THE AMMO TEST

A major evaluation of target grade smallbore ammunition, conducted by Geoff Doe, assisted by a team of shooting internationals.

WHAT IS A CARTRIDGE?

After the initial purchase of a rifle, the most expensive aspect of our sport is the ammunition. We might not realise it because most of us buy it in small quantities as required. It is a frightening thought that, bought at today's prices, I have purchased over £15,000 worth of ammunition in the last 20 years.

My costs could have been reduced dramatically by buying a cheaper brand, but what successes would have been achieved? Why do we buy the particular brand that we use? It is suggested that in most instances it is either that it is the most popular brand at the club without a lot of thought having gone into its selection, or "it is good enough for me". This second attitude is not the right one because, no matter how mediocre a shot you are, a good ammunition will only improve your scores.

We have a tendency to take the .22 rimfire cartridge for granted for it has been with us for 130 years in some form or other, which is longer than any other cartridge.

Birth of the Rimfire Round

In the early 1850s, Wesson of the famous Smith & Wesson empire, experimented to find a self-contained cartridge that could be used in a pistol.

His first effort was to fix a lead ball bearing to a percussion cap by crimping the side walls of the cap. Because of the shape that occurred when a cap was used in one of his pistols, he decided to make a case with the rim already formed in order to accommodate the priming compound, the rest of the case being filled with propellant. The case had to be stronger than the percussion cap to stop it disintegrating when ignited. It was from these ideas, and with the help of Smith, that, on the 8th August, 1854, the rimfire cartridge was patented.

Because of financial problems, the Smith & Wesson company was sold to the Winchester Arms Company in 1855, Smith leaving the company and Wesson staying on as a supervisor, where he continued his search to perfect his rimfire cartridge.

The original development centred on the use of a 'short' case because the cartridge was used mainly in pistols. Loaded with black-powder, the only propellant then available, the original .22" cartridge must have been a puny mite. Because of the demand by the shooter to increase its power and range, some twenty years later manufacturers lengthened the case, increased the powder charge and bullet weight and called it the .22 Long rifle. This gave a very much more powerful cartridge and was basically the forerunner of the cartridge we use today.

Most of us take it for granted that, having loaded a cartridge into the breech and squeezed the trigger, a hole will appear in a piece of paper down range. How many of us have stopped and thought how much engineering skill and expertise has gone into the production of that cartridge? All the components have to be made to very fine tolerances and brought together under carefully controlled conditions to ensure a good end product.

Rimfire Requirements

In general, the requirement is for a regular uniform product that functions satisfactorily in all makes of .22" rimfire target rifles. The external dimensions of the cartridge must conform closely with the chamber dimensions. The bullet weight must be consistent, and the cartridge ignition system must be such that it will fire when struck on the rim from a blow of about 0.15 foot pounds.

If we consider the train of events from the moment the trigger is squeezed until the bullet strikes the target, it will be apparent that, as the striker travels forward and hits the rim, the metal must deform rapidly in order to ignite the priming charge. Thus the metal thickness and hardness must be such that this rapid deformation can readily take place and yet must not be such that the striker pierces the rim. The priming composition must ignite without fail under the energy of the striker blow and then must, in turn, initiate the burning of the propellant. Not only must the priming produce the same amount of hot gas each time, but it also must do so in the same small interval of time. No mean feat!

Once the priming has been initiated under the striker blow, it burns very rapidly evolving hot gases and particles in the process. These gases and particles, and particularly the latter, ignite the main propellant charge and it, in turn, burns rapidly, although relatively much more slowly than the priming composition, and produces hot gases. Being confined to the cartridge case this evolution of gas results in a rapid rise in pressure, until the force produced on the base of the bullet is sufficient to push it out of the case mouth and into the leed of the rifling. At the same time as this is happening the heel diameter must increase, to ensure there is *no leakage of gas* past the bullet. This **must** occur with absolute regularity from round to round.

Under the gas pressure the case expands to the walls of the chamber, but this must be an elastic expansion. When the pressure has returned to that of the atmosphere, the case must contract sufficiently to facilitate extraction after firing. As the bullet moves along the barrel, the volume available for the gas increases, causing a reduction in the rate of pressure rise. After a movement of about ½", the rate of increase in pressure due to burning propellant, and the rate of reduction in pressure due to increased volume available, are equal. From then on the pressure falls from its maximum of some 9 tons per square inch, to about ½ ton per square inch when the bullet exits the barrel. During the period of about 3 milliseconds between leaving the case and reaching the muzzle, the bullet has been accelerated to approximately **1060 feet per second** with a rotational speed of some **50,000 revolutions per minute.**

Principles of Manufacture

Let us now consider the manufacture of a cartridge. Different manufacturers have different methods of arriving at the end result but the general principle of production is much the same for all.

Firstly, let us look at the case. To assist with technical terms, reference should be made to the detailed drawing. Initially a small disc is stamped out of a sheet of metal. This disc then passes through a series of deep drawing dies, to change it into a similar shape to the case we know. I say 'similar', as there are still a number of processes through which it has to pass.

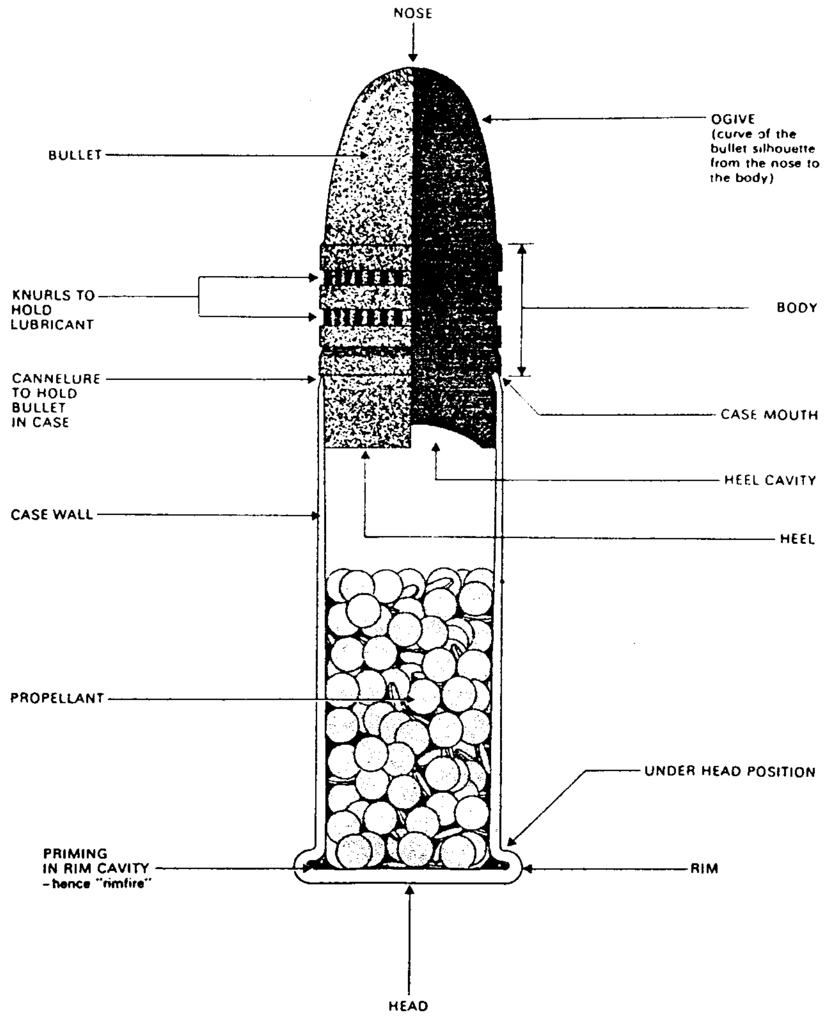
It is *very* important at this stage of the process that the HEAD is of a uniform thickness, as well as being constant one to another.

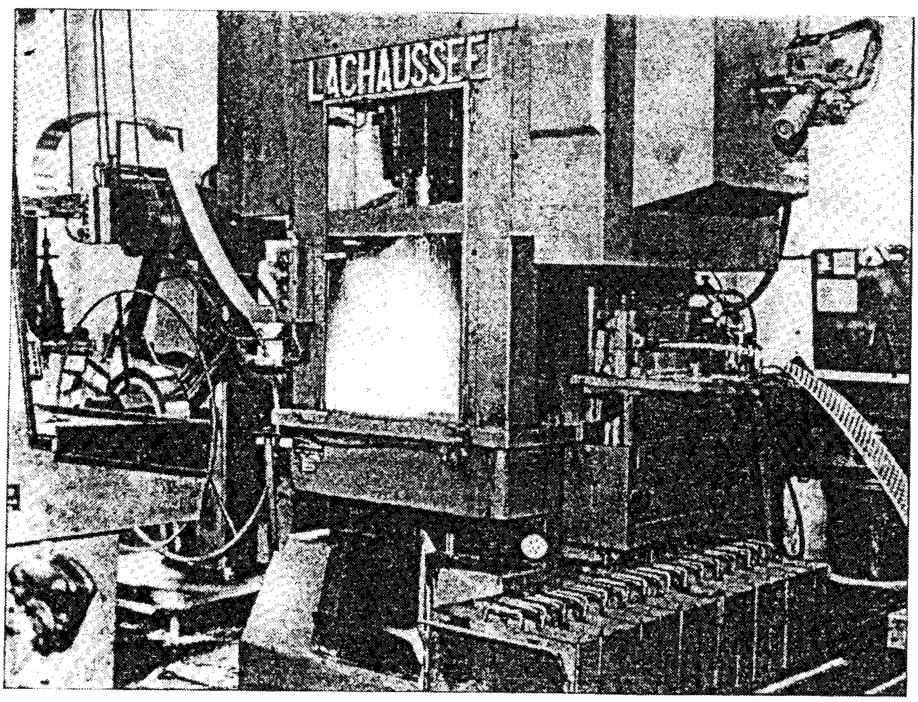
CIP regulations require that the manufacturers of rifles *must ensure* that there is a gap of at least 43.3 thousandths of an inch between the end of the barrel chamber and the face of the action. This is to allow the case to fit snugly into position. However, should there be excessive space, the case will be 'loose' and when the bullet is propelled forward, there will be a reverse movement on the case. Excessive rearward movement of the case can result in a drop in pressure and velocity, and a possible degradation of the accuracy potential.

The RIM must be correctly formed for it is into the rim cavity that the primer must flow in order to be ignited when the rim is struck by the firing pin. The cavity is approximately 9 thousandths of an inch. It is because the firing pin strikes on the rim that we have the term rimfire cartridge.

The UNDER HEAD POSITION is the flange that seats on the breech face of the barrel. The chamber is slightly radiused at its start to accommodate the slight curve at the underhead position of the rim. Different makes have slightly different underhead radii, which is why it can sometimes be more

The .22 Rimfire Cartridge





Right: A case making machine in action. Strip rolling in at left, cases dropping into bins, right foreground..

difficult to close the action on certain makes. It can be seen that, because of the restriction on the rifle manufacturer to ensure that the head space in the breech is not less than 0.0433", the cartridge case must not be more than this same dimension.

It is this case that is to be charged with both priming compound and propellant before being 'topped' off by a bullet. The case, at this stage, is slightly bell mouthed. The primer, in liquid, paste or powder form, is introduced and forced into the rim. In its dry state the priming compound is a very volatile substance. When struck, it must ignite spontaneously around the whole rim in order to ignite the propellant evenly and rapidly. The propellant has to be fed into the case in an *exactly measured* quantity.

It should be noted that priming compounds, of which lead styphnate is the almost universal basic substance used, is in fact a High Explosive (HE) material. Usually mixed with powdered glass or similar material, to provide friction for reliable ignition, it provides such a high source of energy for its minute proportions, that dismantling of live rounds, whether a misfire or not, is extremely hazardous and should *not* be attempted by unqualified persons.

Both primer and propellant must be manufactured under extremely well controlled conditions, as any variation of 'mix' or humidity during preparation will give rise to variations in performance, with consequent loss of accuracy. The primer and propellant mix can be likened to the housewife with her cake recipe. The same ingredients are used time and time again but sometimes the end result is not quite right. The same goes for ammunition.

THE BULLET

Elsewhere in the factory the bullet will be under production.

It can be seen from the drawing that it is a complicated little bit of lead, that has developed over the years into an aerodynamic shape best suited to overcome the variances of the wind. Like the case, the bullet is swaged into shape in a die, following much the same procedure as that of home loaders who swage their own full-bore pistol ammunition.

I have seen some shooters inspecting their ammunition to ensure that there is no damage to the bullet before being inserted into the rifle. This is commendable, provided you know what you are looking for. It is not so important if there is minor damage on the NOSE or the OGIVE. However, should there be damage in the area of the BODY, then you are likely to have 'fliers'. If a shot is a good distance away from the group (and by this I mean some 2" or 3" from a good tight grouping at 100 yards, and the hole appears to be slightly elongated) then the bullet has gone in at an angle instead of straight. This has happened because the spin has not been perfect and the bullet has had an increasing 'yaw' during its flight.

As mentioned before, the case is slightly bell mouthed in order that the bullet can be pressed in without damage. The bullet and case then go through a process called CANNELURING. A machine turns the bell mouth inwards to hold the bullet securely in place. Later in this article you will see a table of figures headed 'Bullet pull'. These tests check the amount of force required to remove the bullet from its case. It is *very important* that this is as constant as possible, because if the bullet is not held firmly enough it may start off down the barrel before the required pressure has built up behind it.

There is one more process through which the bullet has to pass. The bullet is dipped in lubricant. This lubricant is in a liquid state and after the bullet leaves the bath the excess drips off, leaving a thin film over the entire bullet but extra in the knurls. Lubricant is *very important for accuracy.*

If there is no lubricant on the bullet as it passes along the barrel, lead would be removed from its circumference. The lubricant prevents this by forming a very thin film between bullet and barrel much the same as oil in a car engine. The cleaning of a barrel will obviously remove fouling and lubricant deposits. It is necessary to replace the lubricant deposit before maximum potential accuracy is obtained. Tests have proved that it may require at least 10 rounds to be fired before a rifle barrel settles down after cleaning, maybe rather more. If there is a deficiency of lubricant, accuracy can be affected adversely.

THE TESTS

The tests were set up to compare the potential accuracy of various types of ammunition in rifles. The results obtained can be utilised in short barrelled firearms, i.e. pistols. Tests were not conducted in pistols because other factors intrude which can materially affect results, such as malfeeds, which damage the rounds and result in inaccuracies not applicable to the quality of the cartridge.

The problem with testing ammunition is that it has to be fired in a rifle. There then comes the difficulty as to whether one is testing the ammunition or the rifle for accuracy. To try to obtain as fair a comparison as possible, several different rifles were used.

Shooters will be aware that there are numerous makes of ammunition produced around the world. The eight selected were chosen as being the *most popular* brands sold from the National Smallbore Rifle Association. It is considered that any brand not included in the survey is used by less than 5% of the smallbore shooters in this country.

The prime object of the exercise was to establish whether the more expensive cartridges were more accurate. The brands chosen fell into three distinct price bands.

All the prices quoted are based on price per hundred calculated from the 5,000 rate obtainable from the NSRA for affiliated clubs or life and annual members. Prices are correct at the time of going to press (mid February, 1985).

Band A: over £4
Eley Tenex £4.62
RWS R50 £4.56

Band B: over £3 but below £4
CCI Competition Grade £3.04
Winchester Premium £3.05
Eley Match £3.41

Band C: under £3
Eley Club £2.38
Winchester Expert £2.26
Remington Standard Velocity £2.21

The ammunition was purchased from stock at Bisley. Two thousand rounds of each brand were bought from two separate batches. The objective was to obtain a mean result for each brand. Hopefully, if one batch was particularly good (or bad) it would average out with the other batch to indicate the typical quality of manufacture.

The first thing one notices when purchasing any product is presentation. All cartridges were packed in plastic trays, but that is where the similarity stopped. RWS R50 and both brands of Winchester had a cardboard sleeve around 50 cartridges. These were then boxed in packs of 500 for ease of handling. CCI and Remington were initially packed in trays of 100 in an all plastic clear box, CCI then being brought together in boxes of 500, whereas Remington presented theirs in a flip top box of 1,000 intended for display on a shop counter. The Eley brands were also in clear plastic boxes of 50 with two boxes shrink-wrapped to form 100s, there being no further wrapping.

Slight disadvantage was found with the Eley brands not being wrapped in boxes of 500 or 1,000. It is easier to hold two boxes of 500 than 10 packs of 100, especially when they are wrapped in a slippery material.

All individual boxes were marked with the batch number. To gain access to the cartridges for the Remington and Eley brands, one had to break a seal. This prevents dishonest persons substituting an inferior brand of the same make and making an enormous profit.

The only disadvantage that could be seen in CCI and Remington being presented in boxes of 100 is that if a club member wants to buy 50 cartridges then it is tedious to split the box. All of the plastic boxes had a lid that had 'pips' moulded on to the underside so that it would slide back in steps to facilitate ease of counting out the number of rounds required.

It was noticed that one batch of Remington had the letter 'U' on its case as a product symbol but the second batch had the identification mark 'Rem'. Only Remington stated on the packaging any technical details such as bullet weight, velocity, etc.

The lids on the boxes of CCI nearly broke a thumb in trying to slide them back, let alone a thumb nail, and a screwdriver had to be used in several instances. By the time entry had been gained the detail would have been over.

Each batch was tested in several different ways. Firstly for consistency of manufacturing tolerances and then for performance under controlled conditions.

Rim Thickness

The importance of head-space and constant rim thickness is not appreciated by many shooters.

Head-space is the distance between the end of the barrel chamber and the face of the bolt, or breech block, when in the firing position (see Diagrams A and B). In most new rifles the head-space is about 0.043" to 0.045", and while, in theory, there should be no excess head-space in a rifle, experience has shown that these tolerances are acceptable. Due to wear, the head-space may increase, with a resultant loss of accuracy. No maximum figure can be given before deterioration of group size occurs but certainly a head-space of 0.047" or more should give rise for concern. Should this figure be in excess of 0.060" the rifle is potentially dangerous. When the case expands under pressure created by the ignition of primer and propellant, if it is not encased by the chamber of the rifle, a hole is likely to be blown in the side of the case around the rim area.

Figure A is the conventional method of showing head-space and the immediate effect of excessive head-space will be to lessen the striker protrusion. However, with the leed of the rifling offering resistance to the insertion of the cartridge, it can be seen that the excess head-space will not be between the case and the bolt face, as in Figure A, but is more likely to be between cartridge and barrel, as in Figure B. The immediate effect is to deprive the cartridge of the anvil on which the rim is struck.

Cartridges will fire under this condition, but it is clear that under the striker blow, either the cartridge moves forward or the rim is deformed slightly, both undesirable happenings. Figure C depicts targets which show a lack of tightness about the groups with excessive head-space, although they still may be capable of scoring possibles.

A major variance with the rim thickness of a cartridge will obviously affect the head-space and, consequently, the accuracy.

Rim Thickness Measurements

Ten cartridges were taken at random from each brand of ammunition to carry out this test.

PACKAGING

Brand	Plastic Box	Card. Box	Boxed in 50s	Boxed in 100s	Boxed in 500s	Boxed in 1000s	Sealed
Eley Tenex	x		x	x			x
RWS R50		x	x		x		
CCI	x			x	x		
Eley Match	x		x	x			x
Winchester Premium		x	x		x		
Eley Club	x		x	x			x
Remington	x			x		x	x
Winchester Expert		x	x		x		

RIM THICKNESS MEASUREMENTS

Brand	Min.	Max.	Average	Diff. between Min. & Max
Eley Tenex	0.0400	0.0405	0.04010	0.0005
RWS R50	0.0405	0.0420	0.04095	0.0015
CCI	0.0400	0.0410	0.04035	0.0010
Eley Match	0.0395	0.0405	0.04010	0.0010
Winchester Premium	0.0415	0.0430	0.04200	0.0015
Eley Club	0.0395	0.0410	0.04015	0.0015
Remington	0.0385	0.0405	0.03985	0.0020
Winchester Expert	0.0400	0.0420	0.04140	0.0020

Measurements are in parts of an inch. It was noticed that the batch of Remington with the 'Rem' symbol stamped on the case generally had a greater rim thickness. It was interesting to note, when it came to testing for accuracy from the rest at 100 yards, that this batch produced better groups in every rifle. Was it due to there being less excessive head-space because it was a thicker case?

It can be seen from the table that Eley Tenex has the tightest tolerances on manufacture, there only being one half of one thousandth of an inch between minimum and maximum.

Lubrication

It was mentioned earlier that there is a need to have sufficient lubrication to assist with maximum potential accuracy. No quantitative tests were undertaken, however, all cartridges appeared to have sufficient. The Eley brands, RWS R50 and CCI using beeswax and tallow, the rest paraffin wax.

Cartridge Bullet Diameter

It is important that when a cartridge is pushed home into the chamber it seats in snugly. It must match up to the barrel and chamber diameter of the rifle. Too tight and it will be damaged in the region of the body of the bullet, a most critical area for ensuring good flight performance. If it is too loose then, when the cartridge is fired, the bullet will not 'set up' evenly in the barrel, thus giving a poor exit from the barrel and loss of accuracy.

Ten cartridges from each batch were measured.

We can see here that the Canneluring machine that finishes off the sizing of the bullet is extremely accurate. Even on the worst examples, the tolerances are within one-half of one thousandth of an inch and for Eley Tenex the tolerance is down to two-tenths of one thousandth of an inch. All Eley brands have the edge over their competitors.

Bullet Pull

As with all tests, one is looking for the least variation between minimum and maximum figures. A more consistent bullet pull will contribute towards a more consistent pressure being built up within the cartridge case, before release of the bullet from the case. This consistent pressure will help to give consistent velocity and we know that consistent velocity is a major factor for accurate grouping.

The number in brackets after the brand name, is the batch number identification used throughout these tests.

It can be seen that Eley Tenex has the least difference between minimum and maximum, with CCI and Eley Match and Club following closely behind.

The variation in RWS R50 figures was rather surprising. For a top brand ammunition one would have expected the tolerances to have been a lot better. This may account for the fact that, whilst many of the groups obtained were of a similar dimension to Eley Tenex when testing for accuracy, there was a pattern build up of eight or nine shots that would form a very tight group, much better than any other brand, but there would be the odd one or two shots away from the group. If one had set one's sights for centring up the group where the eight or nine shots fell, one would have undoubtedly had nines with the 'fliers'.

Figure A. Loose Leed Rifle

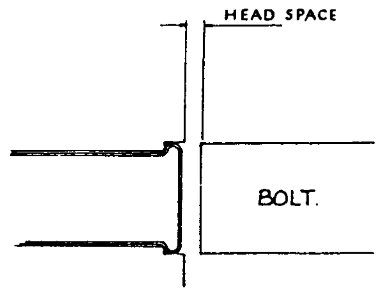


Figure B. Tight Leed Rifle

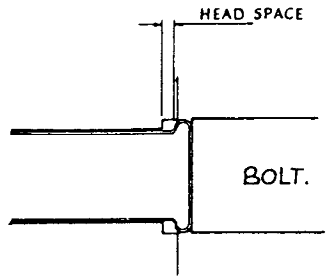
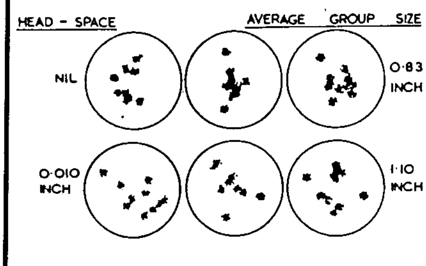


Figure C.



Reproduced with kind permission of "Target Gun" and Geoff Doe.

CARTRIDGE BULLET DIAMETER

Brand	Max.	Min.	Diff. between Min. & Max
Eley Tenex	0.2242	0.2240	0.0002
RWS R50	0.2245	0.2240	0.0005
CCI	0.2245	0.2239	0.0006
Eley Match	0.2245	0.2248	0.0003
Winchester Premium	0.2255	0.2250	0.0005
Eley Club	0.2244	0.2248	0.0004
Remington	0.2255	0.2250	0.0005
Winchester Expert	0.2250	0.2245	0.0005

BULLET PULL OUT LOADS (figures in pounds)

Brand	ID No.	Max.	Min.	Av.	Diff. between Min. & Max
Eley Tenex	(1)	43	34	38.2	9
	(2)	44	38	41.6	6
RWS R50	(1)	52	34	46.3	18
	(2)	43	33	35.2	10
CCI	(1)	47	36	43.3	11
	(2)	53	46	48.8	7
Eley Match	(1)	44	30	39.0	14
	(2)	42	34	38.7	8
Winchester Premium	(1)	45	27	37.2	18
	(2)	48	24	39.1	24
Eley Club	(1)	50	40	45.5	10
	(2)	45	36	40.5	9
Remington	(1)	47	27	32.7	20
	(2)	35	22	29.4	13
Winchester Expert	(1)	54	40	46.4	14
	(2)	52	42	46.9	10