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WHITE PAPER

What's the Difference Between Alloy Steel and Carbon Steel Coiled Spring Pins?

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Coiled Spring Pins provide superior strength and flexibility compared to many other types of fasteners. Coiled Pins also absorb shock and vibration effectively and therefore function as active components in dynamic and fatigue applications. Material selection is critical in order for the Coiled Pin to exhibit the spring properties necessary for optimal performance.

Carbon steel and alloy steel are the most cost effective and versatile materials available for use in Coiled Pins. These materials are readily available, easy to process and have very uniform and predictable performance characteristics. While these materials have limited corrosion protection, they are adequate for most applications. Both materials provide similar mechanical properties and should be viewed as equivalent for Engineers from a design standpoint.

Description	High Carbon Steel	Alloy Steel
Grade	UNS G10700 / G10740 C67S (1.1231) / C75S (1.1248)	UNS G61500 51CrV4 (1.8159)
Specification	ASTM A684 / A684M SAE J403 EN 10132-4	ASTM A506-05 EN 10132-4
Hardness, Vickers	HV 420 – 545	HV 420 – 545

Heat treated Coiled Spring Pins

Carbon steel is less expensive than alloy steel, which is why it is the generally preferred material for Spring Pins. However, Coiled Pins with large diameters (> Ø.500" / Ø12mm) should not be produced from carbon steel because they cannot be quenched quickly enough to achieve the desired mechanical properties needed for static or dynamic applications. Hence, alloy steel is the material used for large diameter Coiled Pins because the quenching requirements are more relaxed and therefore achievable.

HEAT TREAT OVERVIEW

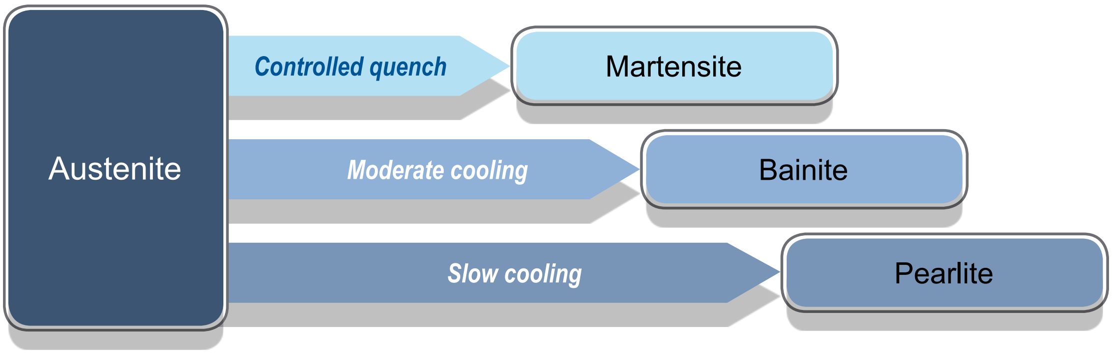
All carbon steel and alloy steel spring pins are heat treated to optimise strength, flexibility and hardness. The heat treating process for Spring Pins manufactured from these materials involves base hardening, quenching and tempering. Heat treating allows manufacturers to manipulate the microstructure of a product; this is important because the microstructure dictates its characteristics.

The first step is base hardening, where the Coiled Pins are heated to temperatures just under 2000°F (1100ºC), exceeding the eutectoid temperature at which the microstructure is austenite. At this point the material's microstructure can be controlled by quenching, which is the process of cooling the material to ambient temperatures. The rate (time to ambient) at which a material is quenched dictates the resulting microstructure. Iron-carbon alloys quenched from the eutectoid temperature can result in three primary microstructural products of transformation: pearlite, bainite and martensite. Martensite exhibits the best mechanical properties of the three. In Spring Pin functionality, this equates to shear strength, fatigue life, flexibility, hardness, etc.

Theoretically, the goal of heat-treating Spring Pins is to achieve a 100% martensitic microstructure. While this is not feasible in practice, an effective heat treating process will optimise the martensitic composition within the material. Martensite is formed when the material is quenched rapidly enough to prevent carbon diffusion. If the quenching process is too slow, the carbon atoms escape the desired atomic geometry and less desirable microstructures will form (pearlite, bainite).

The final step of heat treatment is tempering. This is performed after the pins have been quenched to ambient temperatures. Tempering occurs at temperatures under 1000°F (540ºC) (below the critical eutectoid temperature). Tempering improves the ductility and toughness of martensite because the pins are brittle immediately after being quenched. The tempering process must be below the temperature at which the metal transforms into austenite. These low temperatures relieve internal stress, decrease brittleness and maintain high hardness. Springs (i.e. Coiled Spring Pins) tempered at higher temperatures result in greater loss of hardness and strength, but they display improved elasticity. Therefore, the heat treating recipe is integral for the Coiled Spring Pin manufacturing process.

Heat treatment is one of the most critical processes in the production of Spring Pins, as it directly impacts the performance and lifetime of the assembly using the pin. Seemingly minor variations in time (minutes) and temperature (± 10°F (± -12ºC)) can have a drastic impact on the quality of a Spring Pin. For this reason, it is critical that fastener manufacturers have effective control measures in place.



CARBON STEEL VS ALLOY STEEL

Carbon steel Coiled Pins must be quenched to ambient temperatures within several seconds in order to achieve a high martensitic composition. Conversely, alloy steel allows for a much longer quenching time (~1 minute) in order to achieve a high martensitic composition. The quench time is adversely affected as the Spring Pin gets larger and has more mass. Specifically, the outside of the pins will achieve a high martensitic composition, but the inside of the pins will not. Coiled Spring Pins at diameters of Ø.500"/Ø12mm (or less) are able to quench quickly enough to use carbon steel. However, Coiled Pins with larger diameters require the use of alloy steel so that the entire composition of the pin has the opportunity to achieve optimal martensitic composition.

FIELD IMPACT – INEFFECTIVE HEAT TREAT

Static Applications

If a Coiled Pin does not achieve the desired metallurgical microstructure, the pin carries a risk of failure in the field after being exposed to applied loads. This may present itself in the form of bending or shear failure.

Dynamic Applications

If a Coiled Pin does not achieve the desired metallurgical microstructure, the pin's fatigue life will be sacrificed. This limits the number of cycles the pin can withstand in the field, reducing the assembly's functional lifetime.

CONCLUSION

Designers should view carbon steel and alloy steel Coiled Spring Pins as roughly equivalent when looking through a Spring Pin manufacturer's catalogue. However, be wary of large diameter (>Ø.500" / Ø12mm) Coiled Pins made from carbon steel, as they carry mechanical risks. Heat treating is one of the most critical steps in the manufacturing of Spring Pins, so it's recommended that fastener manufacturers carry out the heat treating process in-house for full control. Although this article offers general design guidelines, it is recommended that Application Engineers who specialise in the design and manufacture of Coiled Spring Pins be consulted to ensure the proper material is selected for each specific assembly.

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