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Alfin (Ni-Resist) Ring Groove Inserts

Alfin or Ni-Resist ring groove inserts are manufactured into pistons to reduce ring groove wear in diesel engines and thus increase engine and piston life. Contrary to the belief of many, these inserts are not present to strengthen the piston. In reality, as they represent a discontinuity in the structure of the piston, they are a potential point of weakness. Traditionally, alfin inserts are made of Ni-Resist cast iron, which is a nickel alloyed cast iron with a coefficient of thermal expansion very similar to piston grade aluminiums. If this were not the case, the rapid and massive temperature fluctuations experienced in the piston crown would result in the piston alloy and the alfin insert expanding and contracting at very different rates and by different amounts. This would cause failure of the bond between the two materials. While many manufacturers use the shape of the alfin insert to help lock it into the casting, the real strength of the insert in the piston is the result of a molecular or atomic bond between the insert and piston materials. Aluminium has a very strong affinity for iron and so before the insert is fitted into the piston mould and the casting poured, the alfin insert is 'soaked' in a molten aluminium bath for some time. This allows the insert to come up to temperature and gives time for the molecular interaction between the iron and aluminium molecules.

Manufacturers typically have strict quality control procedures to ensure the bond between the alfin insert and piston alloy is acceptable. If the insert isn't 'soaked' long enough, if it takes too long to get the insert into the mould and the casting poured, if the surface of the insert is contaminated with oils, dirt etc. or if the piston experiences excessive forces in the clamping and machining processes or is dropped or knocked, the alfin insert bond can be compromised. Some piston manufacturers check the alfin insert bond of each and every piston they produce - after machining - by either x-ray or ultrasonic testing. It should be noted that very few pistons ever have 100% alfin bonding. Manufacturers usually accept between 80 and 85% bonding. A typical O.E. piston manufacturer's quality specifications for alfin inserts includes:

- Concerning de-bonding between the alfin insert and piston. Some de-bonding is acceptable within the following limits. Total separation length should be less than 3% of the bore circumference, with any individual separation being less than 0.4mm wide and less than 2.00mm radial length by visual inspection.
- After dye penetrate crack testing, it is acceptable to have the radial length of all separations, located on the upper and lower edges of the insert, to be within 20% of the bore circumference.

Many newer model pistons have the top ring groove and alfin insert situated very close to the piston crown to reduce dead space above the top ring and thus reduce emissions. This presents problems for the integrity of the alfin bond both during the manufacturing process and operation. This threat has caused some manufacturers to use ceramic fibre ring groove inserts. The ceramic inserts are of a very fine 'honeycomb-like' structure, with approximately 6% density. They are placed into the piston mould at elevated temperature and the molten piston alloy is injected into the mould under high pressure in a process called 'squeeze casting' or 'liquid forged casting'. The molten alloy fully impregnates the ceramic insert, such that the two become integral - it is impossible to separate or debond them. This is an expensive process which has become popular with some piston O.E. manufacturers, but there are some suggestions that the process will be abandoned due to the cost. More recently, a piston manufacturer has developed a process called Electronic Beam Fusion (E.B.F.), which involves a copper band being 'fused' into the aluminium casting around the top ring groove. This process was developed to help promote a better bond and reduce stresses in the bond between the piston alloy and alfin insert.

WARNING: All diesel pistons must be fitted to the engine block to check piston protrusion heights before engine assembly. Incorrect protrusion can be corrected by decking the block, decking the piston crown, resizing the conrod length or fitting graded head gaskets. Many engine builders machine the piston crowns to set the piston protrusion heights, not realizing that they could be compromising the integrity of the alfin insert bond in the process. Extreme care must be taken in clamping the piston in the lathe or milling machine and then in machining the crown, ensuring the piston crowns do not experience shock or load. Alfin insert debonding of a piston in operation can result in catastrophic failure of the engine.