top-coats. A guideline and some training resources on the topic of cladding, as well as technical bulletins concerning self-protecting cored wire electrodes are in the process of being devised.

AG V 2.8 “Arc physics”

The Working Group V 2.8 “Arc physics” runs the “Arc physics” workshop on a yearly basis. The workshop event addresses current topics arising from research into Arc Welding. Device manufacturers and users also present the new developments from research findings and their methods of implementation. The working group also coordinates the collaboration of various research institutes and business in research projects. The workshop plays an important role in transferring knowledge gained from research into the industry.

New DVS technical codes for practice

Guideline DVS 0980 “Verifying power sources for arc welding equipment” (in progress)

DIN EN 1090 means that manufacturers of steel and aluminium constructions have to have their in-house production control systems verified, among other things, in order to ensure that welded products have a high level of quality. As such, it is necessary to be able to comply with the welding parameters with sufficient accuracy time and time again. The European standard DIN EN 50504 requires the use of verified welding equipment, as the quality/durability of welded joints depends on parameters such as power, voltage, speed, gas flow rate etc. being set precisely and in such a way that can be replicated.

A joint working group made up of the DVS and DKE, Deutsche Kommission Elektrotechnik Elektronik Informationstechnik in DIN and VDE, with representatives from welding educational and research institutes from the GSI – Gesellschaft für Schweißtechnik International mbH – as well as the German employer’s liability association and the industry itself, have collaborated to generate proposals on how to further develop DIN EN 50504 and how to draft a DVS guideline on the right methods to calibrate, validate and verify welding power sources.

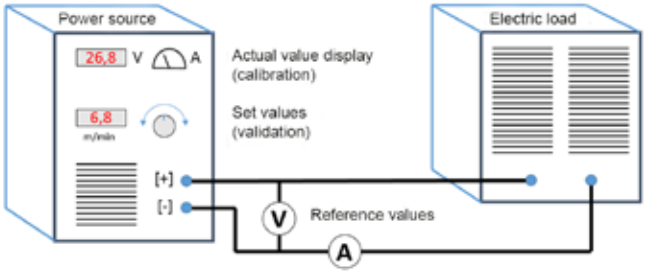
This DVS guideline will be closely oriented around DIN EN 50504, adding and substantiating this standard with practical information. The prospective DVS guideline will provide information on how to implement validation processes for arc welding power sources and calibration processes for measuring devices in practice.

This close collaboration between the DVS and DKE committees has led to the production of a comprehensive guideline for users of welding power sources.

Technical bulletin DVS 0973-2: “Welded joint preparation as per DIN EN ISO 9692-1” (in progress)

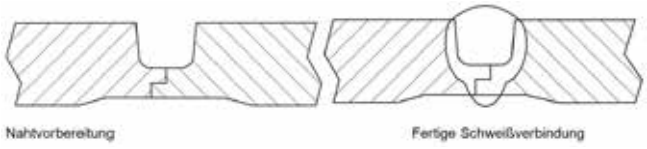
The DVS has set the objective of making it easier for businesses to start employing modern process regulation variants. The technical bulletin DVS 0973 entitled “An overview of process regulation variants for GMAW” and the supplementary sheet 1 entitled “Overview of process regulation variants for GMAW in table form” provide users with concrete guidance on which processes are suitable. The operating principles, types of arcs and areas of application for these regulation variants are all explained in the technical bulletin. Process properties of the regulation variants most well-known only under corporate names are explained in the supplementary sheet.

In order to make it possible to exploit modern welding processes to their full potential, guidance on how to efficiently prepare weld-



Measurement configuration for arc welding power sources.

ed joints when using modern GMA process regulation variants is required. The DVS technical bulletin 0973-2 entitled “Welded joint preparation following DIN EN ISO 9692-1” provides information on this topic. More efficient geometries for welded joint preparation are outlined in the DVS technical bulletin, grouped into either semi-mechanical or automated GMAW. The technical bulletin is scheduled to be published at the end of 2017.



Source: DWT GmbH

Example for easy to fit – Welded seam preparation.

The regular GMA process variants detailed in the technical bulletin along with the suitable methods of preparing welded joints, are not covered in DIN EN ISO 9692-1 “Welding and allied processes – Recommendations for joint preparation – Part 1: Manual Metal-Arc Welding, Gas-Shielded Metal-Arc Welding, Gas Welding, TIG Welding and Beam Welding of steels”. These variants have been developed by various power source manufacturers over the course of the past few years and then successfully employed by different users. The most diverse range of investigations performed by power source manufacturers and neutral institutes, as well as welding educational and research institutes demonstrated that it is possible to deviate from the processes for preparing welded joints detailed in DIN EN ISO 9692-1. One particular advantage that can be gained from this is that volumes of welded joints are significantly decreased, which in turn leads to economic advantages. If processes of preparing welded joints deviate from the processes described in DIN EN ISO 9692-1, the quality of welded joints should be tested accordingly, as per the procedure tests outlined in DIN EN ISO 15614-1.

The DVS series of technical bulletins 0973 consists of the following technical codes:

- DVS 0973 “An overview of process regulation variants for GMAW”
- DVS 0973 supplementary sheet 1 “An overview of process regulation variants for GMAW in table form”
- DVS 0973-2 “Welded joint preparation as per DIN EN ISO 9692-1” (in progress)

EWM-Award “Physics of Welding”

By awarding this prize, EWM AG encourages young scientists from universities, research institutes or welding educational and research institutes to realise their vision in welding technology. The company has been involved in the research of welding processes for many years and provides the prize winner with financial support to work on significantly expanding their knowledge in this area.

Since 2009, the EWM awards have taken place every two years with the aim of generating new ideas and scientific approaches for arc, laser beam, electron beam and hybrid welding procedures. Innovative approaches which increase the energy efficiency of joining procedures are a key focus, as it helps EWM’s sustainability initiative, “BlueEvolution”, to make advancements.

Talented young people up to 30 years of age can make their applications in writing, outlining the concept for their planned research and development work. An independent jury chooses the prize winner, who will then receive funding for their scientific research in the amount of 30,000 euros.

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Education in the DVS

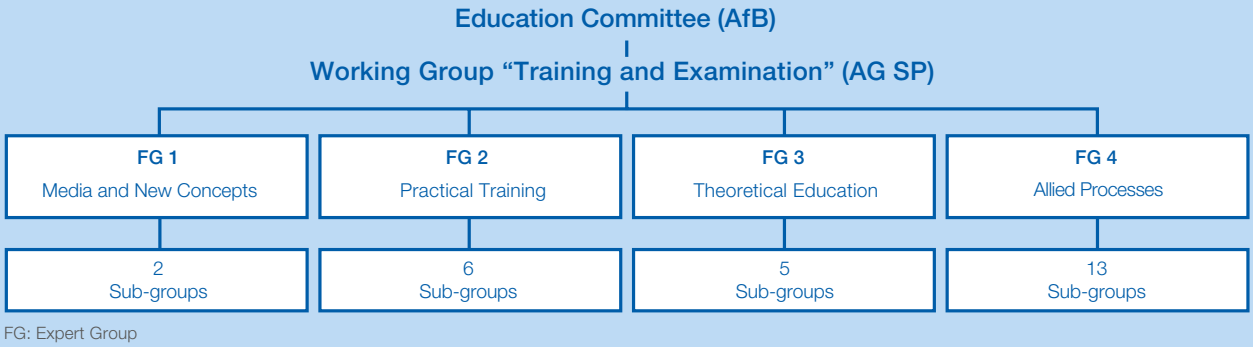
The Education Committee (AfB)

The Education Committee initiates measures to adapt the training and certification offered by DVS to current developments and to prepare them for future requirements. The committee is supported by the Working Group “Training and Examination” (AG SP), which is responsible for training and certification, to create uniform training and testing materials within the framework of the qualification of technical specialists and managers. In doing so national and also current European and international requirements are implemented in the training and examination standards. The scope of responsibility of the AG SP is the development of the teaching and learning content of the technical training and further education as well as all other areas related to the training and examination The DVS-PersZert, the personal certification body of DVS, ensures that these training and examination standards are ultimately adhered to and implemented nationwide.

Expert Groups FG 2 “Practical training” and FG 3 “Theoretical training” are in charge of generating the content for basic and advanced training courses on Arc Welding. They focus on drafting DVS guidelines concerning staff qualifications and exami-nations within the domain of Arc Welding. Furthermore, training guidelines are regularly issued within the domain of the Working Group V 2 “Arc Welding” in the Technical Committee.

The current training and further education on offer from the DVS can be found under: www.dvs-bildungskatalog.de

Structure of the Education Committee (AfB)



FG: Expert Group

Training and career paths in the domain of Arc Welding

Guideline DVS 1184 "Operators of fully-mechanical and automated welding equipment" and supplementary sheet 1 "Gas metal arc welding (GMAW), special requirements, educational and test content"

Specialist personnel operating automated welding equipment must take an operator examination as per DIN EN ISO 14732. However, in the future, operators will have a very different occupational background. Many of them do not have any, or have very little, prior knowledge of welding, or they have never come into contact with the programming.

Operator training should make sure that levels of knowledge are standardised. The training concept was devised by experts in basic and advanced training, robot manufacturers and users in the committee for technology (in the Working Group V 2.6.5 "Training") and adapted to the current requirements of staff working in the domain of automated welding technology. The guideline DVS 1184 "Operators for fully mechanical and automated welding equipment", as well as supplementary sheet 1 "Gas metal arc welding (GMAW), special requirements, educational and test content" should not only prepare future operators for their examinations, but also, participants on the course are trained according to their prior knowledge and the subsequent requirements. The objective is for operators to have a standardised knowledge of automated welding technology by employing modular educational content tailored to the need of the participant.

DVS and robot manufacturers working with the DVS have devised the concept that both manufacturer-specific and welding-specific knowledge should be part of training courses. Specific training initiatives provided by robot manufacturers working with the DVS are integrated into the entire training programme offered by a DVS-certified educational institute. Training courses according to guideline DVS 1184 are completed when participants take an examination which may include an operator examination as per DIN EN ISO 14732. As such, participants can also obtain the operator examination as required by the technical code, as well as a qualification.

Guideline DVS-IIW/EWF 1170 (IAB 252) "Welding supervisors – minimum requirements for training, examination and qualification"

Welding supervisors are assigned according to a recommendation by the International Institute of Welding (IIW) depending on the type and/or complexity of the manufacturing process:

- Welding supervisor with extensive expertise:
  DVS-IIW/EWF international welding engineer
  (SFI/IWE/EWE)
- Welding supervisor with special and technical expertise:
  DVS-IIW/EWF international welding technician
  (SFI/IWE/EWT)
- Welding supervisor with basic technical knowledge:
  DVS-IIW/EWF international welding specialist
  (SFI/IWS/EWS)

Guideline DVS 1181 "DVS training course for welding designers"

DVS welding designers are responsible for the design, dimensioning and structure of weldments. After having obtained their qualifications, these specialists have the knowledge necessary to design weldments by selecting the appropriate materials and to optimise weldments from the perspective of manufacturing costs. As such, DVS welding designers guarantee that welding procedures are effective and products meet all the requirements in terms of sustainability and usability.

The training course is split into modules; the two-part introductory course (E) entitled "The basics of welding technology" and a total of five different advanced training courses specific to manufacturing (A) entitled "Construction with welding"...
... steel constructions subject to cyclic stresses (A1),
... aluminium and aluminium alloy constructions (A2),
... pressure equipment (A3),
... machine construction (A4),
... vehicle construction (A5).

Guideline DVS-IIW/EWF 1111-1 "International welder (IS) – minimum requirements for training, examination and qualification – Part I: General information, requirements, topic overview"

Guideline DVS-IIW/EWF 1111-1 "International welder (IS) – minimum requirements for training, examination and qualification – Part II: Rules and instructions for test objects"

The testing standards for welding do not include a programme on how to train and educate people to become qualified welders. However, the industry needs welders with more comprehensive skills in order to achieve flexibility in production processes.

Part 1 of this guideline provides welders with a standard qualification which is recognised both in Europe, as well as across the rest of the globe. It acts as a framework for welders' theoretical and manual training, meaning the requirements established in the standardisation series DIN EN ISO 9606ff are fulfilled. The standardisation series states that only those who have received special training and/or have practical experience in the industry in the domains covered by the welding test, can be approved to take this test. As such, the basic principle of these international standards can be explained in simple terms: If a welder passes the examination, they are not only qualified for those topics covered in the test, but also for all other welding connections that are denoted as easier to weld according to international standards.

Part II of the guideline goes above and beyond manual skills, and welders will be trained how to interpret drawings (including knowledge of welding drawing symbols), as well as how to assemble equipment and how to follow the corresponding instructions (e.g. WPS). This aims to teach welders operational procedures, as well as to teach them how to use drawings to manufacture semi-finished work pieces (including the process of welded joint preparation) with the correct welding filler material as per the WPS.

Guideline DVS-IIW/EWF 1178 "International welding quality inspectors"

Specialists with extensive knowledge in the subject areas of "welding technology" and "welding quality inspection" can be regarded as international welding quality inspectors. With trained welding quality inspectors, the industry will have supervisory staff with two types of competencies. With respect to existing core competencies, the work of international welding quality inspectors begins before the start of the actual welding work and continues to be performed throughout the entire welding production process, finishing with findings being conclusively documented.

The scope of the activities performed by welding quality inspectors is broad and diversified. Before welding work begins, drawings and specifications need to be checked, as well as the qualifications of welders and operators of welding equipment, the equipment in the workshop, the basic materials required for the manufacturing process, the welding fillers, the preparation of the installation and the welded joint preparation. Furthermore, the welding process is monitored by welding quality inspectors, as is the type of welding procedure selected and its method of application. If welding goes ahead, the measures implemented to inspect quality represent an important part of the quality assurance system. Within this system, the individual stages of inspection are stipulated in a testing and inspection plan. International welding quality inspectors summarise the results available in reports and result logs. Furthermore, these specialists develop procedural instructions and check that non-destructive testing procedures are implemented correctly.

Specialised media and teaching materials for “Arc Welding”

The DVS Media GmbH

The DVS Media GmbH is the right starting point for comprehensive publications and media regarding joining, cutting and coating. The publishing program includes German and foreign-language trade journals, technical books, teaching media, DVS technical bulletins and guidelines, videos and software. The products from the DVS Media GmbH represent all the fields of activity of the DVS Association and all the results that they develop.

Numerous items of the DVS Media GmbH specialist media are devoted to the working results in the areas of research, technology and education around Arc Welding: These include specialist books and periodicals, as well as training materials and individual or collections of DVS technical bulletins and guidelines.

Sources for the DVS technical codes

DVS members have free access to all DVS technical bulletins and guidelines under www.dvs-regelwerk.de.
Interested persons who are not members of the DVS can refer to the DVS technical codes under www.dvs-media.info.

Your contacts for specialised media and teaching materials

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Publications on Arc Welding

DVS-Fachbücher, Band 133:
Bolzenschweißen. Grundlagen und Anwendung.

Stud Welding was first introduced into industrial manufacturing processes in the 1940s. Nowadays, millions of studs are welded per day. This is sometimes done manually with a semi-mechanical device similar to a handgun, however it is increasingly being done with full-mechanical welding equipment, and even with robots. Stud Welding requires expertise and experience. This specialist book provides the user with support and guidance.

R. Trillmich, Dr. Welz
12th edition, 2017
204 pages, 217 pictures and figures, 30 tables
ISBN: 978-3-87155-240-3, Article number: 102400

English edition, volume 12:
Stud welding. Principles and application

Stud Welding demands knowledge and experience. The present specialist book is intended to offer help on this subject. In this respect, the spectrum extends from the historical development and the fundamentals via the appliance technology and the fabrication in the case of various applications right up to the quality assurance and the set of rules.

R. Trillmich, Dr. Welz
1st edition, 2016
200 pages, 217 pictures and figures, 50 tables
ISBN 978-3-945023-47-1, Article no.: 180014

DIN-DVS-Taschenbuch 8:
Schweißtechnik 1: Schweißzusätze

Welding fillers are used across the globe. The 18th edition of the DIN-DVS pocketbook 8 “Schweißtechnik 1” serves as an up-to-date reference book for welding fillers, including around 50 DIN-EN-ISO standards which are predominantly uniform across nations.

Classification standards vary as they depend on the material group (e.g. steel, aluminium, copper, nickel, titanium) and the welding process (e.g. Manual Arc Welding, Submerged Arc Welding, Tungsten Inert Gas Welding).

DIN Deutsches Institut für Normung e. V. and DVS – Deutscher Verband für Schweißen und verwandte Verfahren e. V.
18th edition, 2017
582 pages
ISBN: 978-3-96144-013-9, Article no.: 505710

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DVS maintains a tight network made up of **research**, **technology** and **education** as a core element of the technical-scientific cooperative work.

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DVS is at your service. Your participation in our committees is worthwhile!

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