

Test parameters and equipment specifications AvA2

When we decided to make these films, for us the idea was simple. Dress a mannequin from the waist up in as accurately made armour and clothing as we could, shoot it with accurately made arrows from a proper weight bow and talk about what happens. No pre-written scripts, no hype, no fluff, no pre-determined TV outcomes; just factual truth. What happens is what we show you.

This last line “What happens is what we show you.” is really important, because it means so much. We could mislead, misrepresent, fake, cut out, lie, hide, exaggerate and whatever else just to make a film, to prove a theory, to entertain; but what does that achieve? What’s the point?

A very important part of this is not just how we present our films but the equipment we use. Naturally some people disagree with what choices we made for equipment or how we set up the tests, but importantly we try to give as much information as possible, to allow you to decide if what you are seeing is valid. We tell you everything and hide nothing.

So the philosophy is tell the truth in all ways, always.

So here is description or specification for as much of what we did as possible.

General information

Distance

15m. This was chosen to allow us the accuracy needed for the tests and of course is far lower than even ‘flat shooting’ would have been, but also shows the best possible result for the bow. At further distances the arrow speed does drop off and there is a table below setting out these speed and energy drops out to 60m.

Bow

Joe Gibbs

Swiss yew, drawing to 160lbs at 30”, delivers 85g arrows at 181fps (average over 10)

Made by Joe Gibbs and based off the Mary Rose bows in Swiss yew.

Temperature was 26 Centigrade, full sun and light cloud.

Height 175.26 cm, weight 85kg, draw length 30”

Arrows

Will Sherman

The test arrows use heads of wrought iron unless stated otherwise, are 31.5” long x 1/2”

tapering to 11/32” at the nock with horn inserts and an ash shaft with and 7.5” goose feather fletchings and silk whipping.

Overall weight 85gram (Nominal) with a 62gram shaft and a 23gram head.

Heads were based on A5698 from the Museum of London which is dated approximately 13thC - 14thC according to the museum, but more likely 14thC - 15thC based on socket size.

Steel heads are made from a billet of bloomery steel from Owen Bush and are approximately 0.4-0.5% carbon. They were water quenched and tempered by drawing back to a straw colour.

Case hardened heads were industrially hardened and were wrought iron. Depth of case is unknown and could not be specified due to the unknown starting specification of the material, however I asked for a "good" case, so they would have made it thicker rather than thinner.

Armour

Augusto Boer Bront

Helmet based on Wallace Collection A69 and made in mild steel. Variable thickness from 3mm at the front/centre to 1.5mm at the edges and weighing 2.8 Kg.

Visor based on Wallace Collection A69 and made in mild steel. Variable thickness from 3mm at the tip of the snout to 1.2 mm at the edges and weighing 1.1 Kg.

Breastplate based on Churburg 14 and made in mild steel. Variable thickness from 3.2 mm at the front/centre to 1.5 mm at the edges and weighing 2.89 Kg.

Arms based on Churburg 10 and made in mild steel. Lower cannons 1 mm thick, upper cannons 1 mm thick, Spaulders are 1.4 mm thick, Elbow couters 1.5 mm thick. Differs from the originals in that it has rotating upper cannons. Weight of each arm, comprising both spaulder and arm harness, is 1.23 Kg.

Aventail

Isak Krogh

Based on Churburg 15. All rings are hand made by Isak. Rings are nominally round and wedge riveted mild steel, 2mm diameter wire in 9mm internal diameter rings in a 4 in 1 pattern. Sewn to a linen canvas liner stuffed with raw cotton.

Standard

Phil Parkes

Based on Museum number 1856,0701.2244 from The British Museum, a mid 14th Century standard with a 6 in 1 collar. The central rings are all hand made by Phil, the rings away from the centre are carefully selected commercially available rings. The handmade rings are mild steel and wedge riveted from 1.5mm diameter wire in 7.2mm internal diameter rings. All rings in the mantle are mild steel and wedge riveted from 1.3mm diameter wire in 7.2mm diameter rings, woven in 4 in 1. The collar of the standard is 6 in 1, made from half solid and half riveted rings. The riveted rings are the same as in the mantle, the solid rings are 7mm internal diameter, 10mm outer diameter and 0.85mm thick. Collar is lined with several layers (approximately 5) of linen canvas. Riveted are round, solids are flat.

Hauberk

Cap a Pie

Commercial mild steel mail cote made from solids and wedge rivetted rings. Rings are from 1.25mm diameter wire in 7mm internal diameter rings. Solids are o/d 9mm, i/d 6mm, 0.85mm thick. Riveted are round rings, solids are flats.

Arming cote

Christine Carnie

Based on various images from the late 14th to the early 15th century. The quilting design is leaning more towards the early 15th century, and designed to maximise moveability. The quilting lines stabilise in one direction while allowing compression in between the lines. The garment parts are made from multiple layers that differ in number and make-up depending on which part of the garment it is.

Materials used are coarse linen canvas, medium and fine linen fabric, wool cloth (main body only) and 28/2 and 16/2 waxed linen thread.

Quilting line distance varies from 3/8" to 3/4" – 10 to 20mm

Make up:

Skirts: 8 layers of various linens; main body: 7 layers (6 layers of various linens, 1 layer of wool cloth); upper sleeve: 4 layers of various linens; lower sleeve: 5 layers of various linens.

Materials: over 10m of 130-150cm wide linen fabrics, over 70g of linen thread.

Garment pieces were quilted in a frame, then assembled and the quilting lines joined.

Entire garment weighs 2002g – 4.4lbs

Films

Arrows vs Armour 2 - Main film

All equipment as specified above, shot at 15m by Joe Gibbs using a 160lbs self yew bow.

The main torso was sculpted from a block of archery foam with a stiff steel armature and weighted with lead sheet on the rear and fixed down to the stand. The torso was mounted on a wheeled stand which was placed on a flat base board, allowing movement and the stand was deliberately narrow to allow instability/wobble. The stand was weighted with a 20kg block.

The arms plugged into the torso armature and each were constructed of 2 lengths of 5mm aluminium armature wire with lead weights above and below the elbow.

The head was sculpted from archery foam with a steel armature and had a decibel meter and GoPro mounted inside and connected to the torso armature using 7mm aluminium armature wire.

Arrows were our standard test arrows as specified above, 85g with wrought iron heads unless specified as case hardened.

Bow was 160lbs self yew made and shot by Joe Gibbs.

Armour material test

Target plates were all 1.5mm.

Charcoal iron was sourced from Topp and Co via Kevin Legg, 0.0% carbon

Modern mild steel 0.1-0.2% carbon

Modern carbon steel, annealed 0.5%

Cross laminated bloomery iron made by Owen Bush, approximately 0.0% carbon

Cross laminated bloomery steel made by Owen Bush, approximately 0.4%-0.5% carbon

Wrought iron processed by Owen Bush, carbon content unknown, age unknown but likely several hundred years old.

Target samples were all nominally 1.5 mm thick mounted directly on an archery foam target at 11"/28cm thick. They were hand ground to thickness using a hand grinder and measured using Acme Armour calipers.

Arrows were our standard test arrows as specified above, 80g with wrought iron heads, but modified to shoot from the Longbow Simulator.

Longbow Simulator is a Jandao Chace Sun II crossbow, unmodified. 150lbs draw weight.

We constructed the following data table from our results, showing depth of penetration.

Sheet metal material	Penetration depth (cm)
Control (no metal)	43
Charcoal Iron	14
Medieval wrought iron (bell clapper)	14
Cross laminated bloomery steel	13
Cross laminated wrought iron	10.5
Modern medium carbon steel	5.5
Modern mild steel	10.5

Arrowhead test

Arrow heads were made by Will Sherman and based on A5698 from the Museum of London which is dated approximately 13thC - 14thC according to the museum, but more likely 14thC - 15thC based on socket size.

Test arrows were from 19thC wrought iron, 19thC wrought iron case hardened industrially, bloomery steel and modern mild steel.

Bloomery steel was smelted and provided by Owen Bush and is approximately 0.4-0.5% carbon. After forging the heads were normalised twice then water quenched and tempered to a straw colour by drawing back.

Target samples were 1.2mm mild steel sheet mounted directly on an archery foam target at 11”/28cm thick.

Longbow was 160lbs self yew made and used by Joe Gibbs.

We constructed the following data table from our results, showing depth of penetration.

Arrowhead material	Shot 1 (cm)	Shot 2 (cm)	Shot 3 (cm)	Average (cm)
Wrought iron	10	10.5	10	10.2
Case hardened iron	13.5	9.5	12	11.7
Bloomery steel	11.5	10.5	10.5	10.8
Mild steel	9.5	10	XXX	9.8

Mail test

Hand made mail sample by Phil Parkes. All rings are mild steel and wedge riveted from 1.4mm diameter wire in 7.3mm diameter rings and sewn to a cote sample of two layers of shirt linen, one layer of wool and one layer of linen canvas.

Commercial mild steel mail sample by Cap a Pie, made from solids and wedge rivetted rings. Rings are from 1.3mm diameter wire in 7.5mm i/d rings. Solids are o/d 10mm, i/d 6.6mm, 0.8mm thick.

Target samples were mounted directly on an archery foam target at 11”/28cm thick.

Arrows were our standard test arrows as specified above, 85g with wrought iron heads.

Longbow was 160lbs self yew made and used by Joe Gibbs

We constructed the following data table from our results, showing depth of penetration.

Mail type	Shot 1	Shot 2	Shot 3	Average
Textile only	30cm	28cm	X	29cm
Commercial	17cm	24cm	19cm	20cm
High quality	23cm	16cm	13cm	17.3cm

What weight is a Warbow?

Bows used are based off the bows found on The Mary Rose, Henry VIII’s flagship sunk in action in 1545. There are no medieval longbows in existence (I am aware of). The bows found on the Mary Rose are in an excellent state of preservation, but must be noted are found in the context of naval warfare and are 130 years later than the Battle of Agincourt, which is the focus of these films.

Bows used were all self yew and were 110lbs, 135lbs and 160lbs, made and shot by Joe Gibbs.

Arrows were all the same off all bows and were our standard test arrows as specified above, 85g with wrought iron heads.

Target samples were 1.2mm mild steel sheet mounted directly on an archery foam target at 11”/28cm thick.

We constructed the following data table from our results, showing depth of penetration.

Bow weight	Shot 1	Shot 2	Shot 3	Average
110lbs	11cm	9.5cm	13cm	11.2cm
135lbs	16cm	9cm	12cm	12.3cm
160lbs	18.5cm	10cm	12cm	13.5cm

Joe meets the longbow simulator

Speed readings were calculated by counting the number of frames from release to impact using a Chronos 2.1 at 1000frames/p/s.

Distances were 0-12m demarcated in 5m increments and in a separate test 50m – 60m in 5m increments.

Longbow is a 160lbs self yew Mary Rose style bow shot by Joe Gibbs and made from Swiss yew.

Arrows are our standard test arrows as specified above, 85g with wrought iron heads; arrows for the simulator had the nocks modified and were taken from the general stock.

Longbow Simulator is a Jandao Chace Sun II crossbow, unmodified.

We constructed the following data tables from our results; as used in the film. However it should be noted that the sample size was small and that Joes shooting naturally varied, especially with later shots, whilst the simulator does not tire. This should be considered when evaluating the data.

Joe 25m						
	0m (chrono)	0-5m	5-10m	10-15m	15-20m	20-25m
Frames (1000fps)		90	181	273	368	464
Difference (frames)		90	91	92	95	96
Speed (m/s)	55.8	55.6	54.9	54.3	52.6	52.1
Speed (ft/s)	183	182.3	180.3	178.3	172.7	170.9
Speed (% launch)	100	99.6	98.5	97.4	94.3	93.3
Energy (Joules)	132	131	128	126	118	115
Energy (%)	100	99.1	97.0	94.9	89.0	87.1
Momentum (kg m/s/s)	4.74	4.72	4.67	4.62	4.47	4.43
Momentum (%)	100	99.6	98.5	97.4	94.3	93.3

Tod 25m						
	0m (chrono)	0-5m	5-10m	10-15m	15-20m	20-25m
Frames (1000fps)		89	178	269	360	451
Difference (frames)		89	89	91	91	91
Speed (m/s)	57	56.2	56.2	54.9	54.9	54.9
Speed (ft/s)	187	184.3	184.3	180.3	180.3	180.3
Speed (% launch)	100	98.6	98.6	96.4	96.4	96.4
Energy (Joules)	138	134	134	128	128	128
Energy (%)	100	99.1	97.0	94.9	89.0	87.1
Momentum (kg m/s/s)	4.85	4.78	4.78	4.67	4.67	4.67
Momentum (%)	100	98.6	98.6	96.4	96.4	96.4

Joe 60m		
	0m (chrono)	50-60m
Frames (1000fps)		212
Difference (frames)		212
Speed (m/s)	52.4	47.2
Speed (ft/s)	172	154.8
Speed (% launch)	100	90.0
Energy (Joules)	117	95
Energy (%)	100	81.0
Momentum (kg m/s/s)	4.45	4.01
Momentum (%)	100	90.0

Tod 60m		
	0m (chrono)	50-60m
Frames (1000fps)		194
Difference (frames)		194
Speed (m/s)	57	51.5
Speed (ft/s)	187	169.1
Speed (% launch)	100	90.4
Energy (Joules)	1138	113
Energy (%)	100	81.8
Momentum (kg m/s/s)	4.85	4.38
Momentum (%)	100	90.4

Chronograph readings – 0m											
	1	2	3	4	5	6	7	8	9	10	Average (mean)
Joe - 160lbs yew longbow (ft/s)	180	182	186	180	180	183	179	186	180	172	181
Joe - 160lbs yew longbow (m/s)	54.9	55.5	56.7	54.9	54.9	55.8	54.6	56.7	54.9	52.4	55.1
Joe – energy (joules)	128	131	137	128	128	132	127	137	128	117	129
Tod – simulator crossbow (ft/s)	181	187	187	186	187	188	187	188	187	187	187
Tod – simulator crossbow (m/s)	55.2	57.0	57.0	56.7	57.0	57.3	57.0	57.3	57.0	57.0	56.8

Tod – energy (joules)	129	138	138	137	138	140	138	140	138	138	137
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Force of impact

Shooting at 15m.

Torso was dressed in our arming cote, hauberk, mail standard, aventail and helmet. The AvA2 breastplate was given as a backer reward and was unavailable so we used a mild steel variable thickness reproduction of the Churburg 14 plate from another project and made by Armour Services Historical.

Ballistic gel was 20% and sourced from Defensible Ballistics (35kg). Foam torso was sculpted from archery target foam without weighting (1.5kg).

Arrows are our standard test arrows as specified above, 85g with wrought iron heads; arrows for the simulator had the nocks modified and were taken from the general stock.

Longbow Simulator is a Jandao Chace Sun II crossbow, unmodified.

Armour defeated!

Shooting at 15m.

Torso was dressed in our arming cote, hauberk, mail standard, aventail and helmet. The AvA2 breastplate was given as a backer reward and was unavailable so we used a mild steel variable thickness reproduction of the Churburg 14 plate from another project and made by Armour Services Historical.

Arrows are our standard test arrows as specified above, 80g with wrought iron heads; arrows for the simulator had the nocks modified and were taken from the general stock.

Armour, cote, mail, stand, torso etc are all as previously specified, with the exception of the breastplate. The AvA2 breastplate was given as a backer reward and was unavailable so we used a mild steel variable thickness reproduction of the Churburg 14 plate from another project and made by Armour Services Historical.

Longbow Simulator is a Jandao Chace Sun II crossbow, unmodified.

Arm armour test

The torso was turned to 45 degrees and fitted with the cote and mail but without breastplate. The arms were supported on two 5mm square aluminium armature wires weighted with lead rolls in the upper (3kg) and lower arms (1.7kg). Only wrought iron heads were used for these shots.

Neck armour test

The torso was turned full on to the shooter and had a section of the throat hollowed out to create a void into which an egg was fitted in approximately the position of the larynx. Over this was fitted our mail standard, over this our mail cote. The helmet was then placed in position, allowing the mail aventail to fit in place over the neck. Only wrought iron heads were used for these shots.

Helmet test

The Torso was turned to 45 degrees allowing the 'flat' on the side of the visor to be struck at 90 degrees. All available arrows were used for these tests and were a mixture wrought iron, mild steel, bloomery steel and case hardened wrought iron.