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[Redacted]

Gentlemen:

Following is a summary of my findings in the above matter.

On 16 September 1985 I received from you two circle saw blades and a piece of a tooth tip of one blade. Both blades were marked "7-1/4", carbide tipped blade for wood, No. 185-11B." One blade was new, still in its case bearing the price stamp. The subject blade had been used, and showed rust and rubbing marks on the sides. I numbered the teeth on both blades from 1-16, progressing counterclockwise as one faced the side with printed information. Both blades were of the composite type, with carbide tips joined to the steel of the saw blade body. Part of the tip of tooth No. 1 of the subject blade had come off during use, causing injury. Subsequently, part of the tip of tooth No. 14 on the subject blade had broken due to a 3-foot drop in a parking lot. I was asked to determine whether defects in materials or workmanship caused the fracture of the tip of tooth No. 1.

My study consisted of the following:

- Photography of both blades in the as-received condition.
- Study of the chip and teeth Nos. 1 and 14 on the subject blade and teeth Nos. 2 and 3 on the new blade with unaided eye, a hand lens, and a low power binocular microscope.
- Breaking the tips off teeth Nos. 2 and 3 on the new blade with pliers to test the strength of the tip and joint.
- Cutting teeth Nos. 1, 14 and 16 from the subject blade and teeth Nos. 1, 2 and 3 from the new blade for more detailed studies.
- Metallographic study of tooth No. 16 on the subject blade and tooth No. 1 on the new blade.
- Scanning electron microscope (SEM) studies of the chip, teeth Nos. 1 and 14 on the subject blade, and tooth No. 2.
- EDAX chemical analysis of joining material and tip composition on tooth No. 1 from the subject blade and No. 2 from the new blade.

The tips of new teeth 2 and 3 snapped off only after application of considerable bending force with a pair of pliers. The tips thus seemed to be solidly joined to the blade body. Fracture was mostly at the carbide:joining material interface.

Energy dispersive X-ray (EDAX) analysis of subject tooth No. 1 and new tooth No. 2 showed the tooth tips to contain large amounts of tungsten and smaller amounts of cobalt.

The tips are thus apparently of tungsten carbide, cemented together with a cobalt binder. Such "cemented

carbides” are often used for cutting surfaces. On both teeth the joining material contained mostly silver with lesser amounts of copper and zinc. The joint material is thus of the “silver solder” or “silver braze” type. Such materials wet very well and are often used to join dissimilar materials.

Metallographic study of subject tooth No. 16 and new tooth No. 1 revealed a significant amount of joint porosity in the former and very little joint porosity in the latter.

The chip was coated with foreign matter which even repeated cleaning would not remove. SEM study of the chip was therefore not very successful. SEM study of subject tooth 14 (which had chipped due to a fall in the parking lot) showed that the tip had broken through the carbide. Study of subject tooth No. 1 (which had caused the injury) showed that the fracture had occurred about equally through the carbide and along the carbide:solder interface. Fracture was along the carbide:solder interface from the tip of the tooth to about halfway to the base of the carbide, and through the carbide the rest of the way. I enclose SEM print GC-20 which shows subject tooth No. 1 and on which I have written some notations. The tip of the tooth is at the bottom of the print. The threaded objects are set screws which hold the tooth in place in the microscope. The “pock marks” in the joining material are crater-like pores, left during the joining process. The pores would diminish the strength of the joint somewhat.

Higher magnification SEM study of the joining material near the tip of subject tooth No. 1 revealed that whereas in the half of the joint nearest the tip, the joining material had peeled away from the carbide tip in a proper, ductile manner, the half nearest the remaining carbide showed no deformation. The lack of deformation shows that the carbide tip had never been bonded to the joining material. Print GC-20 shows a clear line of demarcation between the two regions.

The forces on the tooth tip during operation are such as to cause the carbide tip to tend to “pull away” from the joining material in the nonbonded region. Therefore, the absence of a proper bond on the region observed is especially deleterious and would lead to a significant decrease in the force needed to remove the tip from the tooth.

By contrast, the surface of the joining material on new tooth No. 2 showed the ductile fracture mode characteristic of a proper joint.

There are various possible causes of an improper joint of the type found on subject tooth No. 1; improper cleaning or fluxing, or improper control of temperature or atmosphere are common causes of such poor joints.

In conclusion:

- The tooth tips were of tungsten carbide with cobalt binder.
- The tips were joined to the blade bodies with a silver-copper-zinc alloy of the “silver-solder” or “silver-braze” type.
- The tip of the subject tooth was not bonded to the tooth over a significant part of the joint area.
- The total strength of the tip:tooth joint was seriously reduced by this lack of bonding.
- A tip deliberately broken from a tooth on a new blade of the same type was properly bonded to the tooth.

I can have copies made of all photographs at a time of your choice.

If I can be of further assistance to you in this or other matters, please let me know.

An invoice and the positive of SEM picture GC-20 are enclosed.

Respectfully submitted,

Kenneth C. Russell
Consultant

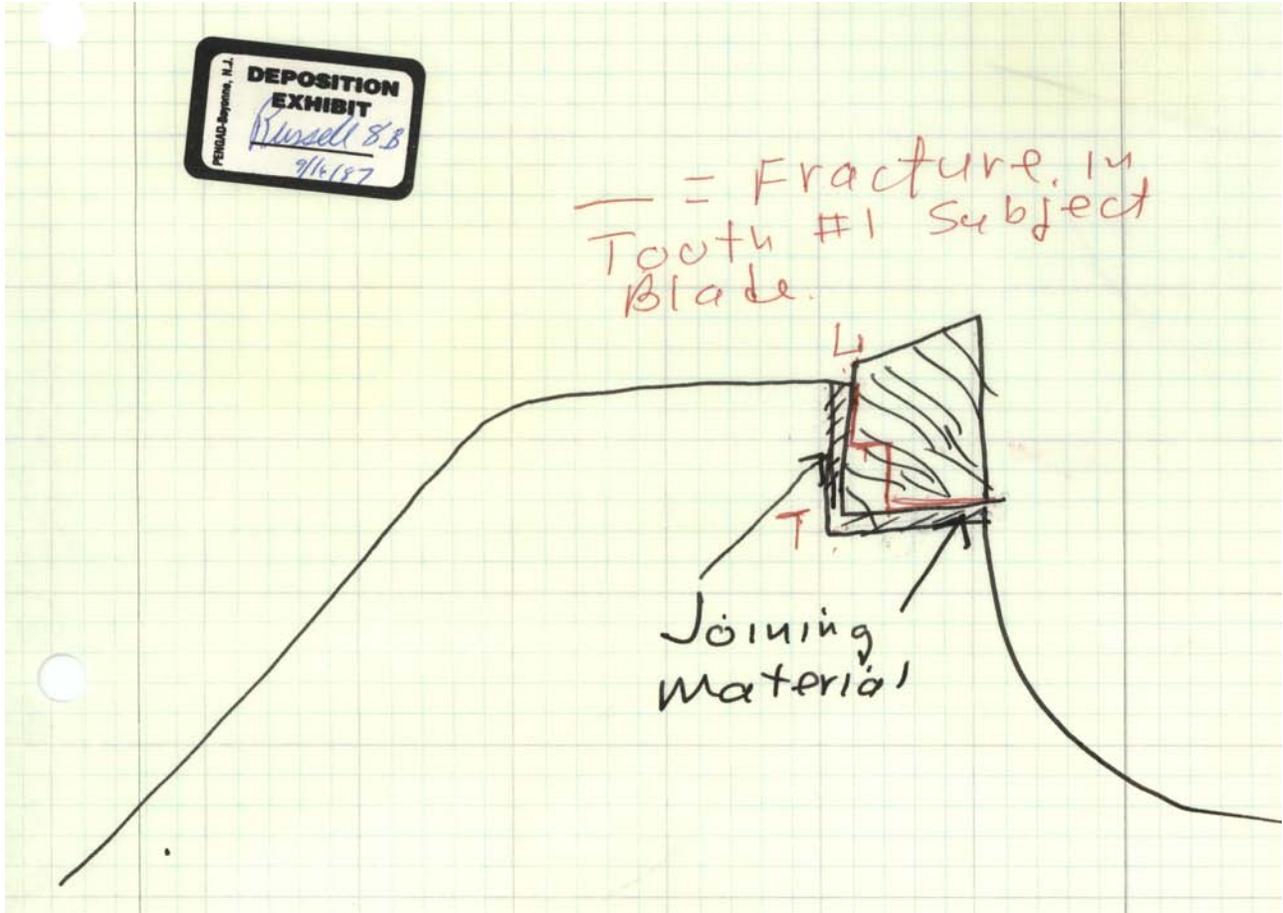


Figure 1: Schematic of saw blade, showing how the carbide tooth fractured both along the joint and through the carbide.



Figure 2: Subject blade, showing multiple broken teeth.

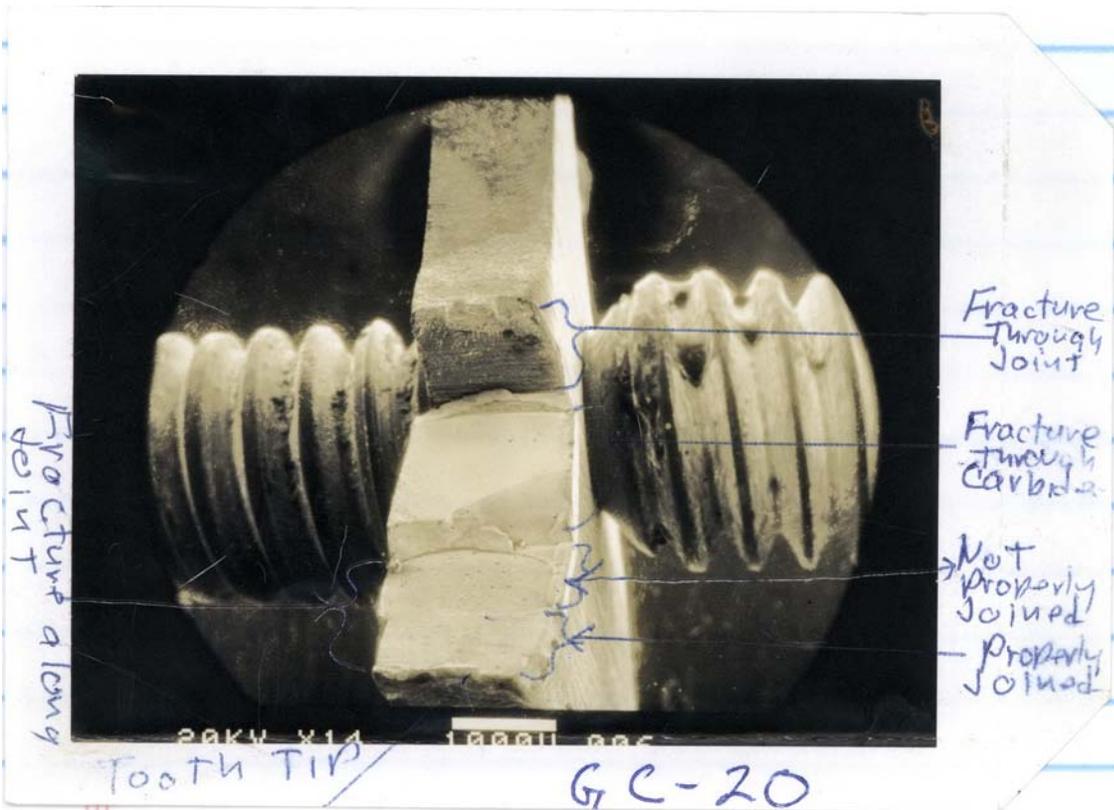


Figure 3: Detached tooth No. 1 in SEM mount, edge-on, showing fracture through the joint and the carbide.