



*Worldwide repairs carried out with PolymerMetal®*

**REP-#139**



After many years of working, the worn-out rock shaft of a crushing plant for recycling demolition material was repaired with MM-metal SS-steel 382 in September 2002. First the driving fly wheel was carefully dismantled to receive access to the shaft. After the surface preparation of the up to 1 mm worn-out shaft area, MM-metal SS-steel 382 was applied and then machined down to the desired diameter. A replacement due to the necessary dismantling of the damaged shaft, the purchase and the assembly of a new shaft, would have involved considerable additional costs and time. An examination 4,5 years later (March 2007) has come to the result, that the repaired work piece is still in function without any complaints.

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*Worldwide repairs carried out with PolymerMetal®*

REP-#152



Onto a damaged area of an axle end MM-metal SS-steel, later MM-metal SS-steel 382 was applied to receive a higher surface quality. After curing, the work piece was machined down with a lathe to the desired diameter.

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## Technical Report PolymerMetal<sup>®</sup>

### TEC-# 007

The corrosion-chemical behaviour of PolymerMetals in combination with casting material (contact corrosion)

### Used products

MM-metal SS-steelceramic / MM-metal SQ / MM-metal SS-steel 382 / MM-metal SS-steel / MM-metal oL-steelceramic / MM-metal UW / Ceramium<sup>®</sup> / MM-metal S-steel

### Introduction

PolymerMetals are used for repairs of metallic constructions which were damaged by physical loads like tear, impact, erosion, abrasion, corrosion and cavitation or by chemical load.

Questions of customers concerning the contact corrosion of our PolymerMetals lead us to do tests.

The following report shows how the test has been carried out and what results have been obtained. Tests have been made with seven different PolymerMetals in artificial sea water (laboratory test) as well as in aggressive marshy soil. The PolymerMetals used were potentially equivalent or potentially superior to the base material (cast iron).

### Place of repair

Moorland in the North of Germany and laboratory

### Preparation of test samples

56 plates measuring 150 x 95 x 25 mm and 95 x 47 mm have been cut off cast iron. The surface of 23 plates has been treated mechanically. 2-3 bore holes of different diameters were installed in order to create different proportions between cast iron and PolymerMetals.

### General information

An ordinary salt spray test proved insufficient. As the tested PolymerMetals are non-electrical conductive products it was decided not to measure the current density potential curves. The contact resistance in the Meg-Ohm-sphere was too high.

### Test in moorland

Marshy soil is to be said very aggressive (DVGW rating no. -15 up to -19)

Reasons are:

- very low soil resistance (appr. 950-1200 Ohm x cm)
- very high salt content (chloride 800 - 1250 mg/kg / sulphate 4300 - 19000 mg/kg)
- very high moisture contents (appr. 55 - 85%)
- anaerobic conditions, proved by hydrogen-sulphide

The cast iron plates and PolymerMetals, machined and non-machined, were stored in a considerable depth of marshy soil for more than one year.

### Test in artificial see water (laboratory test)

The cast iron plates and PolymerMetals - machined and non-machined - were stored in a laboratory in considerable depth of artificial sea water (DIN 50 900) for more than one year.



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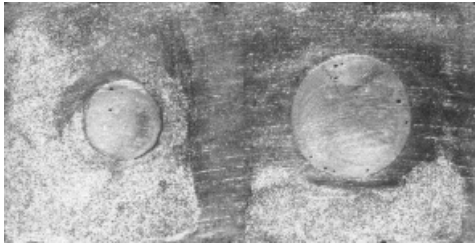
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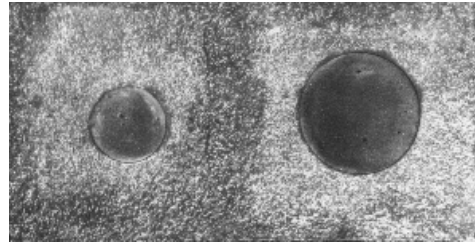
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## Samples

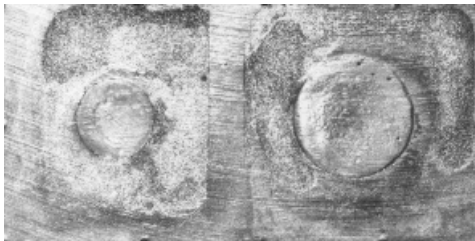
The following photographs show the different PolymerMetals applied to cast iron which have been partly machined after full curing. After they have been stored for 12 months in aggressive moorland or artificial sea water the samples have been examined. The following four photographs concern machined samples which have been exposed to artificial sea water:



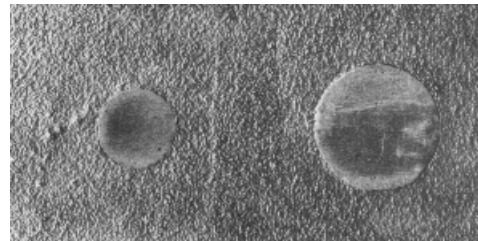
Sample MM-metal SS-steelceramic



Sample MM-metal SS-steel



Sample MM-metal oL-steelceramic



Sample MM-metal UW

## Result

The results of both tests were nearly the same. Due to the strong reaction caused by the aggressive soil or by the sea water the cast iron plates were coated with ferric hydroxide. While the surface of the cast iron plates were differently affected, the PolymerMetals still remained unchanged after storage of more than 12 months. They were only covered with rust deposit. Even peak-to-valley heights from previous treatments could clearly be recognised. There was no contact corrosion, not even at the transitional point of the PolymerMetal and the cast iron. It was proved that PolymerMetals are not electrically conductive and cannot constitute any local element with cast iron.

## Tested PolymerMetals

MM-metal SS-steelceramic  
 MM-metal SS-steel 382  
 MM-metal SS-steel  
 MM-metal SQ  
 MM-metal oL-steelceramic  
 MM-metal UW  
 Ceramium®  
 MM-metal S-steel

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## Technical Report PolymerMetal<sup>®</sup>

### TEC-# 008

Repair of a shaft with PolymerMetals

### Used products

MM-metal SS-steelceramic / MM-metal SS-steel 382 / MM-metal SS-steel / MM-metal SS-aluminium / MM-metal SS-copper / MM-metal SS-bronze / Ceramium<sup>®</sup> / Molymetall<sup>®</sup>

### Introduction

The high quality PolymerMetals from MultiMetall can be used to repair worn shafts by restoring material. This report is supposed to assist the applicator during the repair. Because of the different sizes of wear length areas and diameters of the shaft to be repaired and the available processing time of the PolymerMetals (pot life appr. 30-35 min at 20 °C) the application of the PolymerMetals was divided into four variants.

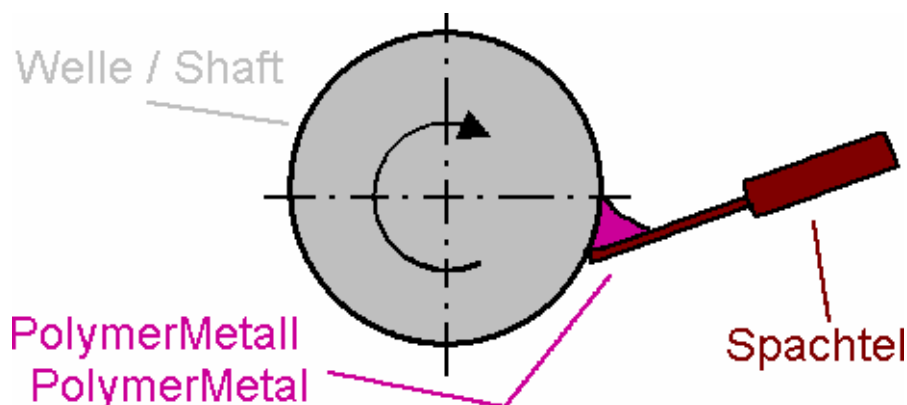
### Preparation

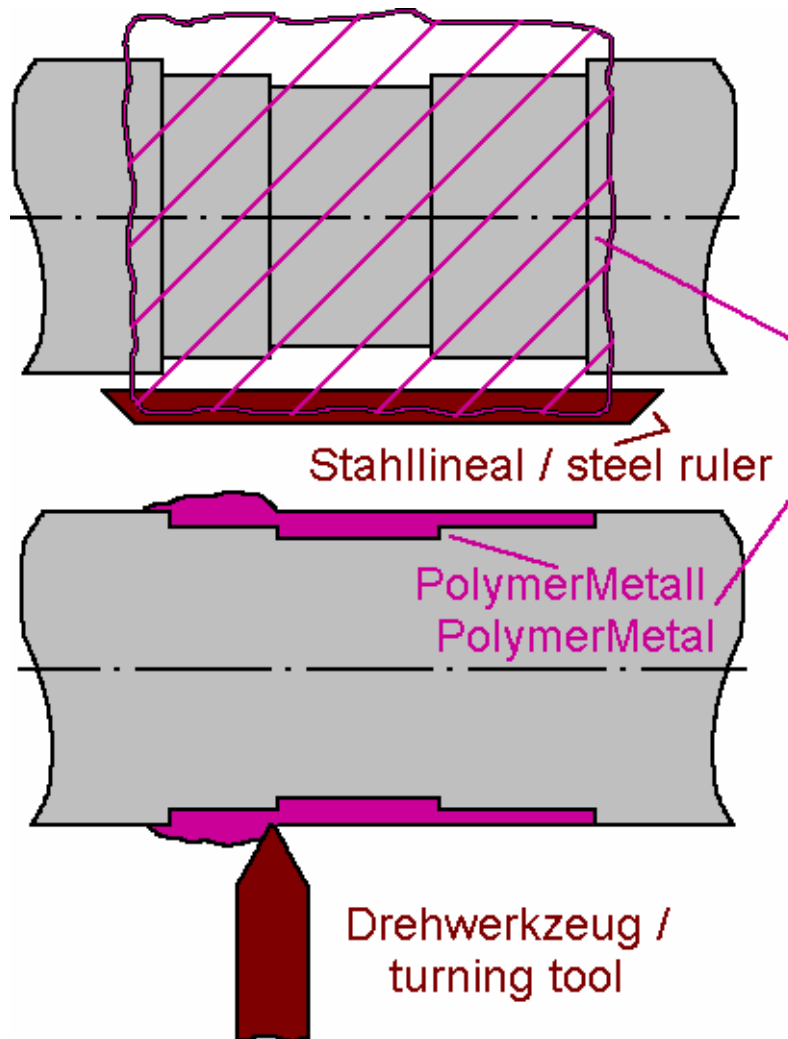
- shaft has to be turned off in the area of the damaged part to at least 1 mm undersize from target diameter, the surface quality should be appr. Rz 100 afterwards
- clean shaft from oil, grease, coolant etc with MM-Degreaser Z or MM-Degreaser C
- adhere to Technical data sheet of used PolymerMetal especially consider the available processing time (pot life)

### Application of PolymerMetal

**Variante 1:** Shaft length of wear area < 150 mm and diameter < 200 mm

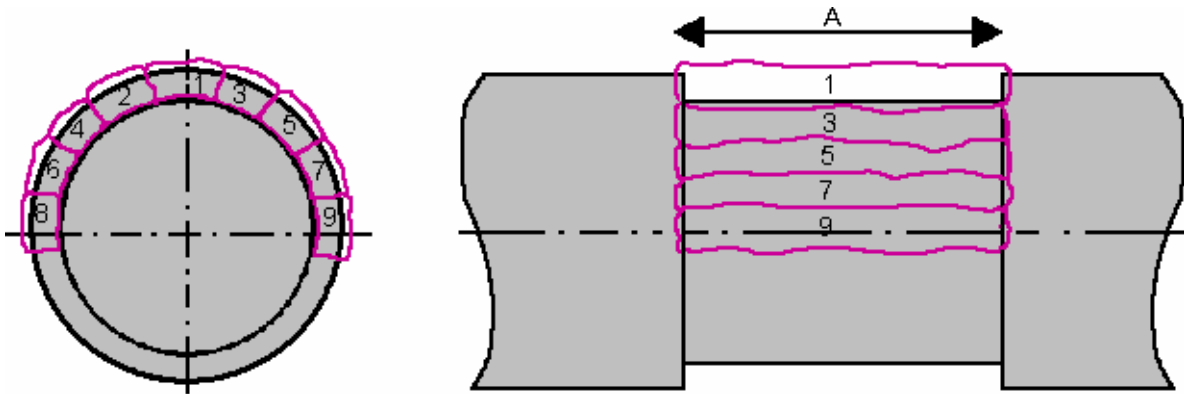
- Shaft hold by lathe has to run with a low turning speed during all following repair steps
- Apply a thin layer (max 0,5 mm) of PolymerMetal with a spatula with pressure on the complete wear area of the shaft to avoid air bubbles in the interface between metal and PolymerMetal
- Apply PolymerMetal on complete wear length of shaft in a layer of appr. 2 mm oversize against target diameter
- By using a metal rule which is long enough (and therefore reaching over the complete wear length) the surface of the PolymerMetal should be smoothed so that an oversize of only 1-2 mm remains





**Variant 2: Shaft length of wear area < 150 mm and diameter > 200 mm**

- Shaft hold by lathe has to be turned by hand during all following repair steps
- Apply a thin layer (max 0,5 mm) of PolymerMetal with a spatula with pressure on the first part of the wear area („1“ on sketch) of the shaft to avoid air bubbles in the interface between metal and PolymerMetal; then apply PolymerMetal on the same part of the wear area in oversize of appr. 2 mm against the target diameter
- Apply a thin layer (max 0,5 mm) of PolymerMetal with a spatula with pressure on the second part of the wear area („2“ on sketch) of the shaft to avoid air bubbles in the interface between metal and PolymerMetal; then apply PolymerMetal on the same part of the wear area in oversize of appr. 2 mm against the target diameter
- Go on applying PolymerMetal in the same way on all other parts of the wear area till the complete wear area is coated
- If possibly there is enough pot life, use a metal rule which is long enough (and therefore reaching over the complete wear length) to smoothen the surface of the PolymerMetal so that an oversize of only 1-2 mm remains
- Hint: the transitions shown in the sketch i.e. between part area 1 and part area 2 are fluid and do not have to be kept strictly

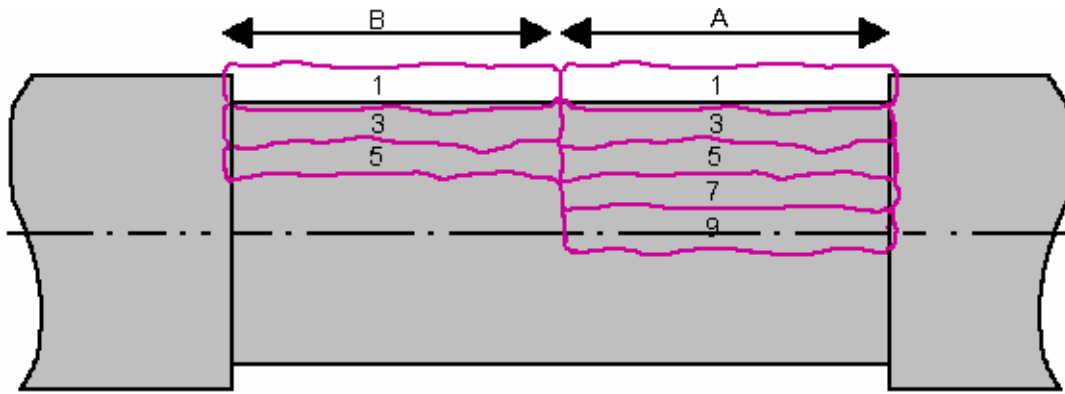


**Variant 3: Shaft length of wear area > 150 mm and diameter < 200 mm**

- Shaft hold by lathe has to run with a low turning speed during all following repair steps
- Apply a thin layer (max 0,5 mm) of PolymerMetal with a spatula with pressure on the first part of the wear area on the length of appr. 150 mm on the complete shaft perimeter to avoid air bubbles in the interface between metal and PolymerMetal; then apply PolymerMetal on the same part of the wear area in oversize of appr. 2 mm against the target diameter; use a metal rule which is long enough (and therefore reaching over the complete wear length) to smoothen the surface of the PolymerMetal so that an oversize of only 1-2 mm remains
- Apply a thin layer (max 0,5 mm) of PolymerMetal with a spatula with pressure on the second part of the wear area on the length of appr. 150 mm on the complete shaft perimeter; then apply PolymerMetal on the same part of the wear area in oversize of appr. 2 mm against the target diameter; use a metal rule which is long enough (and therefore reaching over the complete wear length) to smoothen the surface of the PolymerMetal so that an oversize of only 1-2 mm remains
- Go on applying PolymerMetal in the same way on all other parts and smoothen the surface of the PolymerMetal till the complete wear area is coated and pulled

**Variant 4: Shaft length of wear area > 150 mm and diameter > 200 mm**

- Shaft hold by lathe has to be turned by hand during all following repair steps
- Divide the shaft into several max appr. 150 mm long areas
- Apply a thin layer (max 0,5 mm) of PolymerMetal with a spatula with pressure on the first shaft section of the wear area („A“ on sketch) on the length of appr. 150 mm of the first part of the wear area to avoid air bubbles in the interface between metal and PolymerMetal; then apply PolymerMetal on the same part of the wear area in oversize of appr. 2 mm against the target diameter
- Apply a thin layer (max 0,5 mm) of PolymerMetal with a spatula with pressure on the first shaft section of the wear area („A“ on sketch) on the length of appr. 150 mm of the second part of the wear area; then apply PolymerMetal on the same part of the wear area in oversize of appr. 2 mm against the target diameter
- Go on applying PolymerMetal in the same way on all other shaft sections and parts till the complete wear area is coated
- If possibly there is enough pot life, use a metal rule which is long enough (and therefore reaching over the complete wear length) to smoothen the surface of the PolymerMetal so that an oversize of only 1-2 mm remains



### Further processing

- Wait till PolymerMetal has been totally cured (adhere to Technical data sheet)
- Further processing of the shaft without cooling/greasing agent
- Depending on used PolymerMetal machine the coated surface with Diamond or standard tools

<b>Material</b>	MM-metal SS-steel 382 MM-metal SS-steel MM-metal SS-aluminium MM-metal SS-copper MM-metal SS-bronze each with Hardener yellow  Molymetall® with Hardener Molymetall®	MM-metal SS-steelceramic with Hardener yellow  Ceranium® with Hardener CE
<b>Type of machining</b>	<b>standard tools</b>	<b>diamond tools</b>
<b>General machining data</b> Cutting speed $v_c$ Cutting depth $a_p$ Feed $f$	40...55 m/min 0,5...1 mm 0,1...0,2 mm/U	60...125 m/min 0,5...1 mm 0,1...0,2 mm/U
<b>Recommended machining data at rough turning</b> Cutting speed $v_c$ Cutting depth $a_p$ Feed $f$		80 m/min 2 mm 0,125 mm/U
<b>Recommended machining data at finish turning</b> Cutting speed $v_c$ Cutting depth $a_p$ Feed $f$		125 m/min 0,5 mm 0,125 mm/U
* For machining we recommend to use Syndite (trademark of the „De Beers Industrial Diamond Division“) PKD tools grade 010 respectively 025. After machining with PKD tools the surface quality of the coating has a medium peak-to-valley value of $R_a$ 3,4 $\mu$ m.		

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## Technical Report PolymerMetal<sup>®</sup>

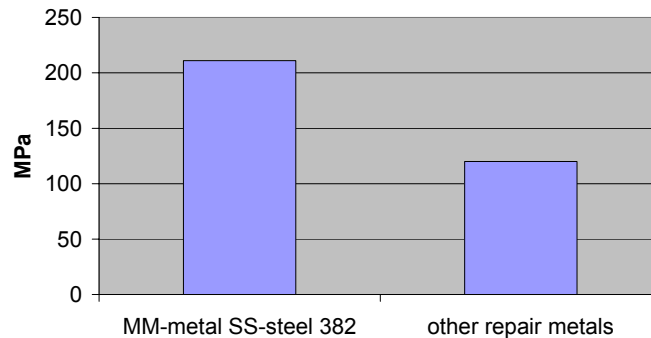
### TEC-# 009

Compressive strength, Brinell hardness & bending strength of MM-metal SS-steel 382

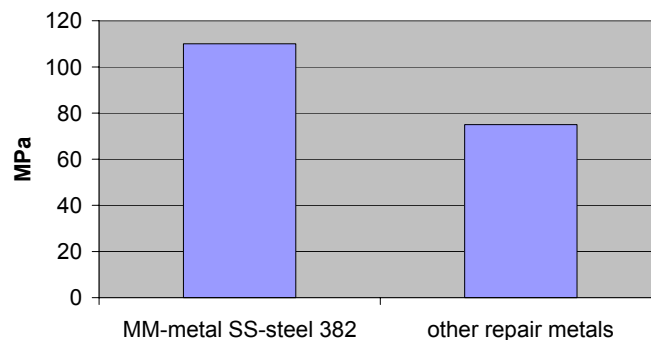
### Used products

MM-metal SS-steel 382

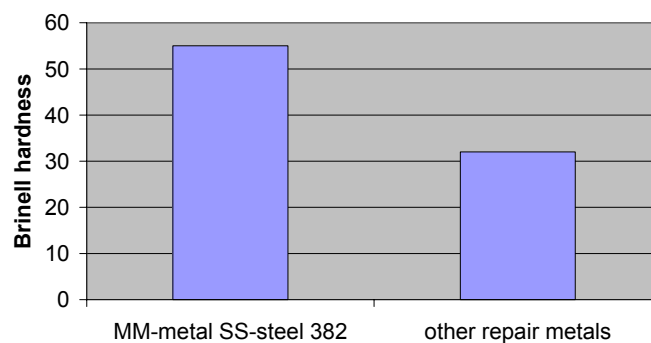
Compressive strength DIN ISO 604



Bending strength DIN 53452



Brinell hardness DIN 50351



### Description

MM-metal SS-steel 382 is a PolymerMetal on the basis of steel, which is suitable for all metals at highest technical demands. It can be machined with all normal tools.

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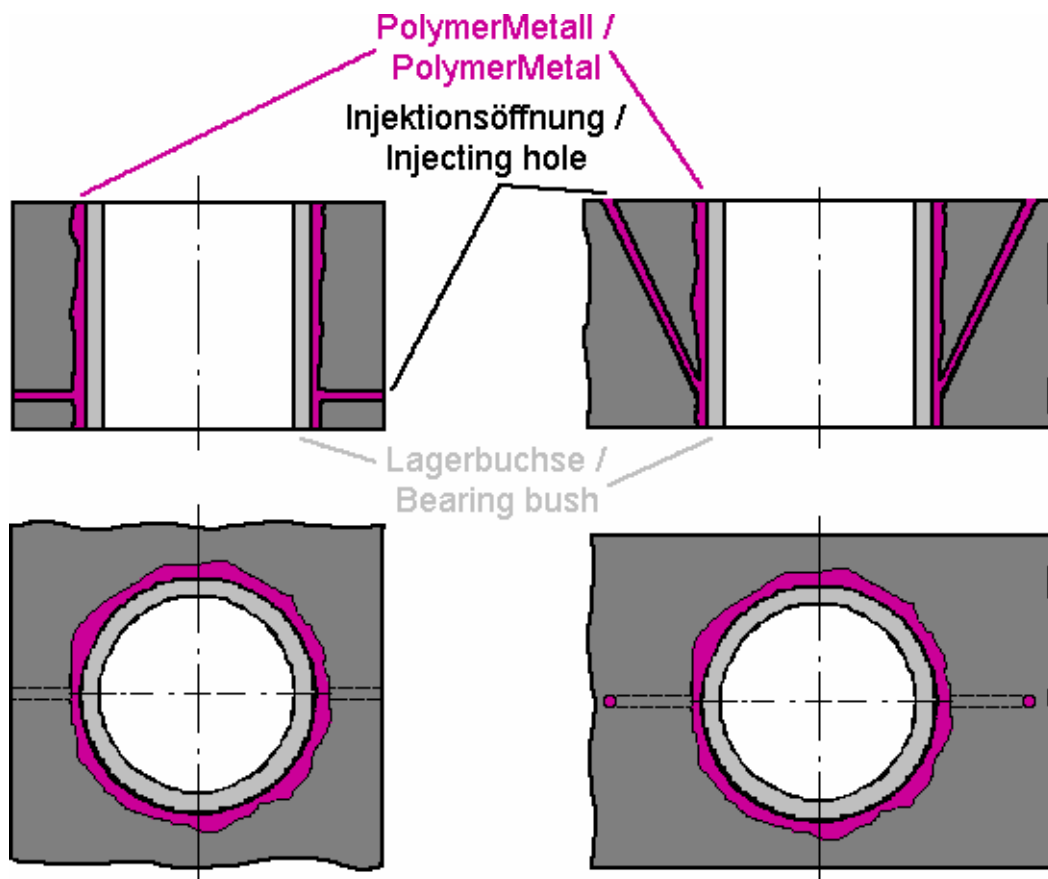
## Technical Report PolymerMetal®

### TEC-# 019

Injection of PolymerMetal

### Used products

MM-metal SS-steel 382, liquid / MM-metal SS-steel, liquid / Ceramium®, liquid



### Description

Next to a pasty or brushable application consistency many PolymerMetals are available in a liquid application consistency, too. An essential advantage of these liquid PolymerMetals is that they can be injected at i.e. difficult accessible repair sites to fill up hollow spaces or gaps in devices. Air bubbles embedded in the PolymerMetal do have a bad influence on the bonding between PolymerMetal and device. Therefore it is important, that the air can escape from the area which is supposed to be filled with PolymerMetal. We recommend drilling a channel, so the PolymerMetal can be injected. The channel should be constructed in a way that through the injection hole the PolymerMetal fills the space or gap from the bottom to the top so that the trapped air can escape.

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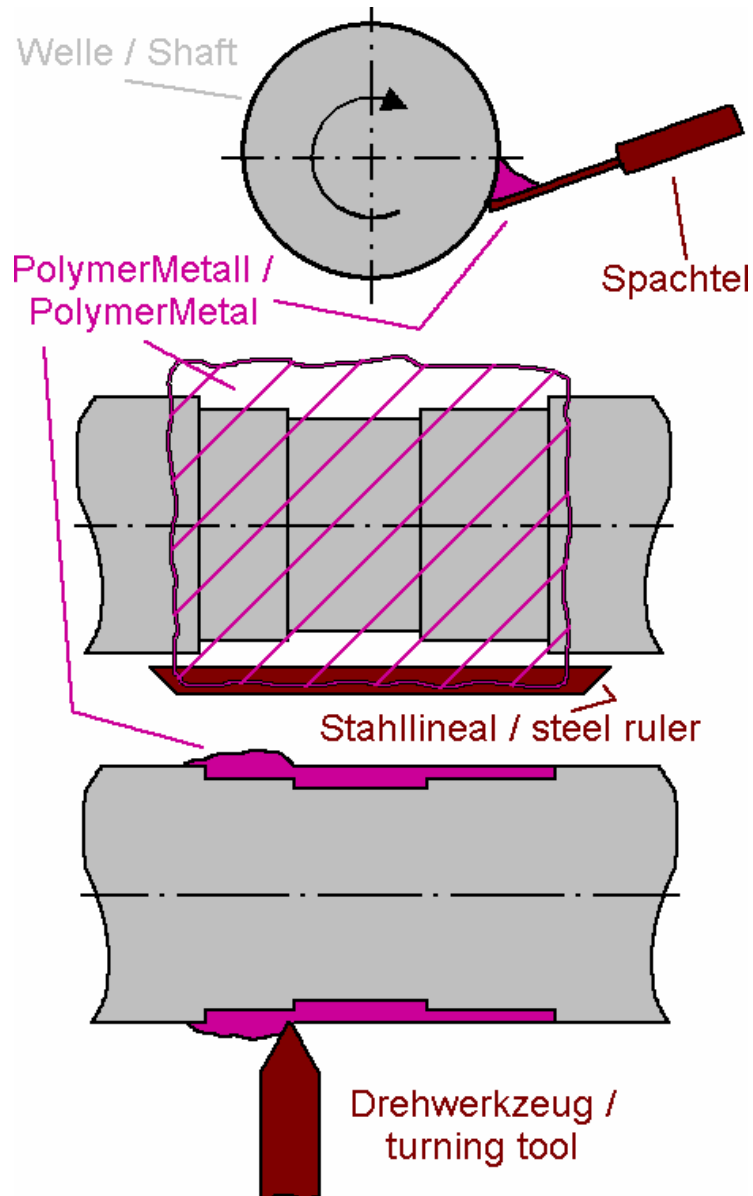
## Technical Report PolymerMetal®

### TEC-# 020

Repair of a propeller shaft with PolymerMetals (short version)

### Used products

MM-metal SS-steelceramic / MM-metal SS-steel 382 / MM-metal SS-steel/aluminium/copper/bronze / Ceramium® / Molymetall®



### Description

PolymerMetals can be used to repair worn shafts by restoring material. Here the PolymerMetal can be applied during running shaft followed by turning down to nominal diameter. For this repair should be used one of the above mentioned PolymerMetals. Further information concerning the repair of a shaft with PolymerMetals can be found in the „Technical Report TEC-# 008“.

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## Technical Report PolymerMetal<sup>®</sup>

### TEC-# 023

Comparison compressive strength

### Used products

MM-metal SS-steel 382, MM-metal SS-steel

### Description

All manufacturers from polymer-metallic repair products are endeavoured to offer highest product quality. To do justice to these requirements, MultiMetall develops and produces polymer-metallic products on a high level.



The strength particularly the compressive strength describes, how much a work piece can be stressed before it breaks.



Important are the cohesion forces which hold together the smallest parts of a work piece. As soon as the loading exceeds the cohesion forces the work piece breaks.

Based on its high user-orientated and developing potential MultiMetall does have a superior position in the area of polymer-metallic materials for years.



The following table compares the highest compressive strength data of polymer-metallic repair products from other producers with the data of some PolymerMetals produced by MultiMetall. The compressive strength of the MultiMetall-products has been determined by tests executed by IFAM / Germany according to DIN EN ISO 604.



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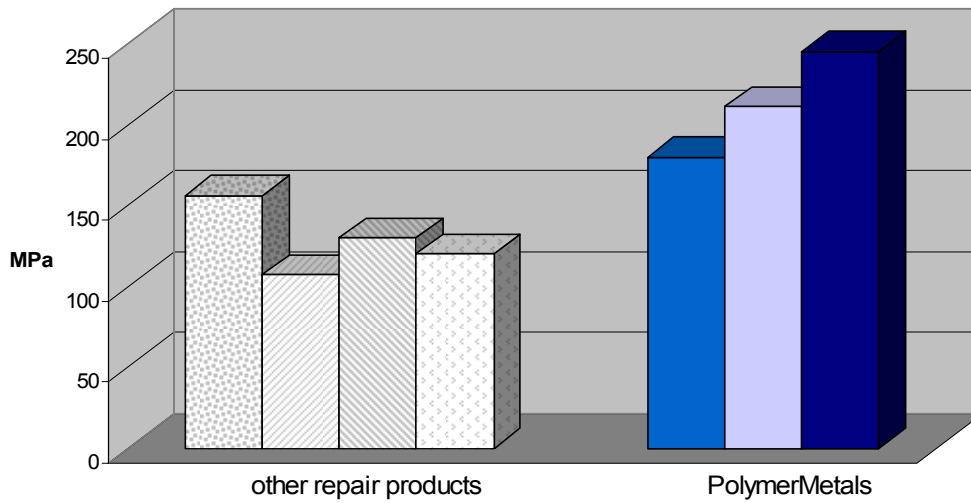
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<b>Repair products from other manufacturers</b>	<b>MPa</b>	<b>PSI</b>
Repair product A	156	22620
Repair product B	107	15515
Repair product C	130	18850
Repair product D	120	17400
<b>PolymerMetals from MultiMetall</b>	<b>MPa</b>	<b>PSI</b>
MM-metal SS-steel	180	26100
MM-metal SS-steel 382	211	30595
MM-metal SS-steel 382 (aftercured)	245	35525

### Compressive strength



The drawing shows, that MultiMetall's PolymerMetals do without exception deliver higher data in comparison with work piece-similar products from competitors.

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## Technical Report PolymerMetal®

### TEC-# 024

Long-time test at high pressure / Deformation under load (creep characteristics)

### Used products

MM-metal SS-steel 382

### Introduction

For a repair of a metallic work piece, a polymer material is searched for, that needs to withstand a physical stress / pressure of 140 MPa (20.300 psi) for a long period of time when applied to or embedded with a maximum layer thickness of 10 mm. The target of the experiment is to test how a polymer material reacts under pressure during a longer test period in appropriate measurements approximate to the above mentioned maximum layer thickness. Next to MM-metal SS-steel 382, which is a development of our PolymerMetal MM-metal SS-steel 381 offering a compressive strength of 211 MPa (30.595 psi) further polymer-metallic materials with compressive strengths of 155 MPa (22.475 psi) up to 180 MPa (26.100 psi) have been tested.



Fully cured samples of polymer-metallic materials with the dimension of 10 mm x 10 mm x 20 mm were prepared. The decrease of pressure during the following tests occurs, because of the materials giving way to the pressure over a longer period of time and therefore are compressed in height and stretched in width / length.

### Test data

Full curing of the samples - at 22 °C	12 h
- followed by curing at 30 - 40 °C	2 h
Test temperature	23 °C
Loading of the samples	140 ... 160 MPa (20.300 ... 23.200 psi)

At the following tests a sample has been clamped and tested under pressure over a length of time. Immediately after the measuring of the pressure at the end of each test period, the sample was exposed to the starting pressure of minimum 140 ... 160 MPa (20.300 ... 23.200 psi) again.



### Polymer-metallic material with a compressive strength of 155 MPa (22.475 psi)

Test period section	1	2	3	4	5	Total
Test period in h	0,5	0,5	0,5	1	2,5	5 h
Pressure in MPa (in psi)	140 (20.300)	140 (20.300)	140 (20.300)	140 (20.300)	140 (20.300)	
Pressure caused by compression in MPa (in psi)	115 (16.675)	131 (18.995)	136 (19.720)	135 (19.575)	135 (19.575) => break	<b>Break of the sample after total 5 h</b>

Dimensions of the sample: base 9,995 mm x 19,980 mm with height 10,005 mm

Test period section	1	2	Total
Test period in h	15	1	16
Pressure in MPa (in psi)	140 (20.300)	140 (20.300)	
Pressure caused by compression in MPa (in psi)	95 (13.775)	130 (18.850) => break	<b>Break of the sample after total 16 h</b>
Measured stretched length in mm	0,58	not measurable anymore	not measurable anymore
Measured compressed height in mm	0,56	not measurable anymore	not measurable anymore

Dimensions of the sample: base 10,020 mm x 19,975 mm with height 9,995 mm

### Polymer-metallic material „MM-metal SS-steel special formulation 202/5“ with a compressive strength of 180 MPa (26.100 psi)

Test period section	1	2	Total
Test period in h	24	72	96
Pressure in MPa (in psi)	142 (20.590)	142 (20.590)	
Pressure caused by compression in MPa (in psi)	111 (16.095)	126 (18.270)	
Measured stretched length in mm	0,43	0,27	0,70
Measured compressed height in mm	0,46	0,24	0,70

Dimensions of the sample: base 9,995 mm x 20,405 mm with height 10,000 mm

### Polymer-metallic material „MM-metal SS-steel 382“ with a compressive strength of 211 MPa (30.595 psi)

Test period section	1	2	3	4	5	6	7	Total
Test period in h	0,5	4,5	15	24	72	24	48	188
Pressure in MPa (in psi)	151 (21.895)	151 (21.895)	147 (21.315)	143 (20.735)	150 (21.750)	143 (20.735)	160 (23.200)	
Pressure caused by compression in MPa (in psi)	139 (20.155)	143 (20.735)	139 (20.155)	141 (20.445)	139 (20.155)	141 (20.445)	155 (22.475)	
Measured stretched length in mm	not measured	0,34	0,13	not measured	not measured	0,12	0,07	0,66
Measured compressed height in mm	not measured	0,36	0,13	not measured	not measured	0,12	0,05	0,66

Dimensions of the sample: base 10,060 mm x 19,985 mm with height 10,075 mm



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## Summary

If a certain compressive strength is required over a long period of time, it is important that the compressive strength of the chosen material is high enough in order to achieve the required compressive strength under high pressure over a long period of time. If a big layer thickness (i.e. 10 mm) is required, the provided data by the manufacturer concerning the compressive strength of x MPa (x psi) might not be enough. Decisive is the measured data of the compressive strength of the samples with a height corresponding to the required layer thickness (so here i.e. 10 mm).

MM-metal SS-steel 382 can be used at very high pressures under load. By the way, the high E-module of MM-metal SS-steel 382 (E-module at 20 °C (DIN EN ISO 6721-5) = 15.600 MPa (2.262.000 psi) / torsional storage module at 20 °C (DIN EN ISO 6721-2) = 5.900 MPa (855.500 psi) opposes against the material's attempt to creep under pressure and works against a deformation at a steady load.

MM-metal SS-steel 382 is a PolymerMetal and construction material, which can optimise the desired material properties. The high performance material MM-metal SS-steel 382 delivers the best technical data under mechanical and physical stress.

**MultiMetal**  
the MetalExistenceCompany™



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## Technical Report PolymerMetal<sup>®</sup>

### TEC-# 027

Examination of shearing strength

### Used products

MM-metal SS-steel 382

### Description

Several cylinder tappets and shells made off steel have been coated with the PolymerMetal MM-metal SS-steel 382. Immediately afterwards the tappets were inserted into the shells. After full curing of the PolymerMetal the compound was stressed in traction direction to determine the shearing strength.



### Result

The extraordinary shearing strength of MM-metal SS-steel 382 with a value of 30 MPa was proved by the tests. MM-metal SS-steel 382 cures without the creation of cracks.

The linear shrinkage of MM-metal SS-steel 382 is according to ASTM D 2566 with a value of 0,0001181 cm/cm extremely low. It is therefore clearly below the values of comparable polymer materials. MM-metal SS-steel 382 is suitable superiorly as construction material.

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