# RepliSet

## Reference Guide

Manual No.: 50900044

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# Reference Guide

This Reference Guide includes additional information and tips on the use of RepliSet.
Please refer to the User's Guide booklet for general information on the use of the RepliSet System

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# 1. RepliSet Compounds

**Materials Safety**

The product contains:

| | |
|---|---|
| Siloxanes | Polymethylvinyl-, Polymethoxyvinyl-, Polyorgano-, Polymethylhydrogeno- |
| Organic Compounds | Silicone/alcoylene polyoxide, polyoxyalcoyleneglycol acetate |
| Inorganic Compounds | Silica, Carbon, Platinum (complexed) |

(A trace of chloroplatanic acid impurity may also be present)
None of the ingredients are classified as dangerous.

**Selection of Compound**
*Viscosity, curing time*

**Notes**

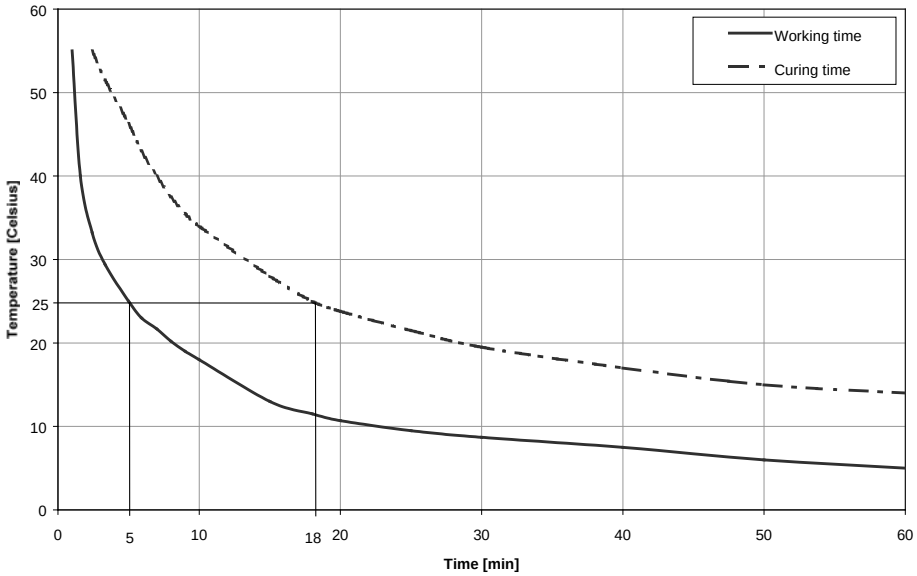
- The process time for RepliSet varies with the temperature. Please see graphs later in the manual. For correct results do not exceed the actual working time or reduce the curing time.
- To prevent damage and loss of the recorded detail, do not touch the replica surface or allow it to touch any surface other than backing paper.
- Never put the replica under pressure.
- Fold the backing paper to cover the copy and keep the replica in a closed plastic bag stored in a box or similar.
- Never leave the surface of the copy in direct contact with plastic bag material.

The compound is available with various viscosities and working life / curing time, tailored for application under different temperature conditions and on horizontal as well as vertical surfaces.
The fluid versions are typically used on horizontal or sloping surfaces and for very rough surfaces in order to minimise air entrapment. The thixotropic versions allow vertical and overhead surfaces to be replicated.
The fast curing compounds are for general-purpose applications.
The rapid cure compounds are designed for low temperature conditions, where rapid results are required or for providing of thick replicas on horizontal surfaces.

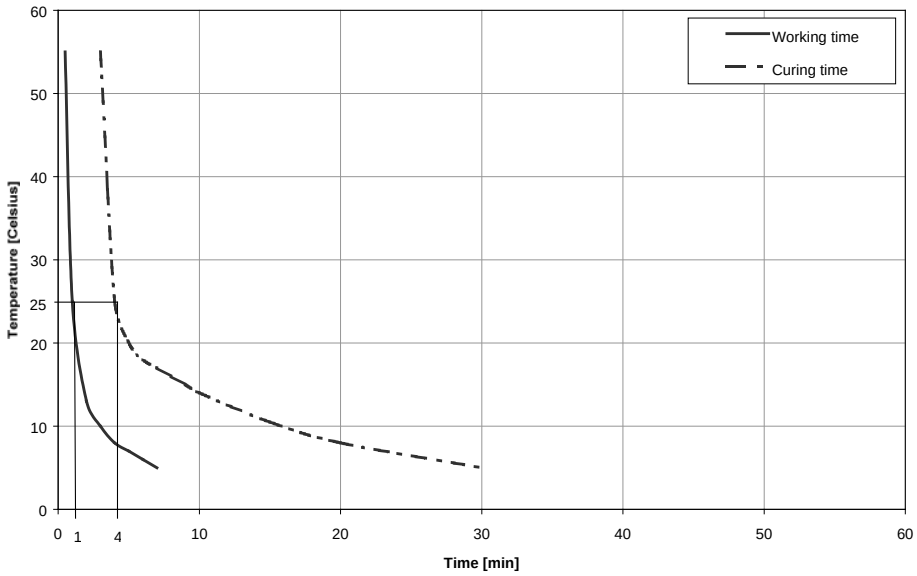
| Surface facing | Temperature of surface | Working life | Recommended compound |
|---|---|---|---|
| Horizontal, sloping | Higher than 20°C | Normal | RepliSet-F5 |
| | | Short | RepliSet-F1/GF1 |
| | Lower than 20°C | Normal | |
| Vertical, overhead | Higher than 20°C | Normal | RepliSet-T3 |
| | | Short | RepliSet-T1/GT1 |
| | Lower than 20°C | Normal | |

The working life and curing time at 25°C are stated on the label and in the description for each type.
At lower temperatures the process time will be prolonged and at higher temperatures the process time will be considerably shorter. Please see the following graphs.
Complete curing (no sticking to the surface) can take up to 24 hours. Curing takes place without perceptible generation of heat.

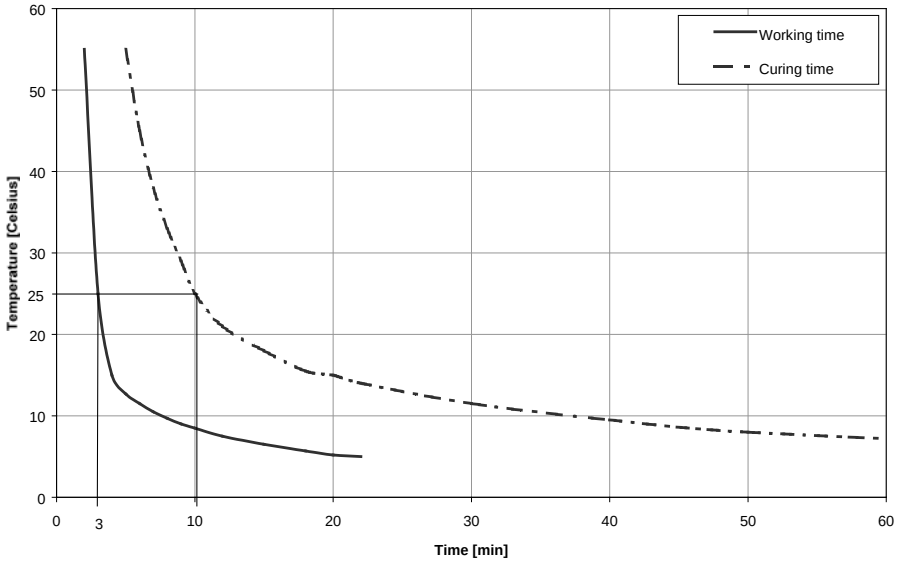
**RepliSet-F5**



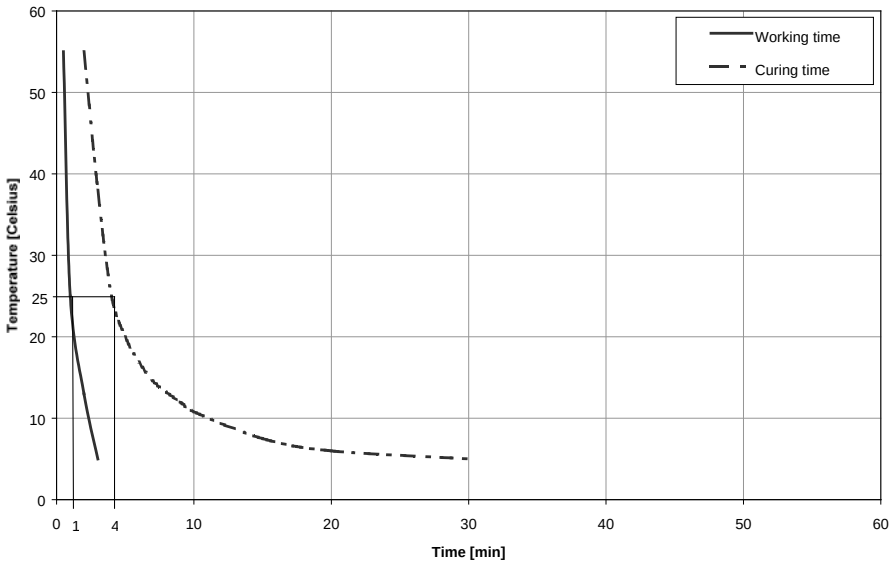

**RepliSet-F1**



**RepliSet-T3**




**RepliSet-T1**



*Use*

Do not ingest and avoid contact with skin and eyes.
Under normal usage the application system will allow the material to be dispensed safely and cleanly to the appropriate location without the need for protective gloves or goggles. However, these may be worn as a precaution, especially in confined or difficult working conditions. Cured products are harmless.

*Disposal*

Uncured compound can be burned in a chemical incinerator equipped with an afterburner and scrubber. Do not dispose of the emptied container unlawfully. Observe all federal, state, and local laws.
Cured product can be disposed as non-hazardous waste.
Cartridges and mixing nozzles are made of the following materials: Acetal, nylon, polyester and polypropylene.

*Compatibility*

The compounds contain minimal levels of fluorine, chlorine,-sulphur compounds and heavy metals and are approved for use on stainless steel in nuclear plants. The materials are designed specifically to be compatible with stainless steels and other engineering alloys and not to compromise future corrosion behaviour should traces of replicas remain after replication.
Free hydrogen atoms are not produced when the base and accelerator in RepliSet are mixed. Hydrogen embrittlement is not expected to occur.

**Storage and Transportation**

The cartridges should be stored horizontally and at room temperature.
RepliSet is best used and transported at ambient temperatures. However, short excursions down to $-5^0$C and up to $35^0$C can be tolerated without seriously affecting the performance of the product. Low temperatures will not harm the material directly, however, temperature cycling between ambient and a low temperature may cause air to be drawn into the cartridge. Such cycling should be minimised.

| | |
|---|---|
| **Lifetime** | RepliSet should be used before the expiry date to ensure optimal product properties. During storage some components may start to settle in the cartridge after a long period. To minimize this effect, the cartridges ***must*** be stored horizontally. The storage box is designed so that the cartridges are stored flat.<br>The expiry month and batch code are indicated on each cartridge |
| Unopened Cartridges | The cartridges are produced 15 months before the expiry month on the label. |
| Opened Cartridges | Opened cartridges should be stored with the nozzle on as a seal. An opened cartridge can be stored at room temperature for at least four weeks until it is used again. The cartridge should be re-used within four weeks to form a new seal. Use again within four more weeks and so on until the cartridge is empty. |
| Expired cartridges | Expired cartridges may still produce high-quality replicas, however Struers cannot guarantee for proper curing.<br>If an expired replica cures normally, the copy in general will be OK. |

# 2. Using RepliSet

**Making a Replica**

*Working Plan*

If many replicas are to be made at the same location, the preparation of all the surfaces should as far as possible be finished, before the replicas are completed. Thus the waste of compound will be minimised.

*Materials Suitable for Copying*

A replica can be taken of all metallic materials and most other solid materials like ceramics, plastics, glass and concrete.
Replicas can generally not be taken on fibrous surfaces like carbon fibres, paper or cloth. However, it is possible to replicate some types of paper and synthetic cloths, using type -T RepliSet.

*Residues of compound*

Under normal conditions, RepliSet leaves no visible residues on the surface. Residues may be left if:

- The first portion of the compound is not discarded after exchanging the cartridge leading to incomplete curing
- The replica is removed before it has cured completely

In most cases a new replica will remove the residues.

RepliSet can leave a shade on rough or porous surfaces.
The RepliSet silicon rubber is chemically resistant and will not melt at high temperatures. It will degrade.

*Replicas of Microstructures*

The surface to be examined for microstructure should be prepared using the normal techniques for non-destructive materiallographic examination. Polishing could be carried out mechanically or electrolytically and etching could be chemical or electrolytic. A good quality etching is important. Replication methods often require a deeper etch than used for direct examination. Normally a small spot (5 – 20 mm) is adequate for the examination of microstructure. Backing paper should always be used for such work. Replicas should be made as thin and as flat as possible and should be mounted on glass slides using double-sided adhesive tape.

*Cleaning of the Surface*

The area to be examined should be clean and degreased. Use cotton wool and a solvent suited for removal of possible contamination. Alcohol will in most cases be sufficient for metallographic applications. Engineering surfaces should be degreased using a suitable solvent like acetone. Make sure that the solvent has evaporated completely from any cavities before application of the compound.

If the microstructure contains large inclusions (like spheroidal graphite iron) or if the engineering surface is very complex, it will be necessary to dry the surface with hot air.

**Notes**

- RepliSet will not cure if residues of grease or solvents are left on the surface.
- RepliSet will leave residues of uncured compound around inclusions, if the cleaning liquid has not been completely dried out.

*Cartridge size*

Each type is available in cartridges of 50 ml.
The 50 ml cartridge is recommended when making small replicas, i.e. up to 100 mm diameter.
Some types are also available in cartridges of 265 ml, which are more cost-effective, when large replicas are made or many replicas are taken at the same time.

*Colour*

RepliSet-F or -T (black) should be used for general purpose and particularly in situations where the replica is examined using optical microscope with incident illumination.
RepliSet-G (grey) should be used in all situations where macroscopic examination is involved.
In some cases RepliSet-GF1 will result in a better image on laser microscopes than RepliSet-F1, depending on the characteristics of the light source and the settings of the microscope. In case of difficulty it is worth trying both alternatives.

The selection of one replica type is usually sufficient. However, it may be advantageous to make both a grey and a black replica in order to be prepared for all examination techniques.

It is recommended that the user who covers a wide application range should have both types on hand.

*Use of Backing Paper*

The backing paper bonds to the replica and facilitates labelling, handling and levelling of replicas.
Identification of the replica can be written directly on the back of the backing paper. The backing paper also serves as a handle when pulling replicas out from re-entrant geometries and can be used for protecting the copy.
If the replica has to be examined in an upright microscope or similar, the aligning of the replica is facilitated if the back of the replica is flat. The backing paper allows the replica to be mounted on a glass slide by means of double adhesive tape.

Mounting Backing Paper

Backing paper should be mounted immediately after application of the compound.

- Apply shiny side of backing paper to uncured replica; position the backing paper so that the replica is positioned to one side of the paper and the other side can be folded over to protect the copy.
- Apply light pressure to the backing paper using a flat stamp or small roller to produce a thin film replica and increase resolution (using a roller also ensures that the whole area is pressurised).
- After the replica has cured, cut away surplus material at the edge with scissors.
- After removal, fold the backing paper around the cured replica to protect the copy.

SEM

*Replicas backed with Struers backing paper can be coated and examined by SEM.*

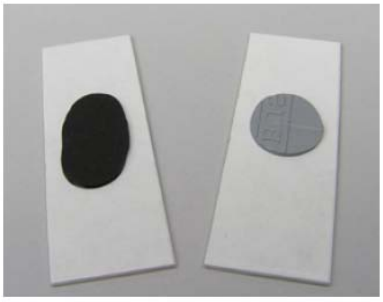
*Backing slides*

- Apply the paper side of the backing slide directly to the uncured replica.
- After curing, lift off the backing slide with the replica.

Backing slides can be used directly on fairly flat surfaces. If a multifaceted 3D geometry has to be replicated with preservation of the complete surface profile, a technique with combined use of Struers RepliSet, RepliFix and Backing slide can be applied.

Mailing and storing of replicas

Backing slides are produced in the standard slide size 1"x 3". This means that replicas mounted on Backing slides will fit into commercially available slide mailers and microscope slide storage boxes, which can be procured at laboratory suppliers. It is recommended to store the replica in such a way that any contact with the copy is avoided.



*RepliSet and RepliSet-G replicas mounted on Backing slide*

*Slide mailer (made by Kartell, Italy), for 3 slides*

*RepliFix replica of gear wheel, mounted on Backing slide*

*Box with room for 20 slides*

**Examination of the Replica**

*Optical Microscopy*

The RepliSet-F and -T replicas are well suited for microstructural evaluation work using optical microscopes with reflected light at magnifications up to 500x for both Bright Field and Dark Field. Backing paper should always be used for such work and replicas should be made as thin and flat as possible and be mounted on slides using double-sided adhesive tape.
The lower reflectivity of replicas compared with original surfaces means that the light intensity should be increased compared to when examining a metal sample and could necessitate removal of filters from the light path, especially at high magnifications.
The use of polarized light and DIC at high magnifications increases both contrast and resolution.
RepliSet-G types are not suitable for optical microscopy using incident illumination.

*Macroscopy*

In many cases it is better to examine a replica than the original surface, because of the uniform reflection of the replica.
At dull surfaces it is recommended to make a replica using a grey compound (RepliSet-G) and tilting the light to be more or less parallel to the surface. This gives a very good contrast with clear information of the topography.
At reflecting surfaces it is recommended to make a replica using a black compound (RepliSet-F or -T) and direct the light more or less perpendicular towards the surface. Here the topography is identified by the light intensity.

The RepliSet-G types are especially designed for Comparatory macroscopy and Stereo microscopy. Oblique illumination by fibre optics and an adjustable tilting stage are recommended. The light should be almost parallel to the surface.

*Laser Measuring Instruments*

The determination of 3D geometrical elements can be carried out using various measuring instruments with a tactile–free working principle. Thus a quantitative figure of what has been replicated can be obtained. Laser measuring equipment, having a typical resolution of 0.1 µm is very well suited. Measuring projectors with 2D or 3D facilities are also very well suited.
Gallium Arsenide lasers, which emit at 670 nm within the red range have been used successfully. It may be necessary to increase the intensity of the beam.
White light chromatic aberration techniques may be used.

| | |
|---|---|
| *SEM / Field Ion Microscopes* | Uncoated 3D replicas may be examined directly by SEM using low kV (about 2 kV at high magnifications, it might be higher at low magnifications) and particularly with field-ion microscopes. For coated replicas it is possible to work satisfactorily at 20 kV if this is required. The best magnification is x2 – 3000.<br>Chemical analysis of loose deposits picked up by the replica can be carried out.<br>SEM is not suitable for the examination of flat microstructure samples. |
| *Coating the Replica* | For high magnification SEM the replicas can be metal coated, but the result depends on the evaporation equipment employed. Double evacuation including back purging with argon is recommended. Take care that the replica does not become overheated. A coating thickness of 100 Angstroms is recommended. The coating will crack, if the replica is not supported adequately. It is best to mount the replica on a glass slide or other solid surface before coating and to examine the sample whilst it is still mounted. |
| *Shadow Graph* | Examination of the replica of a cavity, e.g. examination of the shape of a hole inside. |
| *Contacting Equipment* | As the replica is resilient, the examination by contacting equipment cannot be recommended. |

# 3. Applications

**Engineering Inspection**

The use of high-resolution RepliSet replicas allows inaccessible surfaces, geometries, and irregularities in critical engineering equipment to be examined under laboratory conditions. The purpose might be verification of the internal surface geometry and surface finish or monitoring of surface degradation, damage or wear.
For routine inspections, the replica can be made locally by an operator and sent to a specialist at a central or independent laboratory for evaluation.
RepliSet-F and -T are mainly employed.

**Metallographic**

Typical applications are on-site non-destructive testing in connection with quality control, inspection and maintenance of power stations, oil platforms, bridges, aircraft etc.
Only RepliSet-F and -T can be used.

**Forensic Investigation**

In the course of forensic investigations comparatory macroscopy / microscopy is used to identify whether fine scratch details found in tool-marks can be related to features on the original tool. In these situations image contrast is extremely important, thus reliable identification evidence can be provided for the Court.
In the field, replicas of tool marks are produced using RepliSet-G. For the comparison a replica of the tool surface or an impression in lead is made. The surfaces are analysed using comparatory macroscopy in oblique illumination. Photos indicating identical details are subsequently presented before the court.
For general laboratory applications the police also use the RepliSet-F or -T types.

**Examples of Areas of Application**

Quality Control

- Quality control of edges, corners, heights, angles and thread profiles
- Measurement of the internal geometry of components being injection moulded in plastics
- Measurement of surface roughness after grinding, polishing or super finishing of large workpieces, using laser measuring equipment
- Non-contact laser measurement of curvature of optical lenses.
- Recording of surface defects – eg. chatter marks, scratch marks, dents
- Inspection of internal surfaces such as bolt hole threads and small bore tubing root welds
- Quality control of integrated thread holes in electronics
- Measurement of fine laser drilled cooling holes used in aero engine components
- Measurement of the hole diameter in PCB
- Inspection of thickness and evenness of the plated layer in vias and blind vias with a diameter down to 100 µm on PCB
- Measurement of depth of penetration of solder in PCB
- Examination of composites:
  The replica might give a better image of fibres than the original
- Examination of the surface of welds
  Large replicas 2 m long x 0.5 m wide have been produced on a regular basis of critical circumferential butt welds in stainless steel pipe
- Control of the surface of tools for injection moulding
- SEM examination of the surface of paper rolls (Please observe that RepliSet is generally not recommended for examination of porous surfaces like paper)

Maintenance, Inspection and Reconditioning

- Inspection for corrosion in torpedo tubes in submarines
- Inspection for pitting in tubes in nuclear submarines
- Print roll monitoring:
  Non-contact laser measurement of the depth of the surface pits using RepliSet replicas
- Assessment of surface profile on steel-mill and aluminium rolling-mill textured rolls
- Assessment of the surface condition of aluminium extrusion dies
- Diesel engine cylinder liner honing marks:
  Non-contact laser measurement across a honed area on a cylinder liner wall to assess depth of honing
- Cylinder liners of cast iron for ship engines:
  Monitoring of wear by measuring surface condition with a view to estimation of service needs
- Assessment of surface damage on critical components:
  Impact damage from foreign objects on the inlet compressor blades in aircraft jet engines
- Assessment of surface damage on steel-mill rolls
- Examination of bolt holes in nuclear plants, for cracking.
  Eg. in large austenitic stainless steel casings, which are particularly difficult using conventional methods not only because of the geometry but also because these materials are not ferromagnetic. RepliSet has been used to examine bolt holes of up to 75 mm diameter
- Detection of micro-cracks in stainless steel
- Monitoring of crack-growth and corrosion pit-depth
- Inspection of cracking inside gun barrels
- Monitoring crack growth
- Inspection of fatigue pitting, micro cracking and wear on gear teeth: A replica is periodically taken of the same gear tooth for early detection
- Identification of stress raisers exposed by internal machining of welds in critical components
- Monitoring surface pitting on structural aluminium alloys used in airplanes
- Monitoring pitting in aircraft engine components:
  Turbine blades and the root of turbine blades
- Verification of corrosion on workpieces due to fingerprints
- Corrosion pitting: Chloride corrosion-pit in the surface of stainless steel blades from a gas turbine
- Examination of pitting on ship propellers
- Monitoring the effect of the fermenting process on the surface of stainless steel in the fermenting vessel at a brewery:
  A replica of the surface of the vessel is taken at regular intervals between the brewing cycles in order to identify the variation in surface roughness three-dimensionally

R&D

- Development of new materials / new geometries:
  Compare a replica of the structure taken before and after testing
- Design of wear surfaces:
  Measuring the surface topography by interference microscopy
- Performance of abrasives:
  Taking a series of replicas of abrasive grains, during operation under various conditions. Comparison of the wear on the abrasive grains and the performance

-Replica of ice core

Failure Analysis

- The recording and examination of brittle-fracture surfaces
- Replica of an area of intergranular fracture in a high strength low alloy steel
- Replication of fatigue striations on aluminium alloy fracture surfaces
- Cracking in stainless steel:
  Replica of stress-corrosion cracking close to a weld in stainless steel
- Examination of stress corrosion cracking:
  The replicating material penetrates into the crack, and part of the fracture surface is replicated and retrieved together with corrosion products removed by the replica
- Detection of thermal cracking in an overheated journal of a marine alternator crankshaft
- Detection of micro cracking, which cannot be detected by magnetic particle crack detection
- Creep damage
- Gear tooth surface: Replica of surface contact fatigue-pitting from an overloaded marine gear

The replica can pick up any loose deposits present on surfaces and retain them at their original locations. This could be utilised for subsequent examination of the particles, e.g. from corrosion, surface debris or for cleaning the surface.

Forensic Investigation

- The replica of the inner side of the lock shows the same surface details as a screwdriver that has been used to open the door lock of a car
- The replica of the door lock and a pipe wrench shows identical striation marks where the lock has been attacked with the pipe wrench
- Examination of stamping tools that have been used to produce false chassis numbers
- Credit card number stamps can be identified
- Examination of the inner surface of a gun barrel

Museum Pieces

- Non-destructive examination of museum pieces:
  Internal surfaces of bronze ornament from Viking age, to identify the working up
- Examination of fossils. The replica of a trilobite gives a better reproduction than the original

Other Applications

RepliSet can be used as a sealant:

- To seal a prepared surface and preserve it for future examination
- RepliSet can also be used for protecting prepared samples or critical components from atmospheric oxidation and mechanical damage during transportation or storage

Radioactive Environment

(This application is not supported by Struers)
RepliSet can in many cases be used in applications with high radiation levels. No problems concerning curing properties have been experienced.
The material has to be pressurised with high-pressure pneumatic guns (not included in Struers product range) and can be applied at considerable distances (e.g. 3 - 6 m), using stainless steel tubes equipped with fibre optic video cameras (not included in Struers product range). The tube is left in contact with the replica. When cured the tube and replica are retrieved together. As RepliSet picks up loose radioactive debris the first replica from an area can be 'hot'. Subsequent replicas of the same area exhibit greatly reduced radiation. In general, the third replica has a radiation level of only 2%-3% of the first replica, facilitating inspection.

Underwater Applications

(This application is not supported by Struers)
In many cases, the materials can be used under water using the thixotropic compound (RepliSet-T or -GT).
However, manual application does not work, as a steady flow of compound under high pressure is required. For application underwater, a mat can be used to keep the compound in contact with the surface.

- Underwater inspection of nuclear components including fuel module geometry, corrosion and cracking
- Undersea inspection of offshore equipment including pipeline and ring groove damage

# 4. Technical Data

| | |
|---|---|
| Resolution of cured replica*) | Down to 0.1 micron |
| Shrinkage | Negligible |
| Tear strength | 15-20 kN/m$^2$ |
| Temperature range for the surface to be examined | -10°C to +180°C |
| Life time for unopened cartridges | Please see expiry date on label |
| Life span for an opened cartridge | The cartridge should be re-used within four weeks.<br>(Please refer to the section on "Lifetime") |
| Life span for the finished replica | Practically indefinite provided they are stored according to the instructions |
| Volume in static-mixing nozzle | 50 ml cartridge: 1.1 ml<br>265 ml cartridge: 9.3 ml |

*) The true resolution cannot be determined by optical microscopy. Interferometry or possibly laser microscopy has to be used.

# 5. Trouble-shooting

| Problem | Reason | Action Required |
|---|---|---|
| Nozzle will not fit onto cartridge | Nozzle lug on wrong side | See instructions |
| Dispensing gun fails to pressurise cartridge | Damaged piston slide | Check instructions. Replace slide if necessary |
| Compound does not bond to backing paper | Wrong side of backing paper is used | See backing paper instructions |
| Base piston on cartridge leaks | Excessive pressure on dispensing gun due to nozzle blockage | Remove cured material if possible or replace cartridge |
| Material cures in the nozzle | Stop/start operation, nozzle attached a long period before use | Replace nozzle and proceed without delay |
| Material does not come out of the cartridge after replacing a previous nozzle | Cartridge ports have cured over | Remove cured material or discard cartridge. The nozzle can be used as a seal for up to 4 weeks |
| | Cured material in the previous nozzle has been pressurized, causing the curing agent to be pushed into the top of the base port | |
| When using a new cartridge the first part of the replica does not cure | Cartridge not primed before attaching nozzle | None. Cartridge will work satisfactory with subsequent nozzles |
| Material cures too quickly or too slowly | Incorrect grade being used for the ambient temperature | Choose a grade appropriate for the conditions |
| Air bubble entrapment | Poor application | Keep the nozzle in contact with surface. For blind holes place the tip of the nozzle or a needle at the bottom of the hole |
| Material drips off overhead | Use of fluid grade of compound | Use T3 or T1 grades |
| Light spots when examining in optical microscope | Strain from removal of the replica | Increase curing time before taking the replica off |
| | The specimen has been etched too much | Repeat the preparation |
| Replica distorts and resolution is poor when examined microscopically | Replica too soft when removed due to incomplete curing | Extend curing period |
| | Residues of grease on the surface | Clean the surface with a solvent |
| | Residues of solvents on the surface or absorbed in inclusions | Dry the surface with hot air |
| Replica surface does not cure | Cure inhibited by surface contamination eg. grease, oil etc. | Check surface cleanliness |
| | The solvent used for cleaning has not evaporated completely | Dry the surface.<br>Use hot air if required |
| | The cartridge has not been stored horizontally | Discard the cartridge |
| | The shelf life for the cartridge has expired. See Use by on the label | Discard the cartridge |

| Problem | Reason | Action Required |
|---|---|---|
| Replica breaks during removal | Severe re-entrant geometry.<br>Replica not completely cured | Allow adequate curing time.<br>Remove slowly applying constant pressure |
| Excessive voids when using thixotropic materials | Air entrapment due to poor application | Keep the nozzle in contact with the surface. Overlap runs and use backing paper. |
| Replica adheres to surface | Mechanical attachment to fibres or porous surface | Remove slowly applying constant pressure or use a different method |
| | The working life for the actual RepliSet has been exceeded | Exchange the static-mixing nozzle and work faster.<br>If possible, select a RepliSet type with longer working life |

# 6. Consumables and Accessories

Please refer to the *RepliSet Brochure* for details of the range available.

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