METLAB
LIMITED

Annealing Made Perfect
PO Box 72
Bombay
Auckland 2343

ATTENTION: Alex Findlay

METLAB LTD report number 1231/1A
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SUBJECT - Metallographic examination of various brass cartridge cases

1.0 INTRODUCTION

METLAB LTD was requested to examine the microstructure, microhardness and microhardness profiles in various brass cartridge cases.

2.0 PROCEDURE

The various cartridge cases (from here on referred to as cases) supplied were carefully sectioned longitudinally by clamping in a holder fitted into a metallographic cutoff saw flooded with coolant. The cases were engraved, cleaned and mounted in a clear and colourless cold-setting epoxy resin. Once cured, the mounts were ground and polished to a 1 micron diamond finish and etched to reveal the microstructure. Examination of the microstructure was carried out on a Nikon metallurgical microscope and Vickers microhardness testing was carried out on the cross-section in the mid-wall position on a calibrated Matsuzawa brand microhardness tester at a test load of 500g.

Figure 2.1 shows a typical mount while figure 2.2 shows microhardness indents in the neck area of a case.

Figure 2.1 Typical mounted and polished cases for examination

Figure 2.2 Microhardness indents in the cross-section of the neck, 100x

3.0 223 Cases with the following conditions
A) Virgin case + one pass through neck-sizing die
C) Virgin case + one pass through neck-sizing die + neck and shoulder annealed using your program 43

In the cross-sections of these cases it is evident that the neck in the annealed sample has marginally bigger grains than in the virgin case as shown in figures 3.1 and 3.2. We have not attempted to put a number on the grain size at this stage. For the sake of interest figure 3.3 shows the heavily worked microstructure mid-length along the case while figure 3.4 shows the worked microstructure in the head area which the reader might like to compare with the annealed neck areas. Microhardness testing from the neck progressing along the case for 24mm is shown graphically in figure 3.5.

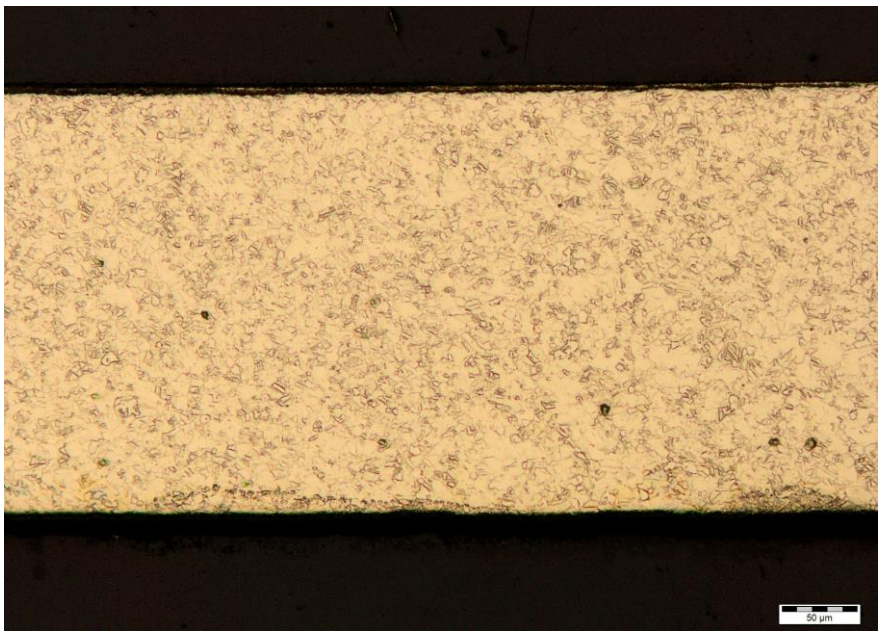

Figure 3.1 Microstructure in the neck of the virgin 223 case, 200x

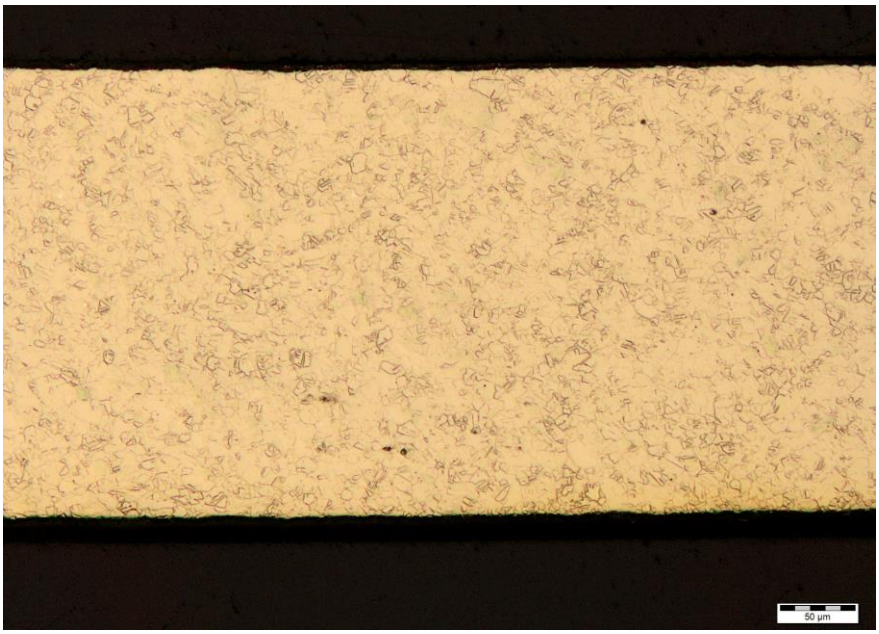

Figure 3.2 Microstructure in the neck of the annealed 223 case, 200x

Figure 3.3 Microstructure mid-length in the 223 case, 200x

Figure 3.4 Microstructure in the head of the 223 case, 25x

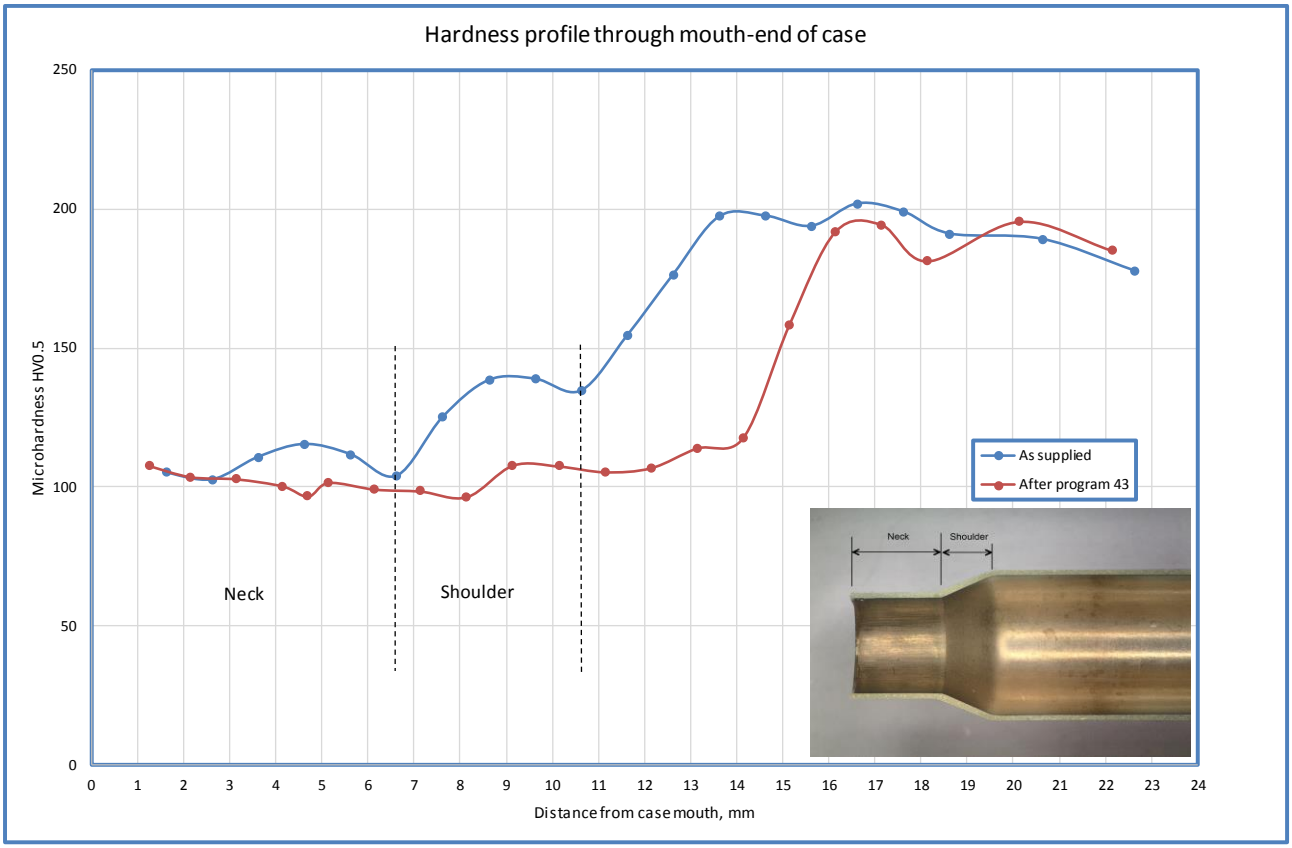

Figure 3.5 Microhardness profile along two cases from the neck end

4.0 223 Whole cases annealed for one hour at 300ºC, 350ºC and 400ºC in a commercial heat treatment oven

4.1 Neck Area

The microstructure in the neck area of the cases annealed for one hour in a commercial heat treatment oven are shown in figures 4.1 to 4.3. It is evident that there appears minimal difference between the microstructure in the 300ºC and 350ºC samples with a minor reduction in hardness in the 350ºC sample. At 400ºC however we observe grain growth at both the inner and outer regions of the cross-section while maintaining the finer-grain in the middle of the cross-section. There is a significant reduction in hardness in the 400ºC sample as shown in table 4.1.

Sample	Ave Neck hardness, mid-wall	
300ºC	136HV	
350ºC	131HV	
400ºC	117HV	83HV and 89HV nearer inner and outer edges

Table 4.1 Microhardness in the neck of annealed cases

Figure 4.1 Microstructure in the neck of the 300ºC/1hr sample, 200x

Figure 4.2 Microstructure in the neck of the 350ºC/1hr sample, 200x

Figure 4.3 Microstructure in the neck of the 400ºC/1hr sample, 200x

4.2 Mid-length

In these samples the microstructure mid-length is shown in figures 4.4 to 4.6. It is evident that the original cold-worked structure has recrystallized and grain growth is occurring as the temperature increases.

Figure 4.4 Microstructure mid-length in the 300ºC sample, 200x

Figure 4.5 Microstructure mid-length in the 350ºC sample, 200x

Figure 4.6 Microstructure mid-length in the 400°C sample, 200x

4.3 Head Area

In the head area of the annealed cases we observe some softening as shown in figure 4.7. The cases as supplied have a cold-worked microstructure in the head area which metallurgically means that the brass is strained and full of dislocations – all of which increase the internal energy in the brass in these areas. This means that during the annealing cycles carried out on these cases the cold-worked microstructure will undergo recovery, recrystallisation and grain growth with a reduction in hardness. We must remember that the neck area in these cases already underwent an annealing cycle during manufacture whereas the head area has not been annealed prior to our annealing cycles.

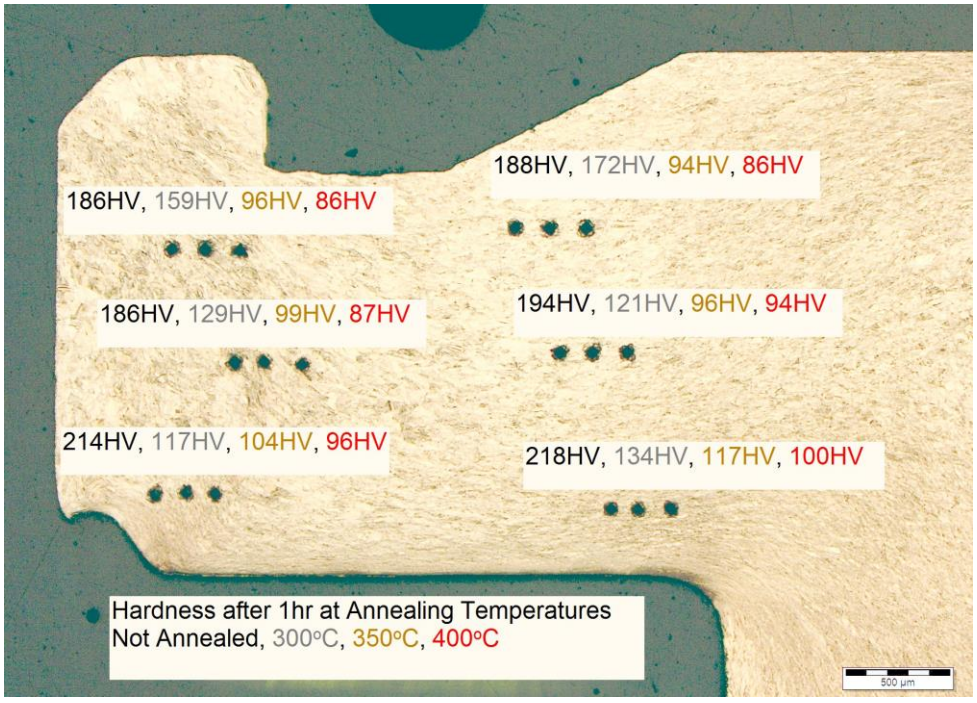

Figure 4.7 Microhardness in the head of cases after 1hr at various annealing temperatures

5.0 223 Cases tumbled in Stainless Steel

Examination of the cross-section of a case which was tumbled in stainless steel shows no obvious deformation of the microstructure, see figure 5.1. Microhardness testing on the cross-section shows a hardness of 98HV.

Figure 5.1 Microstructure in the neck of a SS Tumbled case, 200x

6.0 223 Cases by different manufacturers A and B

Unused cases were supplied from two manufacturers identified as A and B for a comparison.

6.1 Neck

There are no obvious visible differences in the microstructure in the neck area of the A and B cases as shown in figures 6.1 and 6.2. Microhardness in the neck and shoulder regions of these two cases are virtually identical as shown in figure 6.3. Between 9mm and 22mm from the mouth end the A case generally has a lower hardness than the B case, see figure 6.3.

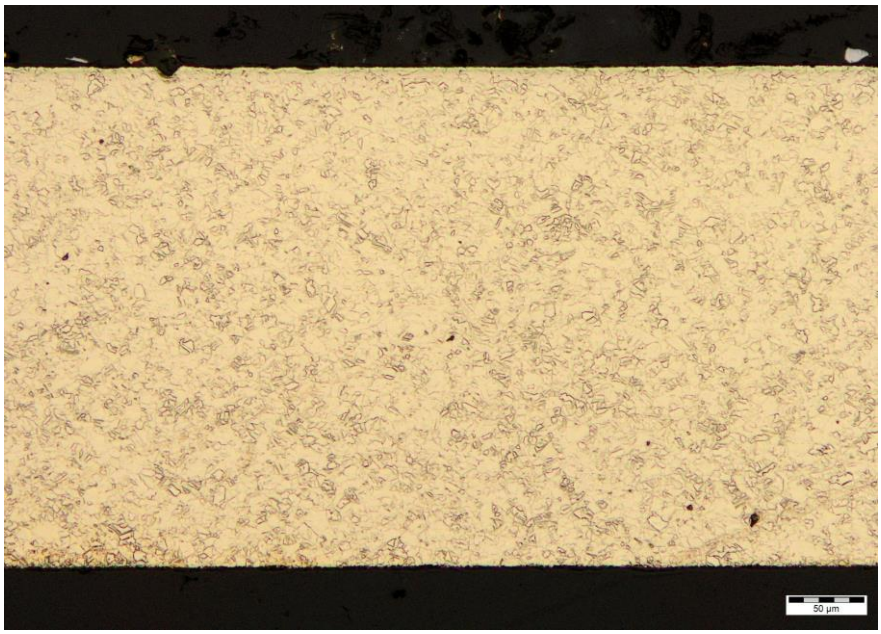

Figure 6.1 Microstructure in the neck of 223 case A, 200x

Figure 6.2 Microstructure in the neck of case B, 200x

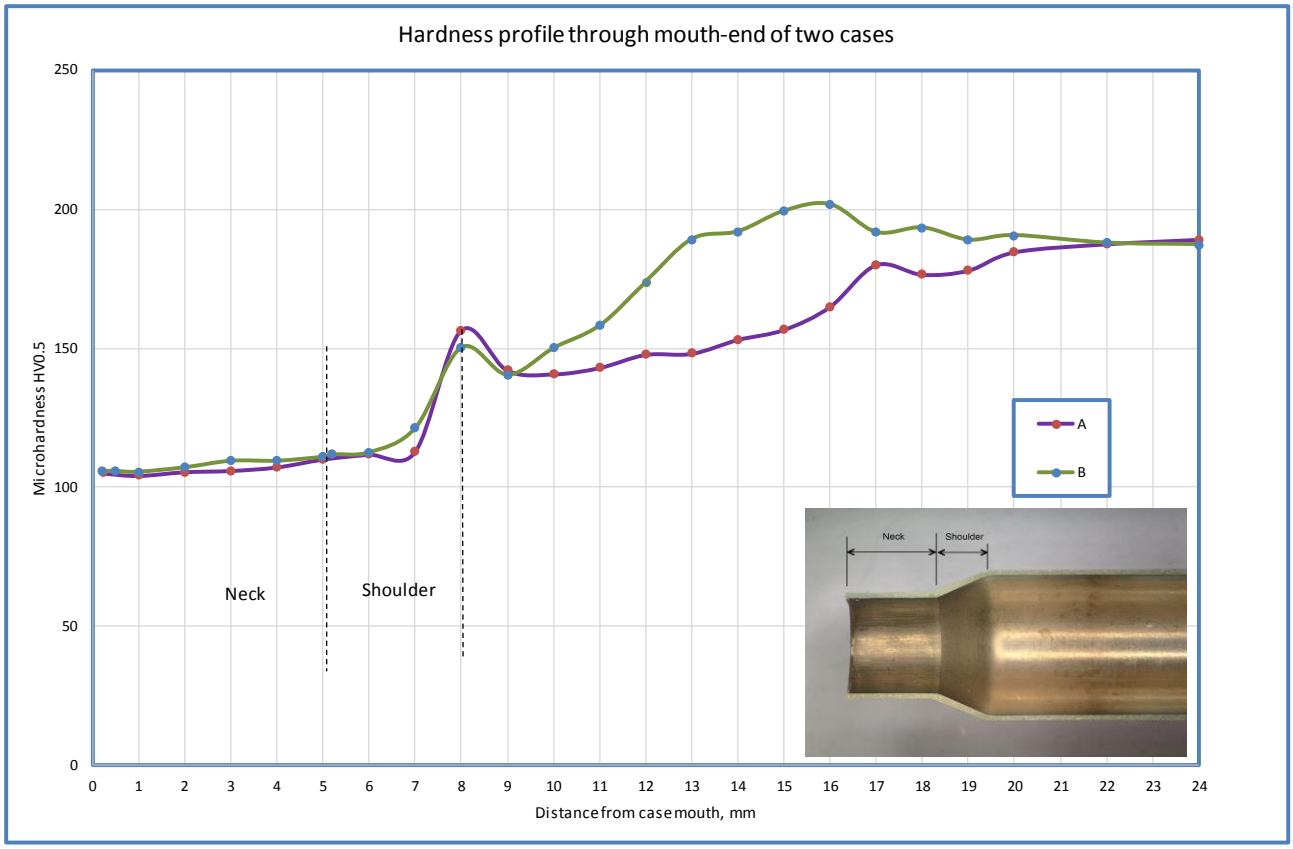

Figure 6.3 Microhardness profiles along two cases from the neck-end

6.2 Mid-length

The microstructure mid-length between the A and B cases shows that the brass in B is cold worked whereas A is much finer grained, compare figures 6.4 and 6.5.

Figure 6.4 Microstructure mid-length of case B, 200x

Figure 6.5 Microstructure mid-length in case A, 200x

6.3 Case Head

At the head of the A and B cases there are some significant differences as detailed below.

6.3.1 Design of forming tools

There is a difference in the design of the forming tools as seen in figures 6.6 and 6.7 where the taper from the side-wall to the head is longer in case A producing different wall thickness measurements. Close examination of these two figures also shows how case A has a finer grain structure.

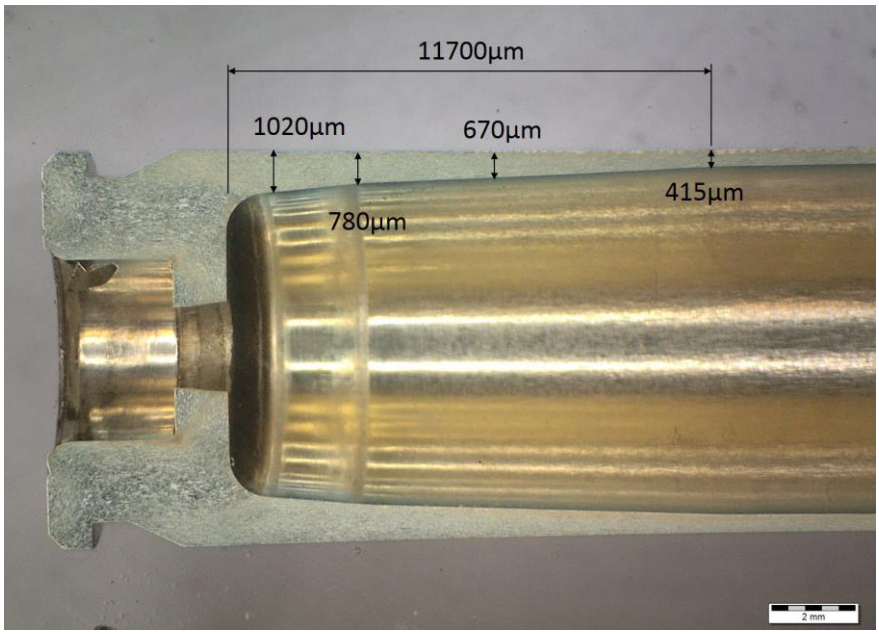

Figure 6.6 Cross-section through case A head, 7.5x

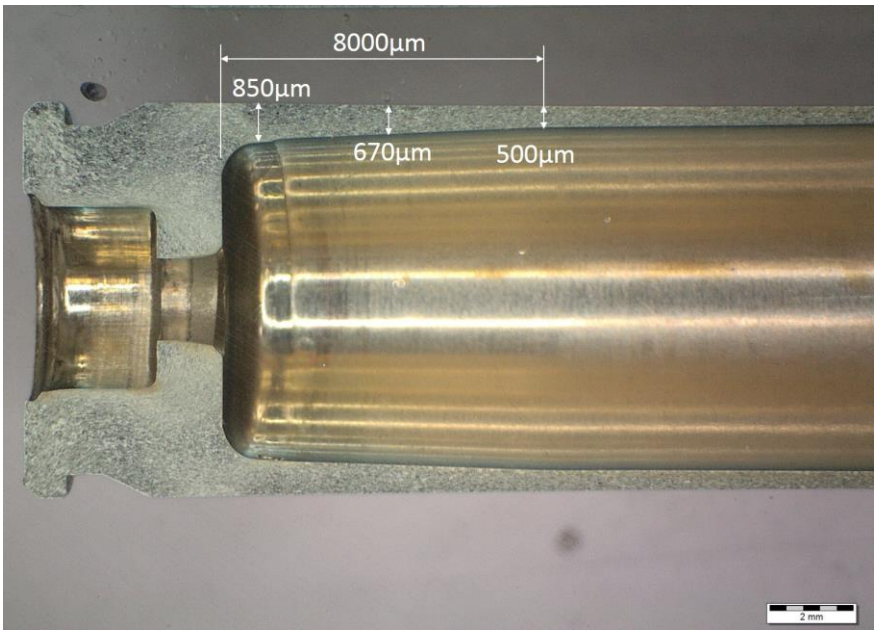

Figure 6.7 Cross-section through case B head, 7.5x

6.3.2 Dimensional differences in the head between A and B 223 cases

There are some dimensional differences at the case head between the A and B cases as seen above. Measurement of these features was carried out with the aid of the microscope software. Figures 6.8 to 6.11 shows the differences measured.

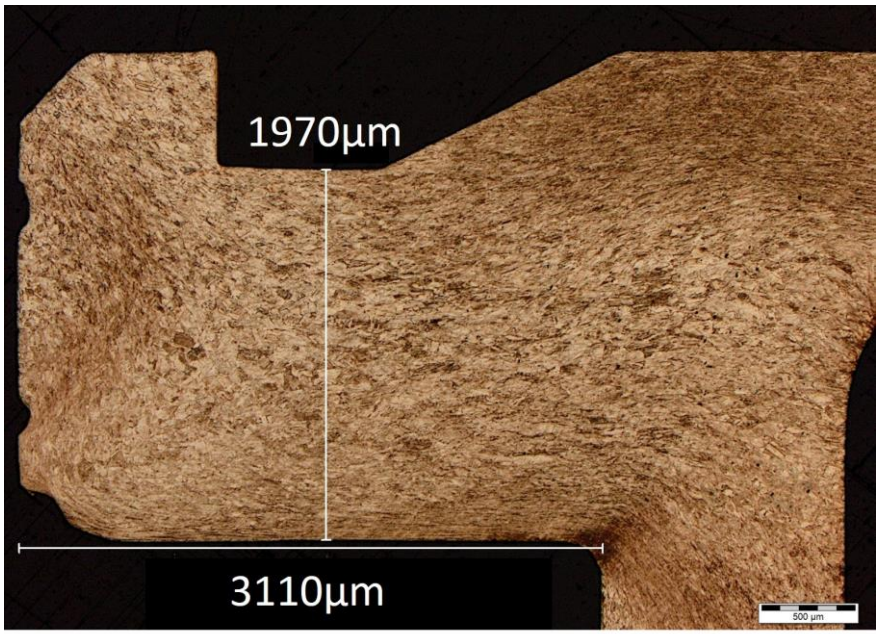

Figure 6.8 Some dimensions in the cross-section through head A, 25x

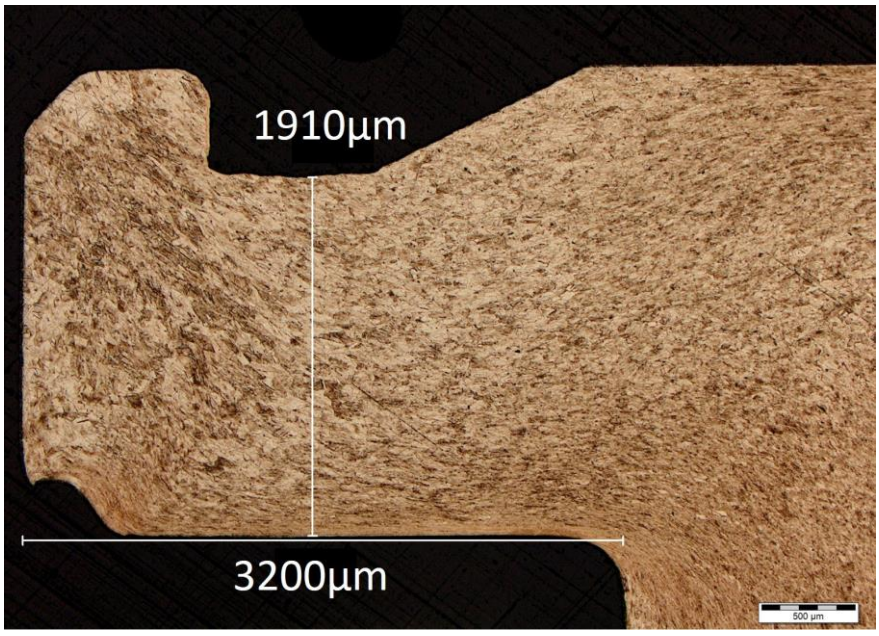

Figure 6.9 Some dimensions in the cross-section through the head B, 25x

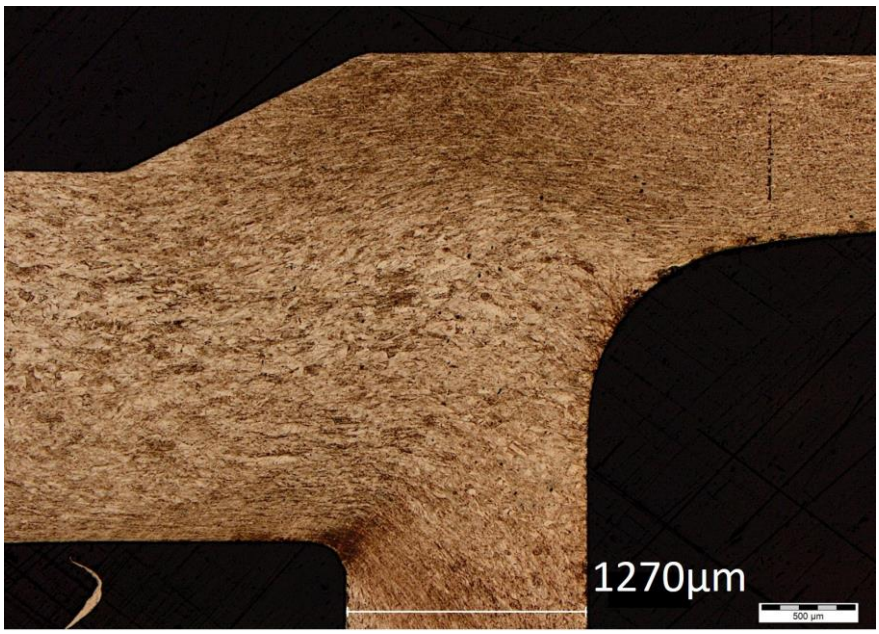

Figure 6.10 Other dimensions in the cross-section through head A, 25x

Figure 6.11 Other dimensions in the cross-section through head B, 25x

6.3.3 Hardness differences in the head between A and B cases

It is evident in figures 6.8 and 6.9 how in the head area of the cases the microstructure varies considerably. Around the tighter corners the grains in the brass are compressed and worked far more than in the middle of the head. Microhardness testing was carried out in six different locations in each head as shown in figures 6.12 and 6.13. In the head of case A the hardness ranges from 183HV to 205HV and in B the head the hardness ranges from 186HV to 218HV. Considering the range in hardness and differences in microstructure observed it is difficult to think of the head as having one specific hardness.

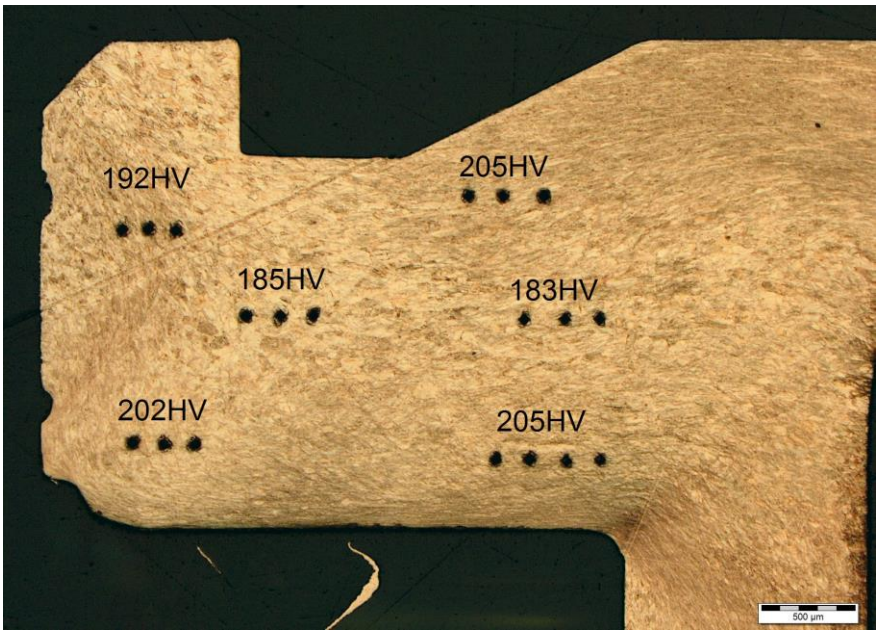

Figure 6.12 Microhardness in the head of case A, 25x

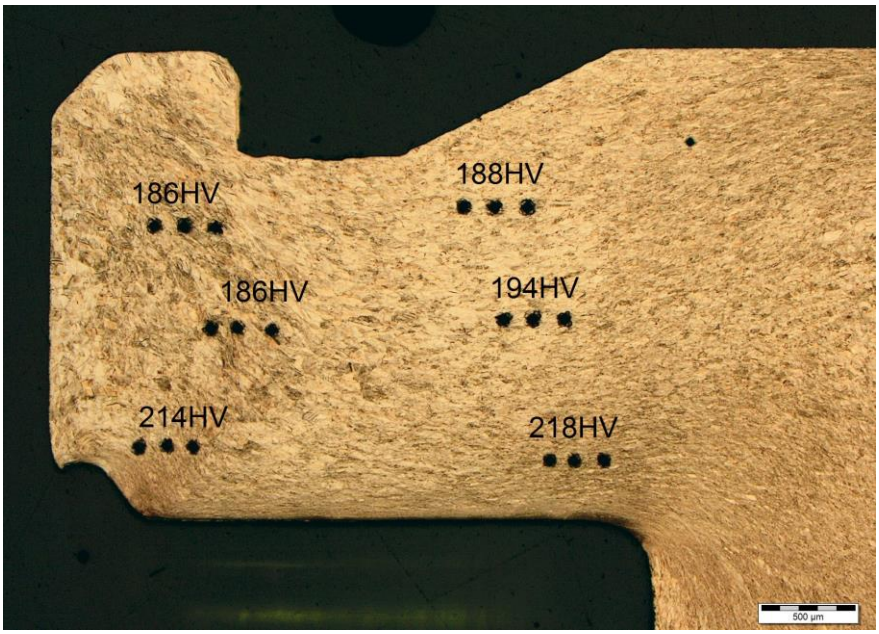

Figure 6.13 Microhardness in the head of case B, 25x

7.0 308 Cases not annealed vs shot 4 times (annealed 3x) and shot 11 times (annealed 10x)

Examination of 308 cases shot and then annealed 3x and 10x respectively shows no difference in microstructure as shown in figures 7.1 and 7.2. Microhardness traversing in the neck area shows a 10HV difference in hardness between the cases as shown in figure 7.3.

At the inside surface in the neck of the case annealed 10x the brass appears in good condition, see figure 7.4.

Figure 7.1 Microstructure in the neck of the 3x annealed 308 case, 200x

Figure 7.2 Microstructure in the neck of the 10x annealed 308 case, 200x

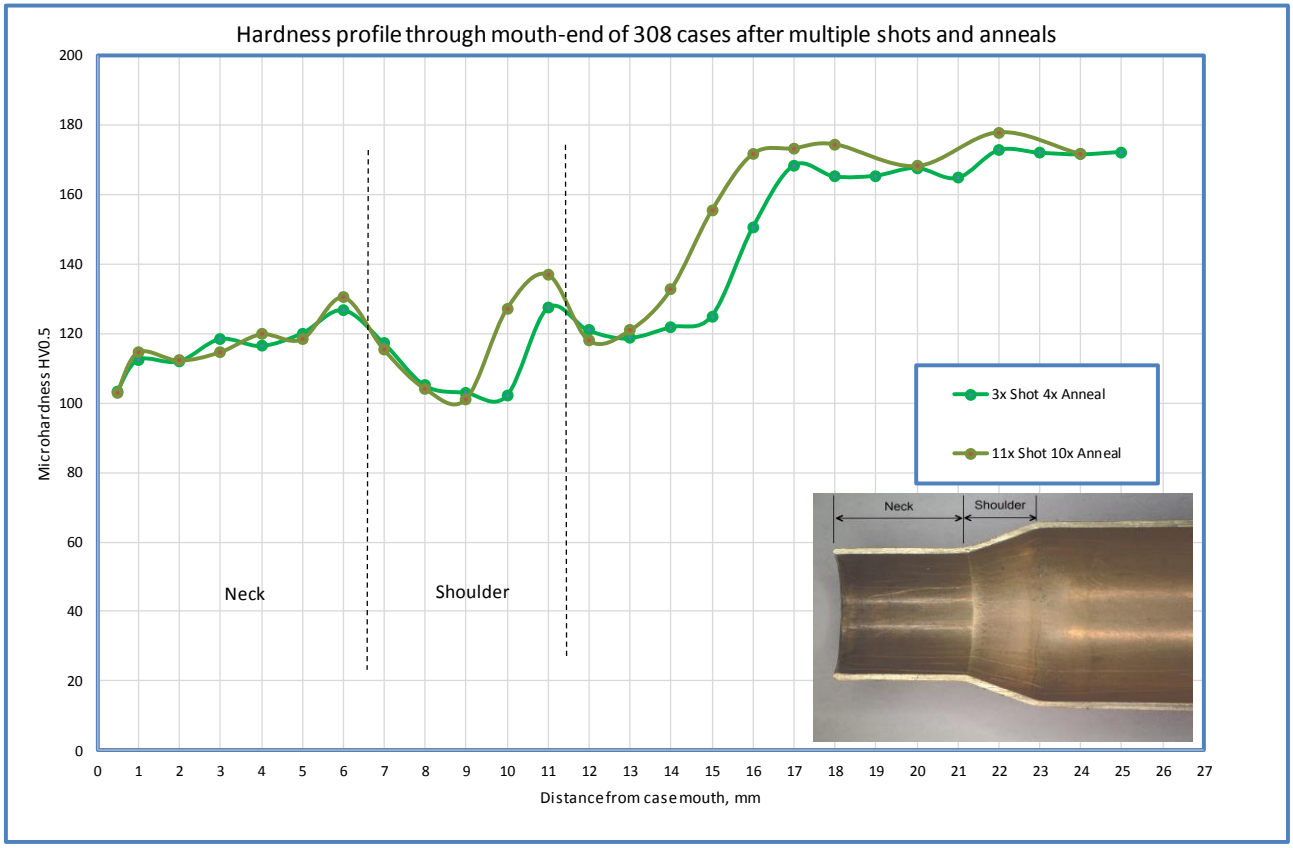

Figure 7.3 Microhardness profiles along the cases from the neck-end

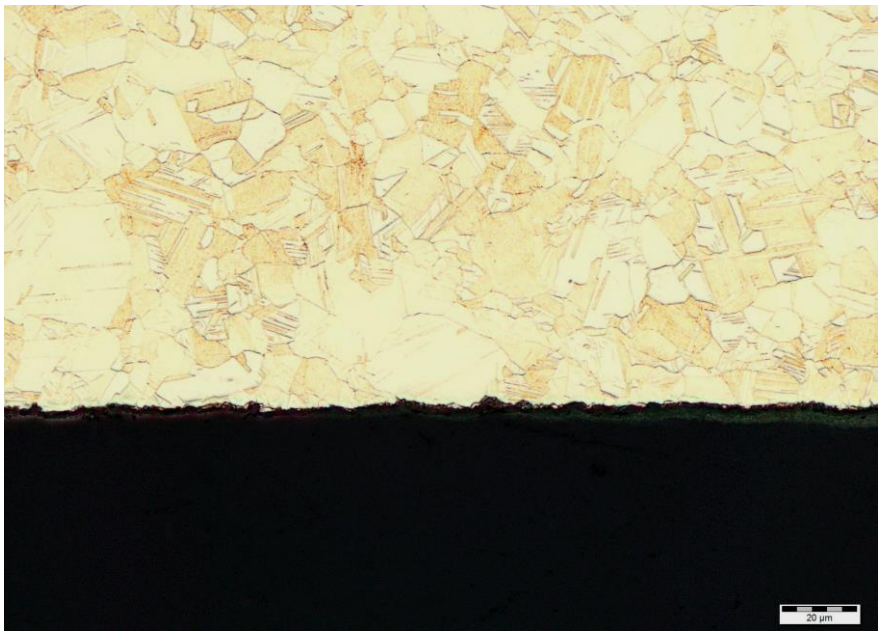

Figure 7.4 Microstructure in the neck inside surface of the 10x annealed 308 case, 500x

If you have any questions or would like some further assistance in this matter please contact us.

Yours faithfully

Andrew Ouwejan BE(Hons) ME
METLAB LTD