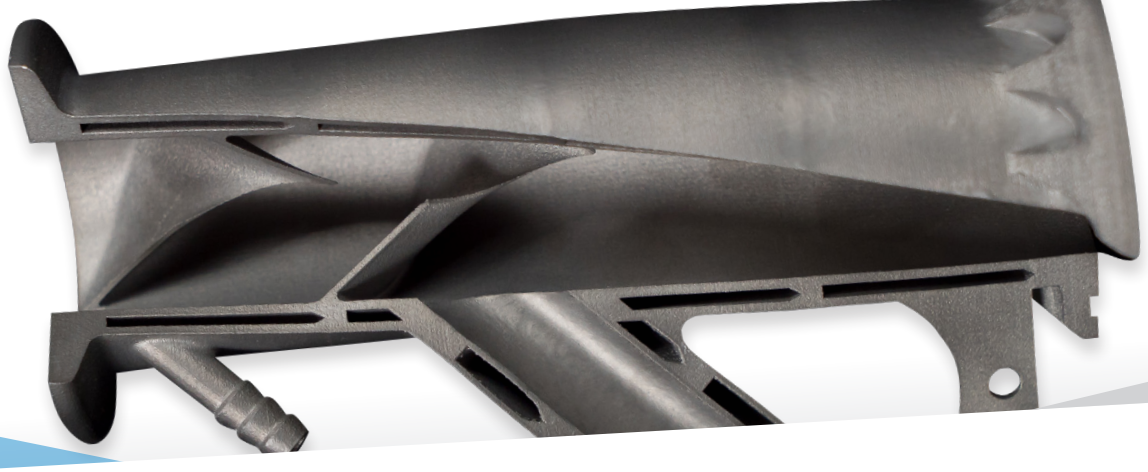


# LaserForm 316L (A)

Extra low-carbon grade stainless steel fine-tuned for use with the DMP Flex 350, DMP Factory 350, DMP Flex 350 Dual, DMP Factory 350 Dual and ProX® DMP 320, producing parts with high corrosion resistance and sterilisability. LaserForm 316L (A) yields crack-free, dense parts for all your applications.

LaserForm 316L (A) is formulated and fine-tuned specifically for 3D Systems' metal 3D printers to deliver highest part quality and best part properties. The print parameter database that 3D Systems provides together with the material has been extensively developed, tested and optimized in 3D Systems' part production facilities that hold the unique expertise of printing more than 1,000,000 challenging production parts year over year. Based on a multitude of test samples, the properties listed below provide high confidence to the user in terms of job-to-job and machine-to-machine repeatability. Using the LaserForm material enables the user to experience consistent and reliable part quality.

## Material description

Austenitic stainless steel type LaserForm 316L is the extra low carbon grade of 316. This steel is used as a general purpose material with excellent mechanical and corrosion properties at room temperature. Its chloride resistance makes this specific grade of stainless steel suitable for marine applications.

LaserForm 316L stainless steel is also the preferred material for use in hydrogen atmospheres or for hydrogen piping / cooling applications. It retains good mechanical properties at sub-zero and even cryogenic temperatures and is suitable for structural components in low-temperature applications.

## Classification

Parts built with LaserForm 316L alloy have a chemical composition that conforms to the compositional requirements of ASTM F3184-16.

## Mechanical properties

| **DMP FLEX 350**<br>**DMP FACTORY 350**[1,2]<br>PROX DMP 320 | **TEST METHOD** | **METRIC** | | **U.S.** | |
|---|---|---|---|---|---|
| | | **STRESS RELIEF** | **FULL ANNEAL** | **STRESS RELIEF** | **FULL ANNEAL** |
| Youngs modulus (GPa \| ksi) | ASTM E8M | | | | |
| Horizontal direction — XY | | 180 ± 15 | 180 ± 15 | 27600 ± 1500 | 27600 ± 1500 |
| Ultimate tensile strength (MPa \| ksi) | | | | | |
| Horizontal direction — XY<br>Vertical direction — Z | | 660 ± 20<br>570 ± 30 | 610 ± 30<br>540 ± 30 | 96 ± 3<br>83 ± 5 | 89 ± 5<br>78 ± 5 |
| Yield strength Rp0.2% (MPa \| ksi) | | | | | |
| Horizontal direction — XY<br>Vertical direction — Z | | 530 ± 20<br>440 ± 20 | 370 ± 30<br>320 ± 20 | 77± 3<br>63 ± 3 | 54 ± 5<br>47 ± 3 |
| Elongation at break (%) | | | | | |
| Horizontal direction — XY<br>Vertical direction — Z | | 39 ± 5<br>49 ± 5 | 51 ± 5<br>66 ± 5 | 39 ± 5<br>49 ± 5 | 51 ± 5<br>66 ± 5 |
| Reduction of area (%) | | | | | |
| Horizontal direction — XY<br>Vertical direction — Z | | 65 ± 5<br>65 ± 5 | 61 ± 5<br>62 ± 5 | 65 ± 5<br>65 ± 5 | 61 ± 5<br>62 ± 5 |
| Hardness, Rockwell C | ASTM E18 | 90 ± 6 | 83 ± 4 | 90 ± 6 | 83 ± 4 |
| Impact toughness[3] (J/cm² \| lb.ft) | ASTM E23 | 215 ± 15 | 220 ± 15 | 158 ± 10 | 162 ± 10 |

[1] Parts manufactured with standard parameters on a ProX DMP 320
[2] Values based on average and standard deviation
[3] Tested with charpy V-notch toughness test, DMV probe

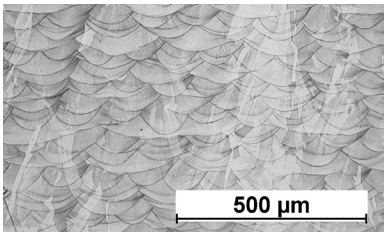
| DMP FLEX 350 DUAL<br>DMP FACTORY 350 DUAL[1,2,3] | TEST METHOD | FULL ANNEAL | | | |
|---|---|---|---|---|---|
| | | METRIC | | U.S. | |
| | | LT30 | LT60 | LT30 | LT60 |
| Youngs modulus (GPa \| ksi) | ASTM E8 | | | | |
| Horizontal direction — XY | | 200 ± 15 | 200 ± 15 | 29000 ± 1500 | 29000 ± 1500 |
| Ultimate tensile strength (MPa \| ksi) | | | | | |
| Horizontal direction — XY<br>Vertical direction — Z | | 660 ± 20<br>570 ± 20 | 640 ± 20<br>590 ± 20 | 99 ± 3<br>85 ± 2 | 93 ± 3<br>85 ± 2 |
| Yield strength Rp0.2% (MPa \| ksi) | | | | | |
| Horizontal direction — XY<br>Vertical direction — Z | | 405 ± 5<br>390 ± 5 | 390 ± 30<br>360 ± 20 | 59± 5<br>56 ± 3 | 56 ± 5<br>52 ± 3 |
| Elongation at break (%) | | | | | |
| Horizontal direction — XY<br>Vertical direction — Z | | 48 ± 5<br>62 ± 5 | 50 ± 5<br>56 ± 5 | 39 ± 5<br>49 ± 5 | 51 ± 5<br>66 ± 5 |
| Reduction of area (%) | | | | | |
| Horizontal direction — XY<br>Vertical direction — Z | | 63 ± 5<br>76 ± 5 | 64 ± 5<br>70 ± 5 | 65 ± 5<br>65 ± 5 | 61 ± 5<br>62 ± 5 |

## Thermal properties[4]

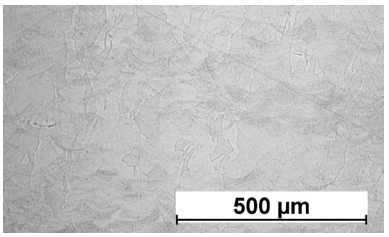
| MEASUREMENT | CONDITION | METRIC | U.S. |
|---|---|---|---|
| Thermal conductivity<br>(W/(m.K) \| Btu/(h.ft.°F)) | At 20 °C/ 68 °F | 15 | 9 |
| Coefficient of thermal expansion<br>(µm/m-°C \| µin/in-°F) | In the range of<br>20 - 600°C / 68-1112°F | 19.0 | 10.6 |
| Melting range (°C \| °F) | | 1370-1400 | 2500-2550 |

## Density

| MEASUREMENT | TEST METHOD | METRIC | U.S. |
|---|---|---|---|
| Theoretical density (g/cm³ J lb/in³) | Value from literature | 8.0 | 0.286 |
| Relative density (%) | Optical method<br>(pixel count) | ≥ 99.9<br>Typical 99.95 | ≥ 99.9<br>Typical 99.95 |



Microstructure after stress relief



Microstructure after full anneal

## Chemical composition

| ELEMENT | % OF WEIGHT |
|---|---|
| Fe | bal. |
| Cr | 16.00-18.00 |
| Ni | 10.00-14.00 |
| C | ≤0.030 |
| Mn | ≤2.00 |
| Mo | 2.00-3.00 |
| Si | ≤1.00 |
| P | ≤0.045 |
| S | ≤0.030 |

[1] Parts manufactured with standard parameters on DMP Flex 350 Dual and DMP Factory 350 Dual, config B
[2] Values based on average and standard deviation
[3] Ten samples have been tested for each orientation and layer thickness
[4] Values based on literature