





# Stainless Steel - What Makes it Un

*Value creation through advanced processing technology and expanding material options are what customers should expect from the world leader in Powder Metal (PM), and GKN Sinter Metals delivers. No one in the global market offers the range of material solutions with the expertise and equipment to deliver quality products that meet and exceed customer expectations like GKN Sinter Metals. From aluminium to prealloy irons, from Metal Injection Molding (MIM) to conventional PM processing, GKN Sinter Metals is there with an answer. Stainless steel is just another example of GKN's extensive product range. Its unique blend of mechanical properties provides solutions where other materials can not.*

Stainless steel is not a single alloy. Stainless steel is made up of a group of iron based alloys containing at least 10.5 % chromium. The chromium is mainly what gives the steel its unique stainless, corrosion resisting properties. Although all stainless steels depend on the presence of chromium, other alloying elements (nickel, molybdenum, titanium, niobium) are often added to enhance their properties. Stainless steels are mainly categorized into three grades based on their metallurgical structure.

**Austenitic:** Typically contain between 16-26 % chromium and 6-22 % nickel with a low carbon content. Type 304 and 316 are the most common grades. Austenitic stainless steels typically have high corrosion resistance and no magnetic response.

**Ferritic:** Typically contain between 10.5-27 % chromium. Type 430 is the most common grade. Ferritic stainless steels typically have medium corrosion resistance and have a magnetic response.

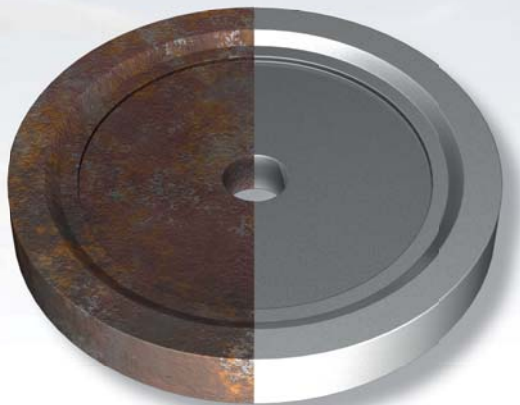
**Martensitic:** Typically contain between 11.5-17 % chromium, but with higher carbon than Austenitic and Ferritic stainless steel. Type 410 is the most common grade. Martensitic stainless steels typically have medium corrosion resistance, have a magnetic response and are hardenable by martensitic phase transformation.



# ique?

## ENJOY THE BENEFITS OF STAINLESS STEEL

When compared to the more familiar plain carbon "mild" steels, stainless steels generally have:



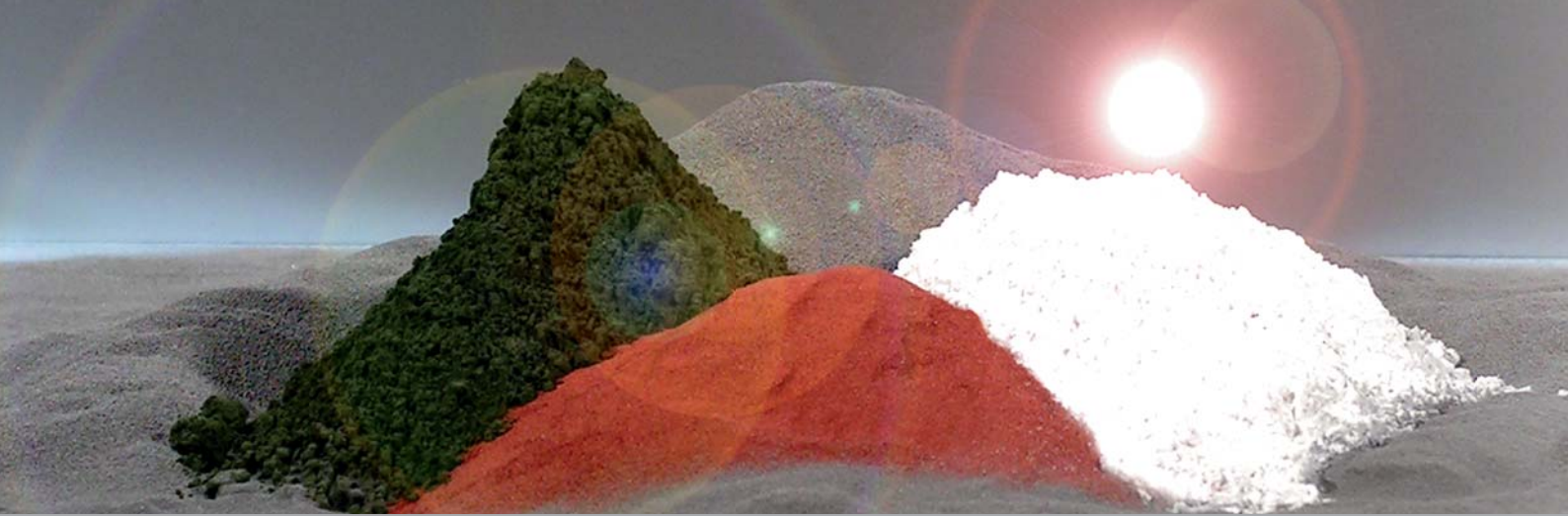
- > Higher corrosion resistance
- > Higher strength and hardness
- > Higher ductility
- > Higher hot strength
- > Higher cryogenic toughness
- > Lower magnetic response (austenitic only)



GKN stainless steels also exhibit the following properties:

- > GKN stainless steel material is the perfect solution against hazardous Cr6 coatings
- > High temperature cyclic oxidation resistance is excellent - significantly outperforms similar wrought grades in that no spalling (and hence loss of mass) occurs
- > Ease of fabrication - can be cut, welded, formed, machined, and fabricated as readily as traditional steels
- > Displays excellent thermal fatigue resistance (high thermal conductivity and low coefficient of thermal expansion)
- > Recyclable - stainless steel offers long term value





# Sintered Stainless Steel - A Superior

When it comes to providing high volume, complex, stainless steel components at a reasonable cost, no other metal working solution provides the value proposition of Powder Metal. Either through conventional PM's netshape precision to MIM's design freedom, GKN Sinter Metals offers customers a multitude of engineering options. In addition, GKN Sinter Metals' global footprint also allows to provide these solutions to nearly every region of the world.

## CONVENTIONAL PM PROCESSING

Combines the high volume process of powder metal compaction with the superior physical properties achieved through high temperature, controlled atmosphere, sintering. It provides the following advantages:

### Aesthetic appearance

- Excellent surface finish is attainable in as-sintered condition without further treatments

### High material utilization

- Low waste leads to lower life cycle costs than casting and machining

### Strength-to-weight advantage

### Wide range of mechanical properties

- Made possible by altering sintering temperature and atmosphere

**Ferritic grades can be readily processed to densities where porosity is no longer interconnected (gas tight)**

**Better dimensional control (tighter tolerances) and surface finish than casting processes**

- This is especially true against sand casting but also compared to investment casting

**High productivity leads to the ability to produce high volumes**



Fig. 1: Automotive exhaust

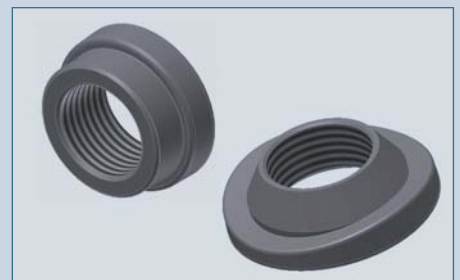


Fig. 2: Automotive exhaust

Made of 434L and 409LE stainless steel, these weld couplings for an automotive exhaust HEGO sensor are a typical example of a conventional PM stainless steel application. The need for net shape, high volume components make them ideal for the conventional PM process. Only the threading is machined into the part.



# Material Solution

## MIM PROCESSING

The MIM process is a key contributor to the economic mass production of high quality stainless steel components for a wide range of industrial, medical and automotive applications. MIM enables the unlimited freedom of design and proves economical where complex shaped components with close dimensional tolerances, demanding mechanical properties and excellent surface finish are required. The MIM technology is particularly useful, if the component has to meet extra high demands in density, strength and corrosion resistance. Where ultimate density is required, MIM parts can be densified up to 100 percent by hot isostatic pressing (HIP).

*Example of stainless steel application in MIM:*



Fig. 1: Handle of arthroscopic surgical tool



Fig. 2: Evaporation assembly with filter element for park heating system

GKN Sinter Metals offers a wide range of corrosion-resistant MIM materials which are comparable to conventional stainless steels manufacturing processes:

- Stainless steel **316L** is one of the most commonly used materials. Its popularity results from its exceptional surface polishability, high ductility and sinterability to high densities. 316L is primarily needed for applications that require excellent corrosion resistance in aggressive media and high bending strength. Examples of applications can include components for apparatus engineering, the chemical industry, jewellery and the medical industry.
- Targeted at applications that require both good corrosion resistance and high heat-treated hardness is **440Nb**. This alloy is especially useful for components like hand tools, cutting blades or fuel injectors in automobiles.
- In contrast, **17-4PH** stainless steel is widely used in applications requiring high strength, hardness and corrosion resistance. The 17-4 PH alloy is generally used for components that have to attach, hold, fasten or connect with high force. Typical applications are found in pump- or medical components as well as the chemical-, automotive- and the aircraft industries.



Fig. 3: GKN MIM parts (17-4 PH)

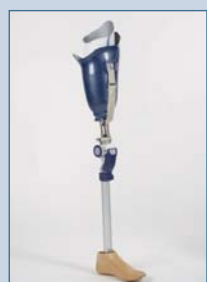


Fig. 4: Artificial limb

*These MIM parts, manufactured in 17-4 PH, work together as a unit within a prosthetic knee joint. They protect the knee joint from accidental flexion and serve for power transmission while stretching or bending the knee. The operational demands on the components are stringent as patient safety is critical. Given these requirements, with the need for corrosion resistance, high strength and an attractive surface appearance; viable parts can only be guaranteed by the MIM technology.*

# Conventional Sintered Stainless Steel

*PM Stainless steels offer engineers a material produced to near-net shape with superior corrosion resistance and a wide range of mechanical properties through various alloy selections and processing options.*

Stainless steels from the 300-series (austenitic) and 400-series (ferritic and martensitic) alloys are available, with some special grades offering enhanced corrosion or improved high temperature resistance. The properties of each grade may be tailored during processing. Our Tech Centre and engineers are able to assist with material selection and development to meet application specific requirements.

## 1.) RAW MATERIAL

In general, high quality, prealloyed stainless steel powders mixed with a solid lubricant are supplied 'press-ready'. A wide range of chemistries are available, the nominal compositions of which are similar to the wrought AISI grades.

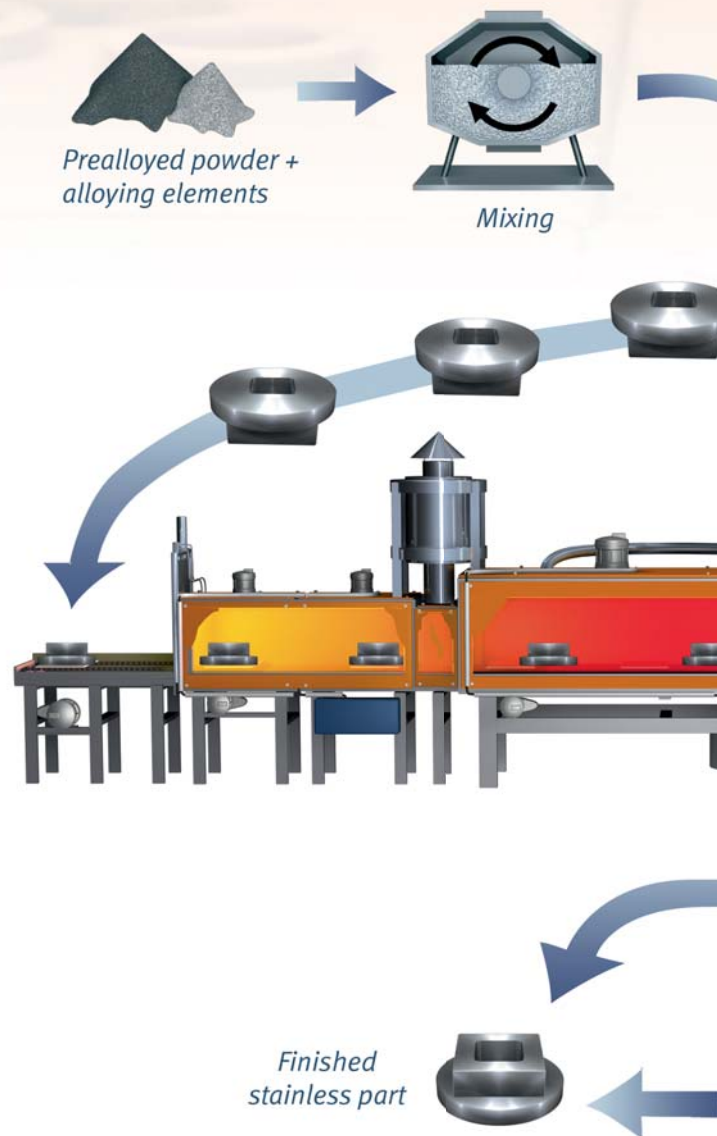
## 2.) PRESSING/COMPACTION

Compaction of the metal powder is achieved by applying uniaxial pressure to the metal powder in a closed die to form the near-net shape "green" compact. GKN has a variety of special presses with multi-level technology enabling parts of complex geometry to be compacted.

## 3.) SINTERING

"Green" compacts are sintered in precision controlled furnaces. Depending on the material and the properties required, sintering temperatures of 1,150°C to 1,335°C (2,100°F to 2,425°F) may be employed. The atmosphere consists of high purity nitrogen and hydrogen, with pure hydrogen atmospheres being used for components requiring the highest levels of corrosion resistance.

Stainless steel materials densify during sintering, with ferritic grades exhibiting the highest rates of densification. This enables gas tight densities (>92% of theoretical density) to be readily achieved in these materials.





## - Conventional PM Process

### 4.) SECONDARY OPERATIONS

Many PM stainless steel parts do not require secondary processing and are complete after the sintering process. However, in some circumstances, secondary processing is required in order to improve dimensional accuracy, material properties or add functionality to a component.

#### **MACHINING**

Machining includes operations such as turning, drilling and tapping. Despite the ability of PM to produce complex geometry near-net shape components, certain features such as threads are not possible and thus are machined post sintering.

#### **REPRESSING / SIZING**

Certain components may be repressed to improve the final density or sized in order to attain more accurate dimensions.

#### **DEBURRING / TUMBLING**

There may be sharp edges or burrs as a result of preceding processes. These may be removed in a tumbling operation, whereby parts are tumbled with abrasive media to remove sharp edges and create a uniform surface appearance.

#### **RESIN IMPREGNATION**

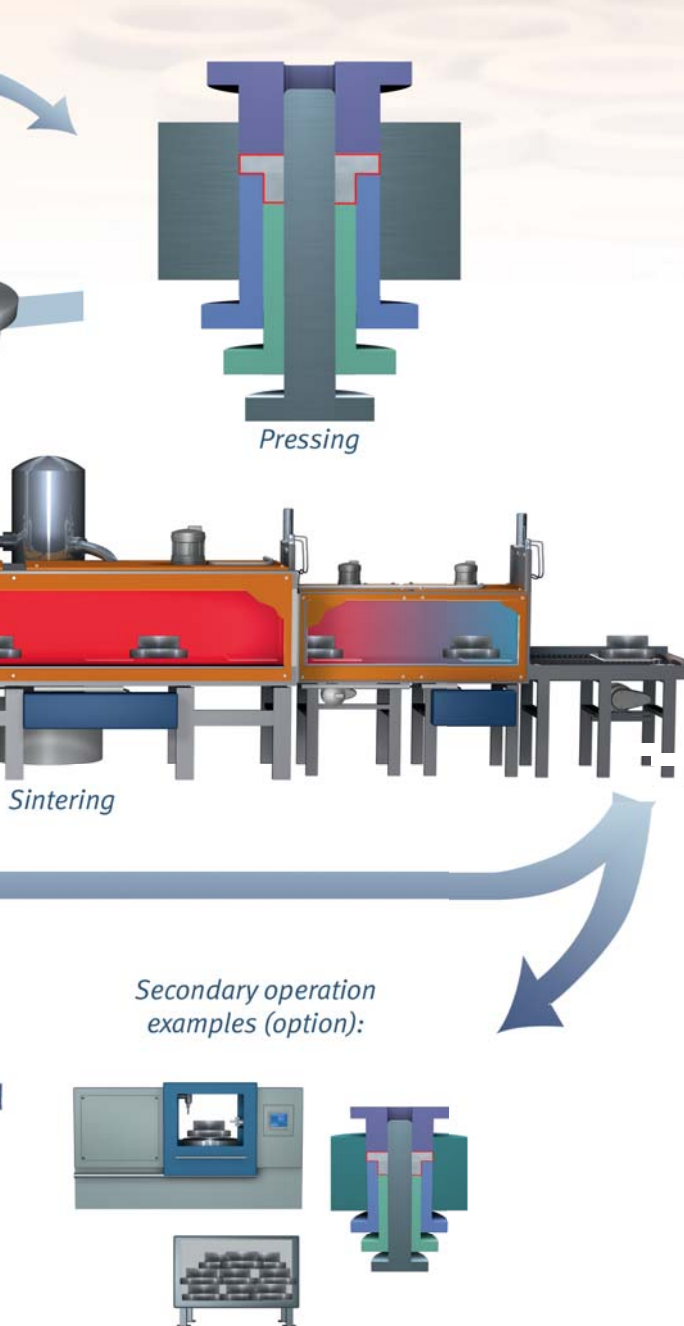
Resin impregnation is used to seal interconnected porosity in a component. It has the benefit of allowing components to be gas or liquid tight as well as significantly enhancing the machinability of a component.

#### **JOINING PROCESSES**

Joining of PM stainless steel components to each other or to other materials may be achieved by various fusion welding or brazing processes. The choice of process is dependant on factors such as the density of the component(s) and the materials involved.

#### **MIM SINTERED STAINLESS STEEL**

For a detailed view of the MIM manufacturing process, please see the MIM technology brochure.





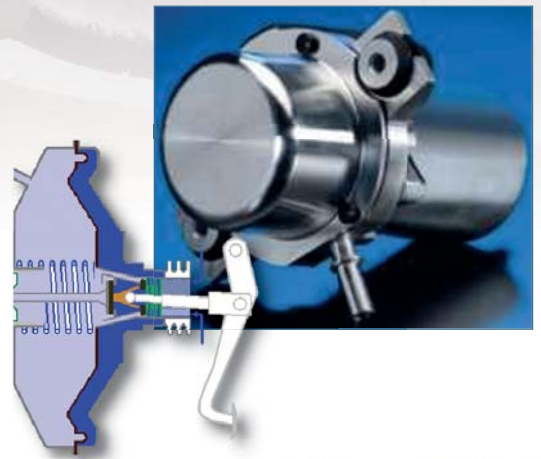
# Sintered Stainless Steel - Applications

## AUTOMOTIVE APPLICATIONS

### FLUID TECHNOLOGY

#### Pumps in corrosive locations

Due to increasing usage of electrical energy for automotive pump drives, the location of the pump is changed from protected positions (inside the engine) to exposed places (outside the engine) that allow for corrosion. Examples can be found in braking systems (vacuum pumps).



### BODY AND CHASSIS COMPONENTS

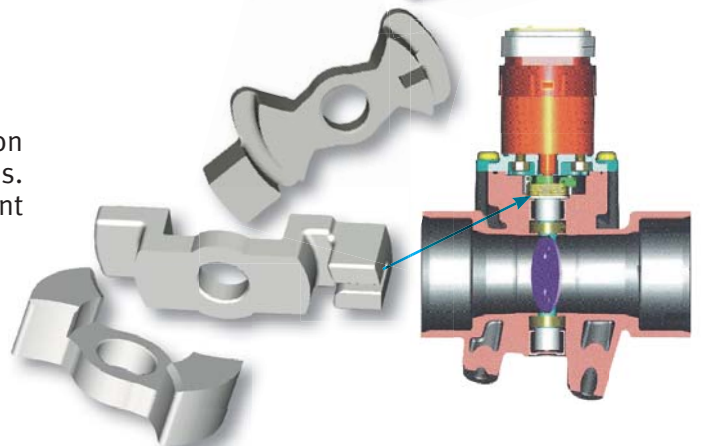
#### Mirror buttons & sensor rings → Parts in visual field

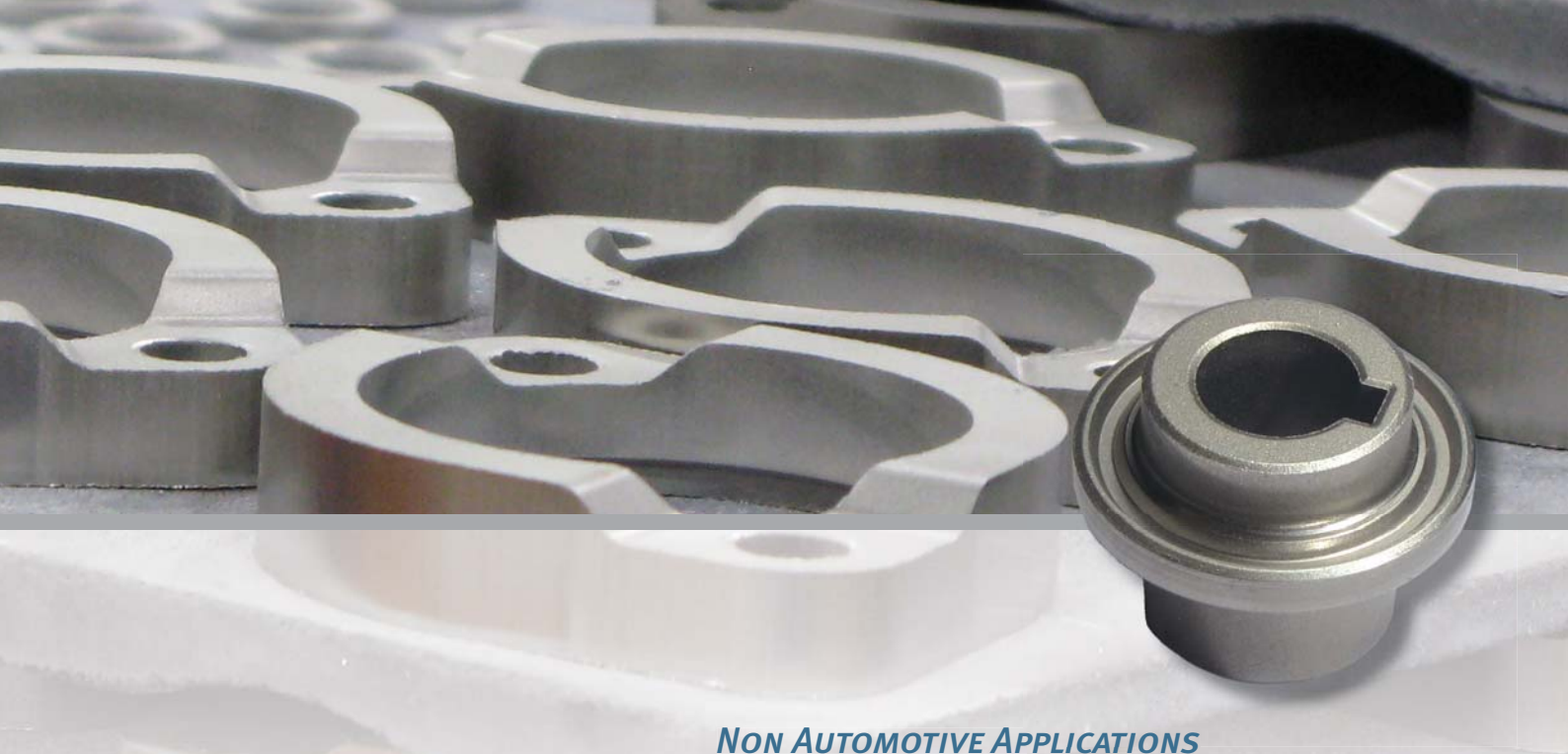
Mirror buttons are needed as a fundamental element between the windscreen and the inner mirror. The beneficial stainless sinter material has the same coefficient of thermal expansion as windscreen glass. Examples can be found in every windscreen fixed mirror.



#### EGR Valves → Parts for CO<sub>2</sub> reduction

Stainless sinter materials in EGR Exhaust Gas Recirculation Valves have to work in corrosive and extreme hot conditions. The mix of the complex shape in combination with the excellent corrosion resistance creates a huge benefit.





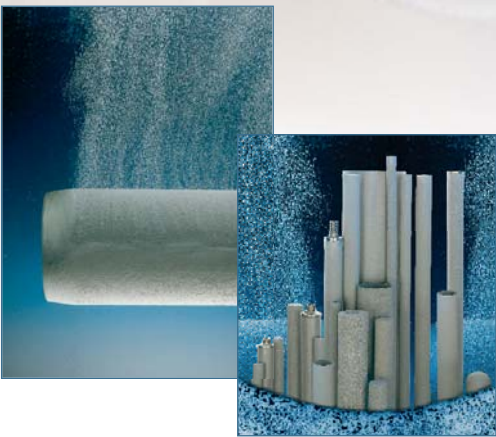
## **NON AUTOMOTIVE APPLICATIONS**

### **FILTER**

#### **Example: static sparging**

In this application gases are sparged via porous stainless steel products into liquids:

- waste water and drinking water treatment ( $O_2$ ,  $O_3$ )
- beverages (beer, mineral water, lemonades)
- chemical process gases



### **POTABLE WATER SUPPLIES**

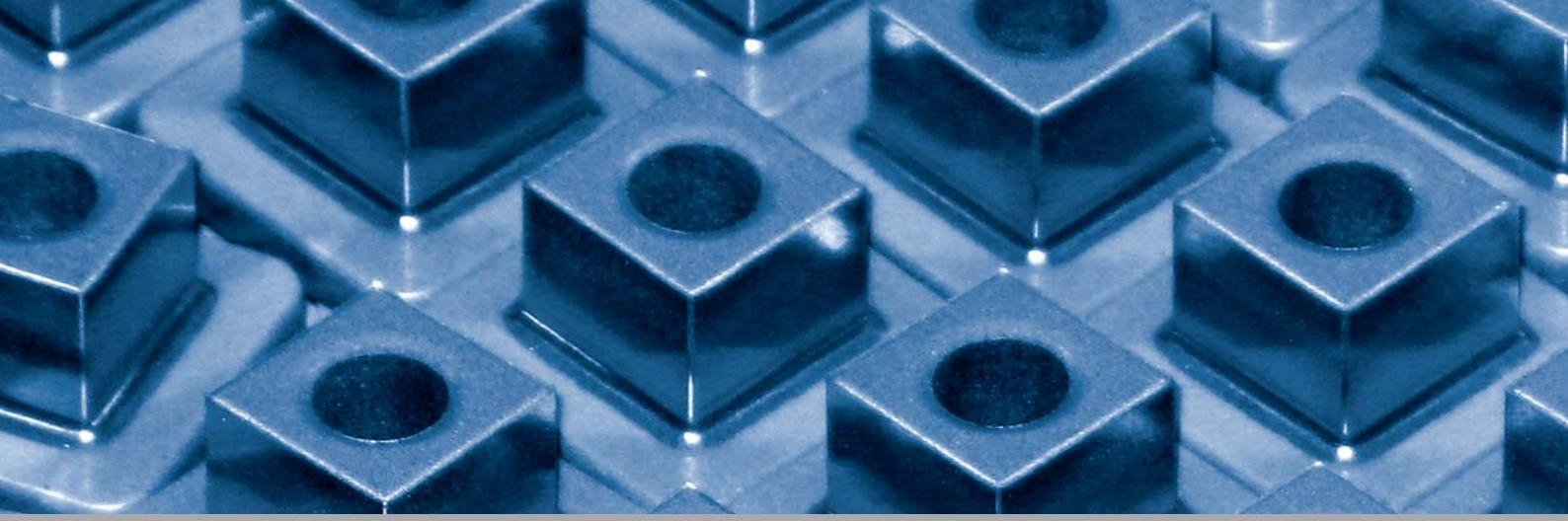
In household water applications high hygienic standards are required. Sintered stainless steel products fulfill these demands. Examples are found in single lever mixer faucets.



### **DISTANCE BUSHES**

#### **Example: compression limiters**

In many cases where plastic and metal parts are screwed together, compression limiters are needed to avoid excess pressure on the plastic which can lead to permanent deformation. In corrosive environments stainless steel is the first choice for these limiters.



# Sintered Stainless Steel - Materials

Type	Standard References I		Typical Properties (References) <sup>2)</sup>									
	MPIF	Density [g/cm <sup>3</sup> ]	Typical composition <sup>3)</sup>	Typical Density [g/cm <sup>3</sup> ]	Hardness HRB	UTS [MPa]	FEL [MPa]	YS <sub>0.2</sub> [MPa]	El [%]	Poisson's Ratio	E [Gpa]	Remark
Austenitic	SS-303N1-25	<sup>1)</sup>	Fe18Cr9Ni	6.4	62	270	90	220	< 1	0.25	105	
	SS-304N1-30	<sup>1)</sup>	Fe19Cr10Ni	6.4	61	300	105	260	< 1	0.25	105	
	SS-316N1-25	<sup>1)</sup>	Fe17Cr12Ni2.5Mo	6.4	59	280	75	230	< 1	0.25	105	
	SS-316N2-33	<sup>1)</sup>	Fe17Cr12Ni2.5Mo	6.5	62	410	95	270	10	0.25	115	
	SS-316H-20	<sup>1)</sup>	Fe17Cr12Ni2.5Mo	6.6	33	240	105	170	7	0.25	115	
	SS-316L-22	<sup>1)</sup>	Fe17Cr12Ni2.5Mo	6.9	45	390	115	210	21	0.27	140	
Martensitic	SS-410-90HT	<sup>1)</sup>	Fe12Cr-0.2C	6.5	23 HRC	720	240	710	<1	0.25	125	Tempered at 180°C
Ferritic	SS-410L-20	<sup>1)</sup>	Fe12Cr	6.9	45	330	125	180	16	0.27	165	
	SS-430N2-28	<sup>1)</sup>	Fe16Cr	7.1	70	410	170	240	5	0.27	170	
	SS-430L-24	<sup>1)</sup>	Fe16Cr	7.1	45	340	170	210	20	0.27	170	
	SS-434N2-28	<sup>1)</sup>	Fe16Cr1Mo	7.0	65	410	150	240	8	0.27	165	
	SS-434L-24	<sup>1)</sup>	Fe16Cr1Mo	7.0	50	340	150	210	15	0.27	165	
	SS-409L	<sup>1)</sup>	Fe11Cr0.5Cb	7.0	45	320	-	180	14	0.27	165	
	SS-409L	<sup>1)</sup>	Fe11Cr0.5Cb	7.25	55	360	-	205	16	0.28	170	

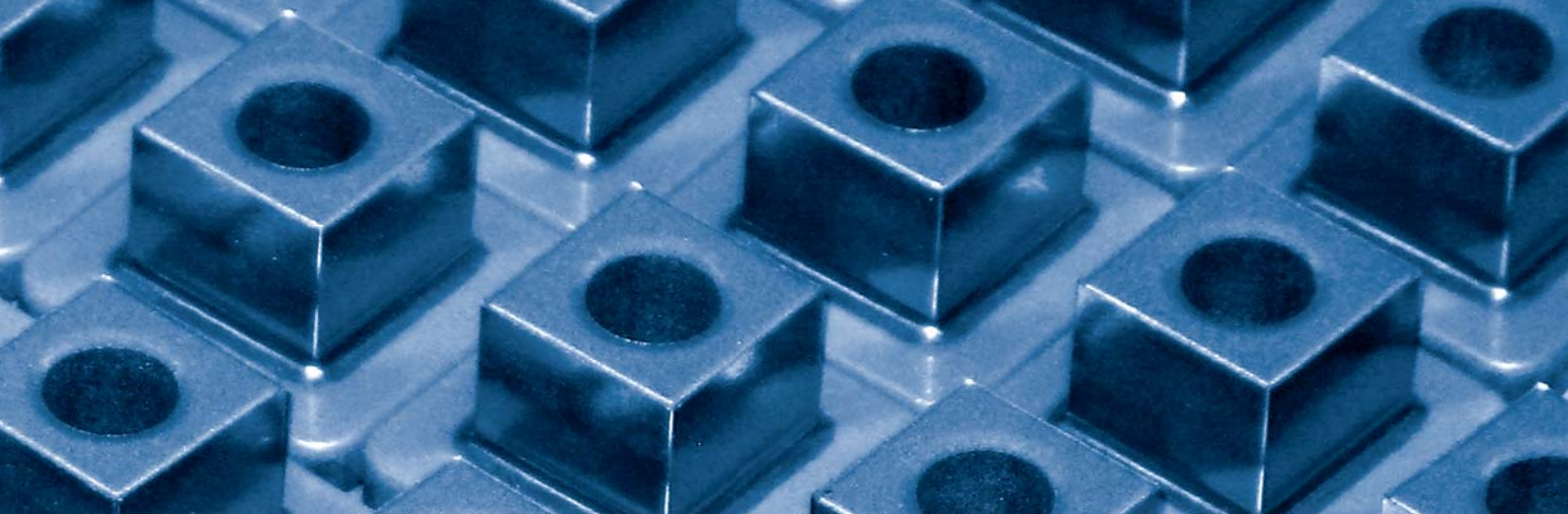
Mechanical property data derived from laboratory prepared test specimens sintered under commercial manufacturing conditions.

<sup>1)</sup> Density range to be agreed upon between supplier and the purchaser.

<sup>2)</sup> Properties shown are typical for the density and processing used. Other targeted properties can be achieved through chemical or processing modifications.

<sup>3)</sup> Data represents certain alloy systems and processing options. Other alloy compositions and processing options exist.





**MIM Materials** - for a detail listing of MIM stainless steels materials, see the MIM materials brochure

Chemical Composition										Standard References II		
C [wt.-%]	Ni [wt.-%]	Mo [wt.-%]	Cr [wt.-%]	Si [wt.-%]	P [wt.-%]	Mn [wt.-%]	N [wt.-%]	Fe [wt.-%]	Others [wt.-%]	GKN SM Material Code	DIN 30910 SINT-	ISO-5755
< 0.15	8.0 - 13.0	-	17.0 - 19.0	< 1.0	< 0.20	< 2.0	0.20 - 0.60	Bal.	< 2.0	PMETSS-303C-N1	n/a	-FL303-170N
< 0.08	8.0 - 12.0	-	18.0 - 20.0	< 1.0	< 0.04	< 2.0	0.20 - 0.60	Bal.	< 2.0	PMETSS-304C-N1	n/a	-FL304-210N
< 0.08	10.0 - 14.0	2.0 - 3.0	16.0 - 18.0	< 1.0	< 0.04	< 2.0	0.20 - 0.60	Bal.	< 2.0	PMETSS-316C-N1	C 40	-FL316-170N
< 0.08	10.0 - 14.0	2.0 - 3.0	16.0 - 18.0	< 1.0	< 0.04	< 2.0	0.20 - 0.60	Bal.	< 2.0	PMETSS-316C-N2	C 40	n/a
< 0.03	10.0 - 14.0	2.0 - 3.0	16.0 - 18.0	< 1.0	< 0.04	< 2.0	< 0.03	Bal.	< 2.0	PMETSS-316C-HL	C 40	n/a
< 0.03	10.0 - 14.0	2.0 - 3.0	16.0 - 18.0	< 1.0	< 0.04	< 2.0	< 0.03	Bal.	< 2.0	PMETSS-316D-H	D 40	-FL316-150
< 0.25	-	-	11.50 - 13.50	< 1.0	< 0.04	< 1.0	< 0.60	Bal.	< 2.0	PMETSS-410C	n/a	-FL410-620H
< 0.03	-	-	11.50 - 13.50	< 1.0	< 0.04	< 1.0	< 0.03	Bal.	< 2.0	PMETSS-410D-H	C 43	-FL410-140
< 0.08	-	-	16.00 - 18.00	< 1.0	< 0.04	< 1.0	0.20 - 0.60	Bal.	< 2.0	PMETSS-430D-N2	n/a	n/a
< 0.03	-	-	16.00 - 18.00	< 1.0	< 0.04	< 1.0	< 0.03	Bal.	< 2.0	PMETSS-430D-H	n/a	-FL430-170
< 0.08	-	0.75 - 1.25	16.00 - 18.00	< 1.0	< 0.04	< 1.0	0.20 - 0.60	Bal.	< 2.0	PMETSS-434D-N2	n/a	n/a
< 0.03	-	0.75 - 1.25	16.00 - 18.00	< 1.0	< 0.04	< 1.0	< 0.03	Bal.	< 2.0	PMETSS-434D-H	n/a	-FL434-170
< 0.03	-	-	10.50 - 11.75	< 1.0	< 0.04	< 1.0	< 0.03	Bal.	< 2.0	PMETSS-409D-H	n/a	n/a
< 0.03	-	-	10.50 - 11.75	< 1.0	< 0.04	< 1.0	< 0.03	Bal.	Nb 0.4-0.8	PMETSS-409E-H	n/a	n/a

UTS: Ultimate Tensile Strength  
EL: Elongation

FEL: Fatigue Endurance Limit  
E: Youngs Modulus

YS: Yield Strength





## About GKN Sinter Metals

GKN Sinter Metals – a wholly owned subsidiary of U.K.-based GKN plc, a global industrial company – is the world's largest producer of precision powder metal products. With a focus on superior delivery, quality and total solutions, the company offers extensive technical expertise in design, testing and various process technologies. GKN Sinter Metals offers a full range of more than 10,000 complex shape, high strength products for the automotive, commercial vehicle, home appliance, lawn and garden, office equipment, power tool, recreational vehicle and process industry markets. The company's global footprint spans more than 13 countries across five continents. GKN Sinter Metals is in close proximity to its customers with more than 30 global locations and a workforce of approximately 5,500 employees.

For more information about GKN's world of solutions visit [www.gknsintermetals.com](http://www.gknsintermetals.com)

## Production Countries

### Argentina

#### GKN Sinter Metals de Argentina S.A.

Ruta Nac. 5 Km. 159,5  
(B6622GKA) Chivilcoy – Bs. As.  
Argentina

Phone: \*54-11-5368-3700  
E-mail: [infoargentina@gknsintermetals.com](mailto:infoargentina@gknsintermetals.com)

### Brazil

#### GKN Sinter Metals Ltda.

Av. Emancipação, 4.500 - Santa Esmeralada  
CEP 13186-542  
Hortolandia – SP – Brazil

Phone: \*55-19-2118-9400  
E-Mail: [infobrazil@gknsintermetals.com](mailto:infobrazil@gknsintermetals.com)

### Canada

#### GKN Sinter Metals – St. Thomas Ltd.

7 Michigan Boulevard  
St. Thomas, Ontario  
Canada N5P 1H1

Phone: \*1-519-631-4880  
E-mail: [infocanada@gknsintermetals.com](mailto:infocanada@gknsintermetals.com)

### China

#### GKN Sinter Metals – Danyang

Number 7 Mechanical Industry Park  
Danyang Development Zone  
Danyang,  
China

Phone: \*86-511-86-885-556  
E-mail: [infochina@gknsintermetals.com](mailto:infochina@gknsintermetals.com)

### Germany

#### GKN Sinter Metals Engineering GmbH

Krebsöge 10  
42 477 Radevormwald  
Germany

Phone: \*49 2191-693-0  
E-mail: [infogermany@gknsintermetals.com](mailto:infogermany@gknsintermetals.com)

#### GKN Sinter Metals Filters GmbH

Dahlienstraße 43  
P.O.Box 1520  
42 477 Radevormwald  
Germany

Phone: \*49 2195-609-27  
E-Mail: [feedback@gkn-filters.com](mailto:feedback@gkn-filters.com)

### India

#### GKN Sinter Metals Ltd.

146, Mumbai Pune Road  
Pimpri, Pune 411 018  
Maharashtra, India

Phone: \*91-20-2742-6261, 6262, 6263  
E-mail: [infoindia@gknsintermetals.com](mailto:infoindia@gknsintermetals.com)

### Italy

#### GKN Sinter Metals SpA

Fabrikstraße 5  
39 031 Bruneck (BZ)  
Italy

Phone: \*39-0474-570211  
E-mail: [infoitaly@gknsintermetals.com](mailto:infoitaly@gknsintermetals.com)

### North America

#### GKN Sinter Metals

3300 University Drive  
Auburn Hills, Michigan 48326-2362  
USA

Phone: \*1-248-371-0800  
E-mail: [infona@gknsintermetals.com](mailto:infona@gknsintermetals.com)

### South Africa

#### GKN Sinter Metals – Cape Town

P.O.Box 156  
Sacks Circle  
Bellville, 7530  
South Africa

Phone: \*27-21-950-6200  
E-mail: [infoafrica@gknsintermetals.com](mailto:infoafrica@gknsintermetals.com)

## GKN Sinter Metals Sales Offices Worldwide

### China

E-mail: [infochina@gknsintermetals.com](mailto:infochina@gknsintermetals.com)

### France

E-mail: [infofrance@gknsintermetals.com](mailto:infofrance@gknsintermetals.com)

### Japan

E-mail: [infojapan@gknsintermetals.com](mailto:infojapan@gknsintermetals.com)

### Korea

E-mail: [infokorea@gknsintermetals.com](mailto:infokorea@gknsintermetals.com)

### Spain

E-mail: [infospain@gknsintermetals.com](mailto:infospain@gknsintermetals.com)

### Sweden

E-mail: [infosweden@gknsintermetals.com](mailto:infosweden@gknsintermetals.com)

### United Kingdom

E-mail: [infouk@gknsintermetals.com](mailto:infouk@gknsintermetals.com)