

Report on Fractured Hypodermic Needle

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Conclusions

1. There is no evidence that improper materials or manufacturing processing was involved in the failure of the subject needle.
2. The subject needle failed in a ductile manner, and only after extensive plastic deformation.
3. Scanning Electron Microscope examination revealed no significant differences in the fracture surfaces of the subject needle and a similar needle, which failed only after having been bent double into a very sharp "U".

General

The purpose of this investigation was to determine the cause of failure of a 0.012" diameter hypodermic needle. Of particular importance was whether the failure was in any way due to improper material and manufacturing processes, which might lead to premature brittle fracture.

A box of similar needles (from which the subject needle has supposedly been taken) was delivered to me for comparative tests. The business ends of the needles are .012" diameter by 13/16" long; the needle extends into a plastic fitting over which the syringe is fitted when in use. All destructive tests were performed on spare needles; the subject needle was not altered in any way.

Preliminary Testing

Material and processing specifications were not available from the manufacturer, so several tests were made to determine these quantities.

Chemical analysis on the spare needles revealed a composition of 18.3% Cr, 9.31% Ni and .085% C. This composition is characteristic of type 304 stainless steel, the common "18-8" stainless.

Optical Microscopy (Figure 1) showed that the needles had been formed from welded tubing. Metallography revealed a very fine grain size, characteristic of cold drawing.

A test with a magnet showed that the needles were only slightly magnetic. Annealed type 304 stainless steel is non-magnetic, but extensive cold working causes formation of small amounts of a magnetic phase.

We can therefore say with reasonable certainty that the needles were of welded, type 304 stainless steel tubing, which had been cold drawn to the final size of 0.012".

A simple mechanical test was performed by grasping the sharpened end and the mount, and bending a needle in a sharp loop (about 1/36" diameter) until it broke. Several needles were broken in this way, and all showed remarkable ductility. The needles retained substantial strength even when sharply bent to a 90° right angle. Only when bent nearly double did the needles fracture on either further or reverse bending.

Scanning Electron Microscopy

The fracture behavior just described is characteristic of sound material. Therefore, any microscopic flows causing premature failure in the subject needle should be identifiable by comparison of the fracture surface with that of the spare needle.

The scanning electron microscope (SEM) is the appropriate tool for this examination. The S.E.M. can focus on a highly uneven fracture surface, whereas the optical microscope has a much smaller depth of focus. Further, the S.E.M. is capable of magnifications to 20,000 times and more, compared to the 1000 times maximum magnification of the optical microscope.

Figures 2-4 show views of the fracture surface of the spare needle which was intentionally broken. In Fig. 2, the overall view, the tension side of the needle is at the top of the picture and the compression side is at the bottom. Compression wrinkles are visible on the curved surface of the needle, near the bottom of the figure. Figures 3 and 4 are magnified views of regions on the top and bottom of Fig. 2, respectively. All three figures show the dimpled, porous fracture surface characteristic of ductile failure. There is no evidence of the planar facets characteristic of brittle fracture.

Figure 5 is a plan view of the extra needle, laid flat on the S.E.M. stage. One observes the extensive deflection that occurred prior to fracture.

Figures 6-11 show S.E.M. photographs of the subject needle, involved in the litigation. In Fig. 6 the compression side, identifiable by the wrinkles, is at the bottom of the figure and the tension side is at the top. The entire fracture surface was scanned by the microscope, with particular attention paid any areas suggestive of brittle fracture.

Figure 7 shows the peak at about 5:00 on the needle (taking the tensile side as 12:00 and the compression side as 6:00). Although this area looks like a facet in Fig. 6, Fig. 7 shows the dimpling characteristic of ductile failure.

Fig. 8 is a closeup of the notch at 3:00. Here again, the fracture surface is porous. This area lies on the neutral axis of the needle, which carries no stress so a crack at 3:00 would not be very deleterious in any case. Fig. 9 is a close-up of the vee-notch 11:00. Again, there is no sign of cleavage failure. Fig. 10 shows the region at 7:00; the dimpling of ductile failure is obvious.

Finally, the plan view in Fig. 11 shows that the subject needle underwent substantial plastic deformation before fracture. The degree of deformation is comparable to that of the extra needle (Fig. 5) and the other needles of the same type which were fractured during this investigation.

Summary

Chemical and magnetic tests and optical microscopic examination showed that the needles had been drawn (or otherwise cold-formed) from welded type 304 stainless steel tubing. Both the material and the process are appropriate (and typical) for fabrication of fine tubing. This material has excellent ductility, and the cold forming gives substantial strength.

The fracture surface of the subject needle and of an extra needle (that had been bent double to failure) were examined by the scanning electron microscope.

Comparison of the resulting photomicrographs showed no significant difference in fracture modes of the two needles. In both cases the surfaces were characteristic of ductile failure.

From these observations, and from the fracture behavior of the extra needle, one may conclude that the subject needle was bent through a substantial angle before failure, and that such failure occurred in a ductile manner. There is no evidence of any flaw or defect that would cause premature failure.

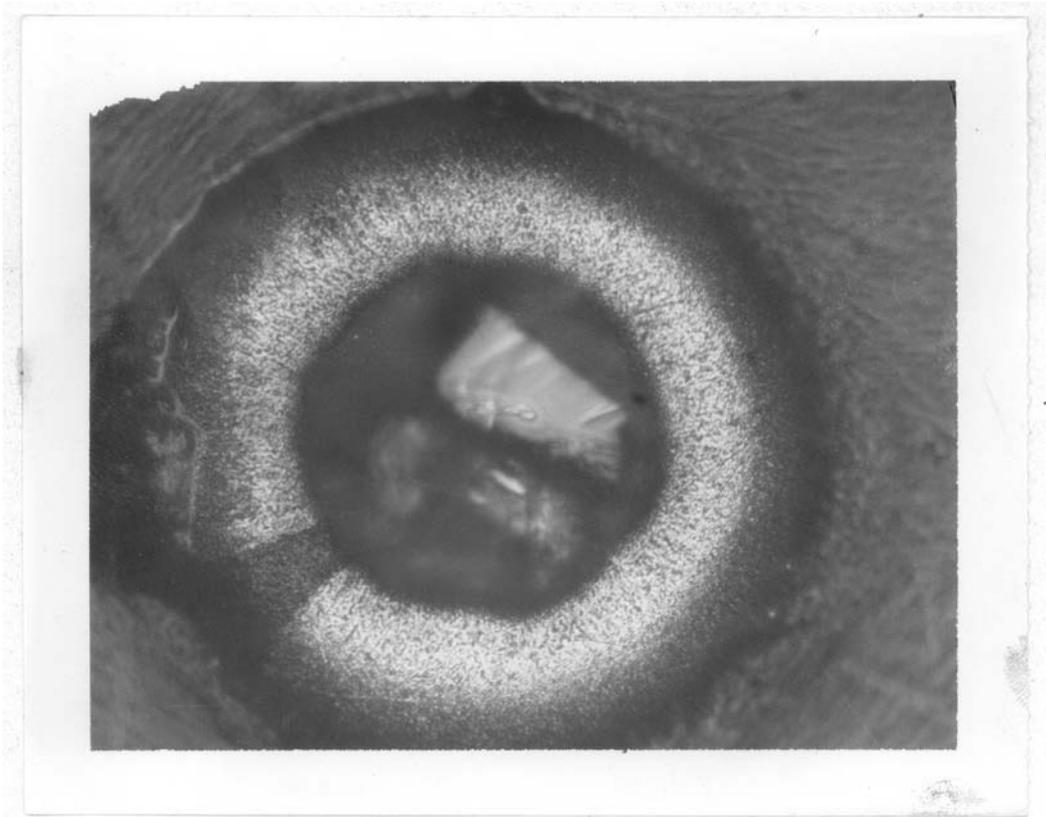


Figure 1: Cross section of extra needle showing microstructure and weld. (350X)



Figure 2: S.E.M. picture of fracture on extra needle. (260X)



Figure 3: S.E.M. picture of region at 12:00 in Figure 2. (650X)

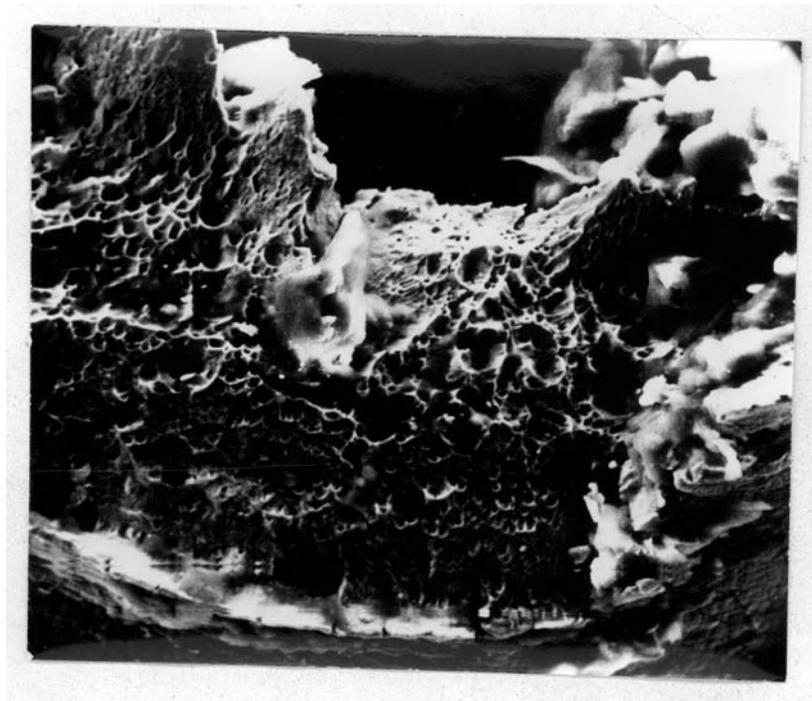


Figure 4: S.E.M. picture of region at 6:00 in Figure 2. (650X)



Figure 5: Plan view of needle showing bending that occurred before fracture. (64X)



Figure 6: S.E.M. picture of fracture surface in subject needle. (280X)

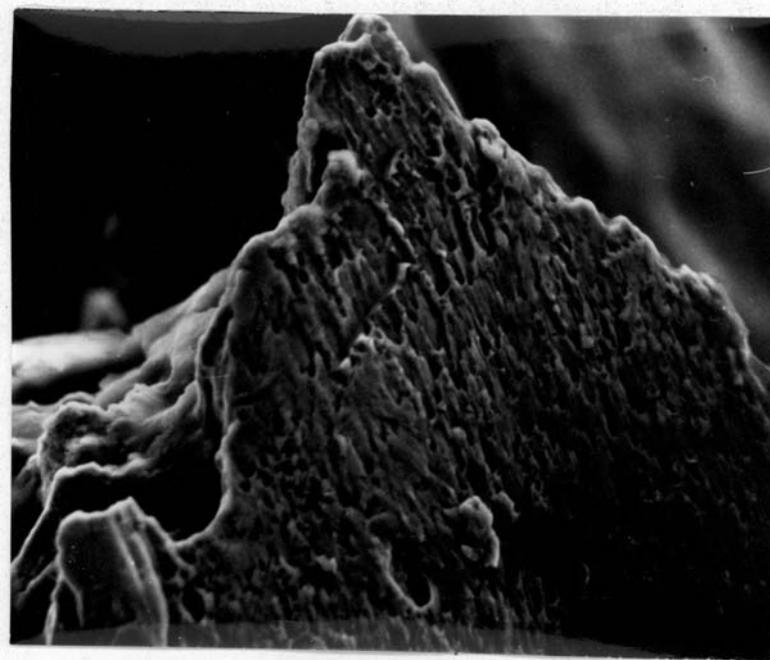


Figure 7: S.E.M. picture of region at 6:00 in Figure 6. (680X)