

INSIGHTS INTO STATE-OF-THE-ART QUALITY CONTROL

Learn how to use the latest metallographic preparation techniques to examine welds

By Dr. Holger Schnarr MSc,
Ph.D Application Specialist,
Struers GmbH



500 μm

WELDS

PREFACE

Quality assurance is a critical process in many industries. It ensures that production delivers according to specifications, and that customers receive products that meet their needs and are free from defects.

Manufacturers are under constant pressure to meet market demands for safety, operational stability, and environmental standards. At the same time, they are constantly looking to improve productivity and reduce costs in order to remain competitive in the global market place. As a result, they need a reliable and efficient quality control process that enables them to effectively measure quality without slowing down production.

This preparation report shows you how to use a state-of-the-art metallographic preparation process to reveal the true structure of a welded component quickly, effectively, and with excellent reliability – so you can check for quality, while maintaining production efficiency.



Dr. Holger Schnarr MSc, Ph.D
Application Specialist, Struers GmbH

THE FIELD OF STUDY

Tremendous advances have been made in joining techniques in recent years. Welds are typically smaller and use multiple materials and more complex component geometries. Materialographic methods have to advance in order to reveal the features of these increasingly complex connections.

Proper metallographic preparation enables you to examine the key quality control parameters of a weld:

- Microstructure
- Weld dimensions
- Weld defects

The objective of this paper is to give you a reproducible preparation method – including cutting, mounting, grinding/polishing and etching – that effectively reveals the key quality control parameters of a weld, without introducing artifacts, such as cracks, reliefs, smearing or pull-outs.



Solution



Cutting:



- Equipment:
- Cut-off wheel:

Labotom-5
30A25

Challenge

To select the appropriate combination of clamping tools for complex component geometries.

Method

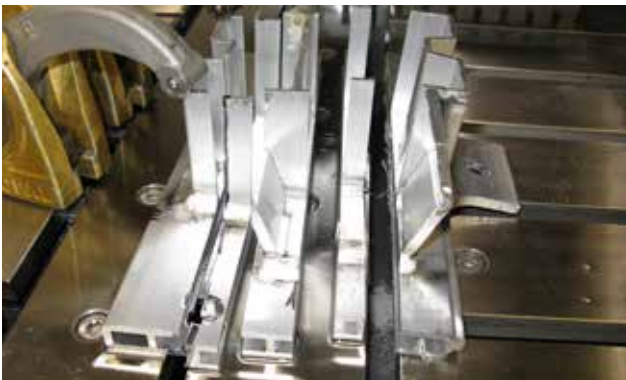
The parts can be clamped with standard clamping tools, such as a vertical clamping device or quick clamping device. When cutting large parts, a Discotom-10/100 or Axitom may be required. Serial cutting on machines with X-table enhances throughput.



1. Large part clamped in an Axitom-5



2. Clamping with a non-pinch clamping device



3. Serial cutting on aluminium welds using a machine with X-table



4. Clamping larger welds

Mounting:



- Equipment: CitoPress-15
- Resin: LevoFast
- Size of mounts: 40mm

There are different ways to mount individual pieces. The mounting technique you choose depends to a large extent on the size and type of weld you are working with. Any diameter is possible; it depends on the size of weld.

Not all pieces need to be mounted, but mounting is recommended as it improves ergonomics and is beneficial when investigating small welds.

Hot or cold mounting

As a general rule, hot mounting is preferable. However, cold mounting is possible when working with epoxies or acrylics. When hot mounting, you should select the resin hardness according to the hardness of the materials.

Large welds

Larger welds do not have to be mounted. They can be ground and polished manually or clamped into a holder.

Small welds

Mounting is recommended when working with smaller welds. Laser welds can often be mounted in smaller diameters.

Grinding/Polishing:



- Equipment: LaboPol-60 with LaboForce-100 and LaboDoser-10
- Disc diameter: 300mm (12")

In most cases, 3 μ m diamond polishing is sufficient. However, fine polishing on a 1 μ m diamond disc or even OP-S polishing is possible.

If better surface quality is required, for example when investigating the microstructure of the weld, additional polishing steps can be carried out.

In order to obtain better surface quality, a semi-automatic system (such as a LaboPol with LaboForce and LaboDoser; a Tegramin; or an AbraPol-30) is recommended.

Step	1	2	3	4
 Disc / Cloth	SiC Foil #220	SiC Foil #1200	MD-Mol	MD-Nap
Speed [rpm]	300	300	150	150
 Suspension			DiaPro Mol 3 μ m	DiaPro Nap B 1 μ m
Pre-dosing	3	3	3	3
Dosing	8	8	8	8
 Lubricant	Water	Water		
Pre-dosing	3	3	3	3
Dosing	8	8	8	8
 Force [N]	50	50	40	20
Single/Holder				
Holder speed	300	300	150	150
 Rotation direction	>>	>>	>>	>>
 Time [min]	2:00	2:00	4:00	3:00
Pause between steps	No	No	No	No



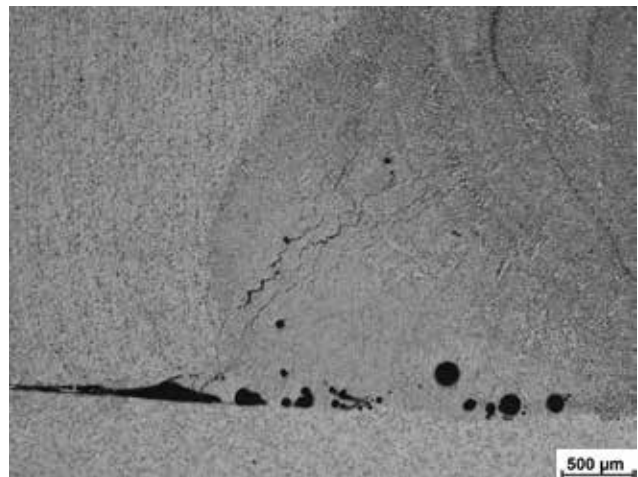
5. Macro-weld etched with nital, ground one step



6. Macro-weld etched with Adler etchant



7. Preparation of weld for microanalysis, polished, etched with nital



8. Aluminium weld, polished, etched with Fuss

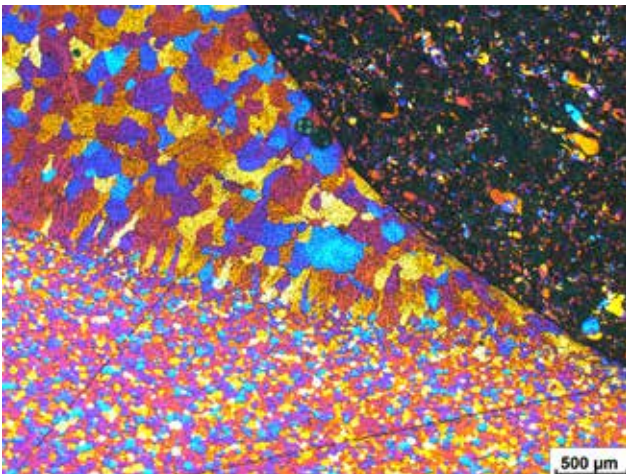
Electrolytical Preparation:



- Equipment: LectroPol-5 A2
- Electrolyte: A2
- Temperature: 15 °C
- Time: 30 seconds
- Mask size: 5 cm²
- Flow rate: 10
- Voltage: 35V

One or two grinding steps are required before electrolytic polishing. These are

- SiC 220
- SiC 1200



9. Aluminium weld, electrolytically etched with Barker's etchant; polarized light



10. Laser weld, electrolytically polished (A2) and etched with oxalic acid (10%)

Electrolytical Etching:



- Equipment: LectroPol-5
- Etchant: 40mL HBF₄ + 760mL H₂O and HBF₄
- Time: 120 seconds
- Voltage: 25V

There are different ways to etch individual pieces. The etching technique you choose depends to a large extent on the type of weld you are working with.

Aluminium welds

For aluminium welds, electrolytic etching with Barker's etchant is recommended. Alternatively, etching with HF-containing acids is possible (Keller, Kroll, Fuss). If macro investigation is demanded, aluminium welds can be etched in sodium hydroxide in water (10%-20%).

Aluminium welds must be investigated in polarized light.

Carbon steel welds

Carbon steels can be etched in nital (1%-5%) for a number of seconds. Electrolytic etching (A2 or A3) is also possible. If macro investigation is demanded for carbon steels for use on SE welds, etching can be done with Adler or nital (5% in water).

External electrolytic etching

When checking corrosion resistant steels, etching can be performed using oxalic acid (10%) or sodium hydroxide in water.

RESULT AND OVERVIEW

This application report gives you an effective and reproducible method for the metallographic preparation of different welded samples.

The method consists of a number of steps. The choice of approach in each step depends on the sample material, sample size and object being investigated.

Step 1: Cutting

Suitable clamping should be used to ensure high quality. Serial machine cutting with X-table can be used to enhance throughput.

Step 2: Mounting

Smaller welds and welds that will undergo semi-automatic grinding/polishing should be mounted in a holder.

Step 3: Grinding/Polishing

Grinding and/or polishing should be performed to obtain a surface finish suitable for electropolishing or etching.

Step 4: Etching

Chemical or electrochemical etching should be used to reveal the microstructure of the weld.

Solution



REACH OUT TO LEARN MORE

If you would like to know more about how to improve the quality, efficiency and cost-performance of your quality control processes, [feel free to reach out to me or other application specialists](#).

[Visit Struers.com](https://www.struers.com) to find contact information, as well as more information on quality control in the automotive industry.





APPLICATION SPECIALISTS

Based on years of experience and expertise from a wide variety of industries, the Struers Applications Specialists team enables our customers all over the world to discover new opportunities for enhancing quality control, failure analysis and productivity, and to develop new applications and methods in order to meet evolving needs.