Based on AGMA 1010-E95

	Failure mode	Appearance	Area affected	Severity
1.	Fretting	Iron oxide powder is generated as a result of fretting that has the fineness and reddish-brown color of cocoa		
2.	Scuffing	The scuffed areas appear to have a rough or matte texture. Under magnification, the scuffed surface appears rough, torn, and plastically deformed. Scuffing is not a fatigue phenomenon and it may occur instantaneously.	The damage typically occurs in the addendum, dedendum, or both, away from the operating pitch line, in narrow or broad bands that are oriented in the direction of sliding. Scuffing may occur in localized patches.	Mild – if occurs only on small areas of the teeth and is confined to the peaks of the surface asperities. Moderate – patches covering significant portion of the tooth Severe – entire addendum , dedendum or both
3.	Macropitting	The edges of a pit are usually sharp and angular. Cracks may be found near the boundary of the pit and fatigue "beach marks" may be evident on the crater bottom.		**Initial Pitting** – Non-progressive Macropitting normally consists of small pits less than 1 (one) mm in diameter. They occur in localized areas and tend to redistribute the load by removing high asperities. When the load is more evenly distributed, the Macropitting stops. **Progressive pitting –** Progressive Macropitting normally consists of pits significantly larger than 1 (one) mm in diameter. Pitting of this type may continue at an increasing rate until a significant portion of the tooth surface has pits of various shapes and sizes. **Flake pitting –** Flake Macropitting consists of pits that are relatively shallow but large in area. The fatigue crack extends from an origin at the surface of the tooth in a fan shaped manner until thin flakes of material break out and form a triangular crater. **Spalling –** Spall Macropitting is progressive Macropitting that occurs when pits coalesce and form irregular craters that cover a significant area of the tooth surface.

4.	Micropitting			Micropitting gives the gear tooth a frosted, matte, or gray stained appearance. Under magnification, the surface appears to be covered by very fine pits (normally less than 20µm deep). Metallurgical sections through the micro-pits show fatigue cracks that are inclined to the surface at an angle of less than 45 degrees. The cracks may extend deeper than the visible micro pits. Micropitting occurs most frequently on surface hardened gear teeth although it may also occur on through hardened gear teeth. It may occur anywhere on the active profile of the gear tooth.
5.	Scaling	Patchy raised areas on the tooth flanks	Entire tooth flanks	
6.	Abrasion	Abrasion causes scratches or gouges on the tooth surface that are oriented in the direction of sliding.	At the addendum and dedendum where sliding is present.	Mild-fine scratches, no significant amount material removed Moderate-remnants of the original machining marks are visible on the tooth surface.

Two major and most common groups of tooth surface failure modes can be distinguished based on the process nature and its initiation mechanism: material adhesion (1-2) and fatigue or overloading (3-5).

#	Failure mode	Description
1.	Fretting	Fretting corrosion occurs between contacting surfaces that are pressed together and subjected to cyclic, relative motion of extremely small amplitude. Under these conditions, the lubricant is squeezed from between the surfaces permitting metal-to-metal contact and causing adhesion of the surface asperities. The relative motion breaks the welded asperities and generates iron oxide powder that has the fineness and reddish-brown color of cocoa. The wear debris is hard and abrasive. Fretting corrosion tends to be self-aggravating because the wear debris builds a dam that prevents fresh lubricant from reaching the contact area.
2.	Scuffing (scoring)	Scuffing is severe adhesion that causes transfer of metal from one tooth surface to another due to welding and tearing. The scuffed areas appear to have a rough or matte texture. The damage typically occurs in the addendum, dedendum, or both, away from the operating pitch line, in narrow or broad bands that are oriented in the direction of sliding. Scuffing may occur in localized patches. Under magnification, the scuffed surface appears rough, torn, and plastically deformed. Scuffing is not a fatigue phenomenon and it may occur instantaneously.
3.	Macropitting	Macropitting may occur when fatigue cracks initiate either at the surface of the gear tooth or at a shallow depth below the surface. The crack usually propagates for a short distance in a direction roughly parallel to the tooth surface before turning or branching to the surface. When the cracks have grown long enough to separate a piece of the surface material, a pit is formed. The edges of a pit are usually sharp and angular. Cracks may be found near the boundary of the pit and fatigue "beach marks" may be evident on the crater bottom.
4.	Spalling	Spall Macropitting is progressive Macropitting that occurs when pits coalesce and form irregular craters that cover a significant area of the tooth surface.
5.	Micropittiong (frosting)	Micropitting gives the gear tooth a frosted, matte, or gray stained appearance. Under magnification, the surface appears to be covered by very fine pits (normally less than 20µm deep). Metallurgical sections through the micro-pits show fatigue cracks that are inclined to the surface at an angle of less than 45 degrees. The cracks may extend deeper than the visible micro pits. Micropitting occurs most frequently on surface hardened gear teeth although it may also occur on through hardened gear teeth. It may occur anywhere on the active profile of the gear tooth.
6.	Scaling	The patchy raised areas on the tooth flanks are due to an oxidation process during heat treatment. When running under load, the tooth force is initially transmitted by way of these projections which rapidly acquire a metallic sheen. This

		phenomenon is known as scaling.
7.	Cavitation	Cavitation is the nucleation and implosion of bubbles in the lubricating fluid. This may cause damage in the gear tooth surface which appears to the unaided eye to be rough and clean as if it were sandblasted. Microscopically, the craters caused by cavitation are deep, rough, clean, and have a honey comb appearance.
8.	Erosion	Erosion is the loss of material from a gear tooth surface due to the relative motion of a high velocity fluid.
9.	Electric Discharge	An electric arc discharge across the oil film between mating gear teeth produces temperatures that may be high enough to locally melt the gear tooth surface. Microscopically, the damage appears as small hemispherical craters. The edges of the craters are smooth and they may be surrounded by burned or fused metal in the form of rounded particles that were once molten. A metallurgical section taken transversely through the craters and acid etched may reveal austenitized and rehardened areas in white, bordered by tempered areas in black. Sometimes microcracks are found near the craters.