Casting and testing a 15. Century

Bronze cannon

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Preface

The so-called Ho group - a group of international scholars - has done experimental research into early guns and gunpowder at the Medieval Center in Denmark for many years.

In 2017 the group decided to start looking at the technology behind bigger bronze cannons. The idea were to reconstruct a 15. century furnace and cast an exact copy of a historic cannon and afterwards test it with real ammunition at the army shooting grounds in Oksbøl in Denmark. We realized early on that the bigger bronze cannons up till 1500 kilos were out of reach but the idea were to make scaled down version in the first experiments - smaller furnace and smaller cannon - and if every thing went well go for the big ones.

The original Cannon were damaged. Note the crack the top of the cannon

We settled for a 120 kilo bronze cannon from Historische Museum, Berlin (Steinbüchse W 437).

The early bronze cannons were made in a technique you could call “lost wax casting” even though the term doesn’t cover the casting process of a cannon entirely.

The group decided before starting the project to go on a study trip to India to look at low technology lost wax work shops in southern India in a town called Swamimalai which has been a center for lost wax casting for hundreds of years. The workshop we were visiting belonged to Stapati Eadhakrishna - a reputed bronze caster who specialize in large religious icons for temples all over the world.

The visit in Swamimalai was interesting and there were no doubt the workshop could build us a cannon after the old descriptions, but at the end of the journey we realized that the Indian bureaucracy would never allow this cannon to be made nor transported to Denmark. After the visit in southern India the group went north to Jaipur to look at the preserved cannon foundry at Jaigahr fort and visiting salpeter producers in the small town Jailaser.

Longtitudenal striations in the cannon from use

The cannon mould

After returning home and publishing our ideas we were contacted by Dr. Bastian Asmus, who offered to build a 15 century reverberatory oven for the group. The oven was build in 2018 at the Medieval center in Denmark.

The process behind casting a cannon could be called lost wax technique as mentioned above, but it differs in many aspects from the traditional Cire Perdue technique. Luckily we have som very informative sources on how to make the mould for an early cannon, but these information only deliver some principal information on the process and lack the hundred of years of experience of the early cannon caster.

In making the cannon mould we heavily leaned on the work by Cristóbal Lechuga (Discurso en el que trata de la Artilleria con uno de Fortificación (Milan, 1611)) where one clearly see the stages in producing a mould. Ours were a bit more simple but basically this was the way we went forward.

Preserved cannon mould from Jaigahr Fort, Jaipur

But once you get started and make the first step of the mould the very big question pops up -   what kind of clay should one use ? You can read all kinds of suggestions on the internet using bits of horsehair in the clay, mix it with sand and horse maneuver and even put in some straw. We know these kind of mix is great for wattle, but we have no information if these clay mixes were used in preparing the clay for cannon moulds.

If we return to the Ho group trip to india we found at the fine preserved cannon foundry at Jaigahr Fort an unused cannon mould where one clearly could document the different layers of clay which were used in building the mould. It consisted of multiple thin layers of fine clay build up to a thickness of approximately 25 cm all around the mould. And if we return to the bronze workshop in Swamimalai in southern India professor Sharada Srinivasan has a very detailed description of how the clay were applied on the wax icons (Sharada Srinivasan: in Indian Bonze: “Technique of bronze casting”, National Museum, Delhi. Sharada Srinivasan 2019: Techniques of South Indian Bronzes. National Institute of Advanced Studies, Bangalore India). It appears here that it all lies in the natural properties of the clay and not so much what you mix in to it and it notes, that thin layers and patience while the layers dry is the way to build up a solid mould that can take the immense pressure of the hot bronze being poured into the mould. Also the article describes how the moulds are burned when finished in order to get rid of any moisture left in the clay. Too much moisture will make the melted bronze boil and then create bubbles and impurities in the cannon.

When we applied this experience to the mould we made for the 15 century cannon we were able to make a very fine and consistent clay mould.

When drying and burning the mould we learned from the illustrations by Cristóbal Lechuga that it was very important to burn the mould from inside out. One simply place a small fire in one end of the mould and you get a effect of an modern rocket stove where the barrel of the cannon function as a chimney and you very fast get some really high temperatures that hard burnes the clay and preserves the inner form of the mould and melt out the wax.

The stages of the cannon mould building goes like this:

1. Making the tapered wooden core - a so-called spindle

2. Apply 10-12mm rope of the lengths of the core and building up the outer form of the cannon

3 Applying a 5 mm wax seperation layer

4. Applying a thick layer of clay ca. 5 cm little by little

5. Applying iron bands on the mould

6. and finally add a 5 cm layer of clay, (clay mixed with sand)

7. Burning the inner form and melting out the wax layer

8. Removing the inner clay form below the wax layer

9. Dry and burn the outside of the mould which probably will create cra-cks. These will be removed by applying more clay and then burn it until you have a solid shell that will resist the melted bronze.

10. Making the inner form - the barrel and the powder chamber - slowly building up the layers of clay

11. Placing the mould on a clay bed or an iron plate

12. Placing the inner form which must be secured in the bottom in some way - otherwise it will float when one pures the bronze.

13. The form is ready for casting.

3 stages in producing the cannon mould

The mould has one special feature which is that this cannon is cast upsi-de down so that the thick powder chamber is the last to be poured. This is unusual because this method is very likely to create bubbles in the bronze. But it is an early cannon and the idea is that the method of ca-sting rise form the technology of bell casting and first later on one learns to cast the cannons with the barrel pointing upwards.

Removing the inner form after baking the mould

The furnace

The finished furnace were delivered to us by Dr. Bastian Asmus and we now had to find a way to make it work properly i.e get the temperatures inside the oven up to around 1150 degrees (C). We have a few useful sources on how to make this special furnace work (Mortensen M.H 1999: Dansk artilleri indtil 1600. Tøjhusmuseet). First of all you need fast burning wood especially in the last stages in heating up the oven. Then you need to understand how to regulate the burn by opening and closing the different shields on the side of the oven. The heating of the oven must happen very slowly and you only feed it with bronze bares when the oven is hot. If you don't do this the bronze could stick to the bottom of the oven and there is no way to get it out after the casting. You have to re-build the inner part of the oven and start again.

When the oven is hot you have a small window to get it up to the desired temperature which actually happens fast compared to the many hours it takes heating the oven. Every shield on the oven must be open to allow as much oxygen to circulate as possible and in this stage you will see the fire circulating in the melting chamber and meter high flames will come out of the four chimneys. When you reach the desired temperature you must keep on adding wood to the burn until all the the bronze is poured into the mould.

The group did 3 castings and made a couple of mistakes and learned a lot and we can say today that we have a pretty good understanding of how a reverbaratory furnaces works and we also have a good grip on making early cannon forms.

For the cannon testing we could not use a homemade cannon. The military wanted a complete cannon without any flaws and we therefore had to make a exact copy from one block of bronze - this was done at a local iron workshop.

Two examples of a casting gone wrong. The first we didn´t secure the inner form so it floated to the top of the mould when we poured the bronze. The second we did the big mistake to stop firing the furnace before pouring the bronze - resulting in the bronze cooling off too fast before pouring.

The shooting trials (considerations by Kay Smith/Axel Müller)

The original gun, from which we made the copy, is not dated but a date of around 1450 can be assumed. It would be ideal therefore if we could load and fire it using data from about the same time. For this period, the best source of information we have comes from the Firework Book (FWB) tradition (*Feuerwerkbuchen*) produced from the first decades of the 15th century on. Fortunately the FWB belonging to the Royal Armouries in Leeds, inventory number I.34, has recently been transcribed and translated. This critical and searching translation contains a great deal that can help us but is not easy to use as the text is not always clear as to exactly what is being said. However, the following programme of testing is based on the FWB text.

The gunpowder

There are a number of recipes within the text but all tend to indicate that the powder is high in sulphur, unlike modern ones in which the sulphur is minimal. Probably the best recipes are those on folios 47r and 47v:

1. How to make common gun powder. If you want to make common powder then take four pounds or four weights of saltpetre and take two pounds sulphur and one pound of charcoal and this is called common powder. Mix it together well and the powder is good to be sold and can pass off as good common powder.

2. How to make better powder than an honest man in his castle. If you want to make a better powder than an honest man in his castle or house who told me: ‘Make me a good powder’. Take five pounds of saltpetre and two pounds of sulphur and one pound of charcoal and mix it together well [*and*] then it will be good powder.

3. How to make powder which fires even stronger. If you want to make an even stronger powder that fires more strongly than the others then take six pounds of saltpetre, two pounds of sulfphur and one pound of charcoal. This makes a good strong powder and fires long distances.

These can be tabulated as:

Powder	**Saltpetre**	**Sulphur**	**Charcoal**	**% saltpetre**
Common	4	2	1	57%
Better	5	2	1	62.5%
Even stronger	6	2	1	66%

Just how the actual gunpowder was made up is somewhat unclear but there is enough evidence to suggest that it was made by mixing the constituents together before wetting them and forming the resultant "paste" into balls of about 10cm diameter - these are called *knollenpulver* in the FWB. These are then dried completely before being ground up into fine powder.

Loading the gunpowder

There is some question of just how to fill the powder chamber – the variables are: filling the chamber completely or filling it part way. For example on folio 15r, the text says:

> According to these instructions you should measure each gun whether it is big or small. Measure its length inside the gun right to the bottom. Divide this measurement into five equal parts. One of these parts should be the [*length of the*] plug as you have to drive it into the gun, another part should be the stone and the third part behind should be filled with good powder. This drives a shot properly from the gun.

This implies that the chamber is filled right up though it is confusing in that it says that one part is the stone.

On folio 2v is the following text:

> The third question [*is*] whether a little powder is likely to break a gun or [*it*] fires further if one fills the gun right up to the plug. To that I say: if one fills the gun right up to the plug then the fire and the vapour do not have the width to carry the shot until the fire has partially burned down backwards and the powder has reached the plug. But if the gun is filled by one third to one quarter then the powder can burn all at once and the vapour can use its strength and fires further and breaks the gun much more readily than if the powder [*is*] compressed and [*comes*] right up to the plug.

We would suggest that we follow this text and do not fill the powder chamber completely.

The texts then says that the powder chamber is plugged with a softwood plug that is $1/5^{th}$ of the length of the powder chamber in length.

> The fourth question [*is*] whether a lime plug [*made*] out of lime wood drives the stone better or whether [*one made*] out of hard wood such as oak or beech as recommended by many masters [*does*] and whether the said plug should be short or longer, dryer or greener.

I say: hard plugs are not good as they are too hard and they cannot be driven [*right*] up to its place and retains the vapour much better than the harder plug [*would*]. Thus, the plug should not be longer than it is broad. The best dry plugs one can have [*are those*] one can make from dry alder wood, but the best green plugs are made out of green alder wood. But the best green plugs are made out of birch wood as soon as it has been cut from the trunk and do this as stated previously.

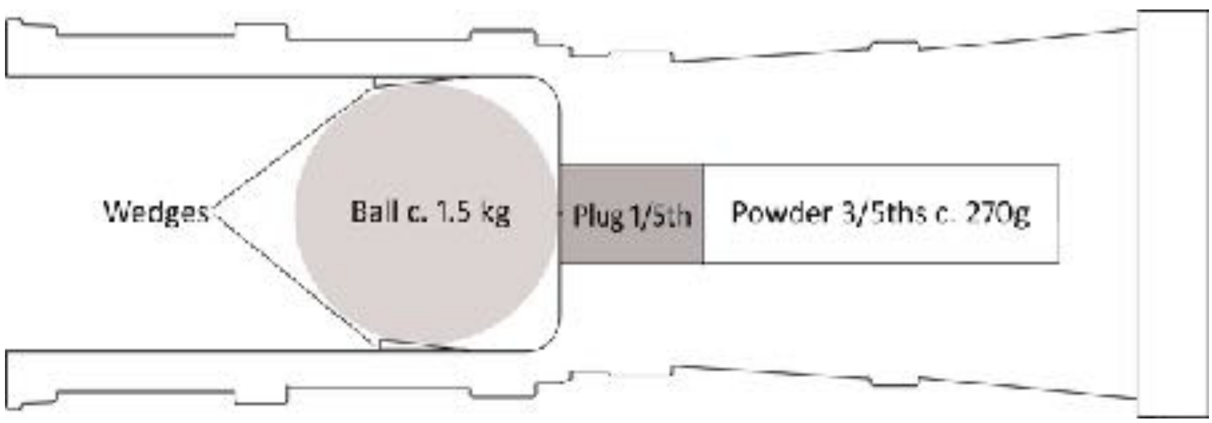
Loading the ball

The text makes it clear that not only is the powder chamber plugged with wood but that the ball is also wedged in place tightly in the barrel – folio 3v says:

> The sixth question [*is*] whether the wedges which one uses to wedge in the stone should be [*made*] out of soft wood or harder wood. I say: [*make sure*] the stone fits properly in the gun and it [*the stone*] has not got more girth than it needs and that it has to fit tightly. Then you have to wedge it in with thin hard wedges of oak wood. But if the stone is a little too small so that it does not fit tightly, then you should wedge it in with thin wedges.
>
> The seventh question [*is*] whether the same wedges should be thick or thin. [*They shall be*] from thinner wood I say. That is [*so that*] the said wedges, should be thick or thin, out of fir wood. But if you do wedge in the stone with what you should wedge it with an iron off-cut at the stone so that the wedge does not go beyond the stone.

Finally it goes on to say that the ball should be further sealed by forcing a piece of waxed textile between the ball and the stone – folio 4r:

> The eighth question [*is*] with what one should block the stone so that the vapour can escape. I say: one should take wax and wax a piece of cloth with it and make it simply into a rope and stuff it, with a good ramrod, between the stone and the gun around the wedge, then it will go far.



This sketch shows how we would load and fire the gun. The powder chamber will be approximately filled to 4/5ths of its capacity – estimated at 270g powder per charge. A softwood plug is then hammered in to seal the powder chamber filling it by 1/5th. The ball is seated on the plug and 3 small wedges used to hold it tight in place. Finally a strip of waxed cloth is pushed around the ball to completely seal it in (not shown in sketch).

The Testings

The testing of the cannon were done in cooperation with Danish Artillery Regiment, Safety- and Ballistic division. The test took place at “Oksbøl Skyde- og øvelseterræn” and the shootings were documented in fine detail with Radar and censors bored into the cannon at the powder chamber and behind the cannon ball which meant the following data could be recorded: muzzle velocity, distance, pressure in chamber, pressure in barrel and decibel. Weight of cannon ball, amount of gunpowder and the different methods of loading were also recorded.

The radar only covered part of the flight of the cannonball so the distance is calculated and in some cases measured as we were able to collect some of the cannonballs after the shootings. Finally other data were collected observations during the shootings. For example many shots were effected by a strong wind which blew both days of the shootings - a wind that caused the cannonballs to deflect pretty much from the ideal line.

The gunpowder we used were made by a pyrotechnician after the description above - all in all ten kilos. (Better powder).

The gunpowder

As mentioned above we used the powder recipe named “better” (5-2-1) and made so-called Knollenpowder from the raw ingredients according to the method mentioned in the source. The powder we used were pretty fast, and suggestions for further trials would be to make knollenpowder and test the other 2 version also - “common “ and “even Stronger”

“No one in front of the cannon when loaded !” - this led to the fabrication of different kind of tools for safe loading

The use of Tampion

The wooden plug were made of soft wood as described in the sources and it was effective in every shot used. It allows to build up high pressure in the powderchamber before the shot were released and the test showed that not using it gave much lower muzzle velocity and shorter distance

The suggestion that there should be air between the Tampion and the powder had no effect whatsoever.

The use of wedges

First we thought these wedges were used for centering the cannonball and hold it in place but the trials suggest that this feature also delays the shot and allow much more pressure to be build up in the chamber before the shot is goes off. The wedges were made of soft wood also.

The use of wax cloth

According to data this had no effect alt all, but it shouldn´t be ruled out because we could have used the wrong cloth and wax and method, so that the ball wasn't packed as tight as it could have been - this would together with the tampion and the wedges give much higher pressure and a longer shot.

The use wear

The original cannon show signs of heavy use with multiple longitudinal striations in the barrel. We tried to document this pattern and the first 9 shot was with a granite ball. Surprisingly they didn't leave much wear in the barrel which underline the first assumption that the original cannon were heavily used or it was used with ammunition of a kind that left heavier traces of wear. We have no way of knowing this.

Few signs of use in the barrel after the shootings

The loading of the gun

Its fair to say that a trained crew could fire the cannon every five minutes or so.

Conclusion

The data from the shootings are shown in the diagrams below. Bjørn H. Priisholm, engineer at DAR gives the following conclusion:

Tampions are the most important factor in getting a long shot according to pressure and muzzle velocity, but the conclusion is not 100% because the wedges in some cases had the same effect on the shot as the tampion, but all in all the use of tampion gives much higher pressure in the barrel which is the basis for a high muzzle velocity.

The other most obvious conclusion is that this little early cannon is way more effective than expected. The length of the shots were far better than anyone could imagine and it now allows scholars to rethink the "siege room" and place the attacking part in far longer distance from the object attacked than imagined before This could lead to consideration about attacks and counterattacks and it also suggest how frequent you could shoot a cannon in a siege situation.

The shootings trials at Oksbøl shooting range this year were quite a succes, but it also left a lot of questions open and it will be necessary to repeat these trials and try and get some answers on the use of the different gunpowders and the contraptions used when loading the cannon.

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The shooting team (some had left early and are not in the picture)
From Left: Axel Müller, Leeds University, Carsten Oksen Middelaldercentret, Frederik V Larsen Middelaldercentret, Henrik Christiansen DAR, Peter Vemming Middelaldercentret, Kim L. Nielsen DAR

Participants not in the picture: Peter Varming DAR, Bjarne I.S.Odgaard DAR, Bjørn H. Priisholm DAR.

Acknowledgements
A project such as this involves a great many people to make it work. We would like to thank the Danish Artillery Regiment in Oksbøl for hosting the test firings, and to the Middelaldercentret, Nykøbing Falster, for financial support and for hosting the Ho group and the experiments prior to the shootings.

Måleskema - middelalder kanon i bronze

	Forsøg	Kugle type	Skud nr.	Kugle nr.	Recorder nr.	Tidspunkt	Elevation [TS]	Kuglevægt [kg]	Kuglediameter [mm] ca.	Mundingshastighed (Vo) [m/s]	Skudafstand [m]	Krudt kammertryk [MPa]	Krudt kammertryk [dBpeak]	Løbstryk [MPa]	Løbstryk [dBpeak]	Lydtryksniveau [Pa]	Lydtryksniveau [dBpeak]	
	2-5 krudt = 216g	Granit	1	30	Dag 1 - 1	1308	22	4,1	140	ingen trig		0,4	206,2	1,1	214,5	423	146,5	
	4-5 krudt = 432g	Granit	2	29	3	1318	22	4,1		107,8	343,2	12,5	235,9	4,7	227,5	1.932	159,7	
tampion	4-5 krudt, tampion (træprop)	Granit	3	28	4	1332		4		135,1		36,8	245,3	9,9	233,9	1.954	159,8	
	3-5 krudt, tampion	Granit	4	31	5	1359		4		104,1		20,9	240,4	8,9	233,0	2.070	160,3	
Bedst	4-5 krudt, tampion, voksklud	Granit	5	32	6	1423	12	4,2		145,1		39,0	245,8	12,6	236,0	2.296	161,2	
	3-5 krudt, tampion, voksklud	Granit	6	27	7	1440	11	4		119,2		26,1	242,3	10,5	234,4	1.664	158,4	
voksklud	4-5 krudt, voksklud	Granit	7	26	8	1450	10	4		120,2	406,4	15,0	237,5	7,6	231,6	2.143	160,6	
	4-5 krudt , tampion, kiler	Granit	8	25	9	1522	14	3,9		137,2	429,1	36,8	245,3	13,4	236,5	1.742	158,8	
	3-5 krudt, tampion, kiler	Beton	9	1	10	1536	11	3,7		116,5		23,5	241,4	6,4	230,1	1.247	155,9	
kiler	4-5 krudt, kiler	Beton	10	2	12	1548	13	3,7		135,8		15,0	237,5	7,0	230,9	2.296	161,2	
	Dag 2:																	
Serie voksklud	4-5 krudt, tampion voksklud	Beton	11	3	Dag 2 - 1	950	311	3,7		154,4		32,1	244,1	8,0	232,0	2.000	160,0	
	4-5 krudt, tampion voksklud	Beton	12	4	2	1012	329	3,7		151,5	680,4	35,2	244,9	9,0	233,1	2.023	160,1	
	4-5 krudt, tampion voksklud	Beton	13	5	3	1029	338	3,7		155,6		39,0	245,8	12,5	235,9	2.432	161,7	
	4-5 krudt, tampion voksklud	Beton	14	6	4	1041	338	3,7		141,7		34,4	244,7	9,5	233,5	2.047	160,2	
	4-5 krudt, tampion voksklud	Beton	15	7	5	1052	338	3,6		139,1		33,6	244,5	7,8	231,8	1.722	158,7	
	Statistik - skud 11 - 15								Min.	139,1	680,4	32,1	244,1	7,8	231,8	1.722,0	158,7	
									Maks.	155,6	680,4	39,0	245,8	12,5	235,9	2.432,4	161,7	
									Diff.	16,5	0,0	6,9	1,7	4,7	4,1	710,4	3,0	
									Middel	148,5	680,4	34,8	244,8	9,3	233,3	2.044,8	160,1	
									Stdafv.	7,6		2,6	0,6	1,9	1,6	253,4	1,1	
Serie kiler	4-5 krudt, tampion kiler	Beton	16	8	6	1107	338	3,6		158,9		38,6	245,7	12,5	235,9	2.047	160,2	
	4-5 krudt, tampion kiler	Beton	17	9	7	1115	338	3,6		150,7		35,6	245,0	15,9	238,0	1.932	159,7	
	4-5 krudt, tampion kiler	Beton	18	10	8	1123	338	3,6		146,6		35,2	244,9	7,1	231,0	1.702	158,6	
	4-5 krudt, tampion kiler	Beton	19	11	10	1130	338	3,6		150,6		35,6	245,0	8,6	232,7	1.824	159,2	
	4-5 krudt, tampion kiler	Beton	20	12	11	1141	338	3,6		164,2	565,0	38,1	245,6	11,1	234,9	2.023	160,1	
	Statistik - skud 16 - 20								Min.	146,6	565,0	35,2	244,9	7,1	231,0	1.702,3	158,6	
									Maks.	164,2	565,0	38,6	245,7	15,9	238,0	2.046,6	160,2	
									Diff.	17,6	0,0	3,4	0,8	8,8	7,0	344,3	1,6	
									Middel	154,2	565,0	36,6	245,2	11,0	234,5	1.905,6	159,6	
									Stdafv.	7,2		1,6	0,4	3,4	2,7	143,5	0,7	
Serie voksklud og kiler	3-5 krudt, tampion, voksklud, kiler	Beton	21	13	12	1156	338	3,6		131,6		26,4	242,4	7,6	231,6	1.722	158,7	
	3-5 krudt, tampion, voksklud, kiler	Beton	22	14	13	1216	338	3,6		128,7		23,0	241,2	10,5	234,4	1.722	158,7	
	3-5 krudt, tampion, voksklud, kiler	Beton	23	15	14	1227	338	3,6		126,3		22,7	241,1	6,9	230,8	1.803	159,1	
	3-5 krudt, tampion, voksklud, kiler	Beton	24	16	15	1239	338	3,6		131,2		24,3	241,7	5,7	229,1	1.845	159,3	
	3-5 krudt, tampion, voksklud, kiler	Beton	25	17	17	1250	338	3,6		133	632,6	27,0	242,6	9,2	233,3	1.449	157,2	
	Statistik - skud 21 - 25								Min.	126,3	632,6	22,7	241,1	5,7	229,1	1.448,9	157,2	
									Maks.	133,0	632,6	27,0	242,6	10,5	234,4	1.845,1	159,3	
									Diff.	6,7	0,0	4,3	1,5	4,8	5,3	396,3	2,1	
									Middel	130,2	632,6	24,7	241,8	8,0	231,8	1.708,2	158,6	
									Stdafv.	2,7		1,9	0,7	1,9	2,1	154,4	0,8	
	4-5 krudt, tampion, voksklud, kiler	Beton	26	18	-	1257	338	3,6		146,4		24,6	-	10,8	-	-	-	B&K trigger
Serie 3/5 del krudt med kiler	3-5 krudt, kiler	Beton	27	19	19	1306	338	3,6		99,3	488,3	8,7	232,8	6,3	229,9	1.702	158,6	
	3-5 krudt, kiler	Beton	28	20		1311	338	3,6		111,31	565,0	8,7	232,8	6,3	229,9	1.702	158,6	
	3-5 krudt, kiler	Beton	29	21	20	1315	338	3,5		109,3		8,7	232,8	3,4	224,5	1.517	157,6	
	3-5 krudt, kiler	Beton	30	22	21	1320	338	3,2		115,5		11,4	235,1	4,2	226,4	1.552	157,8	
	3-5 krudt, kiler	Beton	31	23	22	1326	338	3,6		95,3	427,9	8,9	233,0	3,3	224,4	1.626	158,2	
	Statistik - skud 27 - 31								Min.	95,3	427,9	8,7	232,8	3,3	224,4	1.517,2	157,6	
									Maks.	115,5	565,0	11,4	235,1	6,3	229,9	1.702,3	158,6	
									Diff.	20,2	137,1	2,6	2,3	2,9	5,5	185,1	1,0	
									Middel	106,1	493,7	9,3	233,3	4,7	227,0	1.620,0	158,2	
									Stdafv.	8,5		1,2	1,0	1,5	2,7	84,7	0,5	
											Skudafstanden er afhængig af							

Firing 09 Sept-10 Sept 2020							
	Tid	Skud nummer	krudtmængde (forholdstal		Kuglevægt B eller G		Tampion
	Time	Shot number	Powder amo	Weight of po	Weight / Concrete (B) c		Tampion/Pl
DAY 1							
9/9/20	13:08	MC 30	2/5	216g	4,1	G	No
9/9/20	13:18	MC 29	4/5	432g	4,1	G	No
9/9/20	13:32	MC 28	4/5	432g	4,0	G	Yes
9/9/20	13:59	MC 31	3/5	324g	4,0	G	Yes
9/9/20	14:23	MC 32	4/5	432g	4,2	G	Yes
9/9/20	14:40	MC 27	3/5	324g	4,0	G	Yes
9/9/20	14:50	MC 26	4/5	432g	4,0	G	No
9/9/20	15:22	MC 25	4/5	432g	3,9	G	Yes
9/9/20	15:36	MC 01	3/5	324g	3,7	B	Yes
9/9/20	15:48	MC 02	4/5	432g	3,7	B	No
DAY 2							
9/10/20	9:50	MC 03	4/5	432g	3,7	B	Yes
9/10/20	10:12	MC 04	4/5	432g	3,7	B	Yes
9/10/20	10:29	MC 05	4/5	432g	3,7	B	Yes
9/10/20	10:41	MC 06	4/5	432g	3,7	B	Yes
9/10/20	10:52	MC 07	4/5	432g	3,6	B	Yes
9/10/20	11:07	MC 08	4/5	432g	3,6	B	Yes
9/10/20	11:15	MC 09	4/5	432g	3,6	B	Yes
9/10/20	11:23	MC 10	4/5	432g	3,6	B	Yes
9/10/20	11:30	MC 11	4/5	432g	3,6	B	Yes
9/10/20	11:41	MC 12	4/5	432g	3,6	B	Yes
9/10/20	11:56	MC 13	3/5	324g	3,6	B	Yes
9/10/20	12:16	MC 14	3/5	324g	3,6	B	Yes
9/10/20	12:27	MC 15	3/5	324g	3,6	B	Yes
9/10/20	12:39	MC 16	3/5	324g	3,6	B	Yes
9/10/20	12:50	MC 17	3/5	324g	3,6	B	Yes
9/10/20	12:57	MC 18	4/5 (2 * 2/5)	432g	3,6	B	Yes
9/10/20	13:06	MC 19	3/5	324g	3,6	B	No
9/10/20	13:11	MC 20	3/5	324g	3,6	B	No
9/10/20	13:15	MC 21	3/5	324g	3,5	B	No
9/10/20	13:20	MC 22	3/5	324g	3,2	B	No
9/10/20	13:26	MC 23	3/5	324g	3,6	B	No