Commentary on two airgun videos

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1 Overview

This is a commentary on two airgun videos kindly made available by Mike Burnham of I-O. One video is taken underneath the water and demonstrates the bubble motion and structure well and the other video is taken above the surface and shows both the shot effect and the surfacing of the bubble.

The airgun is believed to be a single 20 or 40 cu.in. (0.33 or 0.66 litre) Sleeve gun firing at 2000 psi (138 bars). The gun appears to be deployed within 2 metres or so of the surface as will be estimated below.

1.1 Video 1: underwater and above the venting airgun: reference mb_io_nearfield.mpg

The video is in slow motion. If this is a 40 cu.in. gun, modelling tells us that the period to the first bubble pulse measured from the peak itself will be around 74 msec and the peak pressure 1m. above the gun will be about 2.7 bars. The peak and first bubble pulse achieve their peak sizes about 20% and 45% of the way into the film clip. The duration between these maximum bubble radii is very similar although antiphase to the duration between the peak and bubble pressure peaks so this suggests that the overall real time duration of the clip is approximately 300msec. Since the duration of the clip is around 30 seconds, the motion has been slowed down by about a factor of 100.

It is very interesting to note that the main peak itself is much more isotropic in terms of corrugations on the outside of the developing bubble. After the bubble has contracted and then begins to expand again, the surface of the bubble is much more anisotropic suggesting that for the peak, higher frequencies will be more uniformly distributed in the radiation field than they are from the first bubble pulse. In the first bubble pulse the development of turbulent eddies is much more pronounced on the order of a few cm., (the Mach number of the motion is much lower here than in the early stages; you can see a similar sort of eddy development in cumulo-nimbus clouds).

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1.2 Video 2: above the surface - the shot effect and venting bubble: reference mb_io_surface.mpg

Here the film is taken above the surface and two gun firings are observed, one in close-up. The film has sound and is taken in real-time and is of duration around 20 sec.

The shot effect when the pressure pulse, which will be of magnitude around 1 bar, hits the underside of the surface just a few msec after the gun fires, is clearly visible here at around 30% into the clip. This disturbance is typically a few cm. but it can be seen here that the suspending buoy appears to amplify the effect throwing water around 1-2m above the buoy. Away from the buoy the usual rather less well developed disturbance is visible. This is particularly well shown if the clip is stopped at 70% into its duration. This characteristic stippling away from the buoy as the surface breaks up anelastically is commonly seen. Another example is shown in Figure 1.

At around 80% into the duration the bubble comes up. Since a spherical cap bubble usually rises at around 1m/sec for an airgun, this suggests that the gun is deployed around 2m. depth.

On a final note, the efficiency of reflection from the underside of the water usually means that the gun is hardly audible from above the surface. In this case, it is most likely that the sound which can be heard apart from compressor noise and the splashing as the thrown water comes down, is being transmitted by the vibrating buoy.

Figure 1: The shot-effect at close quarters revealing the direct disruption of the surface significantly before the bubble breaks the surface. Here the air evacuation of the furthest firing airgun can be clearly seen under the water whilst the shot effect on the surface is already well developed.