FAQs :

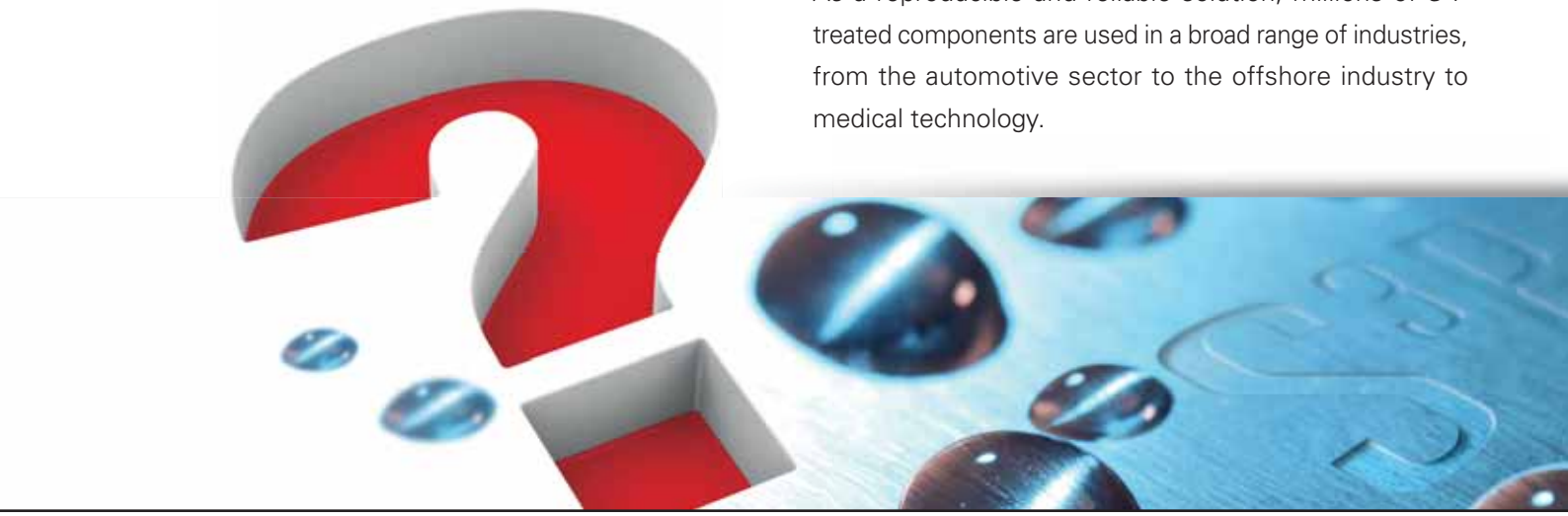
BODYCOTE S³P: PROCESSES FOR SURFACE HARDENING OF STAINLESS STEELS, NI-BASE AND CO-CR ALLOYS

S³P treatments are low-temperature diffusion processes that greatly improve the mechanical properties of corrosion-resistant materials. Due to the low process temperatures, no chromium carbides or nitrides are precipitated. In contrast to standard processes like nitriding or nitrocarburizing, the corrosion resistance of the alloys is maintained.

To allow uniform diffusion and a uniformly hardened zone at such low process temperatures, the surface has to be activated prior to the process and the passive layer reformed afterwards.

The diffusion zone, also called "S-Phase" or "expanded austenite", is very hard but not brittle. Properties like abrasion resistance, fatigue strength, galling- and fretting threshold and cavitation resistance are highly improved. No delamination or flaking off, because the hardened zone is not a coating.

As a reproducible and reliable solution, millions of S³P treated components are used in a broad range of industries, from the automotive sector to the offshore industry to medical technology.



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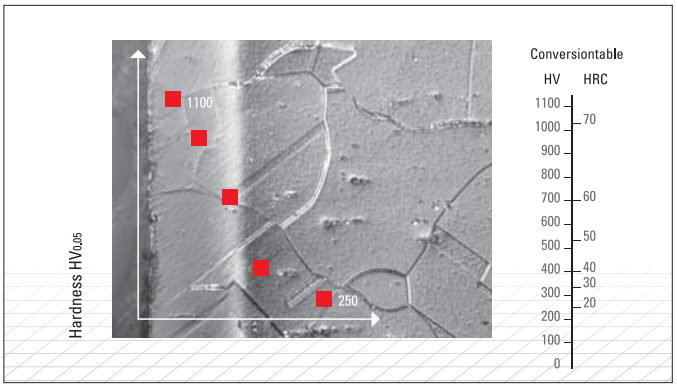
FAQs: K22, K33, K Duplex

The low temperature carbon diffusion treatment is based on the proprietary Kolsterising® process. The different processes K22, K33 and K Duplex mainly differ in their diffusion depth, the proprietary physical principle is the same.

- **Which Materials can be treated?**
  Nearly all austenitic and duplex stainless steels, Ni-base and Co-Cr alloys.
- **Which surface hardness values can be achieved?**
  Common austenitic (1.4404 / AISI 316L) and duplex stainless steels (1.4462 / AISI 2205), Ni-base (2.4668 / Inconel 718) and Co-Cr alloys (2.4964 / Alloy 25) achieve > 1000 HV microhardness (conversion: ~ 70 HRC). Please ask our specialists, if your material can also be hardened.[1]
- **Does the high hardness cause brittleness?**
  The diffusion processes create a smooth transition from hard surface to soft core what prevents from brittle behavior. Carbon is interstitially solved in the face centered cubic (fcc) lattice. The pure carbon S-Phase acts very ductile also for a rapid impact.
- **Do I need to refinish the part concerning optical appearance and tolerances?**
  No, refinishing is not necessary. The low temperature diffusion of Carbon does not affect the shape of a part, also for tight tolerances. Also the color is not changed. For highly polished surfaces like mirror finish a slight increase in surface roughness might appear.[2]
- **Is the corrosion resistance affected?**
  Due to the low treatment temperatures (below 500 °C) no chromium carbides are precipitated. Carbon is interstitially solved and the protective passive layer is uniform and dense after the treatment.[3]
- **Which diffusion depths can be achieved?**
  Between 10 and 40 µm, dependent on the chosen process.[1]
- **What are the maximum and minimum treatable dimensions and weights?**
  Maximum part dimensions are Ø 480 mm x 560 mm with a maximum weight of 250 kg. There is nearly no minimum limitation to parts size and weight.
- **Is the whole surface area treated?**
  The whole surface of a part is treated, also in very small holes and bores.
- **Is bulk material treatment possible?**
  Yes it is possible. Care has to be taken when bulk parts have flat surfaces. Point and line contacts are no problem.



Microhardness vs. diffusion depth of treated stainless steel 1.4404 (316L) and hardness conversion table

Cross section of treated stainless steel AISI 316L after rapid heavy deformation (hammer & nail test)

[1] *Beside the chemical composition of the alloy, the results are also dependent on heat treatment and machining.*

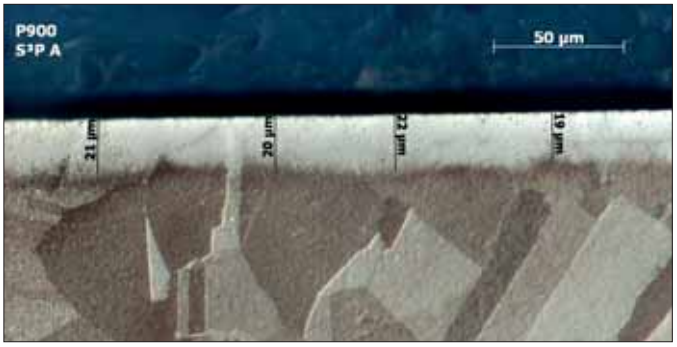
[2] *The appearance after the process is dependent on the delivery condition of the part.*

[3] *The passive layer has the best properties when the microstructure of the base material is uniform. Non-uniformities like sulfides, deformation martensite and delta ferrite might reduce the corrosion resistance.*

FAQs: S³P M, S³P A and S³P D

The proprietary low temperature nitrogen and/or carbon diffusion treatments are based on NIVOX-technology. The different processes S³P M (Martensitic), S³P A (Austenitic) and S³P D (Duplex) are designed to meet the special needs of the different alloy groups.

- **Which Materials can be treated?**
  Nearly all austenitic, duplex, martensitic and precipitation hardened (PH) stainless steels, Ni-base and Co-Cr alloys.
- **Which surface hardness values can be achieved?**
  Common austenitic (1.4404 / AISI 316L), duplex (1.4462 / AISI 2205), martensitic (1.4125 / AISI440) and PH-stainless steels (1.4543 / 17-4PH), Ni-base (2.4668 / Inconel 718) and Co-Cr alloys (2.4964 / Alloy 25) achieve > 1000 HV micro-hardness (conversion: ~ 70 HRC). Please ask our specialists, if your material can also be treated.[4]
- **Does the high hardness cause brittleness?**
  The diffusion processes create a smooth transition from hard surface to softer core what prevents from brittle behavior. Nitrogen and / or carbon is interstitially solved. The pure carbon S-Phase acts very ductile also for a rapid impact, nitrogen S-Phase is less ductile.
- **Do I need to refinish the part concerning optical appearance and tolerances?**
  No refinishing is necessary. Also the color is not changed. For highly polished surfaces like mirror finish a slight rise in surface roughness might appear. Concerning tolerances, it is recommended that especially for martensitic stainless steels the final heat treatment temperature should be above ~500 °C to avoid that the following low temperature diffusion processes cause any deformation or warpage[5].
- **Is the corrosion resistance affected?**
  Due to the low treatment temperatures (below 500 °C) no chromium carbides and/or nitrides are precipitated. Carbon and/or nitrogen is interstitially solved and the protective passive layer is uniform and dense after the treatment.[6]
- **Which diffusion depths can be achieved?**
  Dependent on the chosen material and process between 5 and 40 µm.
- **What are the maximum treatable dimensions and weights?**
  Maximum part dimensions are Ø 1,200 mm x 2,000 mm with a maximum weight of 4,000 kg. Treatment of very small parts is not recommended.
- **Is the whole surface area treated?**
  Normally no. With special fixtures nearly the whole surface area is treated.
- **Is a selective treatment of certain surface areas possible?**
  Yes this is possible. For example mechanical covers or pastes can be used to mask surface areas that should not be hardened.
- **Is bulk material treatment possible?**
  No, due to the physical principle it is not possible to treat bulk.



Microstructure of special steel P900 (1.3815), S³P A treated with a diffusion depth of 19 - 22 µm

[4] Beside the chemical composition of the alloy, the results are also dependent on heat treatment and machining.

[5] Please send a drawing including information about heat treatment to check technical feasibility.

[6] The passive layer has the best properties when the microstructure of the base material is uniform. Non-uniformities, like sulfides, reduce the corrosion resistance.

Typical Applications

- Medical industry
- Food and beverages processing
- Pumps and valves
- Fastening solutions
- Automotive industry
- Consumer products
- Marine applications
- Oil & gas industry

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Certificates for resistance to hydrogen embrittlement, stress corrosion cracking, sigma phase embrittlement and ferric chloride pitting corrosion according to:

- **ISO 15156 / NACE MR0175**
  for austenitic stainless steel 316L (1.4404)
  tested at room and elevated temperatures
- **ISO 15156 / NACE MR0175**
  for duplex stainless steel 2205 (1.4462)
  tested at room and elevated temperatures tested
- **ISO 15156 / NACE MR0175**
  for precipitation hardening stainless steel 15-5PH (1.4545)
  tested at elevated temperatures
- **ASTM A923**
  for duplex stainless steel 2507 (1.4501)
- **ASTM G48-A**
  for nickel base alloy Inconel 718 (2.4668)
- **FDA Masterfile**

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