

Leaf Spring Failure Analysis

Springs are a limited life component.

Regardless of how well a spring is maintained or how favorable the operating conditions are, all springs will eventually fail from fatigue caused by the repeated flexing of the spring. Once the spring life limit is reached a fatigue failure will or has occurred.

Factors influencing fatigue life :

Overloading

- The higher the loads or deflections seen by a spring, the lower its fatigue life.

Shock Absorbers

- A properly functioning shock absorber will tend to reduce the spring deflection as the vehicle hits a bump. Lower spring deflections mean lower operating stresses on the spring which in turn gives longer fatigue life. This is especially true for full taper springs which do not have the high interleaf friction to help dampen spring deflections. Worn or missing shock absorbers must be replaced to maximize spring life.

Brake Adjustments

- Improperly adjusted brakes can also reduce spring life. Under braking, springs are expected to absorb some of the braking forces. If the brakes on an axle are unevenly adjusted one spring will have to absorb more than its share of braking force which can reduce its fatigue life.

Protective Coatings

- Corrosion is one of the major factors in reducing spring life. Proper paints and care during handling and installation can help to slow the spread of spring corrosion. On full taper springs the only acceptable coating is the individual painting of each leaf with zinc-rich paint. This paint may be recognized by its characteristic gray color.

Surface Condition

- The condition of the spring surface also has an effect on fatigue life. Generally, a fatigue crack will start at some sort of surface defect on the spring leaf. Therefore, care needs to be used when manufacturing and installing springs to reduce these defects to a minimum.

Shot Peening

- Extensive testing indicates that shot peening can increase the life of springs by a factor of three or more. It is not enough, however, to simply shot peen the first one or two leaves in an assembly-**all leaves must be shot peened**. All major vehicle manufacturers specify that their OEM springs have each leaf shot peened.

Decarburization and Steel Quality

- Improper manufacturing methods can also reduce fatigue life. For example, poorly controlled heat-treat furnaces can excessively decarburize the leaf surface. Decarburization is the loss of carbon from the steel surface which will result in a soft leaf surface once heat-treating is complete. This soft layer will not be able to handle the spring stresses and will lead to early failure. Poor steel quality can also influence spring life. If the steel has excessive impurities in it, the fatigue life will be reduced.

Maintenance

- Finally, improper maintenance will affect spring life.
- Spring eyes and other suspension components should be regularly greased to prevent binding.
- U-bolts should **never** be reused.
- Axle seats, top plates and other components should be periodically inspected and replaced as required.

Spring failures may be categorized into three types :

Early Life Failures

- These type of failures occur generally due to a spring defect, installation problem or overload. This may be due to the material used, the manufacturing processes or improper installation techniques. This type of failure may also be caused by a short-term overload condition.

Midlife Failures

- Once the spring has passed the time in service which would expose early life failures, a very low failure rate should be observed, assuming the spring is subjected to normal service.

Late Life Failures

- At this point, the frequency of spring failures will tend to increase rapidly as the useful life of the spring has been reached. By this time the spring steel has been fatigued and corroded to a point where its useful life is over.

Failures occurring in early and midlife of the spring are usually most economically handled by repairing the broken leaf rather than replacing the spring. Failures in older springs occur at a point when all leaves have reached their fatigue life the spring should now be replaced. The difficulty, of course, is determining what type of failure the spring has experienced. Basically, the condition of the spring, as well as its service history, will indicate if the spring should be repaired or replaced.

When To Repair

- If the spring has not been repaired or repaired only once. Stamping a 1 in the clip for the first repair and a 2 for a second repair will help identify the number of previous repairs.
- If the spring mileage is less than half of normal life.
- If the repair cost is less than 1/2 the cost of a new spring.

- If no more than two or three leaves are broken.
- If the failure is not of a fatigue type. For example, a leaf broken through the center hole is caused by improper spring clamping brought on by loose U-bolts or worn axle seats, not fatigue. This spring should be repaired, if possible, and the cause of failure corrected.

Even when it appears to make sense to repair, the following should be kept in mind :

1. Repair leaves are usually not shot peened and must often be heavily hand-fit to match the old spring. Therefore, the repair leaf will not be as durable as a leaf in a new spring would be.
2. Since the remaining leaves have lost some of their strength, the replaced leaves will be carrying more of the load than they were originally designed for.
3. When the leaves first broke the remaining leaves in the spring had to carry more load and were probably overstressed.
4. Replacing the broken leaves does nothing to restore the fatigue life of the reused leaves. These leaves will continue to fail since their fatigue life is essentially over.

When To Replace

- The spring has already been repaired once or, at most, twice.
- The spring service mileage has exceeded 1/2 its normal life.
- The repair cost exceeds 1/2 the cost of a new spring.
- More than two or three leaves are broken.
- If small fatigue cracks can be seen running across the leaf width near the U-bolts on the unbroken leaves.
- If the leaf tips have separated away from the leaf above.
- Never attempt to repair a full taper spring.