

Technical Report 2009

# **Relaxation of springs at high temperature**

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### Introduction

When metals are subjected to stresses and increased temperatures a permanent deformation may take place. This phenomenon is called relaxation, a load loss at a constant deformation, or creep, an increased deformation at a constant load. This is an important performance parameter for coil springs which mostly are designed to give a controlled deflection at a certain load or inversely. At temperatures above 500°C the relaxation performance for low alloyed and stainless steels are so low that they can not be used for coil springs. Super alloys give better performance at these temperatures. In the following the relaxation performance for some super alloys at temperature 550°C and above is presented.

### Super alloys tested

In this investigation three different super alloy wires and one stainless steel wire were tested. The main chemical analysis and the mechanical strengths were as presented in the following table.

Material	Ni	Cr	UTS (Mpa)
Super Alloy A	58	19	1300
Super Alloy B	55	19	1050
Super Alloy C	53	17	1200
Stainless steel*			2090

Note \* Grade 17/7PH

### Relaxation test method

A number of coil springs from these materials were manufactured according to the Lesjöfors standard production methods for this type of material and springs. The springs were then compressed with a static load to a specified stress level with help of a mechanical joint. The compressed springs with joints were exposed to specified temperatures for different times. After cooling, the load for each spring was tested again and the loss of load was noted. The relaxation figure presented was defined as follows:

$$(F_b - F_a) / F_b \cdot 100 = \text{Relaxation (\%)}$$

$F_b$  = Load at compression before heating

$F_a$  = Load at compression after heating

Following times and temperatures were used with different stress levels at each:

	Time	Temp 1	Temp 2	Temp 3
Material	[h]	[°C]	[°C]	[°C]
Super Alloy A	50	550	600	650
Super Alloy A	110	550	600	650
Super Alloy B	50	550	600	650
Super Alloy B	110	550	600	650
Super Alloy C	50	550	600	650
Super Alloy C	110	550	600	650
Stainless steel	50	550	-	-

#### Results

The stainless 17/7PH steel failed as expected after 50 hours at 550°C and stress level 150 MPa. The relaxation received was close to 100 %. No more tests were made with this grade. Examples of relaxation results are presented in following diagrams.

#### Conclusions

The results show that stainless steel can not be used at these high temperatures. It also shows the big difference between different super alloy grades. From tested super alloy grades the C grade had the lowest relaxation and performed best at all temperatures. It can also be seen that depending on alloy, temperature and stress the relaxation has to be considered when designing coil springs to be used in applications where high temperatures can be expected.