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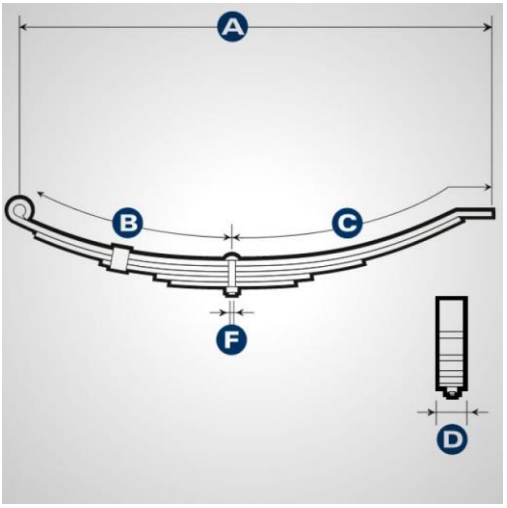
Failure Analysis of a Truck Leaf Spring due to Fatigue



Keywords: Truck, Leaf Spring, Fatigue, Cracking

Material: Alloy Steel

Introduction

Truck leaf springs, the subject of the above referenced caption, were submitted for a cause of failure analysis. It was reported that "The operator of the truck was driving from Overhead Road, Southbound, onto Nichols Road when the rear wheels locked causing the vehicle to slide sideways and overturn. The rear wheels locked and separated from the vehicle when the rear spring assembly failed." it was also reported that this was the first excursion made by the truck after being bought as a refurbished truck from the truck company. Visual examination, non-destructive test, chemical, mechanical and metallographic analyses was performed on the submitted sections to look for root cause of the failure.

Visual Examination

Figure 1 is a photograph showing the leaf spring assembly as it appeared when submitted. Note that the three longest leaves failed on one side (upper left). It should be pointed out here that the spring set is placed upside down in this photograph. In figures, the fracture surfaces on the three fractured leaves, arbitrarily designated 1, 2, and 3, top to bottom in the photographs. The fracture surfaces on leaves one and two are more severely corroded than leaf three indicating quite strongly that the fractures in. leaves one and two anteceded the fracture in leaf three. Also significant is that all three fractures are brittle in nature showing no plastic deformation adjacent to the fractures.

The fractures were cut from each of the three leaves in order to conduct further visual examination. Although these surfaces are rusted (particularly 1 and 2), the origin of final fracture is evident. In order to more clearly define the fracture texture, the sections were cleaned with a solution of citric acid and ammonia. This treatment removes rust but does not attack the underlying metal. The final fracture origins illustrated in Figure 2 are much more clearly defined as are other pertinent structural features. The fracture origins are flat and typical of progressive (fatigue) failure. Moreover, there is a zone of fatigue fracture on the sides opposite the side from which final fracture occurred. This zone is indicated by arrows in Figure 2. The fatigue crack on the opposite side would necessarily have come about due to upward bouncing of the truck body since under normal conditions these sides are in compression. Compressive stress cannot cause fatigue.

Fig 1 Fractured Leaf Spring as received condition

Fig 2 Fatigue feature showed on fracture surface on leave 1&2

The foregoing observations indicate strongly that the leaves all underwent fatigue cracking during a particular period of service and spring leaves one and two had finally fractured through, due to the presence of the fatigue cracks, at some time prior to the day that the accident occurred. Owing to the weakened condition of the spring set due to failure of leafs one and two, leaf three failed during service thus causing complete instability in the wheel set and ultimate overturning of the vehicle.

Non-Destructive Test

The remainders of the three fractured leaves as well as an adjacent leaf were liquid penetrant tested. All four leaves were found to be free of any surface cracks.

Chemical Analysis

A chemical analysis of leaf spring number three resulted in the following analysis:

	Results	AISI 5155
Carbon	0.57	0.51/0.59
Manganese	0.7	0.70/0.90
Phosphorus	0.013	0.035 Max
Sulphur	0.024	0.04 Max
Silicon	0.23	0.15/0.30
Chromium	0.97	0.70/0.90
Nickel	0.02	0.25 Max
Molybdenum	0.01	0.06 Max

The chemical analysis of leaf spring number three conforms to the requirements of AISI 5155 alloy steel, the requirements of which are shown above for comparison.

Mechanical Test

Rockwell hardness test were conducted on the surface of each of the three failed springs with following results:

Leave	1	2	3
Rockwell	C42-43	C42-43	C43-44

These values were corroborated by Knoop microhardness tests conducted on metallographic samples taken from each of the fractured springs.

Microscopic Examination

Metallographic samples were taken from each of the fractured springs and suitably prepared for observation of microstructure which was found to be tempered martensite in all three leaf springs. Figure 3 is a photomicrograph (500X) showing this structure in leaf three and is typical of what was found in the other two leaves.

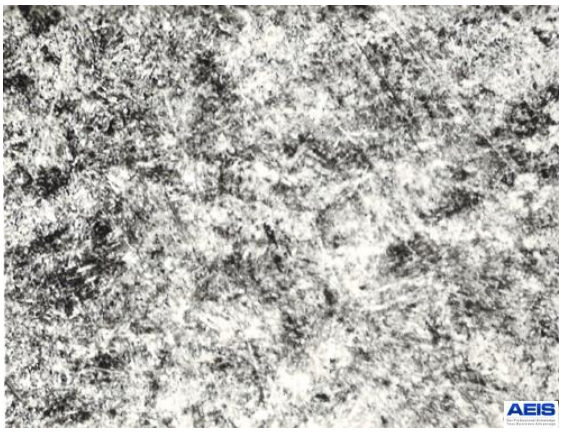


Fig 3 Microstructure of leave 3 shows tempered martensite X500

Conclusion

Failure of the subject spring set and the attendant overturning of the vehicle was the result of preexisting fractures in the two longest leaves. These fractures came about by progressive (fatigue) cracking ultimately resulting in final fracture at some time prior to the day of the accident. The third longest leaf, which also showed evidence of fatigue cracking, failed at the time of the accident due to the excessive loads placed on it because of the previous fracture of the other two leaves.