DVS THE JOINING SPECIALISTS

RESEARCH | TECHNOLOGY | EDUCATION

IN FOCUS

Electron Beam Welding in DVS

www.the-joining-specialists.de

The technical-scientific cooperative work in DVS

DVS is a technical-scientific association that is fully committed to joining technology, with nearly 120 years of experience under its belt. In other words: at DVS, everything revolves around joining, cutting and coating of metallic and non-metallic materials and material composites. The objective of all DVS activities is to comprehensively promote joining technology. This is done in many different ways.

DVS initiates and accompanies research activities, grasps the current state of the art, develops it continuously and makes sure that the DVS training and continuing education offerings, too, reflect the respectively latest state of knowledge from technology and research. This narrow network made up of research, technology and education is the core element of the technical-scientific cooperative work in DVS.

True to the principle „one becomes three“ technical discussions, research questions, or work results are communicated across the various departments, which is why they also mutually positively influence one another. With this interdisciplinary approach, DVS guarantees that its varied work results will always be based on the latest findings and are mutually compatible with each other.

An impressive example of this successful working philosophy is being documented by DVS set of rules, consisting of DVS Technical Bulletins and DVS Technical Codes. For the training and continuing education, DVS set of rules sets high training standards and comparable qualifications. In the technical areas, joining, cutting and coating methods, however, also aspects of testing and quality assurance, industrial safety and environmental protection as well as the added upstream and downstream process stages are being currently described. The foundations for the highest standards and uniform procedures are specified by DVS set of rules.

With the series of booklets titled “In Focus”, we would like to demonstrate to you with the help of specific examples which practically oriented results the technical-scientific teamwork produces in DVS and would like to invite you to get involved in the varied activities in DVS. Every booklet is dedicated to a central topic of interest and shows how the close connection between research, technology and education in DVS not only benefits the respective industry but the entire industrial location of Germany. DVS offers competitive solutions for joining technology – the work results are published among other things by DVS Media GmbH in trade journals, reference books and other publications and are therefore made accessible to the professional circles.

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

Photo: Fotolia

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Electron Beam Welding

The electron beam can be used in the most diverse ways as a tool in research and development, as well as in large scale technical applications. From the electron microscope for the representation of the microcosmos, the exposure of food to radiation and as a tool in radiotherapy, right up to the single-layer welding of thick-walled components with wall thicknesses up to over 200 mm, the electron beam can always be utilised profitably with unique properties. Since it was first used in welding technology in the 50s of the last century, the electron beam has faced up to constantly new challenges and market situations until today.

In welding technology, it is predominantly used in vacuum chambers and is capable of welding nearly all metallically conductive joining members. However, applications in atmosphere are also possible and technically established. Particularly microjoining, the processing of special materials such as refractory metals and the single-layer welding of the thickest cross-sections will be domains of the electron beam in future too. Its unique manipulability, the high available beam power in combination with the very good energy input into the workpiece and the very high energy-related efficiency are constantly opening up new application fields to the electron beam.

Aviation and aerospace, energy plant engineering and heavy mechanical engineering are just a few sectors in which the advantages of the electron beam are recognised anew time and again and where this is then a yardstick for further developments and innovations as a “technology carrier”.

The electron beam must allow itself to be measured increasingly in competition with other welding processes. The deflection possibilities and its unique beam quality make the electron beam also in future a joining tool which will offer the very highest quality, but will be able to shine in mass fabrication too.

Not only a wide variety of development steps, such as the beam jump technique and electron-optical observation possibilities, but also the application of the electron beam in the large chamber in cycle and lock machines, as well as in atmosphere, are generating new stimuli and fabrication possibilities with the electron beam. DVS and, in particular, DVS Working Group V 9.1 as an expert committee in Germany, have taken on the task to accompany the development of the electron beam with instructions, technical bulletins and standards, and thus to make its application accessible to a wide circle of specialists in welding technology.

Dr.-Ing. Ronald Holtz,
Ronald Holtz, Class 4 Laser Professionals AG, Burgdorf, Switzerland,
Chairman of the Expert Committee “Beam Processes” (FA 6) in the Research association of DVS

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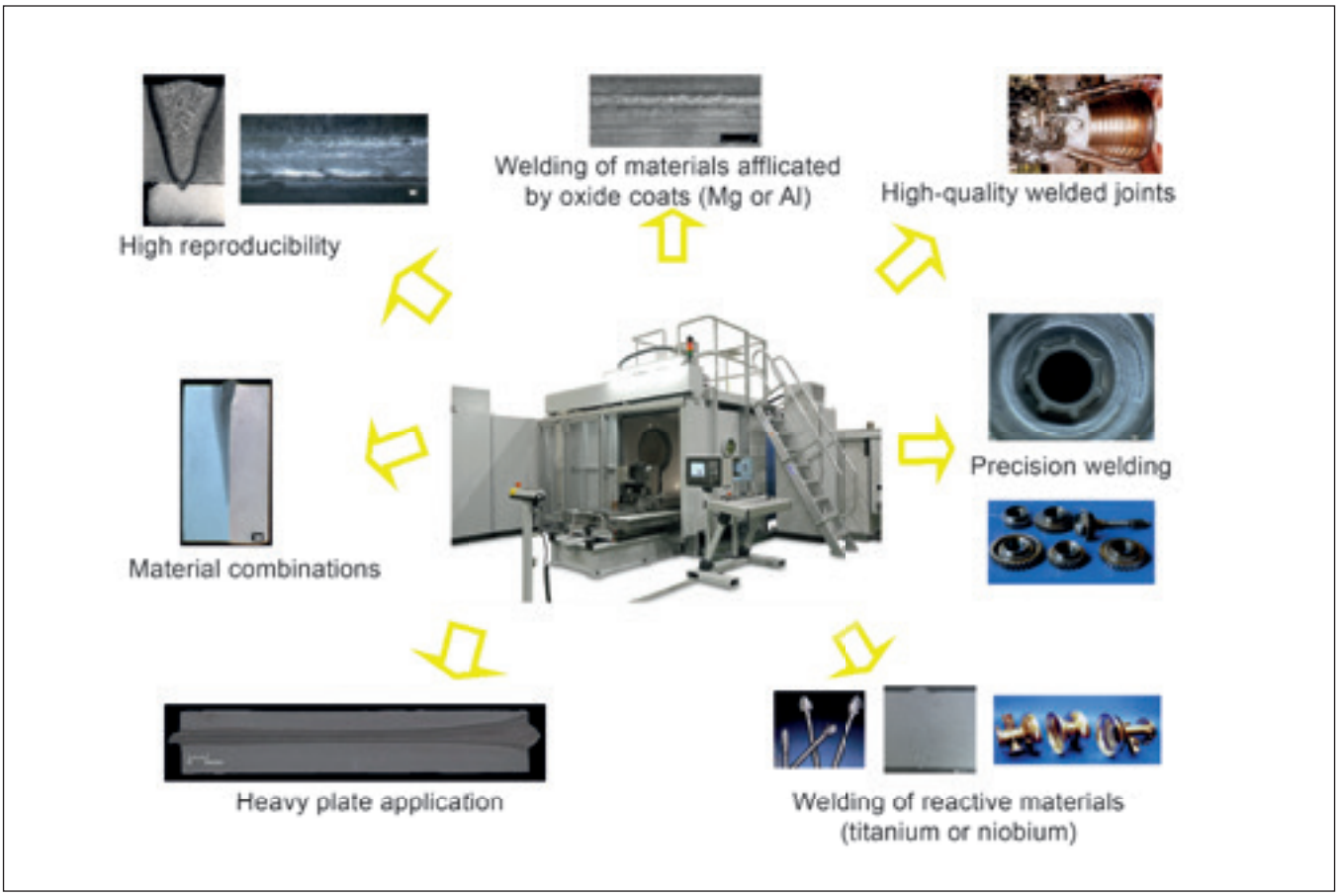
Forschungszentrum Jülich
Central Institute of Engineering, Electronics and Analytics, Engineering and Technology (ZEA-1), Jülich
Chairman of the Working Group “Electron Beam Welding” (AG V 9.1) in DVS

Dipl.-Ing. (FH) Ilka Zajons,
LZH Laser Akademie GmbH, Hannover
Chairman of the Expert Committee “Training for Beam Welding” (FG 4.7)

Examples from welding technology applications



The DVS set of rules on “Electron Beam Welding” offers extensive application-related information about procedure, quality assurance, testing, design, training and materials etc. and, in addition, also defines the special requirements placed on skilled workers in the field of electron beam welding.

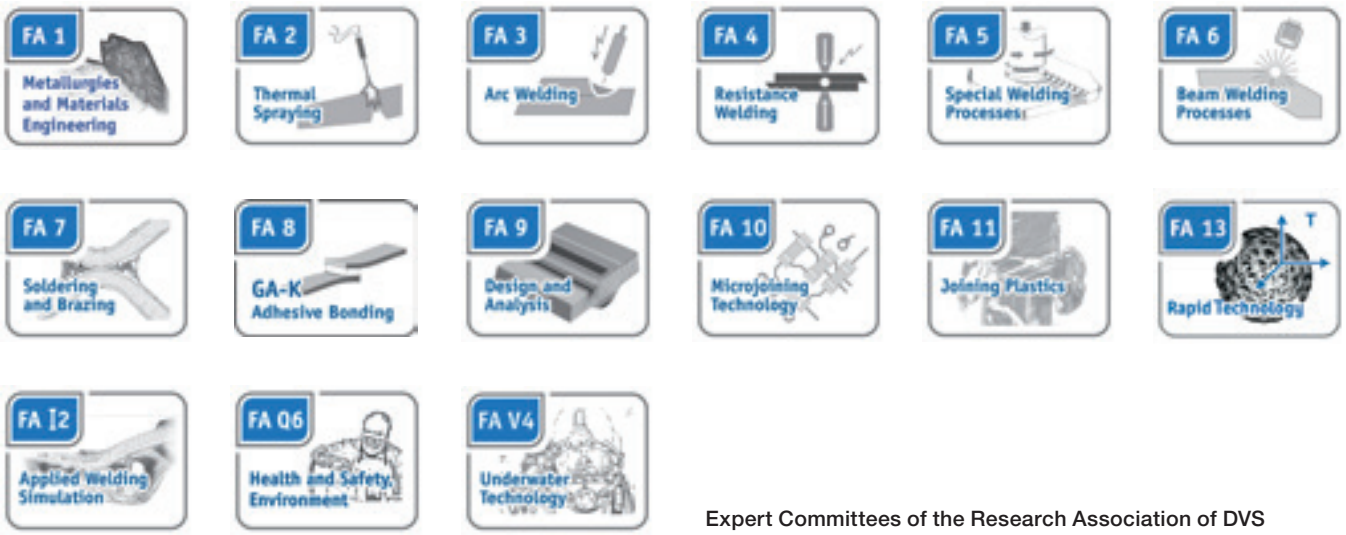
Through interdisciplinary collaboration between the Research Association of DVS, the Technical Committee and the Education Committee, a globally established and recognized DVS policy set has been created, which constitutes a self-contained system.

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

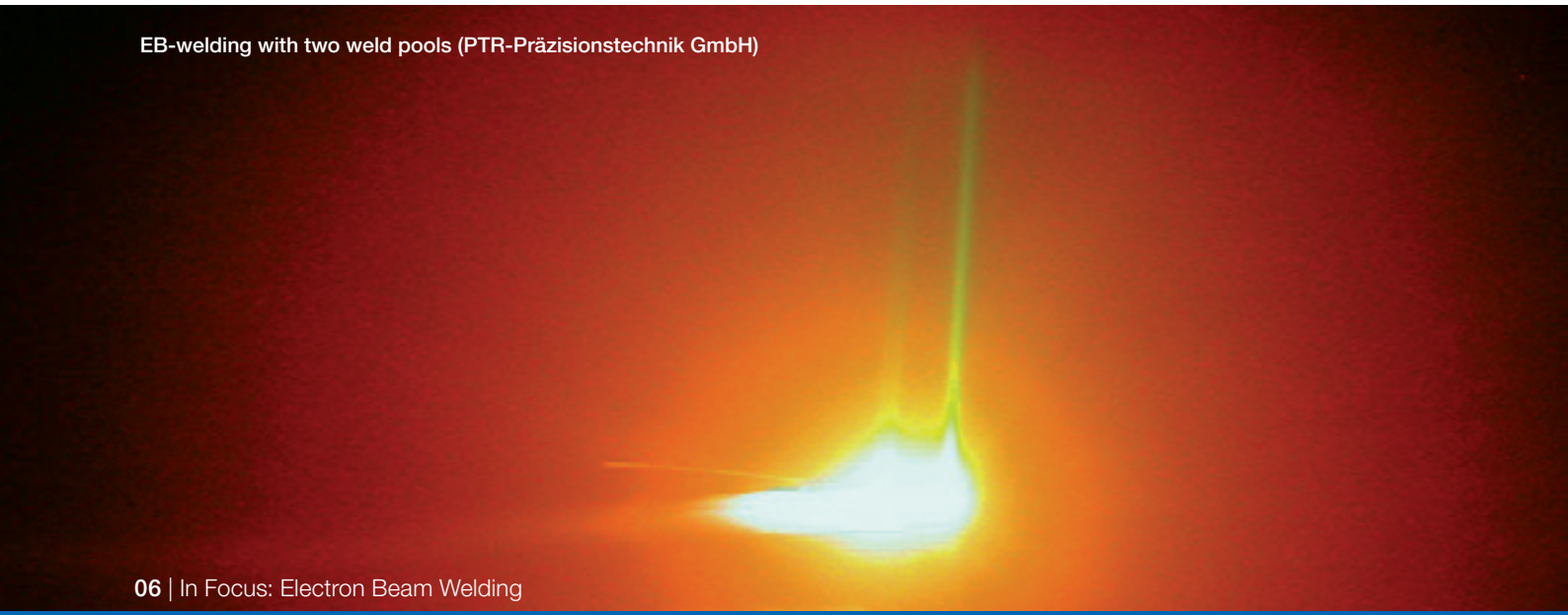
Research at DVS

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

At the core of the Research Association on Welding and Allied Processes e. V. of DVS, there are the expert committees (FA). They are respectively assigned to a given department and as a result have a clearly defined thematic orientation. The functions of the expert committees are defined clearly: They are the interfaces assimilating the knowledge from enterprise, industry, trade and workmanship from the research centres, from the research association itself and from DVS. Each of them contribute their own individual specialist knowledge to the work of the expert committees, something that means that practically oriented research projects and results can be guaranteed from the outset. This is because it is the task of the expert committees to derive research requirements within their respective specialist department and to communicate the results of the respective research. Therefore, the expert committees of the research association of DVS are also involved in all phases of a given research project. They initiate and plan the projects, guide and control their implementation and finally evaluate the results.



Expert Committees of the Research Association of DVS

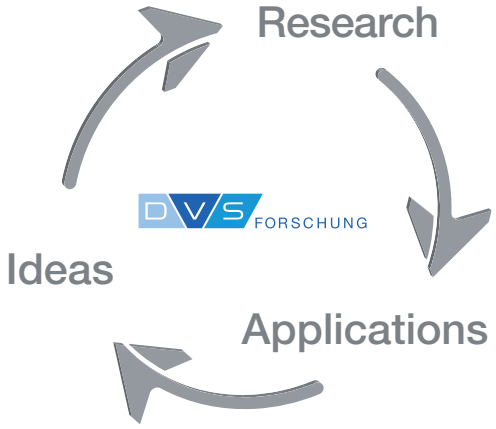


EB-welding with two weld pools (PTR-Präzisionstechnik GmbH)

Cooperative industrial research

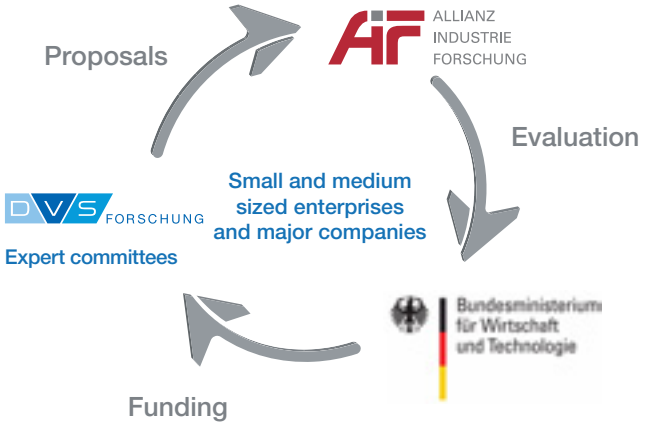
The core activity of the Research Association is the Cooperative Industrial Research (IGF), which orients itself above all on the interests of small to medium-sized enterprises from the joining technology industry which frequently lack the means for own research activities. Via the IGF, these it is possible to intercept these disadvantages that exist for structural reasons and to convert them into real competitive advantages because IGF combines the aspects of minimised economic risk with major research potential.

Core competence of the IGF is the close integration of theory and practice: Requirements that are formulated directly from operational practice form the basis for the research activities. In view of joining-related research, these requirements are announced within the individual expert committees of the research association. In the second step, the research priorities will be derived from this and these will be subsequently investigated by different research institutes in the form of research projects. Owing to the permanent communication with the expert committees and the active cooperation of enterprises going along with it during all the various phases, the aspect of a practically oriented research project always remains guaranteed. In addition, the cooperation of enterprises with the IGF gives rise to a swift knowledge transfer and hence also a parallelism of research and results exploitation. This is because the enterprises can investigate the initial results from the research directly for their practical usefulness and report their findings from this back to the research centres.



Research from practice for practical use:
The principle of the cooperative industrial research

The funding of the research projects takes place via the AiF – Federation of Industrial Research Associations „Otto von Guericke“ e. V. from funds provided by the Federal Ministry of Economic Affairs and Technology (BMWi).



Partners and implementation of the Cooperative Industrial Research

In this context, too, the expert committees of the research association assume important functions for they are the ones to decide which research projects are important for the joining industry and, hence, should be recommended for implementation. These research requirements are finally evaluated by a professional appraiser process of the AiF and, in the event of a positive decision, are recommended to the BMWi for implementation.

Given the complex processes within joining-based cooperative research, the interface functions of the expert committees within the research association manifest in a variety of ways. The way in which these expert committees perform their tasks, however, can be summarized under one umbrella heading: „Research from practice for practical use“.

For more information and updates on the work of the Research Association on Welding and Allied Processes e. V. of DVS, please see: www.dvs-forschung.de

Expert Committee 6 “Beam Welding Processes”

An open communication between enterprise and research institutes characterises the working method in the Expert Committee 6 “Beam Welding Processes” as a committed pool of ideas for research and application. Something else that is very intense is the process of knowledge sharing between the Expert Committee 6 and the topically related Expert Committee 13 “Additive Manufacturing – Rapid Technology”, as well as the Working Groups V 9.1 “Electron Beam Welding” and V 9.2 “Laser Beam Welding and Allied Processes”. Synergetic effects are created through intensive collaboration for research and technological development on the subject of “Beam Processes”.

In many industrial sectors, beam technology has become an integral part of joining technology. The tasks of the “Beam Processes” expert committee are to evaluate newly developed and/or refined beam welding processes, taking into account aspects relating to application technology, and to accelerate the transfer of process innovations to small and medium-sized enterprises (SMEs), by means of supporting research activities. In this respect, special emphasis is placed not only on the development of processes, but also on their simulation.

The experience gathered in recent years shows that improvements in handling, aids for simplification and process or application-specific optimisation measures for installation components, e.g. improved beam manipulation and output systems or processing lenses, frequently very quickly already lead to results which can be implemented in small and medium-sized enterprises.

One important way of helping SMEs is to indicate sensible process and application limits within the framework of projects.

Apart from the process technology, consideration must be given to the particular behaviour of the materials during processing by means of beam technology with little heat at high cooling rates. For this purpose, the peculiarities of so-called short-time metallurgy are taken into account, as are the mechanical-technological material properties caused by this.

Even at an early development stage, new developments in “electron beam” technology, as well as material developments, should already be accompanied by fundamental and/or technological investigations.

Current research fields are as follows:

- Mobile vacuum systems (under reduced pressure)
- Influence on deformation and load bearing behaviour and the structure of beam welded joints
- Reduction of imperfections in aluminium thick sheet metal by alloying control using filler material

Integration of an EB-machine in a fully automatic production cell for welding of switch wheels at VW (PTR-Präzisionstechnik GmbH)

How applied research works – an example

Research subject:

"Application of multi-beam technology to reduce the residual stresses in EB and LB welded components"

Research centres:

Prof. Dr.-Ing. M. Rethmeier, Department 9.3 "Welding technology production processes", Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin

Prof. Dr.-Ing. U. Reisgen, Institute of welding technology and joining technology (ISF), RWTH Aachen University

Runtime: 01.07.2009 - 30.06.2011

IGF-No.: 16.139 N / **DVS-No.:** 6.069

Starting situation:

With the welding of metallic materials, residual stresses arise, resulting from local thermal expansion and contraction of the material. In particular, the high tensile stresses are an undesirable consequence of welding, since they can severely adversely affect the mechanical properties of the material locally. The residual stresses can overlap with the allowed nominal stress and thus lead to the premature failure of the component, especially in cases when the structures are subjected to vibratory and highly corrosive stress.

Particularly in the manufacturing of safety-related components, the costs of the control and minimisation of residual stresses can be very high. Examples of this are valves in the power station area, or also parts of gas turbines in the aviation industry.

Objective:

In addition to their flexibility, the modern beam processes, such as laser welding and electron beam welding, allow a reduced or a precisely dosed (defined) heat input that plays an important role precisely when it is a matter of welding special materials. Through this, thermal distortion or residual stresses can be reduced in the components in comparison to customary welding processes. In addition, beam processes offer the possibility of a process-integrated local heat treatment that can also be used, among other things, for the reduction of residual stresses in the weld seam that is susceptible to failure. Here, fast beam guidance (beam focusing and positioning), which has made great progress in recent years, has great potential.

With a series of FEM simulations and experimental studies on ferritic and austenitic steels, a residual stress reduction process for high longitudinal tensile stresses in the beam weld seams is being qualified and quantified for the users. This process, which has been tested with electron beam processes as well as with laser beam processes, uses the welding beam in a defocused form for heating and generation of tensile stress areas of certain material zones beside the weld seam. For this procedure, a variety of suitable process parameters can be set. The results of the research are meant to provide the user with recommendations for the selection of the process parameters and the respective application purpose (material, component geometry, possibilities of the beam system).

Findings:

With the defocused electron and/or laser beam, it is possible to substantially reduce the high longitudinal residual stresses in beam weld seams. If one uses the defocused beam for heating of the material beside the weld seam to the temperature range that, material-specific, has a high yield strength gradient (reduction of the yield strength with rising temperature), the compressive stresses generated in these areas are able to release through minor dimensional deformations. During cooling and the thermal shrinkage of these heat-treated zones, the material is compressed between the weld seam and the heat-treated areas. The result of this compression is the reduction of the resistor of the material bordering on the weld seam, which resisted the thermal shrinking of the weld seam while cooling down and thus led to the high residual stresses in the weld seam (Fig. 1). Consequently, this tension release is made possible through a mechanical relief effect.

This process therefore offers an efficient alternative to the reduction of the high levels of longitudinal stresses in beam weld seams. Because this process can be applied even long after the welding process is over, it also works as a tool for quality, as well as service life increase, within the scope of component maintenance works on not yet post-treated beam weld seams.

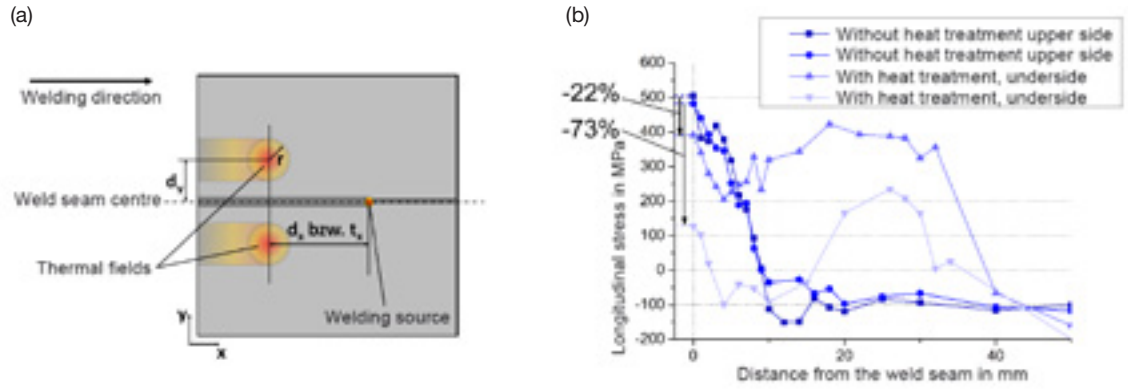


Fig. 1: Process diagram with the geometrical process parameters r, d_y and d_x and/or t_x (Fig. 1a) as well as experimentally measured longitudinal stress profiles on the top side and underside of a welded and a welded and thermally post-treated S355J2+N- test body (Fig. 1b)

References from industry

Dr. Klaus-Rainer Schulze, Schulze-Consulting, Neuberg:
In this project, with great care and range, and by means of numerical modelling as well as with experiments, an approach was pursued that - though being obvious - had however not yet been quantitatively investigated up to now, being to influence, through an additional heat input, the inherent stresses introduced during beam welding in such a manner that the joint can tolerate higher loads. This approach and the positive result demonstrate the great usefulness of basic research for practical application. Of course, the transfer to specific components requires a special investigation in each case since the specific material and the boundary conditions will have a strong influence.

Something that has to be emphasised is the - at first astonishing - finding from the project that it is not mandatory for the heat treatment to be carried out in situ but that an optimum stress releasing will manifest even with cooled down samples. Interesting is also the fact that, with 5 mm of metal sheet thickness and superficial, non-melting heating, a clear residual stress reduction can also be achieved at the metal sheet underside.

DVS Research seminar 2014 – “Electron beam welding as a tool for joining technology”

The primary objective of the research seminar is to highlight research requirements with the electron beam relative to joining technology. In preparation for the DVS research seminar, a study is therefore being conducted by the University of Kassel, Department of Mechanical Engineering, Institute for Production Engineering and Logistics, Department of Cutting and Joining Production Processes. In this study, besides the description of the current state of the art, a status description and a requirements analysis for research topics are also presented in addition, based on information gained from surveys among representatives of science and industry.

The findings of the study will be published in time for the DVS Research seminar in DVS Reports volume no. 299 and serve as a basis for discussion, as well as a reference for future research projects

The DVS Research seminar 2014 will take place on 20. Februar 2014 in the SLV Halle, Germany. All interested people from science and industry are very welcome.

IEBW – International Electron Beam Welding Conference

As a collaborative project between the AWS – American Welding Society, IIW – International Institute of Welding and DVS, the International Electron Beam Welding Conference (IEBW) on electron beam welding is organised every three years. The conference currently takes place alternately, either in the USA or in Germany and/or Europe.

Overall, the conference can measure its success on increasing visitor numbers and experts from 14 different countries. The conference is especially advantageous for young engineers as they can go there to gather information about possible applications of the electron beam.

After the first IEBW in November, 2009 in Chicago IL, USA, the second IEBW was held in March, 2012 in Aachen.

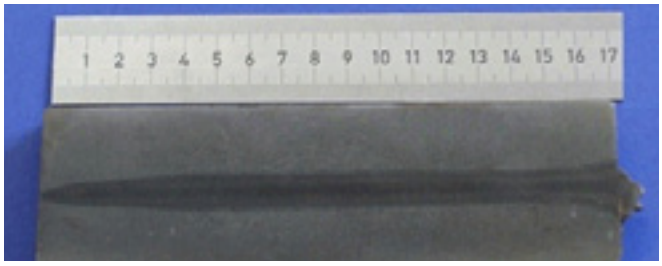
The third IEBW is already planned for November, 2015 and then will take place again in Chicago IL, USA.

Examples and areas of application of electron beam welding

The electron beam offers diverse application possibilities. These include not only the joining of metallic materials by means of welding, but also, just as much, the treatment and hardening of surfaces or electron beam drilling as well.

The main areas of application are as follows:

- Automotive engineering
- Mechanical engineering
- Medical technology
- Aeronautics and Aviation
- Power engineering
- Vacuum technology



Single-layer deep-penetration welding in steel

Welding

Electron beam (EB) welding in a vacuum offers a number of advantages since the high power density of the electron beam permits welds which are narrower than the average, heat-affected zones, with tight limits and without any temper colours, great welding depths and high welding speeds. The exact reproducibility of the welds gives the user the guarantee of constant quality.

High welding speed

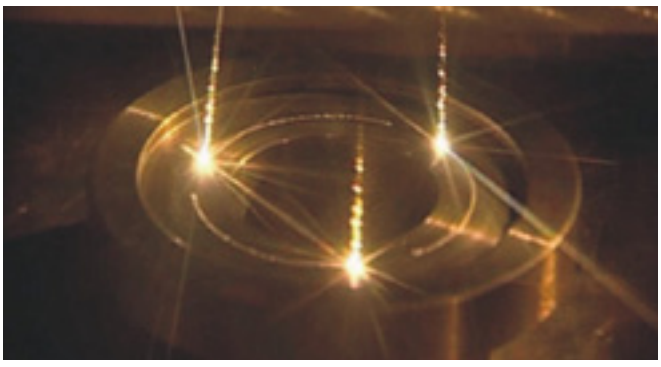
- in the case of thin foils, up to 60 m/min (1,000 mm/s)
- typical welding speeds between 10 mm/s and 100 mm/s for weld-penetration depths between 20 mm and 2 mm; steel plate with a thickness of 200 mm can be welded in a single pass with a feed of 1.25 mm/s (13.3 minutes for a weld length of one metre)

It is also possible to carry out “simultaneous” welding at several points on a suitable workpiece. In this respect, the quick deflection system guides the beam from one welding position to the next within fractions of a second, and the beam continues the welding there before the vapour cavity collapses at this point. The workpiece can also be preheated parallel to the welding.

Maximum productivity due to multipool technique

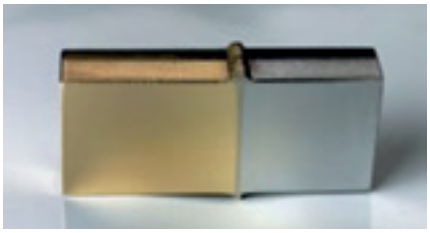
- up to ten weld seams produced simultaneously
- minimised distortion due to low energy per unit length
- welding time reduced by two thirds
- no need for expensive clamping technology or tackwelds

Three-pool technology for welding a switch wheel



Deep-penetration welding

- especially slender, deep welds
- almost all material combinations possible



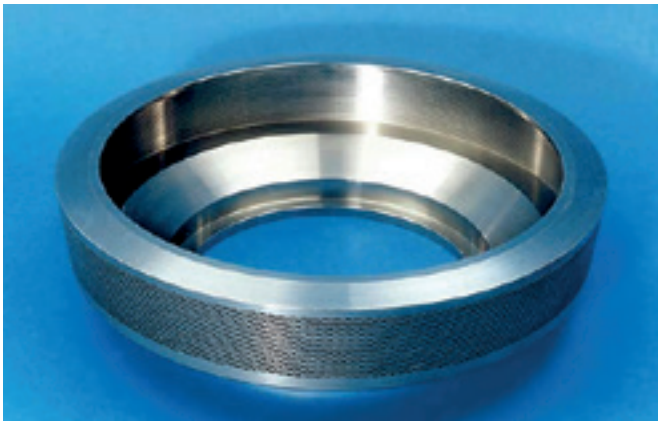
Bronze/Steel material combination (30 mm)

Drilling

When a laser beam is utilised as a drilling tool, it needs several energy pulses per hole in order to penetrate into the depth of the material to be drilled. In contrast, one hole can be produced per beam pulse with the electron beam. For machining purposes, in this case the workpiece is inserted into a vacuum chamber and is perforated with short, much bundled electron pulses with a high performance. The strengths are to be found wherever conventional methods have reached their limits or have become extremely slow.

Strengths of EB drilling

- great economic efficiency with high numbers of holes
- production of screens with very small hole diameters
- very deep bores, large grid ratio (hole diameter to material thickness)
- drilling of tough or hard materials (e.g. cobalt, tantalum, titanium)



Spinning head for the production of glass fibres (EB Drilling)

Hardening, annealing and optimisation of material properties

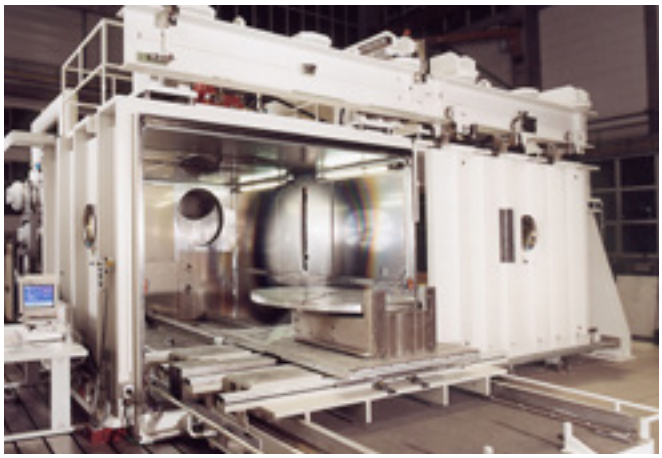
A thermal treatment with the electron beam may influence the structure and certain material properties of peripheral layers of metallic materials. Through targeted heating, it is possible to alter not only the type, distribution and quantity proportions of phases but also residual stress states of materials. In the case of electron beam hardening and annealing, energy is transferred to the material surface on an area of up to 100 mm x 100 mm and is processed in a track shape.

Areas of application of electron beam welding

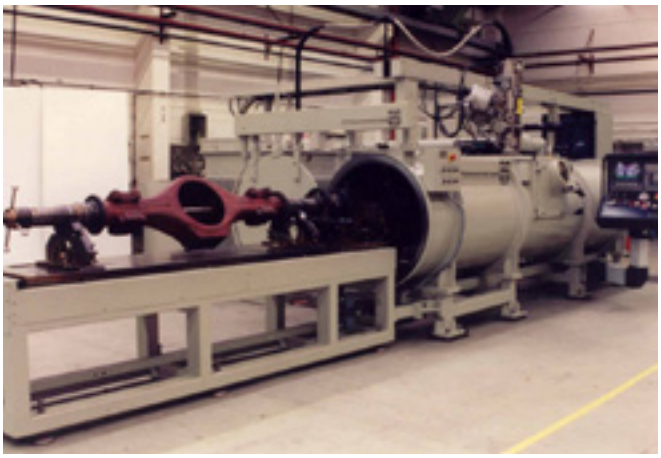
Machine types for electron beam welding range from large-chamber machine, with chamber sizes of more than 600 m^3, right down to small machine for microsystems engineering.

For special tasks, custom-built machine are also designed according to the requirements.

The great advantages of production facilities, such as, for example, continuous flow systems, lock cycle machine etc., are to be found in the fact that the machine-bound non-productive times are minimised due to the specialisation and that the economic benefits of electron beam technology are thus exploited to the full.



The main area of application of chamber machines is the individual machining of larger workpieces with complex weld seam geometries (Steigerwald Strahltechnik GmbH)



Custom-built machine for the welding of truck axles (PTR-Präzisionstechnik GmbH)

Small machine for microsystems engineering (Focus GmbH)

Lock cycle machine (pro-beam)

Technology at DVS

Technical Committee

In view of currently more than 250 different joining processes, whose numbers continue to increase, the technical-scientific cooperative work of DVS can and must be done systematically. Guarantor for this is the Technical Committee (AfT) with its more than 200 subject-oriented working bodies. The AfT unites more than 2,000 specialists from the economic and scientific fields, from authorities and from other areas, that are work together to capture the state of the art and continuously advance it.
The fact that DVS, with this bundled up specialist knowledge, is also recognized in international circles as a sovereign and competent partner in all questions relating to joining technology is obvious. Through its involvement in the International Institute of Welding (IIW) and the EWF - European Federation for Welding Joining and Cutting, DVS decisively supports the international joining technology network in its activities.

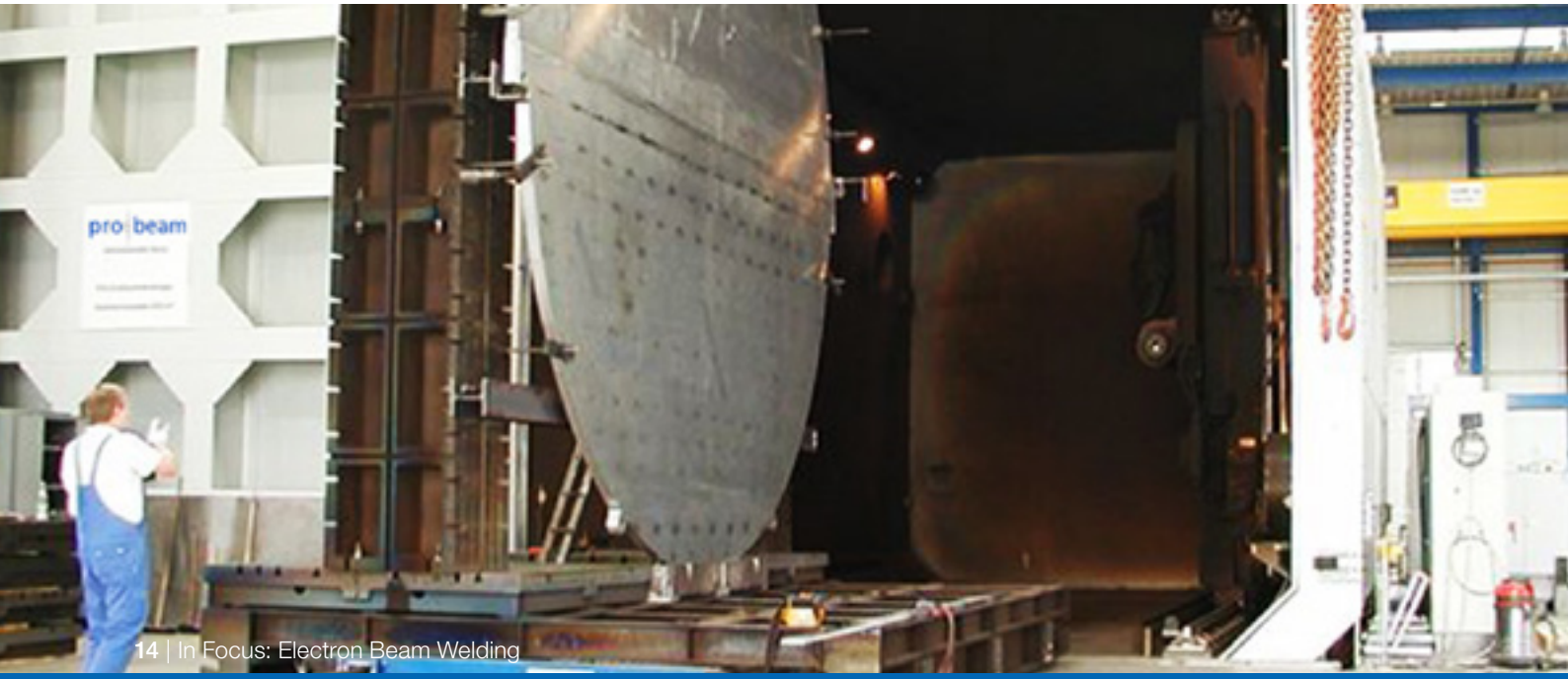
International partners of DVS:

DIN	German Institute for Standardization
CEN	European Standards Committee
ISO	International Standards Organisation
IIW	International Institute of Welding
DIBt	German Institute for Structural Engineering
VdTÜV	Federation of the Technical Inspection Associations
DVGW	German Association of the Gas and Water Industry
AGFW	Association for District Heating
AWS	American Welding Association
NIL	Dutch Welding Association
EWF	European Federation for Welding, Joining and Cutting

The work results in the AfT are published as DVS Technical Bulletins and DVS Technical Codes. Besides, a close collaboration with other rule-making national and international institutions like the German Institute for Standardization, the CEN or others (see table) further ensures that the contents of DVS Technical Bulletins and DVS Technical Codes are sensibly coordinated with the rules and regulations of the other institutions.

DVS members benefit from free access to the German-version set of rules of DVS at www.dvs-regelwerk.de.
All DVS Technical Bulletins and DVS Technical Codes of the association are retrievable there in electronic form.

Large-chamber machine (pro-beam)



Structure of the Technical Committee

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 management for welding	**AG Q 4*** Testing of welds	**AG Q 5*** Demands on welding 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 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)
** Joint Working Group with other Societies, ***SEMFIRA = Safety in ElectroMagnetic Fields, EMF = ElectroMagnetic Fields.

Working Group AG V 9.1 “Electron Beam Welding”

Issuing recommendations and defining action points, as well as describing the state of the art this task is performed by the experts from industry, by machinery manufacturers and research institutes in the Community Committee DVS/DIN AG V 9.1 / 092-00-15 AA „Electron Beam Welding“. They develop DVS Technical Bulletins and Technical Codes, national and international standards and thus offer the users the opportunity to take advantage of their wide range of experience. Instructions, rules and regulations on the use of electron beam welding, with special consideration of its unique features, are at the forefront of the expert activity.

The potential for material machining with the electron beam in high and fine vacuum and in atmosphere are presented. Here, recent developments such as new machine designs, beam deflection and quality assurance are all included in new editions or revisions of regulatory frameworks. Additional fields of work include the continuous updating of terminology for electron beam welding, the development of rules for acceptance testing of electron beam processing machines and quality assurance in the electron beam technology sector.

In fields where the comparison of the electron beam and the laser beam is sensible, or where one topic concerns both beam techniques, the Working Groups DVS AG V 9.1 and DVS AG V 9.2 “Laser Beam Welding and Allied Processes” collaborate closely with each other.

Although the electron beam has already been established in the industry for decades, and is being used unrivalled in many fields, its potential applications are not widely known to the general public. The DVS AG V 9.1 is therefore also working to achieve more exposure for the electron beam and to increase knowledge about the electron beam in initial vocational training in industry, during studies (universities, and universities of applied sciences) and professional further training at DVS training bodies.

Every day, joining technology experts are confronted with new challenges in the fields of research, development and industrial production. New materials always require new solutions.
The electron beam provides excellent benefits for this in a wide variety of technical application areas. The DVS AG V 9.1 „Electron beam welding“, as the expert committee in Germany, has set itself the task of supporting the development of the electron beam with practical guides, recommendations and regulatory frameworks, and of making these accessible to a wide circle of specialists.

DVS Technical Bulletins and Codes in in English!

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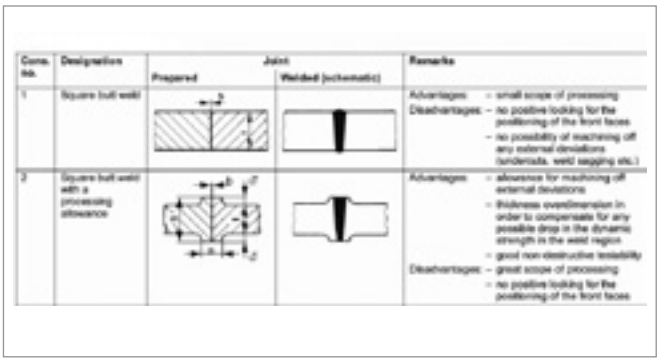
There are a huge number of DVS technical bulletins that were compiled by the DVS AG V 9.1. Until now, these were only available in German. Now, the most important technical bulletins have been selected for making them available in English to international experts around the world. The DVS Technical Bulletins and Codes deal with the following subjects: weldability of metallic materials, surface layer hardening, protection against X-ray radiation, recommendations for cleaning the joint zone, test procedures for quality assurance, wedge test for verification of electron beam weld seams and principles for designing components and the use of electron beam welding in atmosphere.

The practical relevance of the DVS set of rules – two examples

Technical Bulletin DVS 3201 “Fundamental principles for designing components for electron beam welding in fine and high vacuums”

With this technical bulletin, instructions should be given to the designer how the various possibilities of the electron beam (EB) welding process can be used advantageously in vacuum and what production engineering requirements must be complied with for this. Recommendations and design examples were selected that are of general validity for many industrial sectors.

In extracts, Table 1 is shown.



Conn. no.	Designation	Joint: Prepared	Joint: Welded (schematic)	Remarks
1	Square butt weld			Advantages: – small scope of processing Disadvantages: – no positive locking for the positioning of the front faces – no possibility of machining off any external deviations (undercuts, weld sagging etc.)
2	Square butt weld with a processing allowance			Advantages: – allowance for machining off external deviations – thickness overdimension in order to compensate for any possible drop in the dynamic strength in the weld region – good non-destructive testability Disadvantages: – great scope of processing – no positive locking for the positioning of the front faces

Table 1: Examples of weld types

DVS Technical Bulletin 3204 “Electron beam weldability of metallic materials”

The suitability of a given material for welding cannot be evaluated based on material parameters alone and must be determined in many cases by means of welding tests. This is particularly true for electron beam weldability, as a number of materials are known that are not suitable for other welding processes, but can be welded with the electron beam. In addition, it is difficult to formulate the weldability clearly, for example, in the form of a yes/no statement. As is the case for other welding processes, too, the suitability of a material for the electron beam welding process is also dependent on the type of process engineering and equipment complexity required (e.g. type, number and adjustability of welding parameters). Therefore, in this technical bulletin, the weldability of individual materials is broken down into three levels, according to the type of process engineering and equipment complexity required (Table 2):

A = weldable without any particular measures

B = weldable with particular measures
(Preheating and/or pastheating, filler materials or similar)

C = limited weldability

Material no. DIN	Material no. Material performance sheets	Designation	Weldability	Tested weld depth [mm]
3.7025	3.7024	Ti 1	A	50
3.7035	3.7034	Ti 2	A	50
3.7055		Ti 3	A	50
3.7065	3.7064	Ti 4	A	50
3.7105		TiNi 0.8 Mo 0.8	A	50
3.7115	3.7114	TiAl 5 Sn 2.5	A	25
	3.7124	TiCu 2	A	25
	3.7134	TiAl 8 Mo 1 V 1	A	50
	3.7144	TiAl 6 Zr4 Mo2 Sn 2	B	25
3.7145	3.7148	TiAl 6 Zr4 Mo 2 Sn 2 Si	B	25
3.7155	3.7154	TiAl 6 Zr 5 Mo 0.5 Si	B	25
3.7165	3.7164	TiAl 6 V 4	A	50
3.7175	3.7174	TiAl 6 V 6 Sn 2	B	25
3.7185	3.7184	TiAl 4 Mo 4 Sn 2	C	–
3.7195	3.7194	TiAl 3 V 2.5	A	50
3.7225		Ti 1 Pd	A	50
3.7235		Ti 2 Pd	A	50
3.7255		Ti 3 Pd	A	50

Table 2: Electron beam weldability of titanium materials

Furthermore, the tables listed contain information regarding what thickness range the information concerning weldability relates to and they also provide the connection to the corresponding material numbers and designations.

Education at DVS

Education Committee

The Education Committee (AfB) initiates measures to adapt the education and certification offering of DVS to present developments and to prepare for future requirements. At the same time, the AfB acts as a guidance committee for the Personnel Certification Body DVS-PersZert and its activities. In this respect, the AfB assumes the role of a Strategy Committee. In this, it is being supported by the Working Group “Education, training and examination” (AG SP).

The Working Group “Education, training and examination” assumes - in the “Education and Certification” area -the task of creating uniform training and testing material as part of the qualification of joining experts and managers. Thereby, national, but also current European and International requirements of the EWF – European Federation for Welding, Joining Cutting or the International Institute for Welding (IIW) are implemented in the training and testing standards.

Because the AG SP equally considers the interests of industry and trade in its work, the needs of industry are directly reflected in the compiled DVS-Guidelines. The area of responsibility of the AG SP encompasses the development of the specific syllabuses and curriculums for joining-related education and training, in addition, however, also all other areas that are associated with the field of Training and Examination. The fact that these training and testing standards are ultimately truly complied with all over the country, and are actually also being implemented, is something that is ensured by the Personnel Certification Body of DVS, DVS-PersZert.

In order to guarantee the transfer of the latest findings in laser welding technology and electron beam welding technology into methodical-didactic educational concepts, Expert Committee 4.7 “Training for beam welding” continuously works on new training guidelines and adjusts this work to the respective needs of the industry. For instance, the first advanced training course for electron beam welding was created, to prepare engineers, technologists and specialists for the application of the electron beam.

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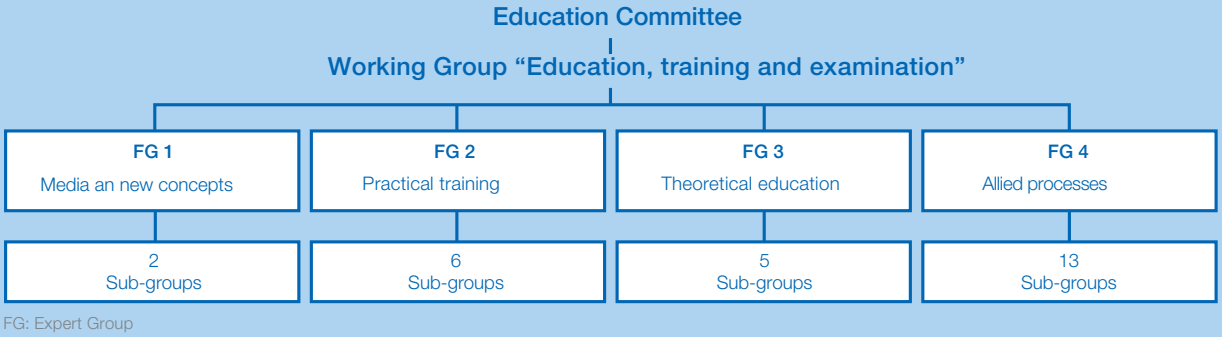
The latest training and further education offers can be found at: www.bildungskatalog.de

Photo: Fotolia

Structure of the Education Committee



FG: Expert Group

Training and career paths in the field of electron beam welding

Guideline DVS 1199 “DVS course relating to training and further education for electron beam welding in stages for engineers, technologists and specialists”

This course offers fundamental training in electron beam welding technology, the prerequisite for people in monitoring, operations planning and scheduling, design, training, machine operation, maintenance, technical sales and customer support. Here, besides theoretical knowledge, practical skills are also taught on the electron beam machine, and these are finally tested.

The theoretical part of the education deals with the following topics:

- Electron beam welding process and machines (e.g. beam generation, safety, welding machines and devices, welding parameters, weld seam quality)
- Materials and their behaviour during welding, (e.g. weldability of metallic materials, heat treatment, beam deflection, strength and corrosion properties)
- Process-specific design (e.g. welding-oriented design, distortion, welding with filler material)
- Manufacturing and applications (z.B. preparation of the workpiece, beam control, production examples, checking of parameters, creating welding procedure specifications, testing and evaluation, welding procedure test, quality assurance, costs, regulatory framework)

The practical training is divided into the following areas:

- Basic practical skills
- Testing of samples, creating documentation

Trade media and teaching materials for electron beam welding

DVS Media GmbH

When it comes to publications and press relating to all aspects of the subject of joining, cutting and coating, DVS Media GmbH is the right place to go. The programme of the publishing house includes German and foreign language trade journals, specialist books, teaching media, technical bulletins and guidelines, videos and software. The products of DVS Media GmbH reflect all fields of activity of the DVS Association and all findings that have been worked out there.

Numerous professional media of DVS Media GmbH devote themselves to the work results that have originated in the areas of research, technology and education in connection with the electron beam welding: This includes Specialist books and trade journals, as well as training materials and set of rules, available individually or collected as a paperback.

How to get DVS Technical Bulletins and DVS Technical Codes

DVS members have free access to all DVS Technical Codes and DVS Technical Bulletins at www.dvs-regelwerk.de. Non-DVS members can order the DVS set of rules under www.dvs-media.info

Photo: istockphoto

Publications on electron beam welding

DVS Reports Volume 285
International Electron Beam Welding (IEBW) Conference

The International Electron Beam Welding Conference, IEBW 2012, offers a forum at which users and manufacturers of electron beam welding an processing technology can meet with R&D specialists to share their experience an learn about the latest developments in the field. This publication contains the lectures of the 2nd IEBW Conference taking place in Aachen in March 2012.

2012, 160 pages, paperback in English
ISBN: 978-3-87155-299-1

compact knowledge
Electron beam technologies

This book deals with the key relationships for the use of electron beam technology for material processing. It clarifies the scientific-technical principles of electron beam technology, the functionality of different machine systems and the chances of this versatile technology in a generally understandable way. It helps reducing information deficits on electron beam technologies in the area of material processing. Especially for engineers of industry, as well as students specializing in mechanical engineering, production technology, etc. and in particular for the designers - not only for welding experts – this book is an important basis for a broad use of this ultra-modern technology.

1st Edition 2012, 80 pages, paperback in English
ISBN: 978-3-87155-225-0

DVS Technical Codes on Electron Beam Welding

This publication contains a number of technical documents which were approved by DVS Working Group V 9.1 “Electron Beam Welding”. Until today, these technical codes and bulletins have only been available in the German language to support German companies. Now, DVS V 9.1 has selected some for translation into English, i.e. those which are very useful for experts and users worldwide. These documents cover the topics of “weldability of metallic materials”, “case hardening”, “x-ray protection”, “recommendations for the cleaning of the joining zone”, “test procedures for the quality assurance” and “wedge specimen for the verification of electron beam welds” as well as fundamental principles for the “designing of components” and “utilisation of non-vacuum electron beam welding”

1st Edition 2013, 56 pages
ISBN: 978-3-87155-244-1

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Your contact person for Research | Technology | Education

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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.

Laser Beam Welding is your subject?

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

- Because you will learn about important changes in the rules and regulations work first.
- Because you will actively participate in shaping technology fields.
- Because you can experience first-hand technical knowledge transfer.
- Because you can identify trends early on.
- Because you can benefit from important national and international contacts.

Become a part of our network of over **3,000 companies** and **16,000 professionals** who are associated with the joining technology.

Please contact us!

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