Evaluation – SPE 191942-MS

AT Wire Wrapped Screen

Performed on 14th of January 2021

Exceptional resistance to wear:

The higher the hardness, the lower the erosion

Equipment and Services for Underground Operations for O&G, Water, Geothermal and Mining

Presentation Outline

- **Introduction**
- **AT Wire Wrapped Screen – a msc resources solution**

  - GSET after SPE 191942 – MS

- **Current and future Test activities**

Exceptional resistance to wear:

The higher the hardness, the lower the erosion

Introduction – My Methodology

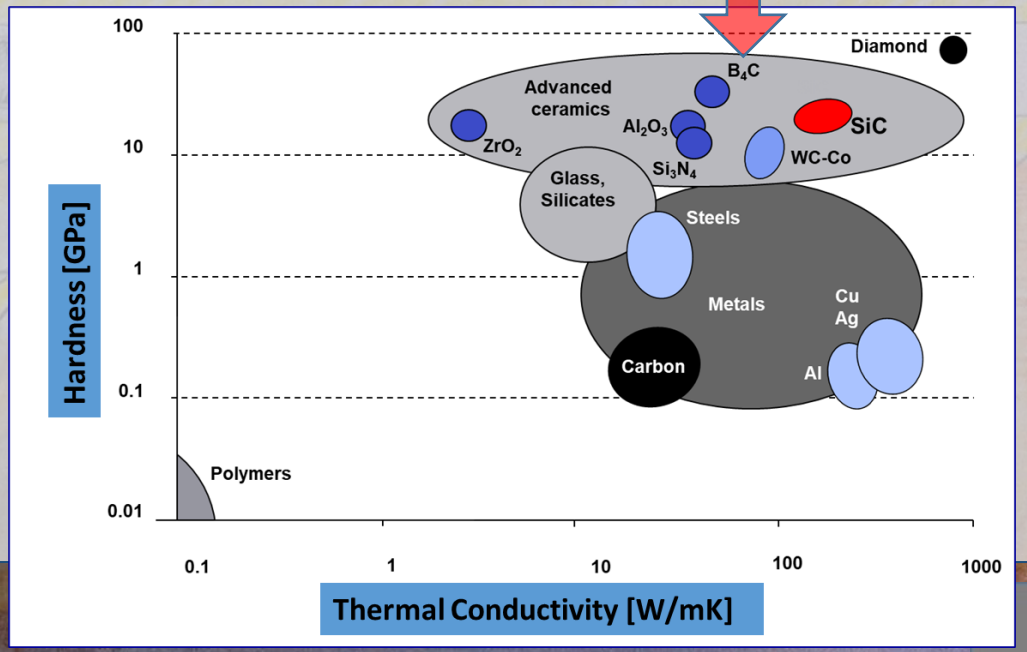
My approach in June 2020:

What is the status quo and what has to be realized to improve existing product?

- **On current Erosion resistant solutions of screens in the market**
  - What are the Disadvantages?
- **Which solution in the market is available, proven and accepted for better performance:**
  - Material
  - Erosion
  - Corrosion
  - Type of Screen

Used Materials in the market

- **Stainless Steel…**
- **SiC – 3M**
- **WC-Co - conslot**
- **ZrO_2 - conslot**
- **B_4C - ???**



Exceptional resistance to wear:

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Introduction - Independent Studies on Advanced Screens

What is done - Process for Erosion Testing on Screen, Design and Material

- **SPE-191942-MS,** Gas Sand Screen Erosion Tests (GSET). It was initiated by 3M for Petronas, tested in Australia to compare effects on Erosion between a regular Wire Wrapped Screen with a Ceramic Sand Screen, used to be called “PetroCeram”.

- **The Gas Sand Screen Erosion Tests (GSET)** were carried out for 2h and 48h and under the following test conditions (see table).

gas flow rate	102 m^3/h
sand injection rate	1.48 g/min
sand weight percentage	750 ppmw
test temperature	298.15 K
particle size (sand)	100 µm
impact velocity	80 m/s to 100 m/s
impact angle	90°

Source: Fraunhofer IEG

- **Fraunhofer IEG** in Bochum / Germany prepared and repeated this test with:
  - Coated Wire Wrapped Sand Screen of Conslot in December 2020
  - AT Wire Wrapped Sand Screen, a msc resources solution in January 2021

Exceptional resistance to wear:

The higher the hardness, the lower the erosion

Introduction - Armouring Technology - Extreme hardness for metal tools

The Material - What has to be realized to improve

Boron - remember from the image before…

- **Boriding** is a thermochemical surface treatment for ferrous metals where boron diffuses into the metal surface to provide an extremely hard and wear-resistant surface layer. The method is suitable for components which are exposed to extreme adhesive wear or abrasion and where other treatments reach their limits.

  All ferrous materials as well as numerous high alloy steels are suitable for boriding

- Adhesion between the boride layer and the base metal following various degrees of indentation, **see micrographs of boride layers**

Exceptional resistance to wear:

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Introduction - Armouring Technology - Extreme hardness for metal tools

Various base material properties are clearly enhanced by boriding, including

- Surface hardness - 3 times higher than before boriding
- Hot hardness
- Corrosion resistance to alkali and non oxidizing acids
- Erosion resistance
- Cavitation resistance

After boriding, a number of features remain unaffected, including

- Resistance to heat shocks
- Thermal conductivity
- Electric conductivity
- Thermal expansion
- Material elasticity

Exceptional resistance to wear:

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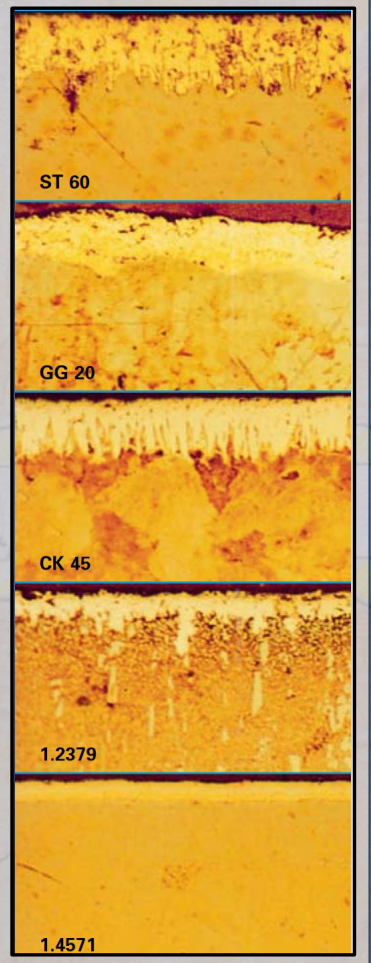
Micrographs of boride layers - various materials



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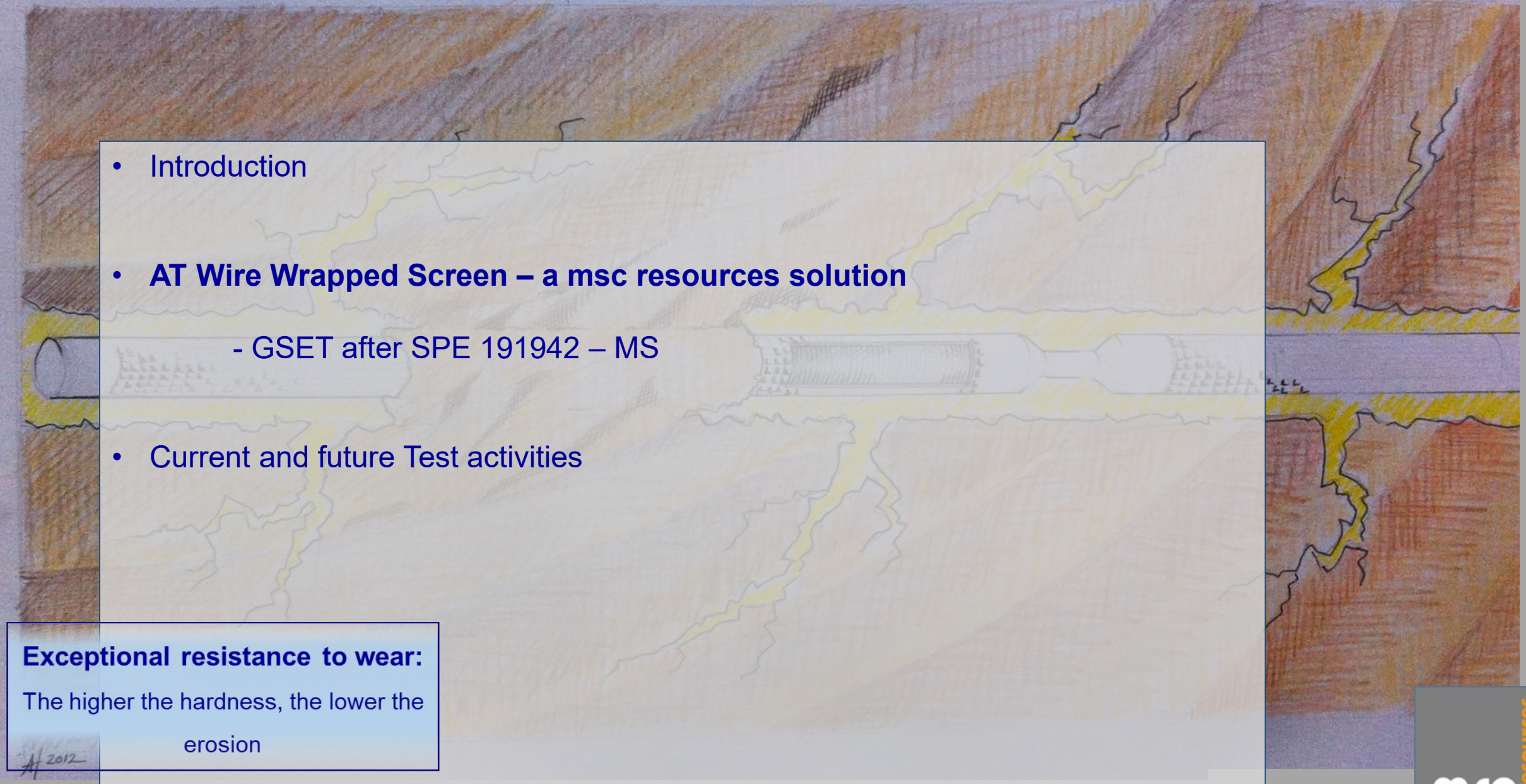
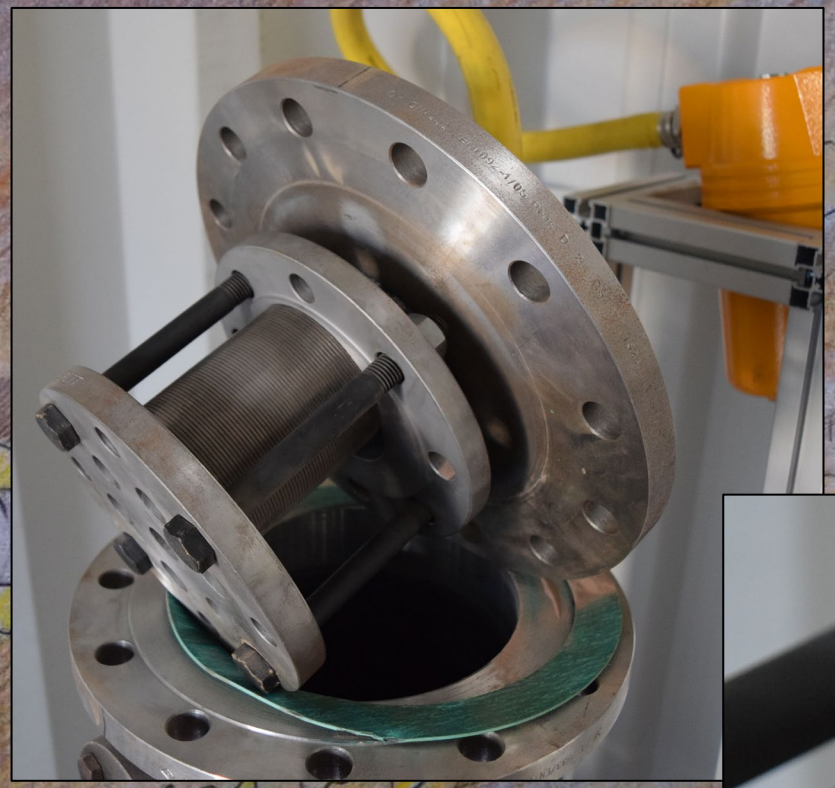
  - GSET after SPE 191942 – MS

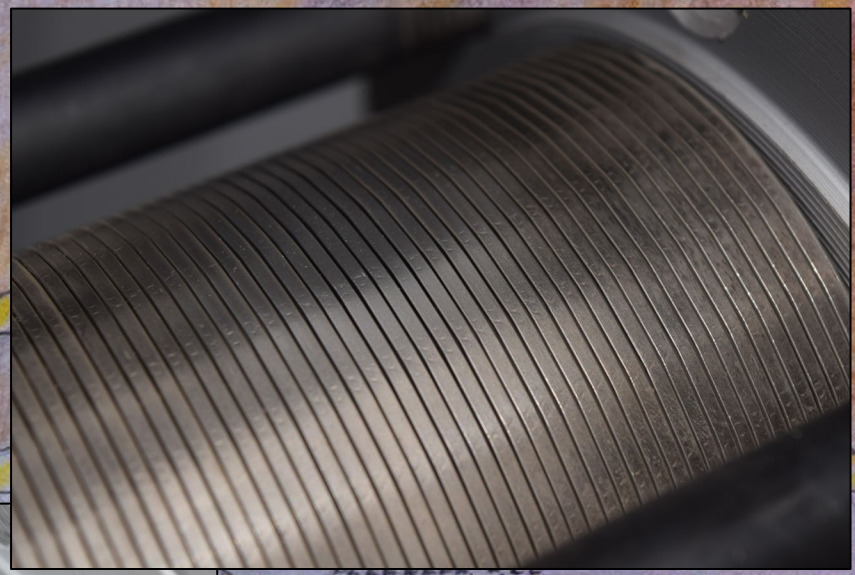
- Current and future Test activities



AT Wire Wrapped Sand Screen – a msc resources solution



Images taken before GSET-Test

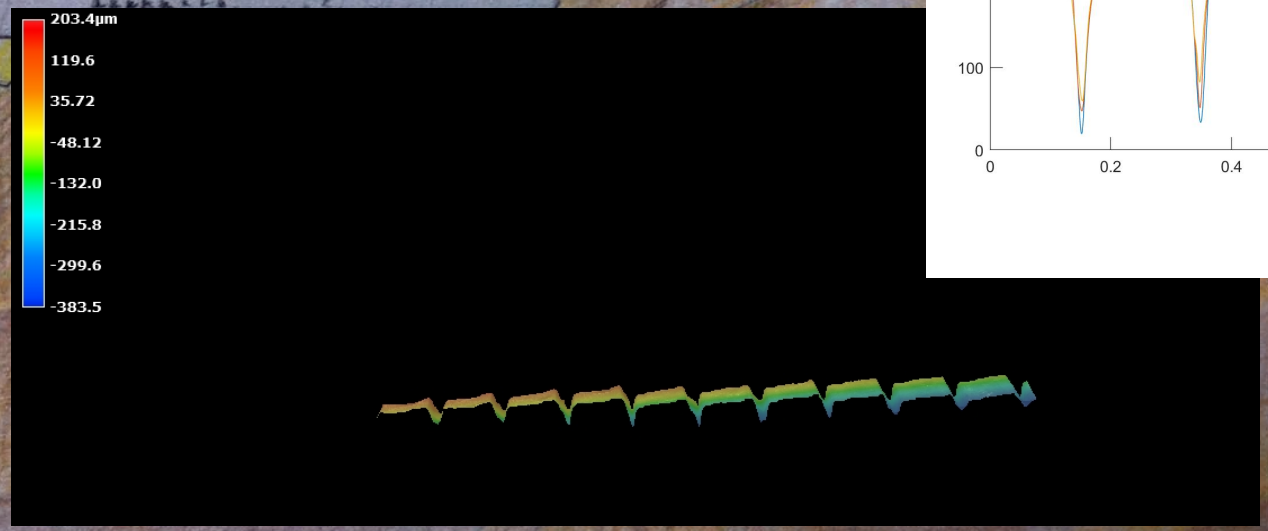


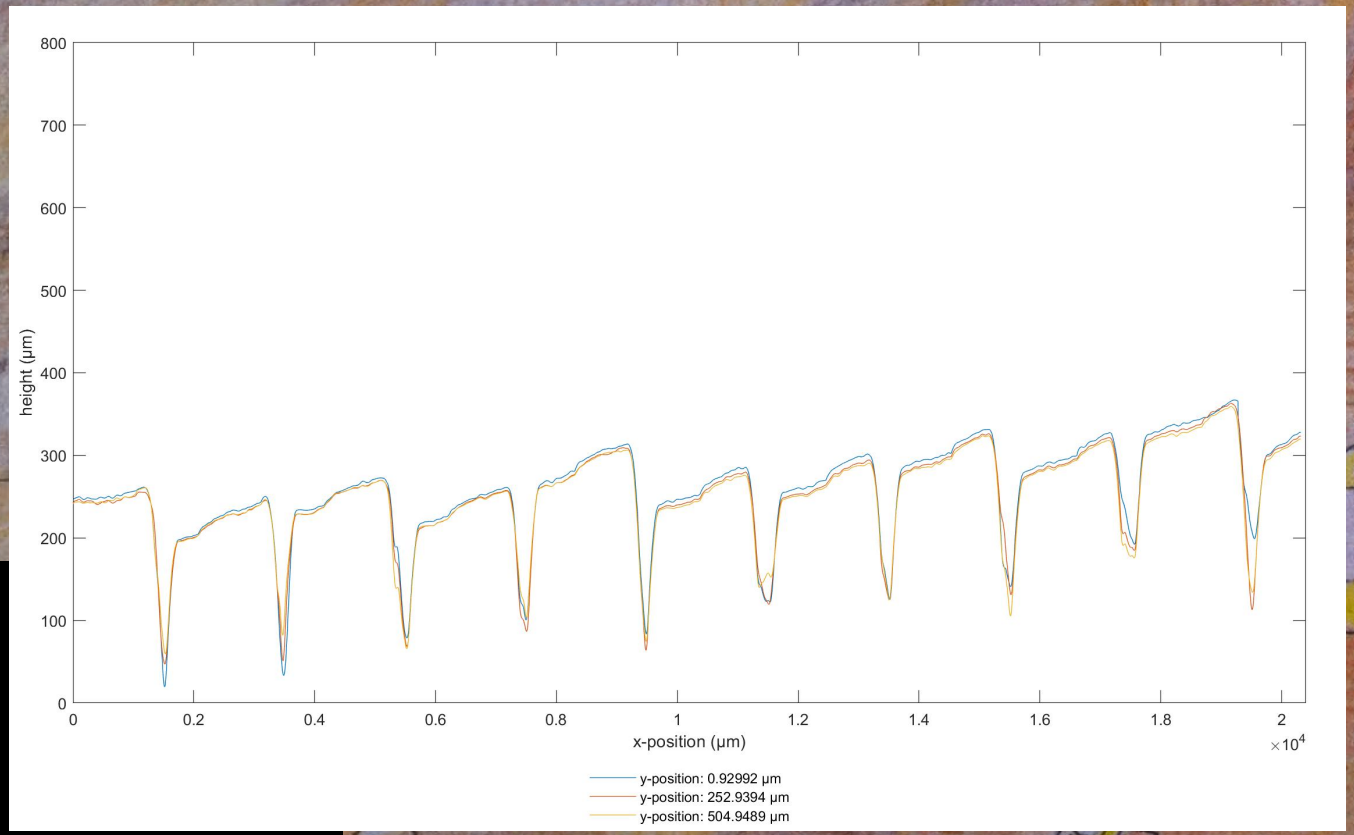
Images: Fraunhofer IEG, before Test

Before GSET-Test

AT Wire Wrapped Sand Screen – a msc resources solution

Measurements taken before GSET-Test

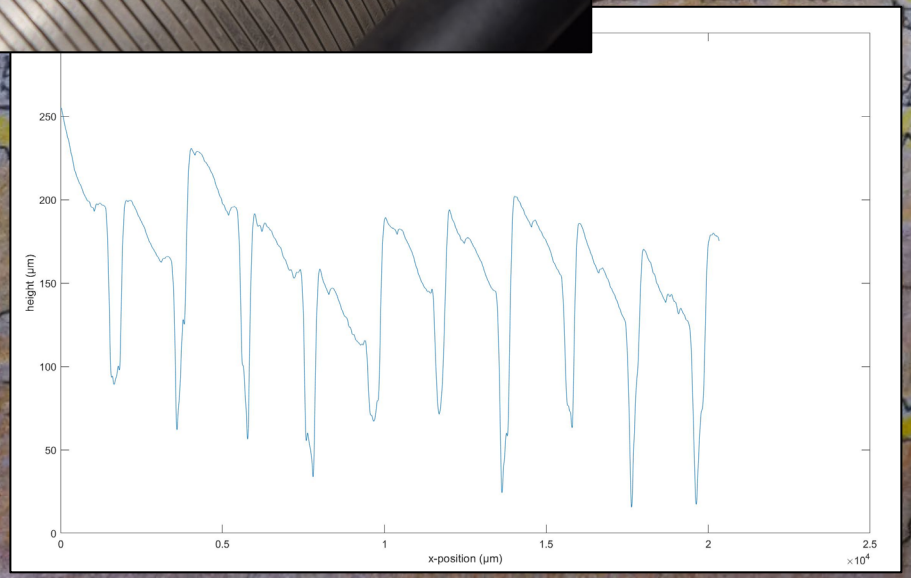




Source: Fraunhofer IEG, before Test

Before GSET-Test

AT Wire Wrapped Sand Screen – a msc resources solution



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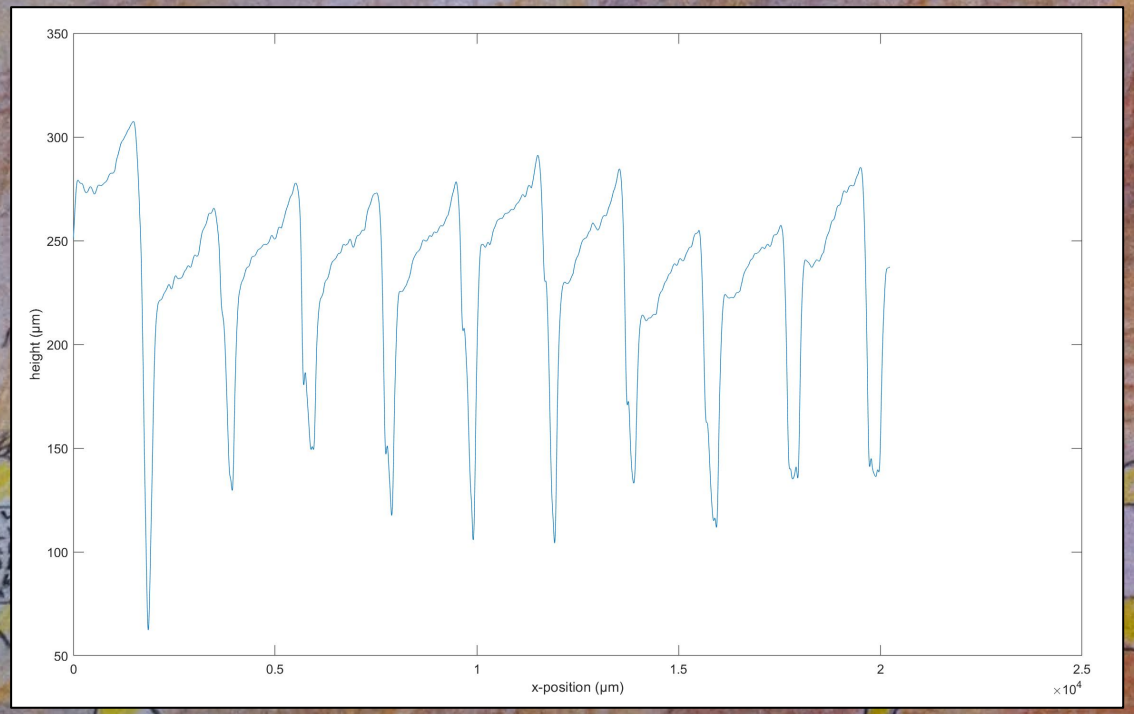


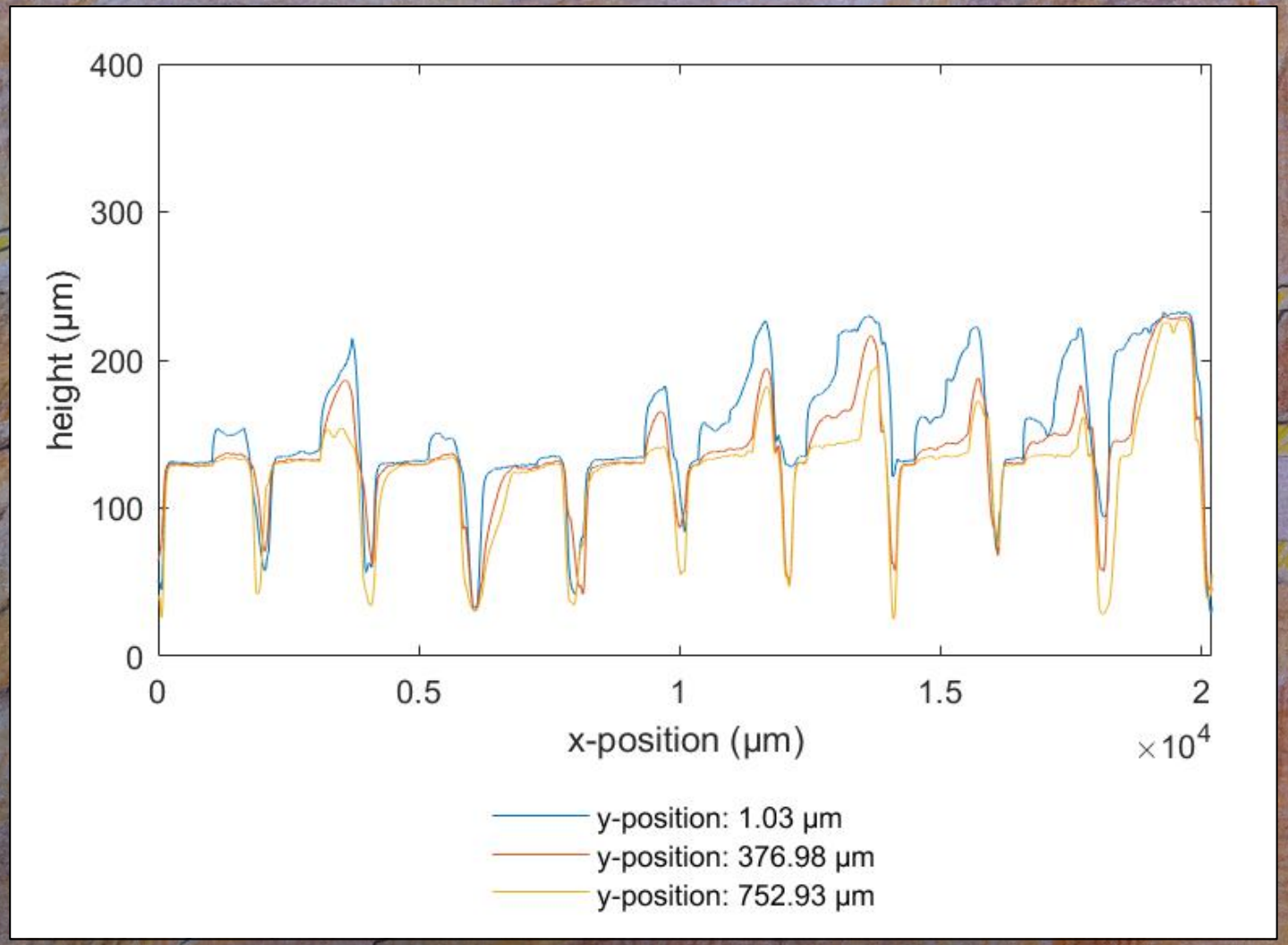
Source: Fraunhofer IEG

Images and Measurements taken after 2h- GSET-Test

Evaluation after 2h GSET-Test

AT Wire Wrapped Sand Screen – a msc resources solution

Measurement taken after 48h-GSET-Test

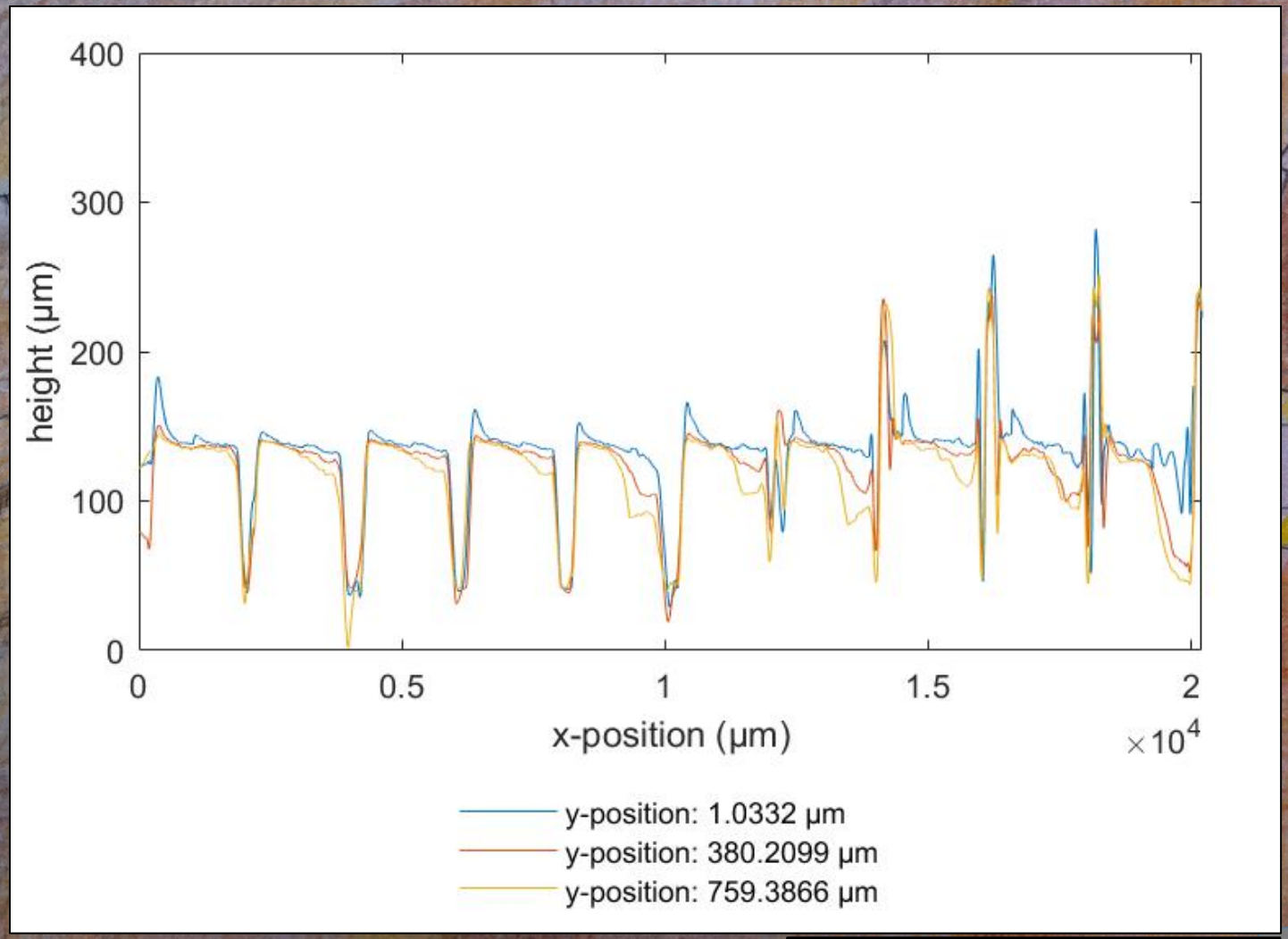


Source: Fraunhofer IEG, after 48h

Evaluation after 48h GSET-Test, Measurement 1

AT Wire Wrapped Sand Screen – a msc resources solution

Measurement taken after 48h-GSET-Test

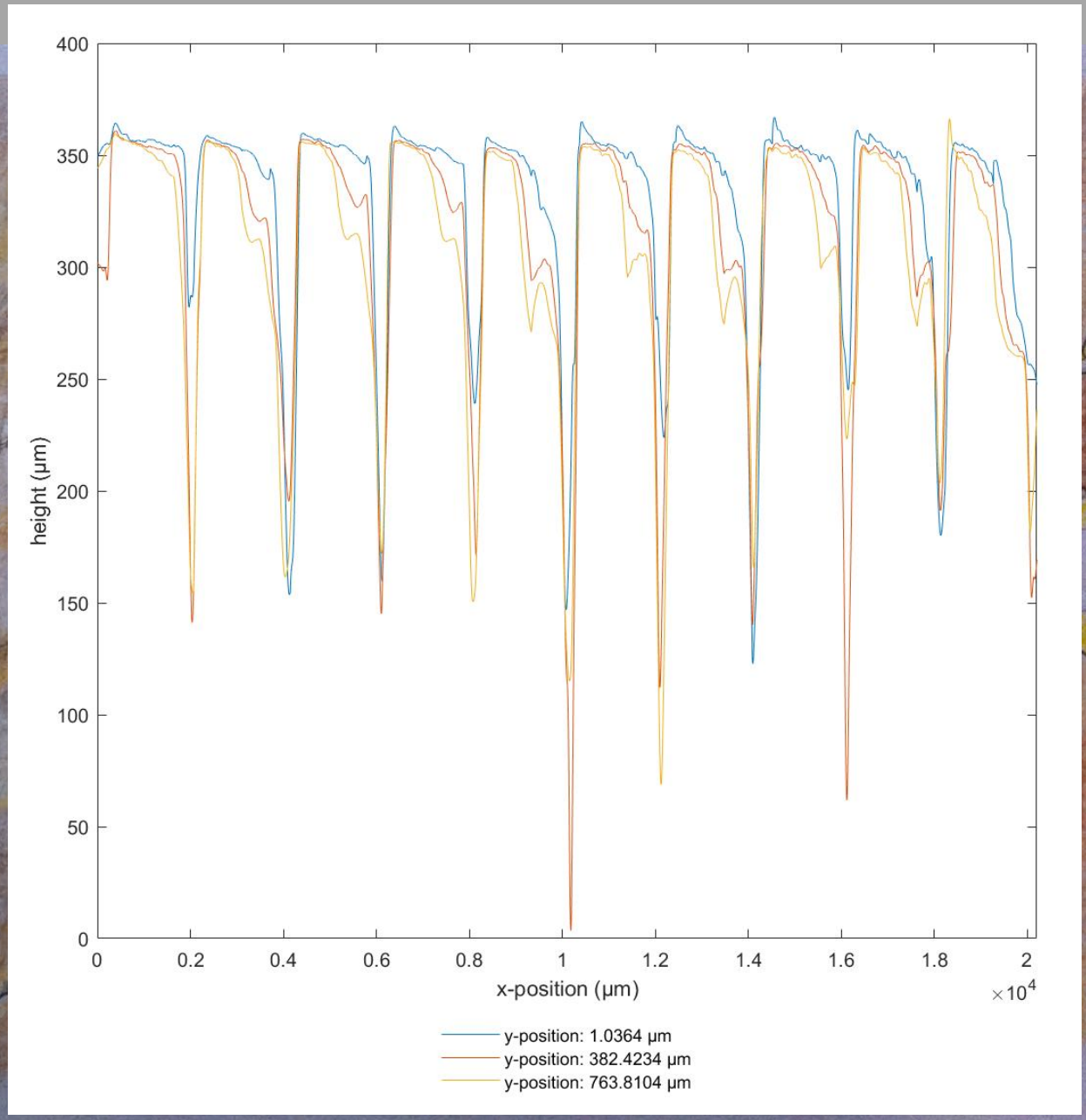


Source: Fraunhofer IEG, after 48h

Evaluation after 48h GSET-Test, Measurement 2

AT Wire Wrapped Sand Screen – a

Measurement taken after 48h-GSET-Test

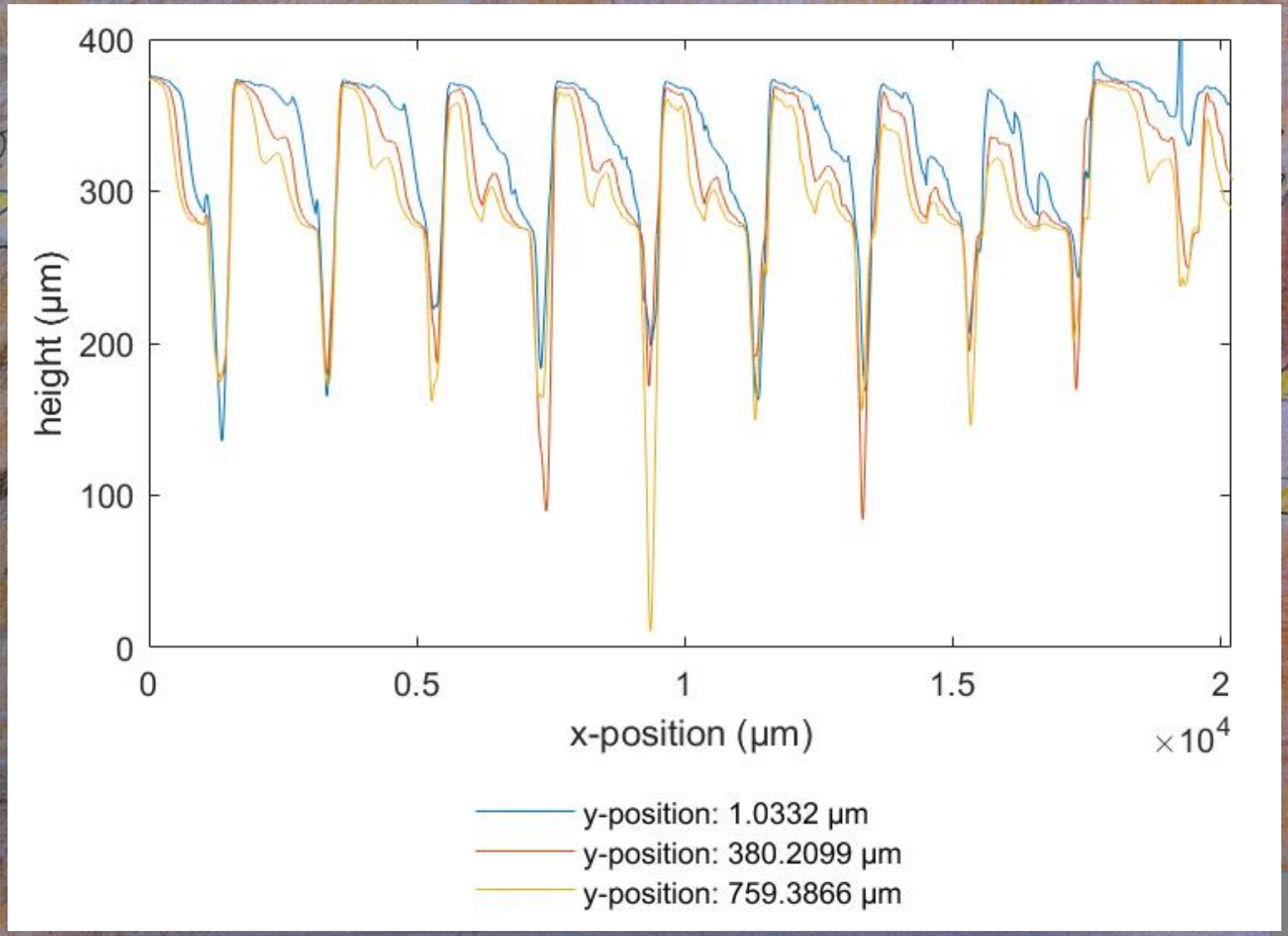


Source: Fraunhofer IEG, after 48h

Evaluation after 48h GSET-Test, Measurement 3

AT Wire Wrapped Sand Screen – a msc resources solution

Measurement taken after 48h-GSET-Test

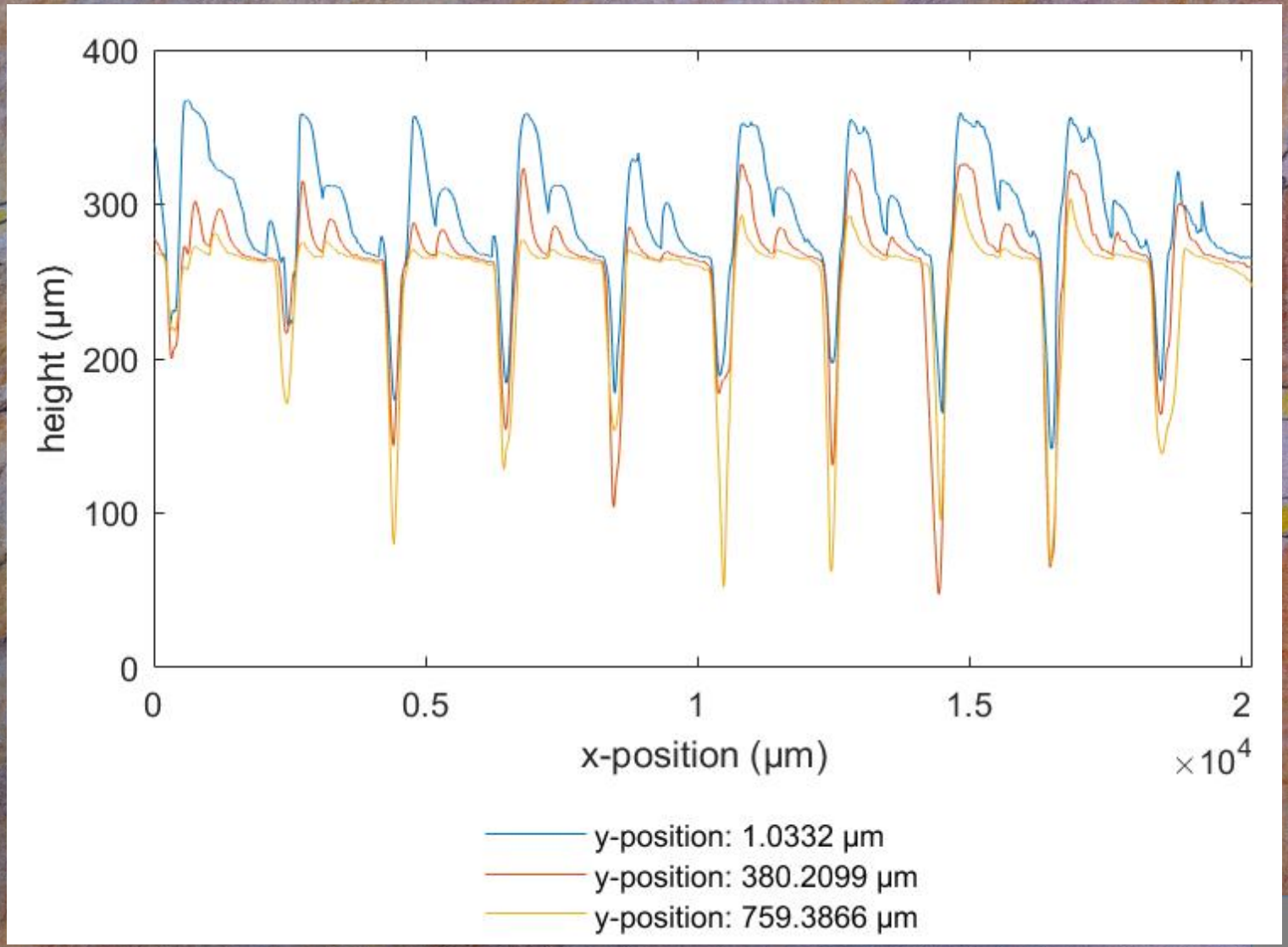


Source: Fraunhofer IEG, after 48h

Evaluation after 48h GSET-Test, Measurement 4

AT Wire Wrapped Sand Screen – a msc resources solution

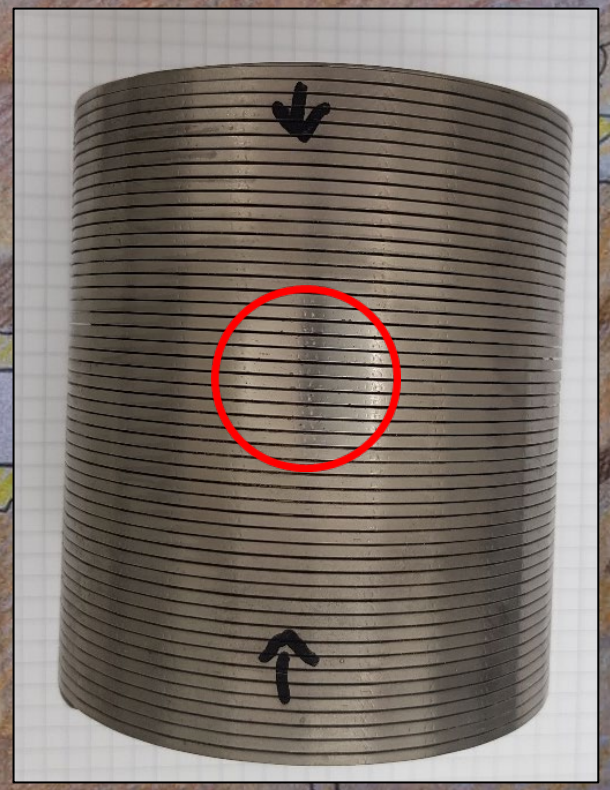
Measurement taken after 48h-GSET-Test

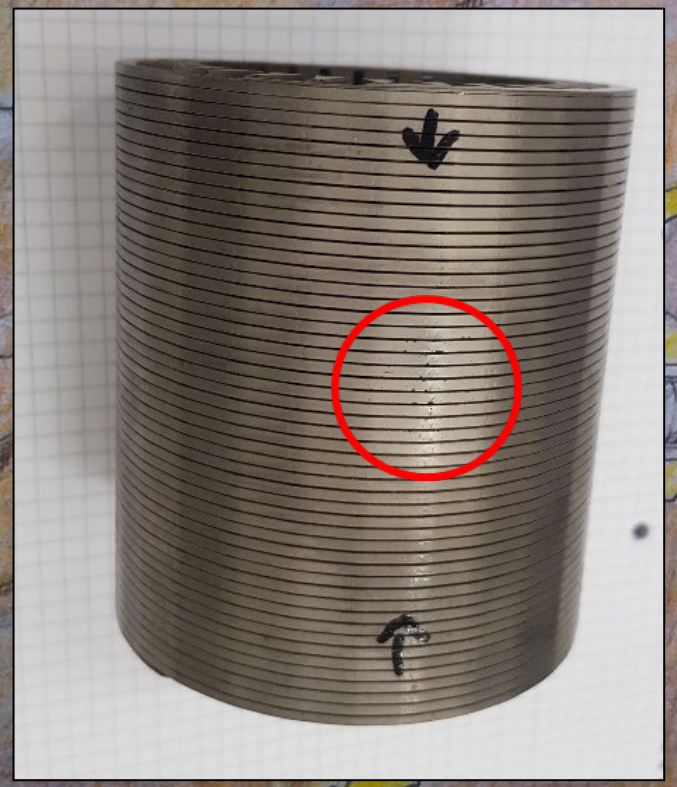


Source: Fraunhofer IEG, after 48h

Evaluation after 48h GSET-Test, Measurement 5

AT Wire Wrapped Sand Screen – a msc resources solution





Images taken after 48h- GSET-Test

Images: Fraunhofer IEG, after 48h

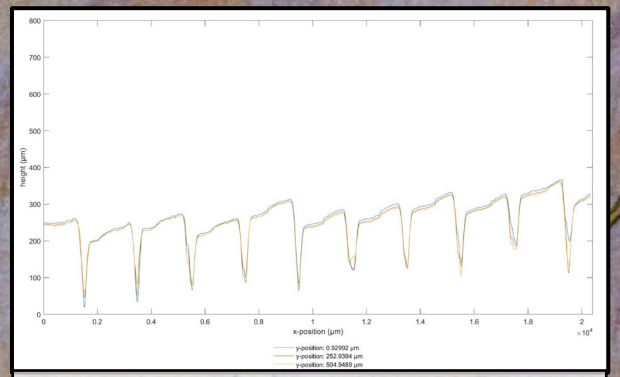
Images after 48h GSET-Test

AT Wire Wrapped Sand Screen – a msc resources solution

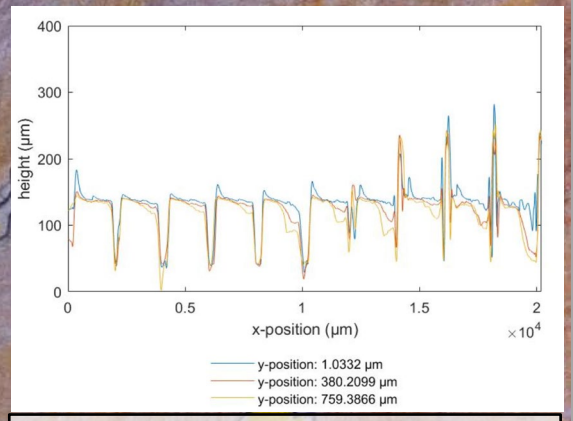
Wire Wrapped Screen treated with Boron in furnace

Specification

- Hardness for B_4C: **29.5 – 33 GPa**



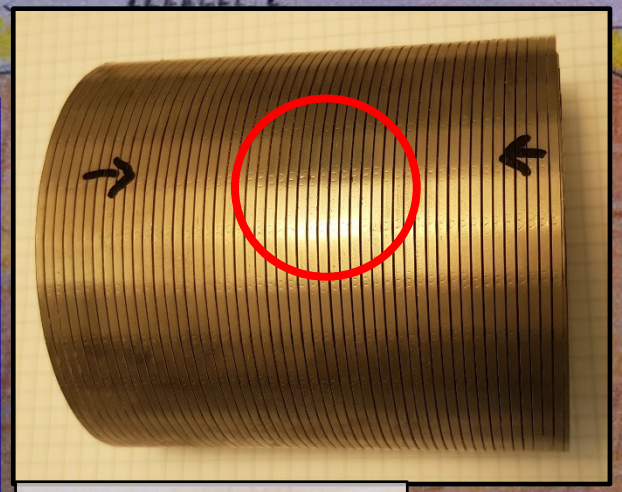
Source: Fraunhofer IEG, before Test



Source: Fraunhofer IEG, after 48h

Testing after SPE-191942-MS

- First Test for 48h to get an impression.
- **No Erosion under microscope to see**



Source: Fraunhofer IEG

Advantages

- Proven Wire Wrapped Screen Application **(++)**
- No BasePipe – Flow environment **(++)**
- No Coating **(++)**
- Full coverage inside screen **(++)**
- Still sharp edges after treatment with Boron **(+)**
- Lower in price than competitors **(++)**

Exceptional resistance to wear:

The higher the hardness, the lower the erosion

Conclusion

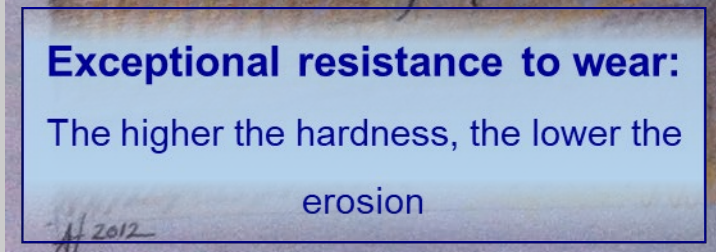
- **The model of the AT Wire Wrapped Screen was exposed to the high speed GSET Erosion Test for 2h and 48h.**
- **Almost no erosion is visible to bare eyes, which could be confirmed under the microscope.**
- **After the test, the roughness over the edge of the impact surface is about 100 µm, which is in the same range as before the start of the test.**
- **The photos and the evaluation of the microscope measurements can be found in the Fraunhofer-ownCloud (owncloud.fraunhofer.de).**

Exceptional resistance to wear:

The higher the hardness, the lower the erosion

Current and future activities

- **Currently different Mechanical Strength tests were initiated to compare the regular Stainless Steel Material used for Wire Wrapped Screens with the same Stainless Steel Material plus treated with Boron in a furnace to improve wear resistance against Erosion and Corrosion conditions.**
- **The conducted tests are Compressional and Tensile Strength.**
- **It will be done by an independent Research Institute in Dresden.**
- **The test will be conducted after an official standard norm.**



Technical Summary

Advanced Screen	Company	Design	Knoop Hardness in GPa	SPE-191942	Result	Advantages / Disadvantages	Price/m in US-$
Wire Wrapped Screen	Different	Wire Wrapped Screen. Stainless Steel. With/No Basepipe.	< 0.5	2h Testing	Average increase in gap aperture size is 114.0 µm.	Design (++) Sharp edges for bridge building (++) Material against Erosion (--)	750 to 1,500
Hard Metal / Ceramic Coated Screen	Con-slot	Wire Wrapped Screen. Stainless Steel. No Basepipe. Outside coating with Hard Metal or ZrO_2.	Hard Metal: 16 ZrO_2: max. 21.7	48h Testing	Erosion for all coating surfaces: 140µm to > 300µm.	Coating can get loose (-) No coverage inside screen (-) No sharp edges for bridge building (-)	5,100 to 6,300
SiC Ceramic Screen	3M	Build from SiC and Stainless Steel. With Basepipe. SIC Rings stacked above each other. Hold in place with springs.	21 – 25	48h Testing	Average increase in gap aperture size is 23.4 µm.	Material (+) SiC rings are very briddle (-) If one ring or a spring breaks, the whole screen falls apart (--)	>10,000
AT Wire Wrapped Screen	msc resources	Wire Wrapped Screen. Stainless Steel. No Basepipe. Treated with Boron in Furnace.	29.5 – 33	48h Testing	No Erosion under microscope.	Proven Wire Wrapped Screen App. (++) No BasePipe – Flow environment (++) No Coating (++) Full coverage inside screen (++) Sharp edges after treatment with Boron (+) Lower in price than competitors (++)	3,950 to 4,800

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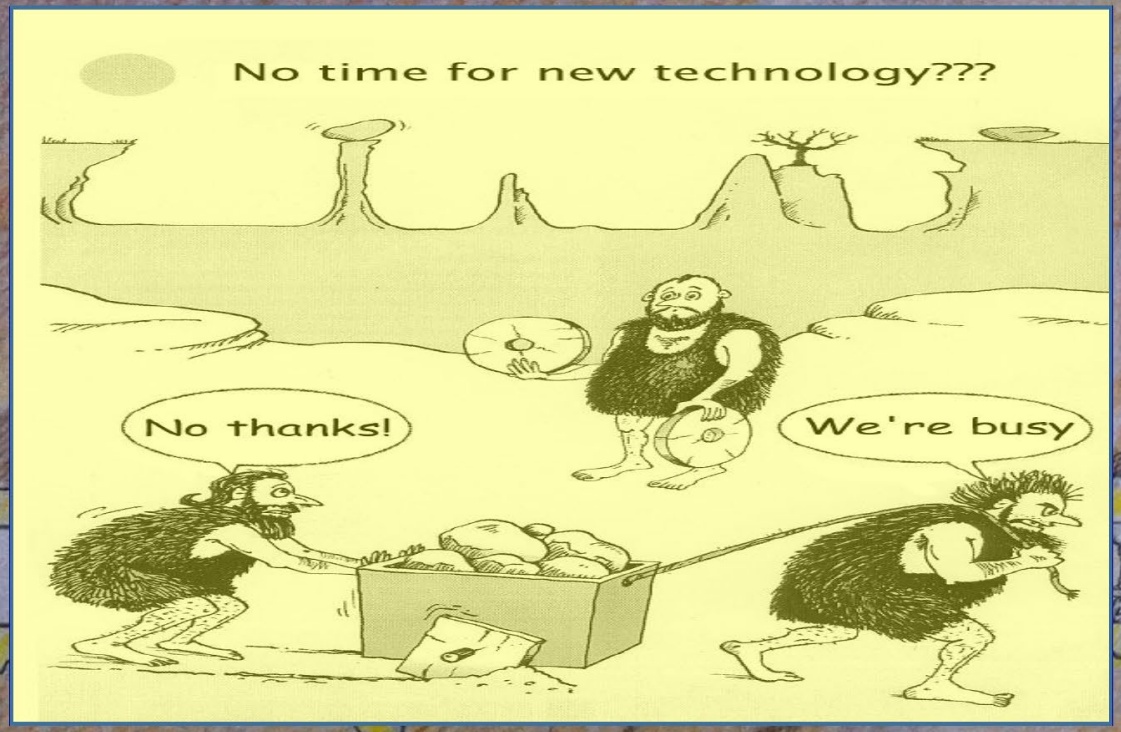

Vielen Dank für ihre Aufmerksamkeit