South Texas Marksmanship Training Center

MIRAGE AND CONDITIONS THAT EFFECT TARGET IMAGE IN RIFLE SHOOTING

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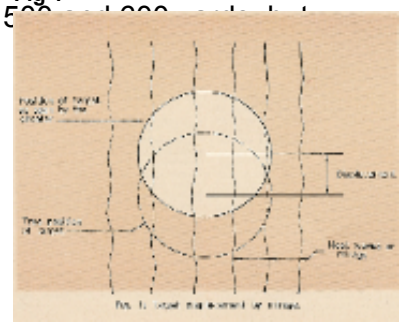
The smallbore rifle shooter can, when conditions are difficult, fire many sighting shots to verify his judgment and determine the correct sight settings before beginning to fire his record score. The high power rifle shooter has only two (2) sighting shots before firing his record string at long range. It is therefore important that he develop the ability to "read" wind conditions at long range, and before beginning a string-of-fire at long range. The shooter must take advantage of all the indicators available – range flags, trees, grass, dust, smoke and mirage and be able to interpret them. Since the high power rifle shooter has only two sighting shots, the ability to read mirage can make the difference between merely a good score and a possible a high-X score.

A mirage condition is not a handicap, since it offers a very accurate method of perceiving small wind changes which, if time permits, may be waited out. Not all wind changes can be waited out; therefore the shooter needs some understanding of the ways in which various mirage conditions can affect the target image.

The term "mirage" as used by the shooter does not refer to a true mirage, but to heat waves and the refraction of light as it is bent passing through air layers of different density. Light which passes obliquely from one wind medium to another it undergoes an abrupt change in direction, whenever its velocity in the second medium is different from the velocity in the first wind medium; the shooter will see a "mirage".

A familiar example is a stick projecting from water. The water surface is the plane separating the two (2) mediums, (air and water), and the stick has the appearance of being bent at the water surface. The same phenomenon occurs as the light from target to shooter passes obliquely downward through an atmosphere at uniform temperature. The bending is due to this refraction; which is barely perceptible at 1000 yards and negligible at 5[illegible] nevertheless it is present.

Fig 1



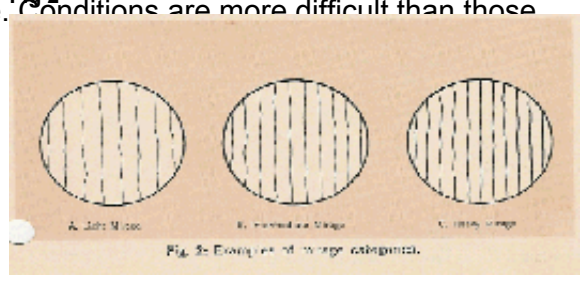
The density of air, and therefore its refraction, varies with its temperature. A condition of cool air overlaying warm air next to the ground is the cause of heat waves or "mirage". The warm air, having a lower index of refraction, is mixed with the cooler air above by convection, irregularly bending the light transmitting the target image to the shooter's eye. (Fig. 1) shows greatly exaggerated, the vertical displacement of the target image by heat waves. An elevation correction is evidently necessary in order to center a shot on the target.

Heat waves are easily seen with the unaided eye on a hot, bright day and can be seen with spotting scope on all but the coldest days. To observe heat waves, the scope should be focused on a point about midway to the target. This will cause the target to appear slightly out of focus, but since the high power rifle shooter generally does not try to spot bullet holes, the lack in target clarity is more than compensated by clarity of the heat waves.

Classifying mirage density

The sight correction necessary to compensate for mirage, at a given range, will increase as density of the mirage increases. Therefore the shooter should be able to distinguish different densities of mirage, which should be recorded in the scorebook for future reference. An individual just starting competitive shooting should not attempt to classify the mirage into more than three (3) categories, namely: light, intermediate and heavy. The light mirage is associated with a cool or cloudy day, when the sun can not heat the ground, and is seen through the spotting scope as a series of fine, faint lines. Target distortion is minimal. This mirage is very useful to the shooter in detecting slight wind changes which require the merest pinch of windage adjustment; while the mirage correction, which will be shown later in this manual is practically negligible. An intermediate mirage will be present on the perfect shooting day with 70 to 75 degree temperature and normal relative humidity (45 to 55 percent). The mirage is barely perceptible with the unaided eye, but is easily seen through the spotting scope as distinct lines. Target distortion begins to be apparent and each major change in wind velocity will also require a correction for the change in mirage. [illegible] conditions are more difficult than those brought about by a light mirage, but are not the most difficult.

Fig 2



A heavy mirage will occur on hot, sultry days (60 to 75 percent humidity) when heat waves can be seen easily with the unaided eye, and appear as very dense lines viewed through the spotting scope. Target distortion is extreme, small bullet hole spotters are difficult to locate, and any change in the wind velocity will require that the shooter take into consideration the mirage corrections. (Fig 2) shows the appearance of the three (3) mirage categories.

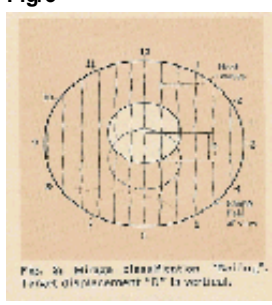
In addition to the three categories of mirage that the beginning shooter should learn to recognize, there are four (4) distinct classes of mirage in each category from each side of the target, plus the vertical mirage. Hence there is a minimum of twenty-five (25) mirage conditions that the beginner may use in detecting wind changes – or that he must cope with, depending on his state of mind.

It may be stated here that the shooter's mental state may be the most difficult condition that the beginning shooter must overcome. Wind and mirage affect all shooters on the firing line more or less equally, and in many cases it is the shooter who creates the impossible conditions. Conditions do change for successive relays of shooters. Owing to the different wind conditions for different shooting relays: the U. S. Army in order to select the "true best shooter" will select the 2 or 3 shooters firing the highest score on each relay to be re-squadded for a "shoot-off". This method will determine the true match winner. This procedure is used in the Wimbledon Cup Match and the Leech Cup Match held at the National Matches.

Wind causes changes!

How do the four (4) different classes of mirage come about?
Wind blows the heat waves as they rise, causing them to move vertically, obliquely, or laterally across the target. The amount that they vary from the vertical depends on the cross wind velocity, within limits from zero (0) to about twelve (12) miles per hour (m.p.h.). As each mirage class is described, you must keep in mind that the description also applies to each category, and to a wind from right (3 o'clock) or from the left (9 o'clock).

Fig 3

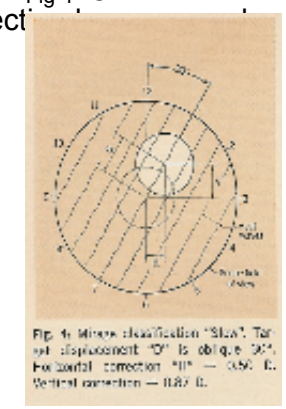


The first class to be considered is the boiling mirage, with heat waves rising vertically as in (Fig 3). A boiling mirage is present when there is no measurable wind, and when the wind blowing from the shooter directly toward the target (6 o'clock wind) or from the target toward the shooter (12 o'clock wind). This mirage class condition requires that the rear sight be lowered, to center the shot group within the target. The amount of correction will depend on the category (density) of the mirage and vision of the individual shooter. An accurate scorebook record of mirage category, mirage classification, wind, temperature, light, sling tension, etc., combined with knowing the rifle's no wind zero and the zero for that distance, will enable the beginning shooter to refine the values given below to fit his particular location.

Although the boiling mirage presents little problems in itself, the near 6 o'clock wind or near 12 o'clock wind which appears as a boiling mirage to the inexperienced shooter can present quite a problem when it is fishtailing from about 11:30 to 12:30 or 5:30 to 6:30.

Wind correction is generally rated as a fraction of the wind's 3:00 or 9:00 o'clock effect, with the 11:00, 1:00, 5:00, and 7:00 o'clock winds being half value. The 11:30, 12:30, 5:30, and 6:30 o'clock winds could be rated as eight value each, while the wind fishtailing from one side of 6-12 o'clock line to the other gives a combined effect of quarter (1/4) value. With .30 cal ammunition of National Match type this will amount to a windage correction of one minute at 600 yards for a 10 m.p.h. wind and a two (2) minute correction at 1000 yards with the same wind. This small change in wind direction is very difficult to detect by feel, but secondary heat wave lines will begin to show up in the mirage and have the appearance of just leaning away from vertical, signaling the shooter that a change in wind direct

Fig 4



A Slow Mirage

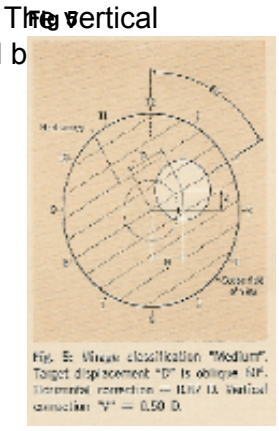
A slow mirage; the second classification, exist during a light air of one to 3 m.p.h. blowing from 3 o'clock or 9 o'clock. Heat waves will be slightly inclined as they move across the target from 7 o'clock to one o'clock of from 5 o'clock to 11 o'clock (Fig 4). Target displacement with the slow mirage requires both an elevation and windage correction. As with the boiling mirage, the rear sight is lowered to correct for vertical component of the apparent displacement. The horizontal component requires a wind correction which will be into the wind, in addition to the correction for wind drift of the bullet.

Since the heat waves are crossing from 7 o'clock to one (1) o'clock or 5 o'clock to 11 o'clock, they are making an angle of 30 degrees with the vertical, and their vertical and horizontal components.

can be computed in relation to the total apparent displacement:
p = total apparent displacement
v = vertical component of D
H = horizontal component of D
Then,
V = D cosine 30 degrees = 0.87 D, and
H = sine 30 degrees = 0.50 D

Experience has shown the total displacement due to heavy mirage amounts to be ≈ 1 ½ minutes. The vertical correction due to heavy-slow mirage will be 1.31 or 1 ¼ minutes, and the horizontal correction will b minute.

Fig 5



As the 3 or 9 o'clock wind rises to a light breeze of 4 to 7 miles per hour, the heat waves will make a greater angle with the vertical and will have the appearance of crossing from 8 o'clock to 2 o'clock or 4 o'clock to 10 o'clock. This gives the third classification, is a medium mirage (Fig 5). The medium mirage will also require both elevation and windage corrections of different amounts than for slow mirage. Changing the angle from 30 degrees to 60 degrees because of the increased inclination, the corrections become:

V = D cosine 60 degrees = 0.50 D
and
H = D sine 60 degrees = 0.87 D

Going back to the total displacement of 1 ½ minutes caused by the heavy mirage, the vertical correction for a heavy-medium mirage will be 0.75 of ¾ minute and the horizontal correction will be 1.31 or 1 ¼ minutes. Again the rear sight is lowered and the windage correction is added to that required for wind drift.

The Effect

How examine the mirage effect with the same heavy mirage during a wind increasing from one to 3 m.p.h. (slow mirage) to 4 to 7 m.p.h. wind is applied, the rear sight must be lowered 1 ¼ minutes and ¾ minute windage added for horizontal component of the mirage. During the string, the mirage picture changes from heavy-slow to heavy-medium which signals the increase in wind velocity. The necessary wind correction is made and an additional ½ minute applied to give a total horizontal correction of 1/1/4 minutes for mirage. Adjusting for the vertical component of the mirage is accomplished in a similar manner. The sight was originally lowered 1 ¼ minutes and the mirage picture now indicates that only ¾ minute is needed, so the sight is raised the difference, which is ½ minute. The beginner shooter should practice mentally so that he is able to make the necessary changes without becoming confused.

Fig 6

A fast mirage, the fourth classification, will be visible when the wind velocity reaches the gentle breeze stage of 8 to 12 m.p.h. from 3 o'clock or 9 o'clock. The heat waves will move horizontallyacross the face of the target (Fig.6) and the apparent target displacement will be only horizontal. The fast mirage thus requires only additional windage correction. Wind velocities over 12 m.p.h. are indicated by the heat waves having the appearance of being

stretched straight, and letups can be detected by slight waves beginning to appear on the mirage lines.

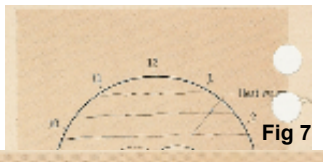


Fig 7

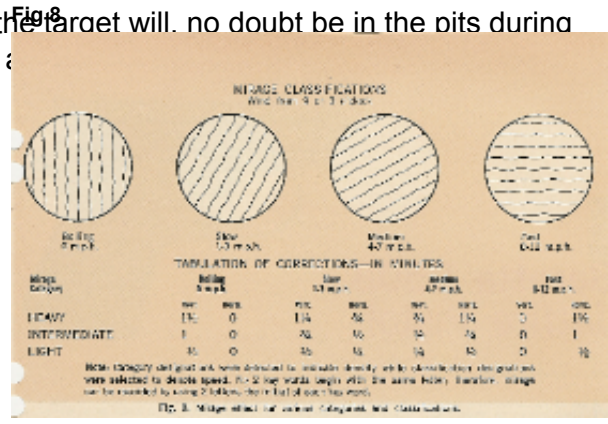
Boiling with lateral movement

The last and most difficult mirage picture to identify is the “boiling mirage wi right secondary heat waves” (Fig.7), which is an indication of the wind com between 9 and 12, 9 and 6, 3 and 12, or 3 and 6 o’clock. An easy scorebook notation is the word “boiling” with an arrow drawn through it to indicate the direction of the secondary heat waves. The primary and secondary heat waves are caused by the 2 components of the wind, a 6-12 o’clock and a 3-9 o’clock component, the latter being the more important in detecting wind shifts. The secondary heat wave lines should be read in the same manner as the previously mentioned classes, with the secondary lines indicating that both vertical and horizontal corrections will be necessary to compensate accurately for the mirage displacement. The new shooter should be on the lookout for the appearance of these secondary waves while firing in the other mirage classes.

Mirage can also be used to determine the true wind direction. Traverse the spotting scope until a “boil” is seen, then the wind is parallel to the axis of the scope. Turning the scope through 90 degrees will be equivalent to observing a 3 or 9 o’clock wind. The mirage classification gives the wind velocity up to about 12 m.p.h.

The beginning shooter can possibly keep abreast of the mirage changes, during slow-fire competition, by plotting them on the call circle in the scorebook. You can draw one or 2 wavy lines through the circle to indicate the mirage classification. A category change can easily be shown by putting the initial L, I, or H in the circle and still have sufficient space remaining to plot the call for the shot. However, do not spend to much valuable time at this. It should not require more than 3 to 4 seconds to note a mirage in this manner and the target will, no doubt be in the pits during that time. If more time is being consumed, additional practice is necessary a matches, with the spotting scope can b beneficial.

Fig 8



(Fig. 8) is a tabulation of corrections in minutes, that will aid the new shooter in learning the effect that mirage can have on the target image. The new shooter, wishing to apply the methods of doping the mirage that have been described, must keep in mind that intensity of the mirage seen will very according to each person’s vision.

The tabulation of corrections was extracted, mostly, from the experience of shooters. Values given will have to be modified somewhat by new shooters for mirage pictures that are distinct to him, at his geographical location.