Metal
Solutions

# EOS StainlessSteel 316L
## Material Data Sheet

# EOS StainlessSteel 316L

EOS StainlessSteel 316L is a high performance marine-grade austenitic stainless steel that is molybdenum alloyed for enhanced corrosion resistance in chloride environments. 316L is a standard material for numerous applications in process, energy, paper, transportation and other industries. EOS StainlessSteel 316L is a stainless steel powder intended for manufacturing parts on EOS metal systems with EOS DMLS processes.

**Main Characteristics:**

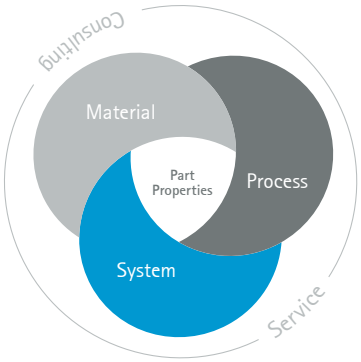
- → High ductility and toughness
- → High strength
- → High corrosion resistance

**Typical Applications:**

- → Chemical industry
- → Food processing
- → Medical devices

**The EOS Quality Triangle**

EOS uses an approach that is unique in the AM industry, taking each of the three central technical elements of the production process into account: the system, the material and the process – together simply described as the Quality Triangle. EOS focuses on delivering reproducible part properties for the customer.




All of the data stated in this material data sheet is produced according to EOS Quality Management System and international standards.

## Powder Properties

The chemical composition of EOS StainlessSteel 316L corresponds to ASTM F138 material standard for Surgical Implants (UNS S31673).

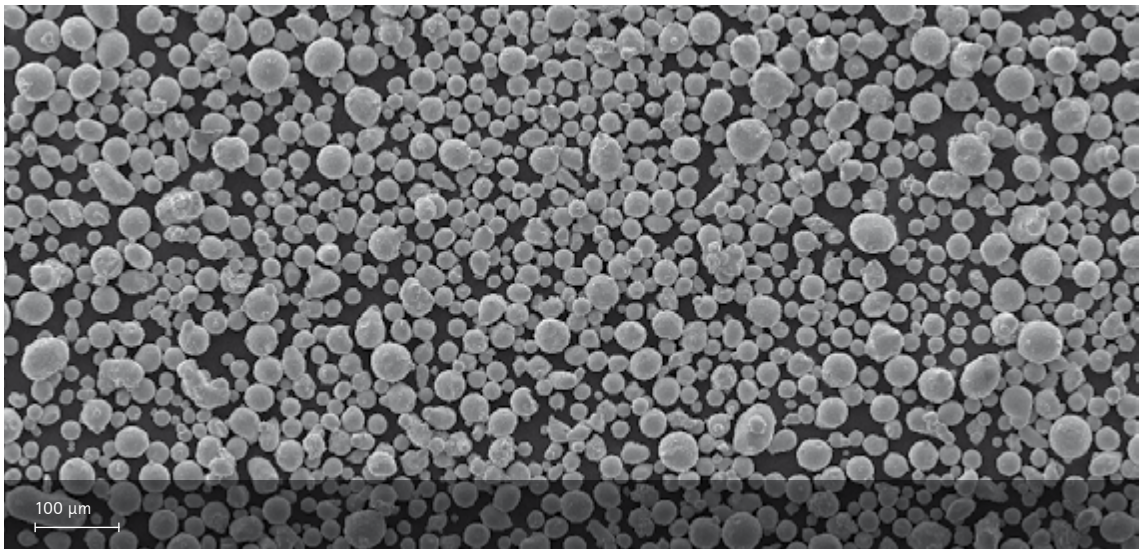
**Powder chemical composition (wt.-%)**

| Element | Min. | Max. |
|---|---|---|
| Fe | Balance | |
| Cr | 17.00 | 19.00 |
| Ni | 13.00 | 15.00 |
| Mo | 2.25 | 3.00 |
| C | - | 0.03 |
| N | - | 0.10 |

**Powder particle size**

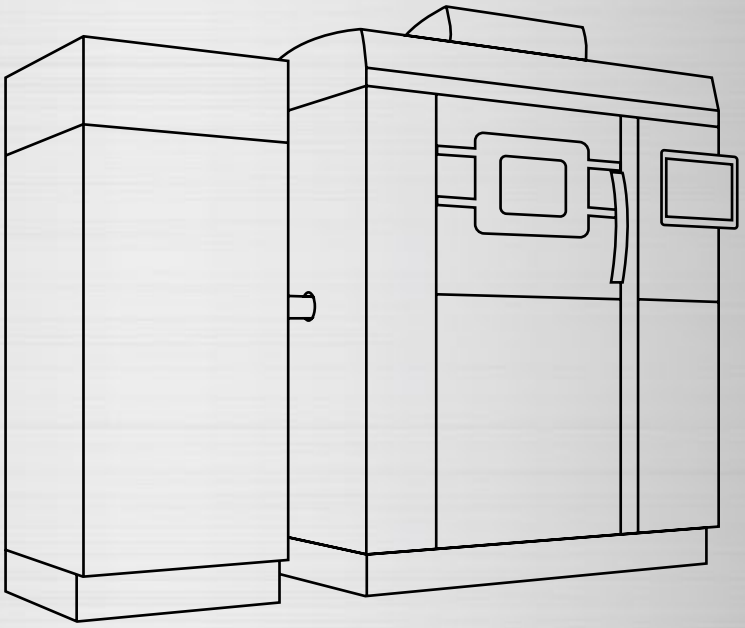
| | |
|---|---|
| Generic particle size distribution | 20 – 65 µm |

*SEM picture of EOS StainlessSteel 316L powder.*



TRL 8

Premium



# EOS StainlessSteel 316L
# **for EOS M 290 | 20 µm**

Process Information

Chemical and Physical Part Properties

Heat Treatment

Mechanical Properties

Additional Data

HHE/05.2014

# EOS StainlessSteel 316L for EOS M 290 | 20 µm

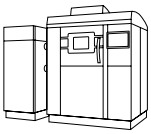
## Process Information

This process product is optimized for robustly building parts with EOS M 290 system using EOS StainlessSteel 316L. The mechanical properties have been validated to TRL8 level.

| System set-up | EOS M 290 |
|---|---|
| EOS ParameterSet | 316L 20µm Surface M290/400W |
| EOSPAR name | 316L_Surface_1.X |
| Software requirements | EOSPRINT 2.7 or newer<br>EOSYSTEM 2.11 or newer |
| Powder part no. | 9011-0032 |
| Recoater blade | EOS HSS blade |
| Nozzle | Standard nozzle |
| Inert gas | Argon |
| Sieve | 63 µm |

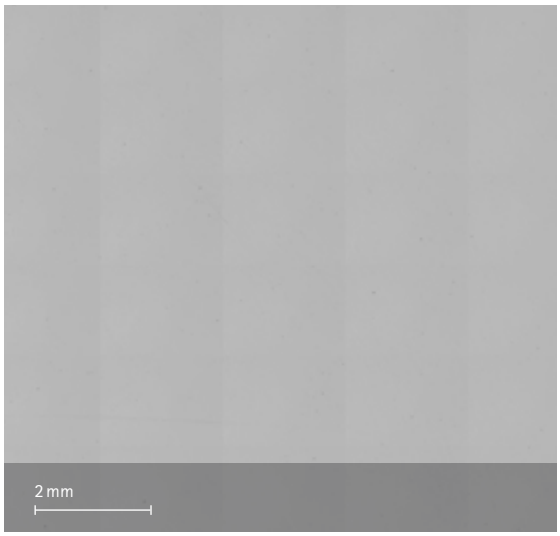
| Additional information | |
|---|---|
| Layer thickness | 20 µm |
| Min. wall thickness | 0.3 - 0.4 mm |
| Typical dimensional change after HT | +0.02 % |
| Volume rate | 2.0 $mm^3/s$ |

## Chemical and Physical Properties of Parts[1]



Chemical composition of built parts is compliant to EOS StainlessSteel 316L powder chemical composition.

**Micrograph of polished surface**




**Microstructure solution annealed**
Etched with etchant Kallings 2


| Defects | Result | Number of samples |
|---|---|---|
| Average defect percentage | 0.018 % | 45 |
| **Density, ISO3369** | **Result** | **Number of samples** |
| Average density | ≥ 7.97 g/cm³ | 45 |

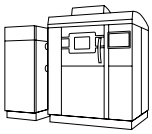
## Heat Treatment

Heat treatment according to AMS 2759 is optional.

Stress relief: Hold temperature 900 °C, hold time minimum 2 h when thoroughly heated, water quenching

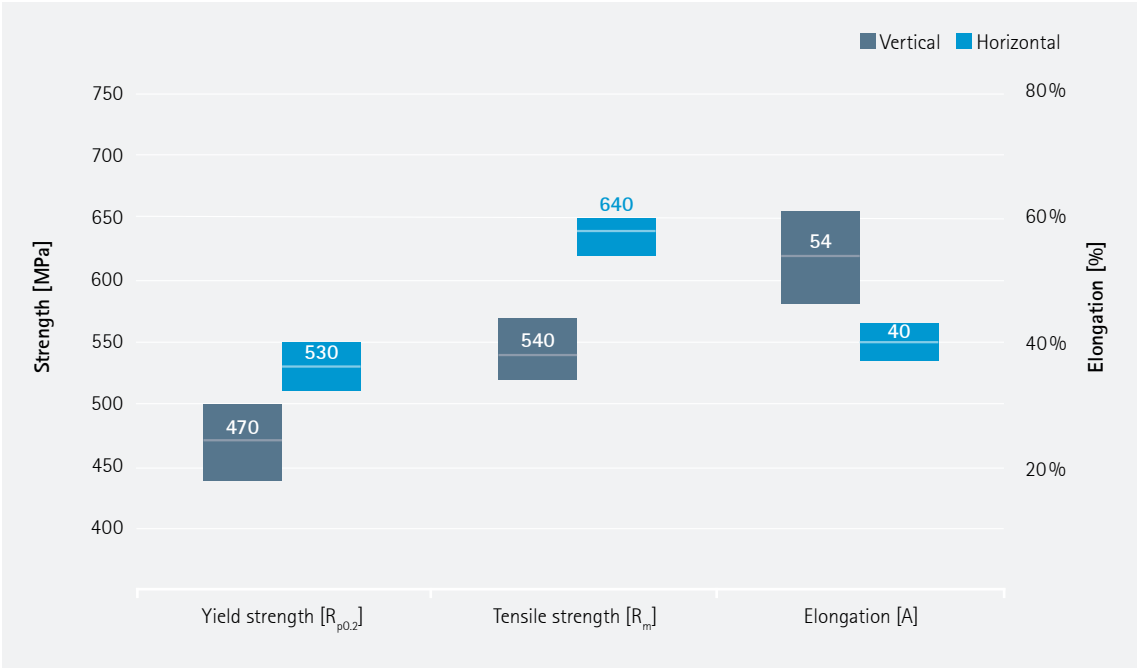
Solution annealing: Hold temperature 1 150 °C, hold time minimum 1.5 h when thoroughly heated, water quenching

# Mechanical Properties as Manufactured[1]

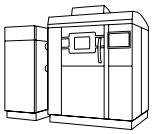


**Mechanical properties ISO6892-1**

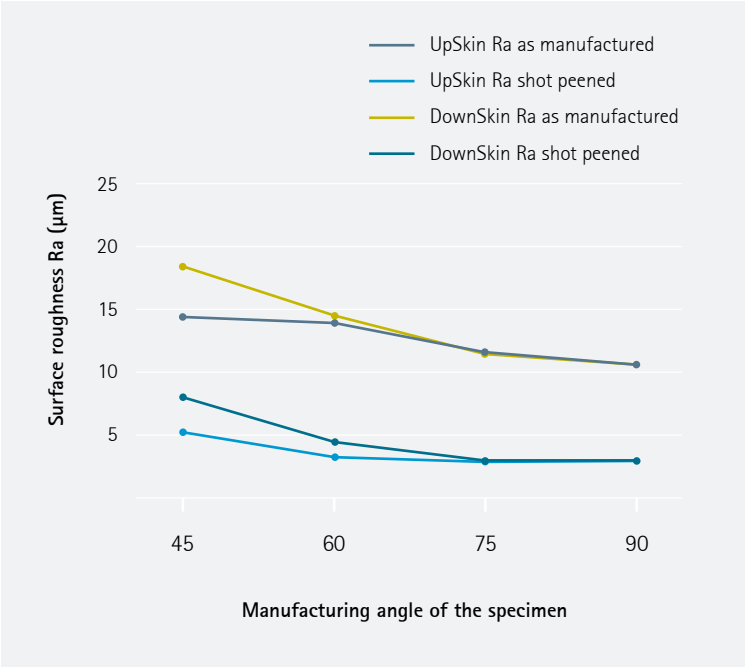
| | Yield strength $R_{p0.2}$ [MPa] | Tensile strength $R_m$ [MPa] | Elongation at break A [%] | Number of samples |
|---|---|---|---|---|
| Vertical | 470 | 540 | 54 | 189 |
| Horizontal | 530 | 640 | 40 | 162 |



# Additional Data[1]



## Surface Roughness

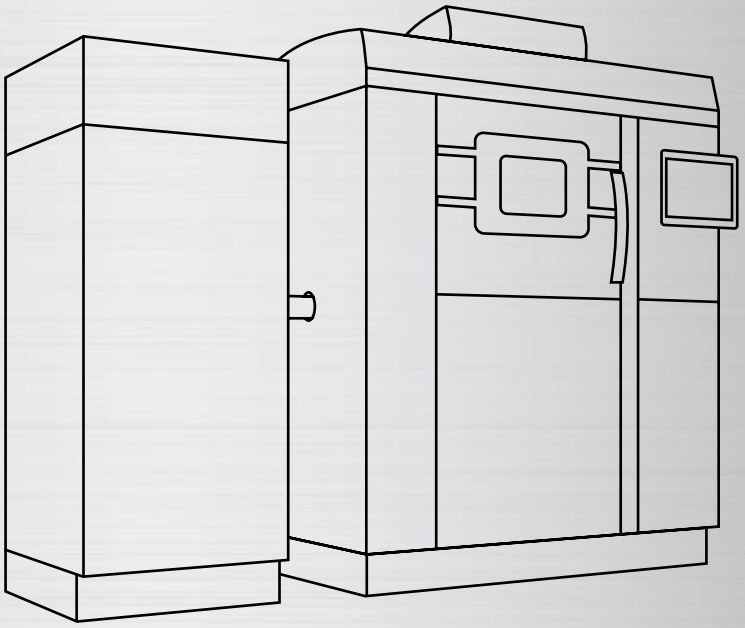



## Coefficient of Thermal Expansion ASTM E228

| Temperature | 25-100 °C | 25-200 °C | 25-300 °C | 25-400 °C |
|---|---|---|---|---|
| CTE | 15.72 *10$^{-6}$/K | 16.75 *10$^{-6}$/K | 17.27 *10$^{-6}$/K | 17.70 *10$^{-6}$/K |

TRL 7

Premium



# EOS StainlessSteel 316L
# **for EOS M 290 | 40 µm**

Process Information

Chemical and Physical Part Properties

Heat Treatment

Mechanical Properties

Additional Data

CR365 v03/12.2016

# EOS StainlessSteel 316L for EOS M 290 | 40 µm

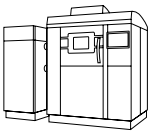
## Process Information

This process product is optimized for building high quality parts with EOS M 290 system reliably using EOS StainlessSteel 316L. Mechanical properties have been validated to TRL7 level.

| System set-up | EOS M 290 |
|---|---|
| EOS ParameterSet | 316L 40µm FlexLine |
| EOSPAR name | 316L_040_FlexM291_1.X |
| Software requirements | EOSPRINT 2.7 or newer<br>EOSYSTEM 2.11 or newer |
| Powder part no. | 9011-0032 |
| Recoater blade | EOS HSS blade |
| Nozzle | EOS grid nozzle |
| Inert gas | Argon |
| Sieve | 63 µm |

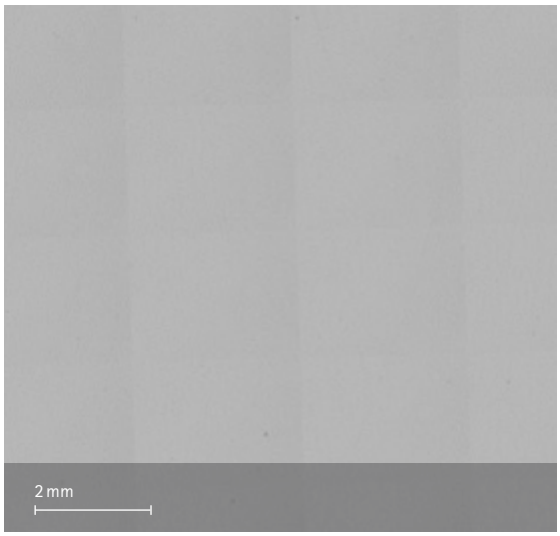
| Additional information | |
|---|---|
| Layer thickness | 40 µm |
| Min. wall thickness | 0.1 mm |
| Typical dimensional change after HT | +0.2 % |
| Volume rate | 3.7 $mm^3/s$ |

## Chemical and Physical Properties of Parts[1]



Chemical composition of built parts is compliant to EOS StainlessSteel 316L powder chemical composition.

**Micrograph of polished surface**




**Microstructure solution annealed**
Etched with etchant Kallings 2


| Defects | Result | Number of samples |
|---|---|---|
| Average defect percentage | 0.015 % | 20 |
| **Density, ISO3369** | **Result** | **Number of samples** |
| Average density | ≥ 7.97 g/cm³ | 20 |

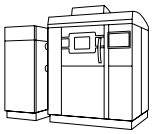
## Heat Treatment

Heat treatment according to AMS 2759 is optional.

Stress relief: Hold temperature 900 °C, hold time minimum 2 h when thoroughly heated, water quenching

Solution annealing: Hold temperature 1 150 °C, hold time minimum 1.5 h when thoroughly heated, water quenching

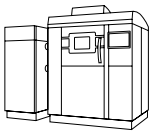
# Mechanical Properties as Manufactured[1]



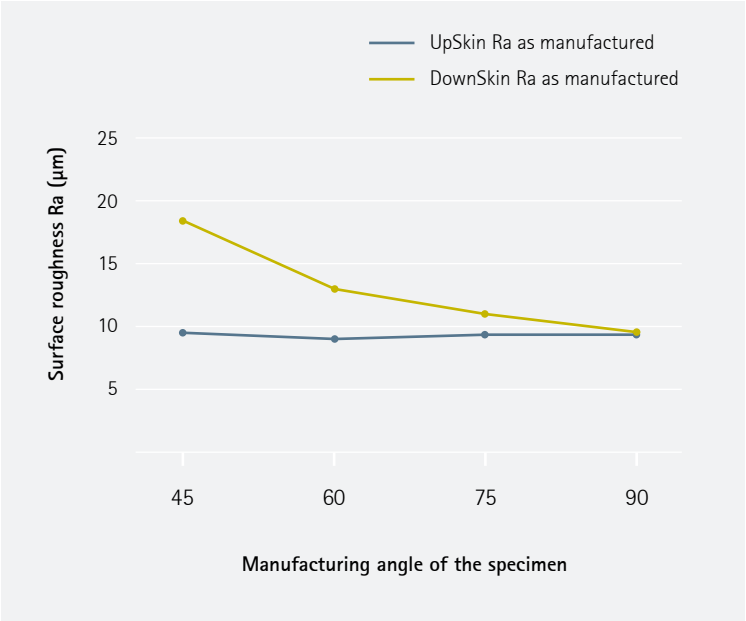
**Mechanical properties ISO6892-1**

| | Yield strength $R_{p0.2}$ [MPa] | Tensile strength $R_m$ [MPa] | Elongation at break A [%] | Number of samples |
|---|---|---|---|---|
| Vertical | 480 | 570 | 51 | 105 |
| Horizontal | 540 | 640 | 40 | 90 |

## Additional Data[1]



### Surface Roughness

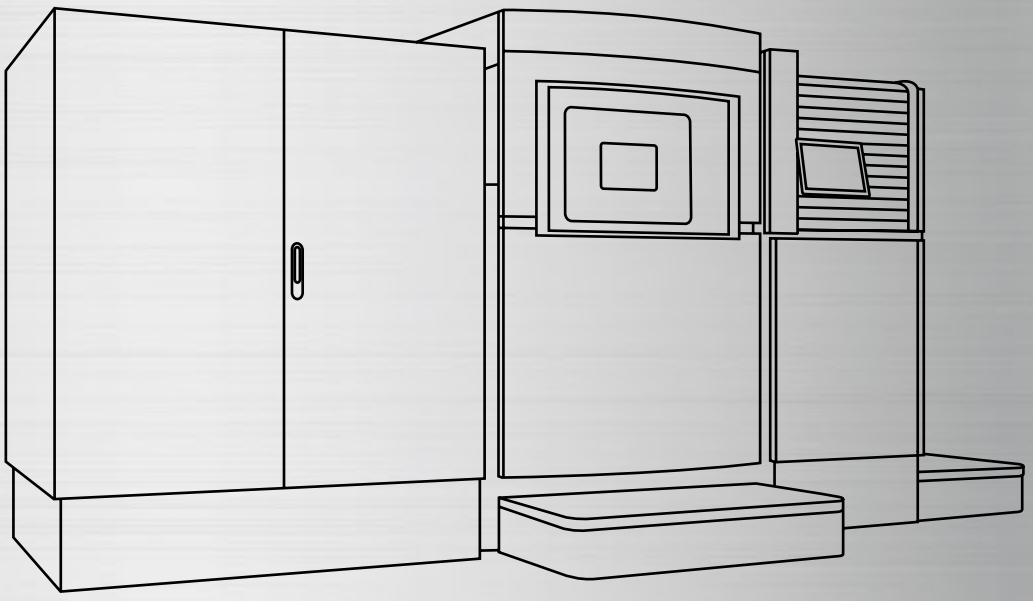



### Coefficient of Thermal Expansion ASTM E228

| Temperature | 25-100 °C | 25-200 °C | 25-300 °C | 25-400 °C |
|---|---|---|---|---|
| CTE | 15.72 *10$^{-6}$/K | 16.75 *10$^{-6}$/K | 17.27 *10$^{-6}$/K | 17.70 *10$^{-6}$/K |

TRL 7

Premium



# EOS StainlessSteel 316L
# for EOS M 400-4 | 40 µm

Process Information
Chemical and Physical Part Properties
Heat Treatment
Mechanical Properties
Additional Data

CR543/06-18

# EOS StainlessSteel 316L for EOS M 400-4 | 40 µm

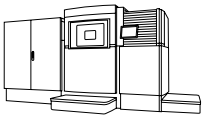
## Process Information

This process product is optimized for building high quality parts with EOS M 400-4 system using EOS StainlessSteel 316L.

| System set-up | EOS M 400-4 |
|---|---|
| EOS ParameterSet | 316L 40µm Flex M 400-4 |
| EOSPAR name | 316L_040_FlexM404_1.X |
| Software requirements | EOSPRINT 2.7 or newer<br>EOSYSTEM 2.11 or newer |
| Powder part no. | 9011-0032 |
| Recoater blade | EOS HSS blade |
| Inert gas | Argon |
| Sieve | 63 µm |

| Additional information | |
|---|---|
| Layer thickness | 40 µm |
| Volume rate | 14.8 $mm^3/s$ |

## Chemical and Physical Properties of Parts[1]



Chemical composition of built parts is compliant to EOS StainlessSteel 316L powder chemical composition.

**Micrograph of polished surface**


**Microstructure solution annealed**
Etched with etchant Kallings 2


| Defects | Result | Number of samples |
|---|---|---|
| Average defect percentage | 0.015 % | 40 |
| **Density, ISO3369** | **Result** | **Number of samples** |
| Average density | ≥ 7.9 g/cm³ | 40 |

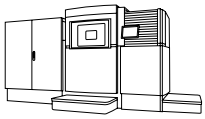
## Heat Treatment

Heat treatment according to AMS 2759 is optional.

Stress relief: Hold temperature 900 °C, hold time minimum 2 h when thoroughly heated, water quenching

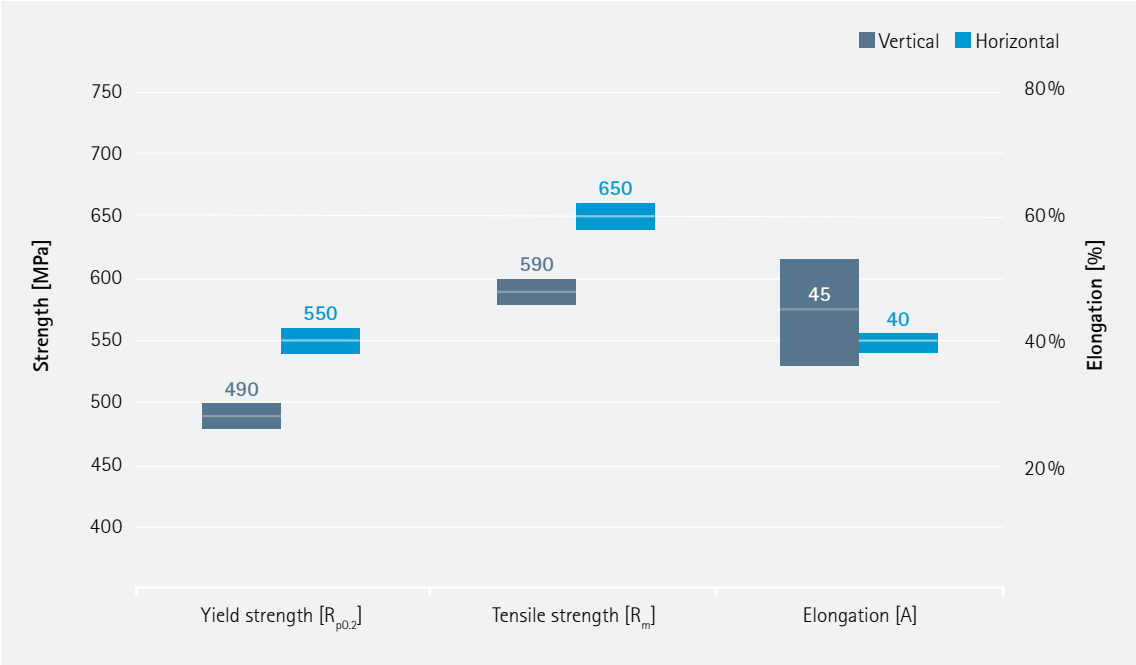
Solution annealing: Hold temperature 1 150 °C, hold time minimum 1.5 h when thoroughly heated, water quenching

## Mechanical Properties as Manufactured[1]



**Mechanical properties ISO6892-1**

| | Yield strength $R_{p0.2}$ [MPa] | Tensile strength $R_m$ [MPa] | Elongation at break A [%] | Number of samples |
|---|---|---|---|---|
| Vertical | 490 | 590 | 45 | 120 |
| Horizontal | 550 | 650 | 40 | 96 |



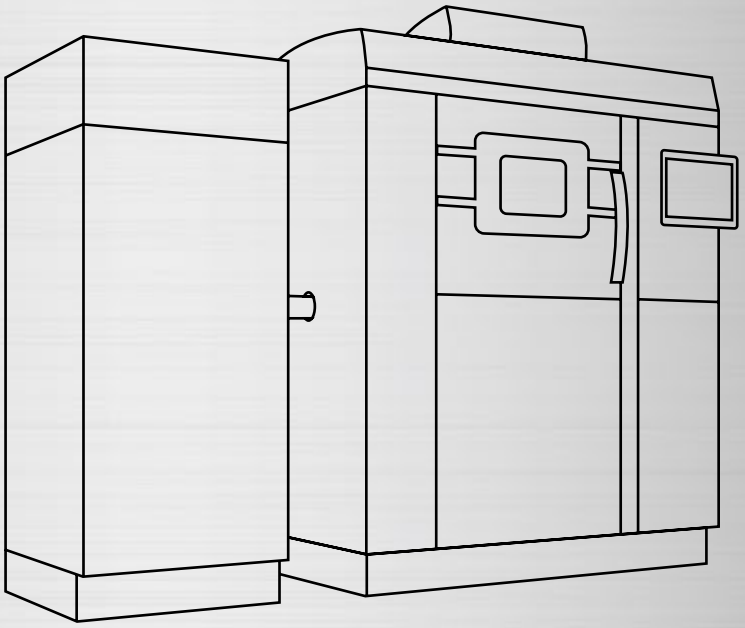

## Additional Data[1]

### Coefficient of Thermal Expansion ASTM E228

| Temperature | 25-100 °C | 25-200 °C | 25-300 °C | 25-400 °C |
|---|---|---|---|---|
| CTE | 15.72 *10$^{-6}$/K | 16.75 *10$^{-6}$/K | 17.27 *10$^{-6}$/K | 17.70 *10$^{-6}$/K |

TRL 3

Core



# EOS StainlessSteel 316L
# for EOS M 290 | 40/80 µm

Process Information

Chemical and Physical Part Properties

Heat Treatment

Mechanical Properties

Additional Data

# EOS StainlessSteel 316L for EOS M 290 | 40/80 µm

## Process Information

This process product is optimized for flexible and fast production of EOS StainlessSteel 316L parts with the EOS M 290 system. The parameter set has three different layer thickness options that can all be utilized within the same build: 40 µm, 80 µm and 40/80 µm Skin.

The 40 µm parameter set is ideal for parts needing great detail resolution and more dense structure. The 80 µm parameter set offers a build rate that is more than double that of the long established 40 µm parameter set.

With the 40/80 µm Skin parameter set, the total build time can be reduced with the same surface quality. The parameter sets are assigned to different sections in the same build job depending on the requirements.

**Main characteristics:**

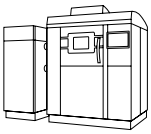
- → Parameter set for fast and cost efficient production of EOS StainlessSteel 316L parts in small series or serial production
- → With 80 µm parameter 100 % increase in productivity compared to the 40 µm FlexLine parameter set
- → Faster production without compromising the part quality

| **System set-up** | **EOS M 290** |
|---|---|
| EOS ParameterSet | 316L 40µm+80µm Core M290/400W |
| EOSPAR name | 316L_040_080_Core M291 1.X |
| Software requirements | EOSPRINT 2.7 or newer<br>EOSYSTEM 2.11 or newer |
| Powder part no. | 9011-0032 |
| Recoater blade | EOS HSS blade |
| Nozzle | EOS grid nozzle |
| Inert gas | Argon |
| Sieve | 63 µm |

| **Additional information** | |
|---|---|
| Layer thickness | 40 µm, 80 µm & 40/80 µm Skin |
| Volume rate* | 3.7 mm³/s (40 µm), 8.4 mm³/s (80 µm),<br>3.7 - 8.4 (40/80 µm Skin) |

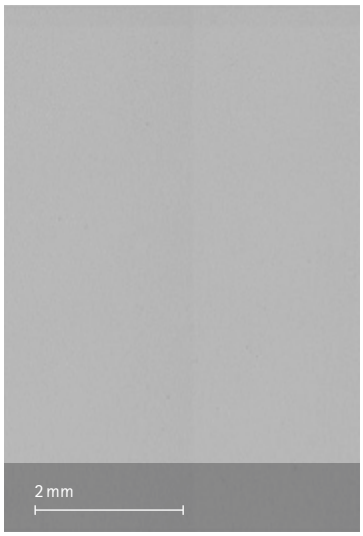
** Volume rate depends on the part dimensions and skin thickness.*

## Chemical and Physical Properties of Parts[1]

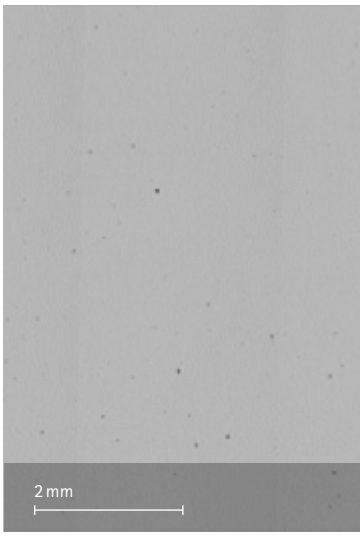


Chemical composition of built parts is compliant to EOS StainlessSteel 316L powder chemical composition.

**Micrograph of polished surface (40 µm)**




**Micrograph of polished surface (80 µm)**




**Microstructure solution annealed**
Etched with etchant Kallings 2


| Defects | Result |
|---|---|
| Average defect percentage | 0.1 %* (40 µm), < 0.2 %* (80 µm) |

** Defect % varies with platform position.*

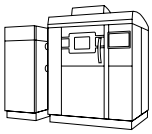
## Heat Treatment

Heat treatment according to AMS 2759 is optional.

Stress relief: Hold temperature 900 °C, hold time minimum 2 h when thoroughly heated, water quenching

Solution annealing: Hold temperature 1 150 °C, hold time minimum 1.5 h when thoroughly heated, water quenching

## Mechanical Properties as Manufactured[1]



**Typical properties as manufactured ISO 6892-1**

| | **Yield strength** $R_{p0.2}$ [MPa] | **Tensile strength** $R_m$ [MPa] | **Elongation at break** A [%] |
|---|---|---|---|
| 40 µm horizontal | 500 | 600 | 35 |
| 40 µm vertical | 450 | 550 | 50 |
| 80 µm horizontal | 500 | 600 | 35 |
| 80 µm vertical | 450 | 550 | 45 |

## Additional Data[1]

### Surface Roughness

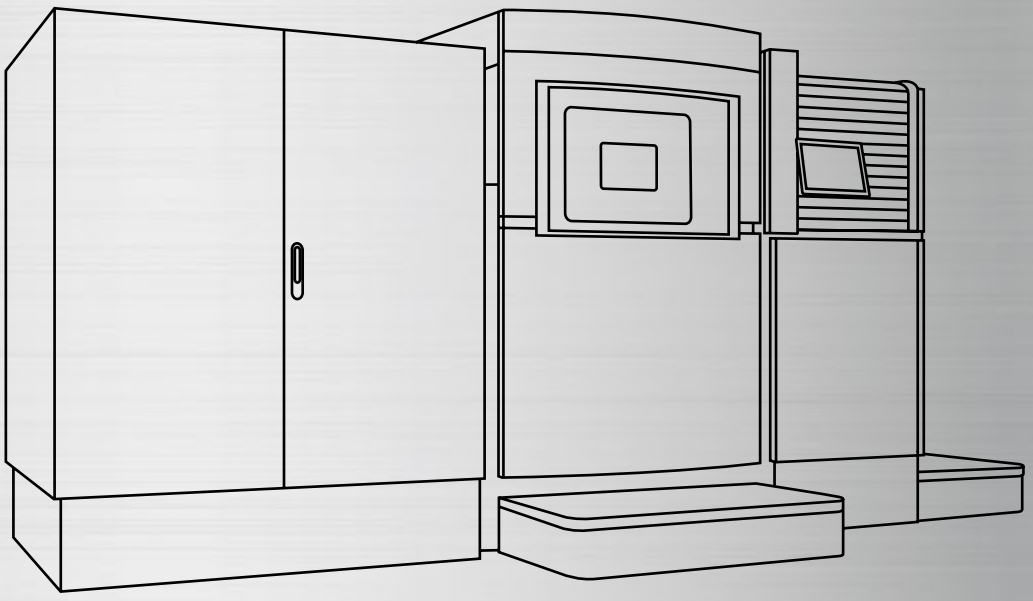
| | |
|---|---|
| Surface roughness | 9 - 15 Ra |
| Surface roughness shot-peened | <5 Ra |

### Coefficient of Thermal Expansion ASTM E228

| Temperature | 25-100 °C | 25-200 °C | 25-300 °C | 25-400 °C |
|---|---|---|---|---|
| CTE | 15.72 *$10^{-6}$/K | 16.75 *$10^{-6}$/K | 17.27 *$10^{-6}$/K | 17.70 *$10^{-6}$/K |

TRL 3

Core



# EOS StainlessSteel 316L
# for EOS M 400-4 | 40/80 µm

Process Information
Chemical and Physical Part Properties
Heat Treatment
Mechanical Properties
Additional Data

# EOS StainlessSteel 316L for EOS M 400-4 | 40/80 µm

## Process Information

This process product is optimized for flexible and fast production of EOS StainlessSteel 316L parts with the EOS M 400-4 system. The parameter set has three different layer thickness options that can all be utilized within the same build: 40 µm, 80 µm and 40/80 µm Skin.

The 40 µm parameter set is ideal for parts needing great detail resolution and more dense structure. The 80 µm parameter set offers a build rate that is more than double that of the long established 40 µm parameter set.

With the 40/80 µm Skin parameter set, the total build time can be reduced with the same surface quality. The parameter sets are assigned to different sections in the same build job depending on the requirements.

**Main Characteristics:**

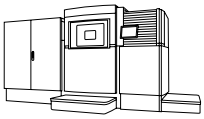
- → Parameter set for fast and cost efficient production of EOS StainlessSteel 316L parts in small series or serial production
- → With 80 µm parameter 100 % increase in productivity compared to the 40 µm FlexLine parameter set
- → Faster production without compromising the part quality

| **System set-up** | EOS M 400-4 |
|---|---|
| EOS ParameterSet | 316L 40µm+80µm Core M400-4 |
| EOSPAR name | 316L_040_080_Core M404 1.X |
| Software requirements | EOSPRINT 2.7 or newer<br>EOSYSTEM 2.11 or newer |
| Powder part no. | 9011-0032 |
| Recoater blade | EOS HSS blade |
| Inert gas | Argon |
| Sieve | 63 µm |

| **Additional information** | |
|---|---|
| Layer thickness | 40 µm, 80 µm & 40/80 µm Skin |
| Volume rate* | 14.8 $mm^3/s$ (40 µm), 33.6 $mm^3/s$ (80 µm) and 14.8 – 33.6 $mm^3/s$ (40/80 µm Skin) |

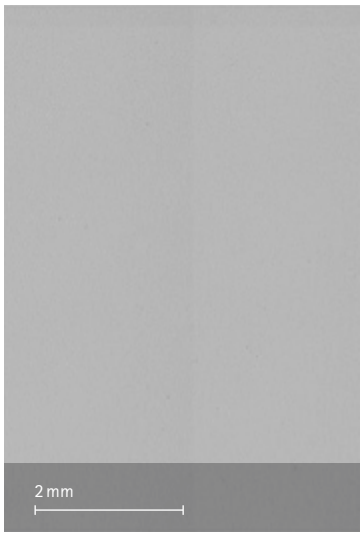
** Volume rate depends on the part dimensions and skin thickness.*

## Chemical and Physical Properties of Parts[1]

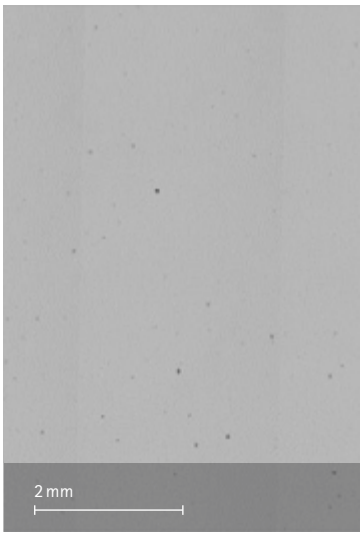


Chemical composition of built parts is compliant to EOS StainlessSteel 316L powder chemical composition.

**Micrograph of polished surface (40 µm)**




**Micrograph of polished surface (80 µm)**




**Microstructure solution annealed**
Etched with etchant Kallings 2


| Defects | Result |
|---|---|
| Average defect percentage | 0.1 %* (40 µm), < 0.2 %* (80 µm) |

** Defect % varies with platform position.*

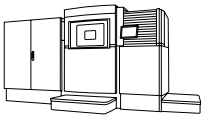
## Heat Treatment

Heat treatment according to AMS 2759 is optional.

Stress relief: Hold temperature 900 °C, hold time minimum 2 h when thoroughly heated, water quenching

Solution annealing: Hold temperature 1 150 °C, hold time minimum 1.5 h when thoroughly heated, water quenching

## Mechanical Properties as Manufactured[1]



**Typical properties as manufactured ISO 6892-1**

| | Yield strength $R_{p0.2}$ [MPa] | Tensile strength $R_m$ [MPa] | Elongation at break A [%] |
|---|---|---|---|
| 40 µm horizontal | 500 | 600 | 35 |
| 40 µm vertical | 450 | 550 | 50 |
| 80 µm horizontal | 500 | 600 | 35 |
| 80 µm vertical | 450 | 550 | 45 |

## Additional Data[1]

### Surface Roughness

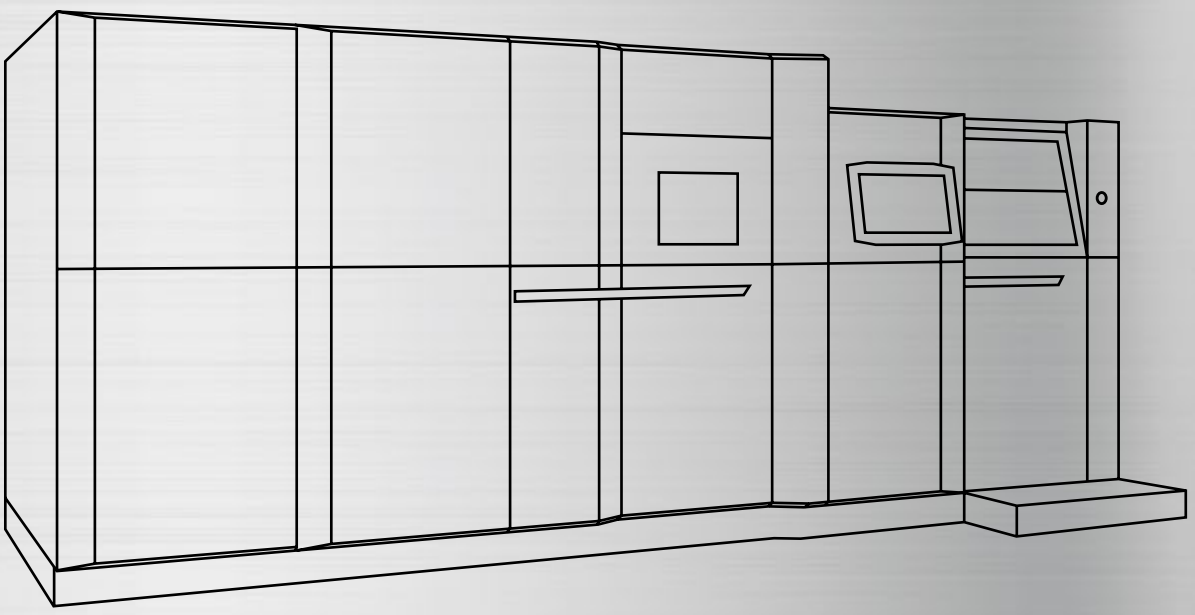
| | |
|---|---|
| Surface roughness | 9 - 15 Ra |
| Surface roughness shot-peened | <5 Ra |

### Coefficient of Thermal Expansion ASTM E228

| Temperature | 25-100 °C | 25-200 °C | 25-300 °C | 25-400 °C |
|---|---|---|---|---|
| CTE | 15.72 *$10^{-6}$/K | 16.75 *$10^{-6}$/K | 17.27 *$10^{-6}$/K | 17.70 *$10^{-6}$/K |

TRL 3

Core



# EOS StainlessSteel 316L
# for EOS M 300-4 | 40/80 µm

Process Information

Chemical and Physical Part Properties

Mechanical Properties

# EOS StainlessSteel 316L for EOS M 300-4 | 40/80 µm

## Process Information

This process product is optimized for flexible and fast production of EOS StainlessSteel 316L parts with the EOS M 300-4 system. The parameter set has three different layer thickness options that can all be utilized within the same build: 40µm, 80 µm and 40/80 µm SkinCore.

For high productivity needs a 80 µm parameter set is included with a build rate more than double the 40 µm parameter set. Both can be used separately for different parts or combined by using 40/80 µm SkinCore with faster 80 µm for the core of the part and higher quality 40 µm building for the surface of the part with defined thickness. Sectioning parts in the vertical direction for different parameters is also possible.

**Main Characteristics:**

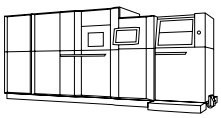
- → Parameter set for fast and cost efficient production of EOS StainlessSteel 316L parts in small series or serial production
- → 100 % increase in productivity with 80 µm parameter compared to 316L 40 µm FlexLine parameter with only minor decrease in quality
- → High part quality – mechanical properties and surface – with 40 µm parameter

| **System set-up** | **EOS M 300-4** |
|---|---|
| EOS ParameterSet | 316L 40µm+80µm Core M300-4 |
| EOSPAR name | 316L_040_080_Core M304 1.X |
| Software requirements | EOSPRINT 2.11 or newer<br>EOSYSTEM 2.15 or newer |
| Powder part no. | 9011-0032 |
| Recoater blade | EOS HSS blade |
| Inert gas | Argon |
| Sieve | 63 µm |

| **Additional information** | |
|---|---|
| Layer thickness | 40 µm, 80 µm & 40/80 µm SkinCore |
| Volume rate* | 14.8 $mm^3/s$ (40 µm), 33.6 $mm^3/s$ (80 µm) and 14.8 – 33.6 $mm^3/s$ (40/80 µm Skin) |

** Volume rate depends on the part dimensions and skin thickness.*

## Chemical and Physical Properties of Parts[1]



| Defects | Result | Number of Samples |
|---|---|---|
| Average defect percentage 40 µm | 0.002 % | 32 |
| Average defect percentage 80 µm | 0.024 % | 32 |
| Max. pore size 40 µm | 100 µm | 32 |
| Max. pore size 80 µm | 150 µm | 32 |

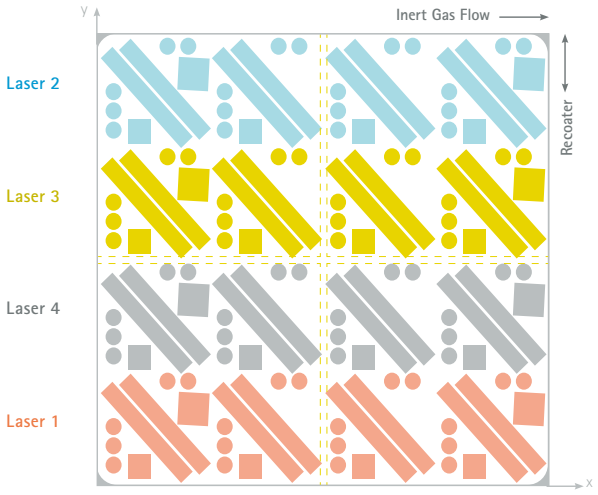
## Mechanical Properties as Manufactured[1]

**Typical properties as manufactured ISO 6892-1**

| | Yield strength $R_{p0.2}$ [MPa] | Tensile strength $R_m$ [MPa] | Elongation at break A [%] | Number of Samples |
|---|---|---|---|---|
| 40 µm horizontal | 575 | 671 | 34.3 | 64 |
| 40 µm vertical | 510 | 607 | 41.3 | 160 |
| 80 µm horizontal | 554 | 660 | 35.6 | 64 |
| 80 µm vertical | 485 | 621 | 41.1 | 160 |

**Layout of test job**

Part properties based on two test jobs each for 40 µm and 80 µm process (as manufactured).




*The values in the tables above are average values and dependent on the build platform temperature, the thermal load of the job layout as well as the position on the build plate.*

[1] Part properties are provided for information purposes only and EOS makes no representation or warranty, and disclaims any liability, with respect to actual part properties achieved. Part properties are dependent on a variety of influencing factors and therefore, actual part properties achieved by the user may deviate from the information stated herein.
This document does not on its own represent a sufficient basis for any part design, neither does it provide any agreement or guarantee about the specific properties of a material or part or the suitability of a material or a part for a specific application.

This powder has not been developed, tested or certified as a medical device according to Directive 93/42/EEC (MDD) or Regulation (EU) 2017/745 (MDR) and is not intended to be used as a medical device, in particular for the purposes specified in Art. 2 No. 1 MDR. Insofar as you intend to use the powder as raw material for the manufacture of pharmaceutical products or medical devices (e.g. as raw material which as a material must meet the requirements of Annex 1, Chapter II MDR), the responsibility and liability for all analyses, tests, evaluations, procedures, risk assessments, conformity assessments, approval and certification procedures as well as for all other official and regulatory measures required for this purpose shall lie solely with you both with regard to the pharmaceutical product and/or medical device manufactured by you and with regard to the properties, suitability, testing, evaluation, risk assessment, other requirements for use of the powder as raw material. This also applies to applications with food contact. In this respect, the limitations of liability pursuant to our General Terms and Conditions and the system sales or material contracts shall apply.

Status 07/2022



Cover: This image shows a possible application.

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