



## **ZEISS ZEN 2 core**

Quality Inspection of Weld Connections

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**Welding is the indissoluble connection of components achieved by applying heat and/or pressure, with or without additional or filler metals. [1, 2] In addition to possessing a high seam quality, the main objective of welding work is to guarantee deformation- and stress-free welded joints that can meet the toughest demands. A prerequisite for quality-oriented execution is the consideration of many factors that influence weldability, which can be impacted by the design and manufacturing stresses [3]. Thus, technical design and the stress state of the component in use are the primary factors that determine welding safety. Unalloyed structural steels are technically relatively easy to weld. In contrast, welding high-strength, fine-grain structural steels requires a comprehensive understanding of the material's behavior (freezing, cooling, structural formation) and the welding conditions (preheating, welding speed, etc.). During the welding process, each weld metal primarily solidifies as a cast structure, whereby the formation of the microstructure depends on the welding parameters, the type and size of the weld pool, and the cooling conditions. The welding process can only result in quality-oriented connections if the preparation of the joint, the follow-up, and the inspection of the connection are carried out carefully and with due diligence [4]. Therefore, quality controlling the actual welding process is absolutely essential because of the complexity of the process and the various factors that can influence it. Typical causes of imperfections in welded joints are a lack of manual dexterity, incorrect device settings (parameters), inadequate weld preparation, wrong choice of material, and ineffective heat management. However, environmental conditions such as hydrogen do affect the welding result. Any irregularities and their permissibility are stated and defined in the DIN standards.**

### Introduction

The quality assurance of welded joints requires a qualitative light microscopic assessment, as existing faults after welding – such as hot cracking, cold cracking, micropores, voids, or lack of fusion – are usually only detected through grinding [4]. For this purpose, the geometry, dimensions, and defects in the weld are measured on a metallographic microsection. The microstructure allows conclusions on the welding process and provides the expected strength of the component. The ZEISS software ZEN 2 core enables the routine examination discussed earlier in connection with the welding process to be carried out efficiently and repeatedly. The software routines for the program are self-explanatory and can be automated. Regular quality checks directly after welding must be carried out efficiently in this manner and can be adapted to the investigating weld type.

ZEN 2 core also allows the report tool to save findings as quality reports in previously created templates in MS Word®. The results can thus be reproduced and shown quickly and comparably.

### Free Mode in ZEISS ZEN 2 core: 2D Image Acquisition Using Welds, Best Image Function and Subsequent Interactive Measurement

In free mode, ZEN 2 core software offers various workbenches that allow a high-quality and efficient microscopic analysis of weld structure in just a few steps. The best image function (Best picture; Figure 1) is particularly suitable for the structural analysis of the welds because their contrasting pictorial representation is often difficult to render. Optimal configuration of the light microscope settings is often time-

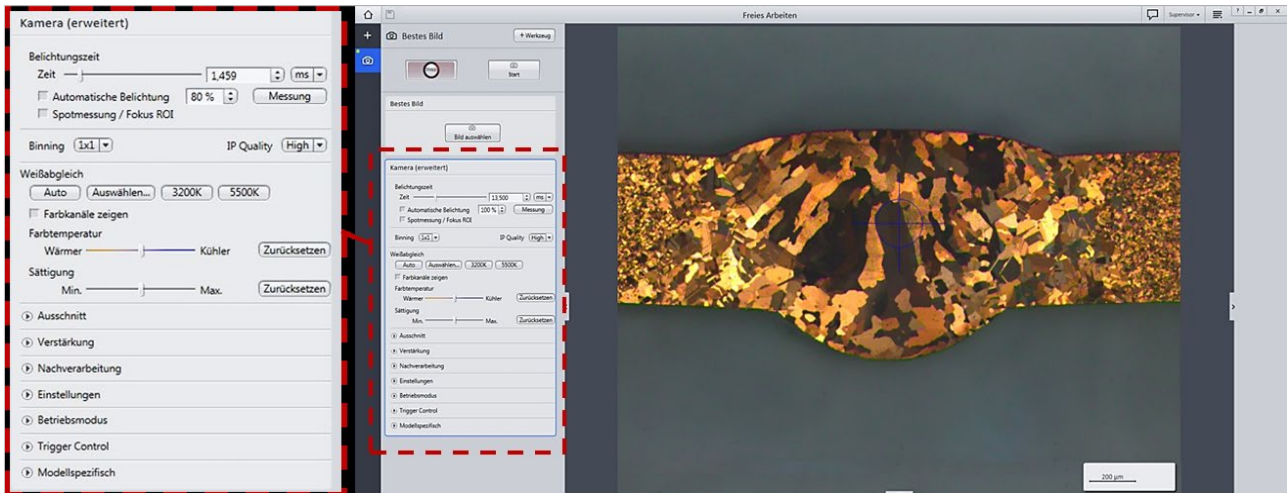


Figure 1 Live mode in the best image workbench

consuming and difficult to implement, especially for users with little experience in microscopy. With the best image function, the user must first adapt an optimized focus and appropriate exposure time in live image view. The best image function will then, depending on the settings for the live image, take eight images whose image acquisition settings will vary in terms of brightness, contrast, and sharpness.

These images are displayed in an image strip (Figure 2) and can be enlarged by clicking on them. The user can click on the "Select image" button to select and store the best image.

DIN EN ISO 5817 for steel, nickel, and titanium or  
DIN EN ISO 10042 for aluminum govern welding inspection

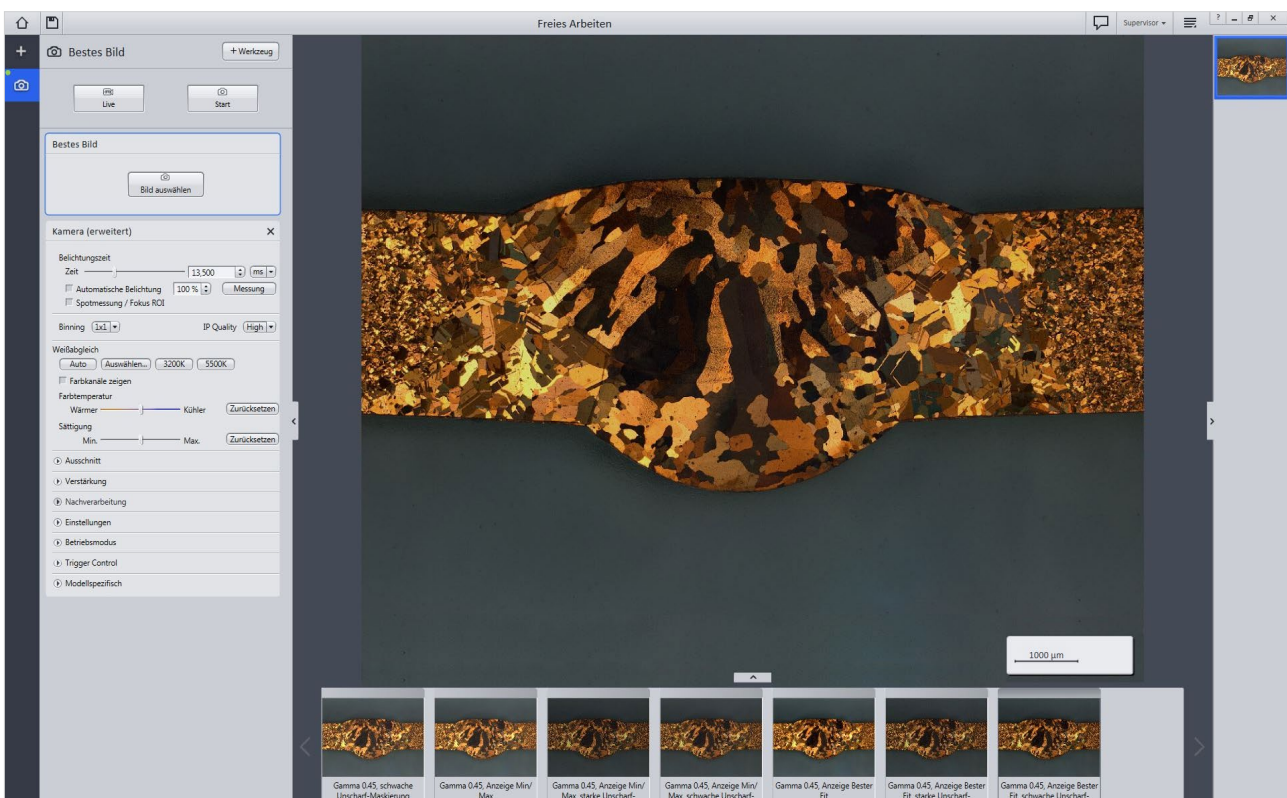


Figure 2 Engineered best image mode – eight pictures taken using different image modes





**Figure 3** Image acquisition with the 2D image acquisition workbench

and evaluation for irregularities in geometry and permissibility. These DIN standards define characteristic, and therefore require weld sizes for different types of weld, and describe the areas to be measured.

Using the 2D image acquisition and interactive measurement workbenches, ZEN 2 core provides a fast, easy, and standardized weld measurement. The camera tool is invoked as a tool in 2D image acquisition. The image settings (exposure, color saturation, etc.) are first set and then the picture is taken after clicking the “Start” button. The scale bar is automatically inserted into the captured image (Figure 3) and matches the magnification used. The interactive measurements workbench can measure the geometric dimensions of the weld seams, which are required for

quality evaluation. It can be used to measure lengths, distances, and angles and draw (auxiliary) lines, contours, and text boxes. The values for the respective measurements are recorded both in the image and in a separate table of measured values.

Various tools are needed in the interactive measurement workbench in order to check the most important dimensions of a weld according to standard (e.g. the A dimension, penetration, gap, etc.). To get the A dimension, a factor that is often measured, an isosceles triangle must be plotted starting from the smallest length of the fillet weld using the lines tool (Figure 4). The height of the triangle gives the A dimension. Penetration depths and widths and the gap dimension can be measured

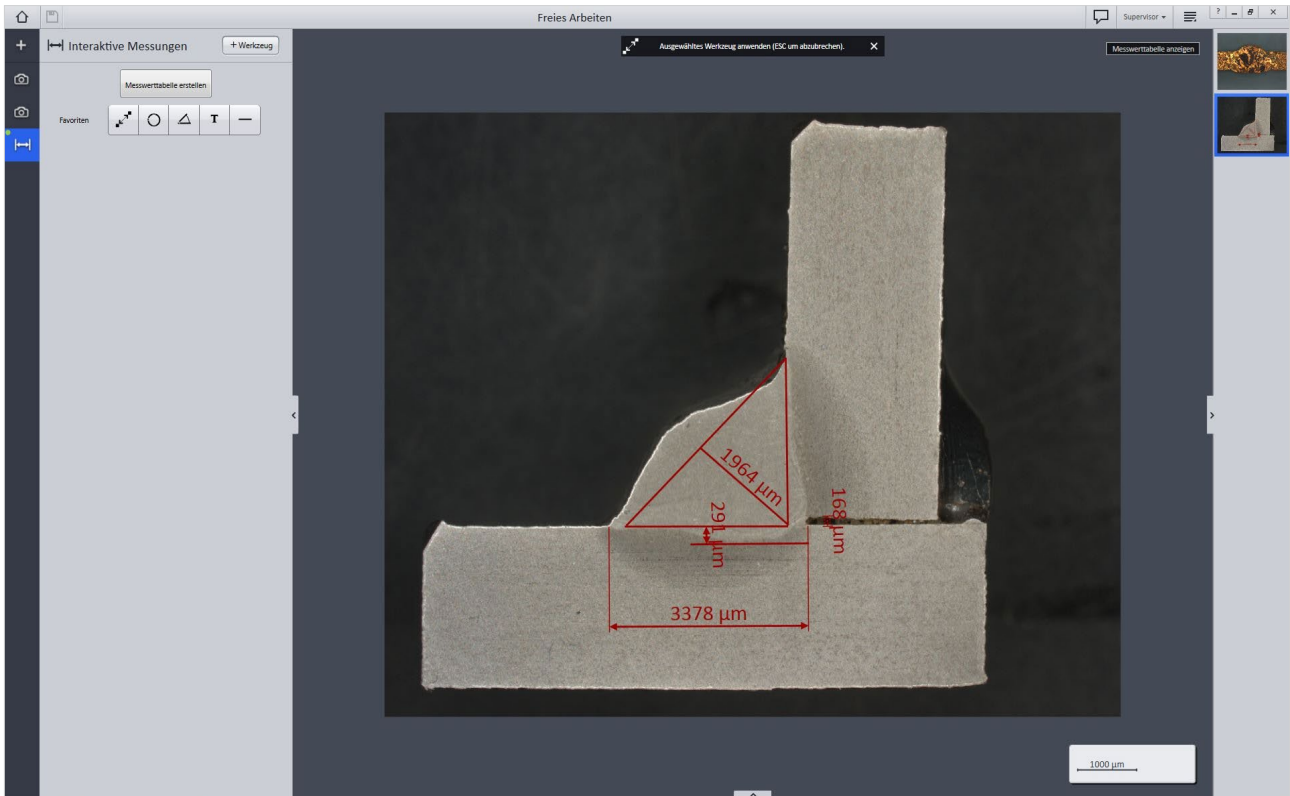


Figure 4 Determining the A dimension, penetration, and gap in a fillet weld (steel)

using the length and distance tool as shown in Figure 5. The measured values and lines can be changed in shape and color. All measurement values are also listed

in the left column (Figure 6, left), and can be summarized in a table by clicking the “Create measuring table” button.

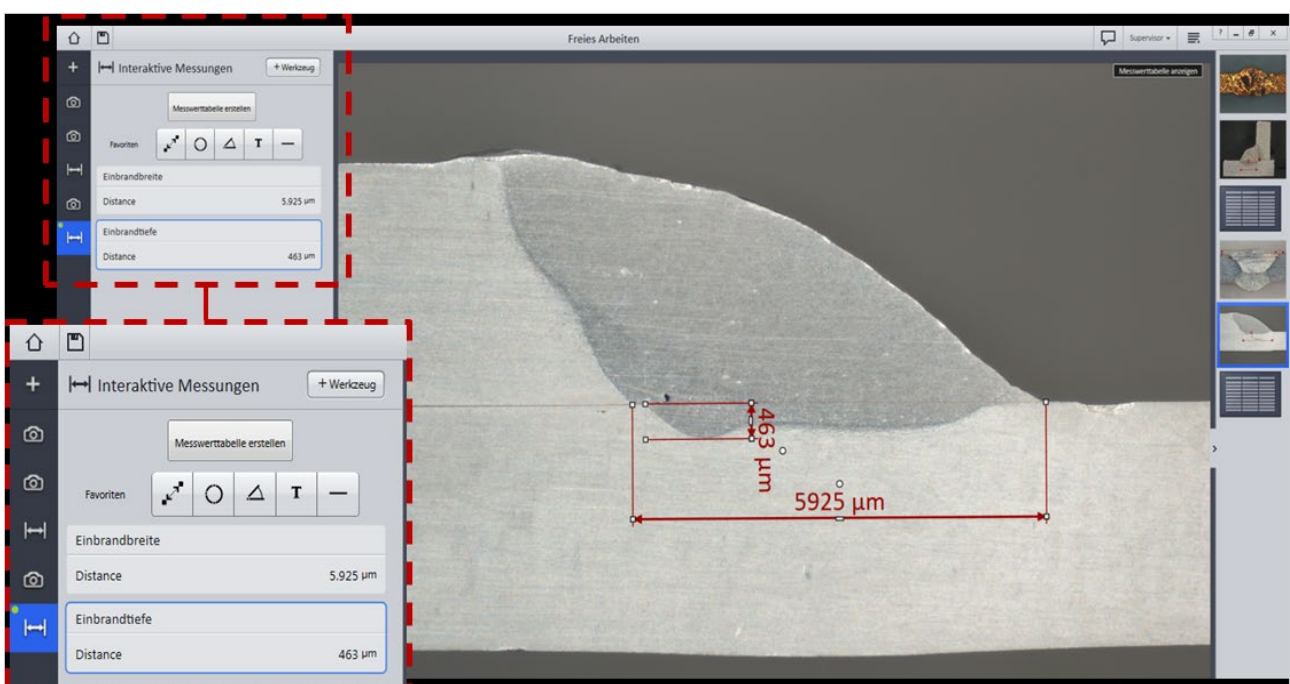
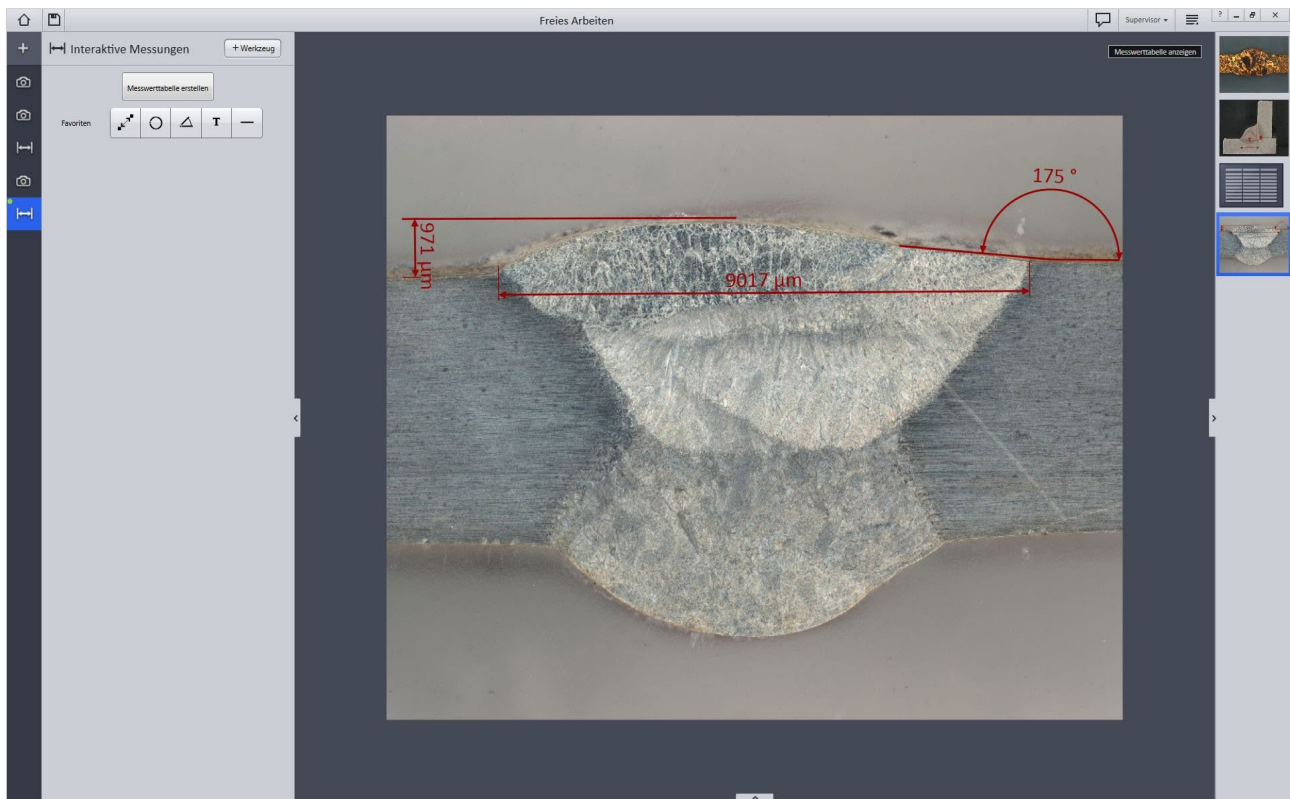


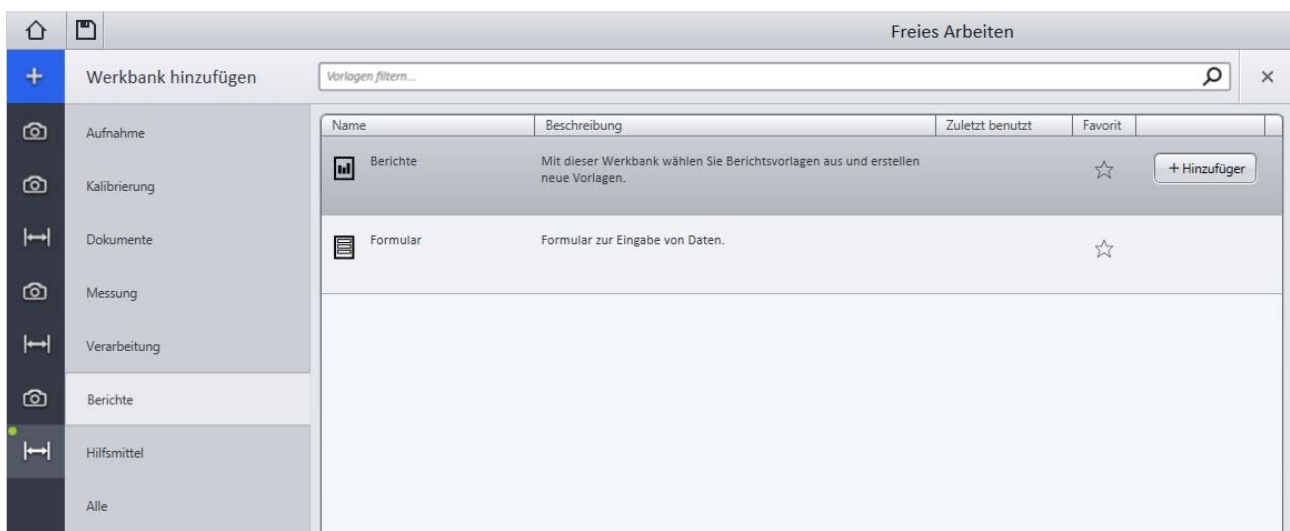
Figure 5 Aluminum welding – measurement of penetration and width



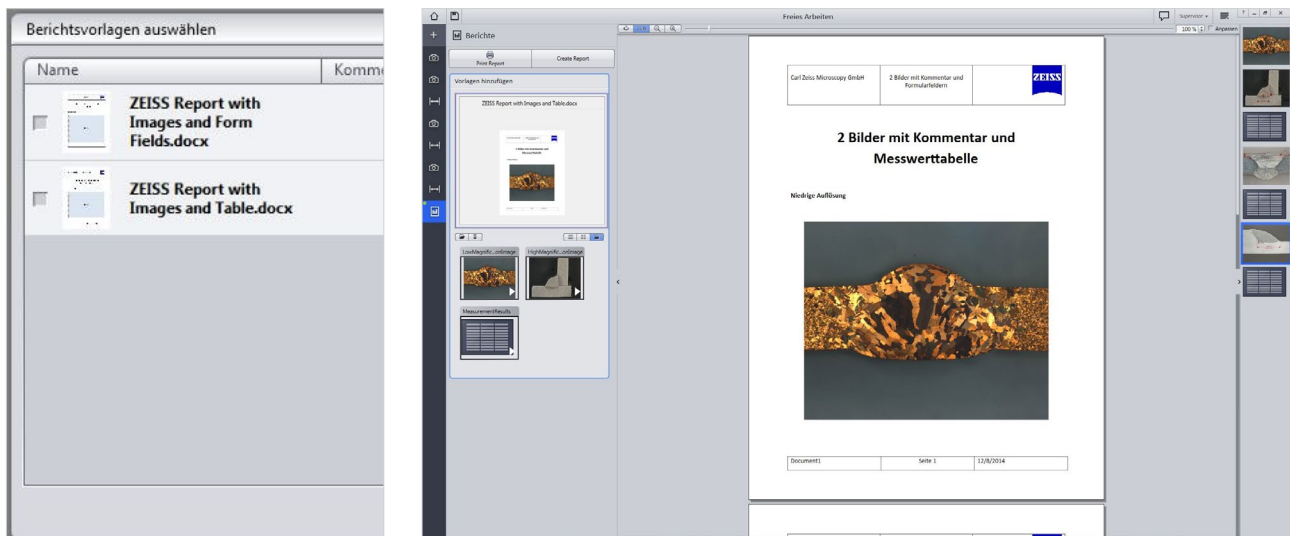
**Figure 6** Root weld seams: measuring seam width and superelevation

Additional image acquisitions and measurements using different settings can be made by adding the two tool benches described (2D image acquisition and interactive measurement). Another example of applying the interactive measurement tool is shown in Figure 7. The length and distance tool

for measuring the width and the superelevation are used as described above after acquiring the image. The same measurement is also applied in the root zone. The angle tool is also used for this measurement; it can measure the weld toe angle.



**Figure 7** Adding the report workbench



**Figure 8** Inserting images and measurement value tables in the report template

ZEN 2 core stores all captured images and generated measurement value tables in free mode in the right taskbar and these can then be included in a report. For this purpose, the report workbench will be added to the menu (Figure 8). The report tool in ZEN 2 core software makes it possible to document findings efficiently in a predefined manner. To do this, the results (grinding images, tables, etc.) are inserted in

predefined templates in MS Word® format (Figure 9, right) and saved. If more than one template is available as an option, the user can select the template that best suits their work (Figure 9, left). If the report template has been filled up with all of the findings, then the “Create report” button can be used to append it to a PDF file and save it.

#### References:

- [1] DIN EN 14610 standard: Welding and allied processes – Definitions of metal welding processes, Trilingual version
- [2] DIN 1910-100 standard: Welding; terms dependent on materials for metal welding
- [3] Klaus-Jürgen Matthes and Erhardt Richter (publishers): Welding technology – welding metallic structural materials, second edition, textbook publisher Leipzig, 2003
- [4] Gaby Ketzner-Raichle: Lecture notes on welding at Aalen University in the Materialography degree program, 2014



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