South African Veterinary Laboratory Scientific Forum

SAVLSF

SAVLSF Harmonized Serology SOP for *Brucella abortus* Complement Fixation Test (CFT)

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DISTRIBUTION LIST

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- Northern Cape
- Gauteng
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- Limpopo
- KwaZulu Natal
- Eastern Cape
- Western Cape
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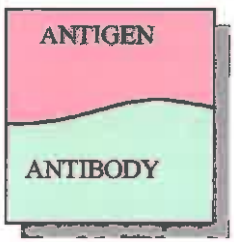
1. PRINCIPLE

The Complement Fixation Test (CFT) is a widely used and accepted confirmatory test for brucellosis. It is complex to perform and requires good laboratory facilities and adequately trained staff to accurately titrate and maintain the reagents. The test has a high specificity though it could give a positive reaction due to S19 vaccination or false positive serological reactions (OIE Manual 2009).

The complement system consists of a complex series of proteins, which if triggered by an antigen-antibody complex, react in a sequential manner to cause cell lysis. In the first stage of the CFT, antigen and test serum are mixed with normal guinea-pig serum (complement). In the second stage, the indicator or haemolytic system is added. The haemolytic system consists of sheep red blood cells, which have been sensitized with anti-sheep red blood cell antibody (amboceptor/haemolysin). If the test serum contains antibodies to *Brucella abortus (B. abortus)* (positive reaction), complement will be used up or fixed so that it cannot react in the haemolytic system. Thus, no lysis of sheep red blood cells will occur, and the sheep red blood cells will remain intact. If the test serum does not contain *B. abortus* antibodies (negative reaction), complement will not be fixed and lysis of the sheep red blood cells will occur.

Antigen | Antibody | Complement | Sheep Red Blood Cells | Amboceptor

POSITIVE SAMPLE



Formation of Immune Complexes

REACTION

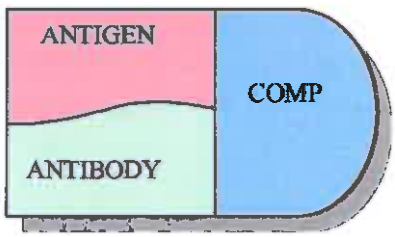
Test Reaction:

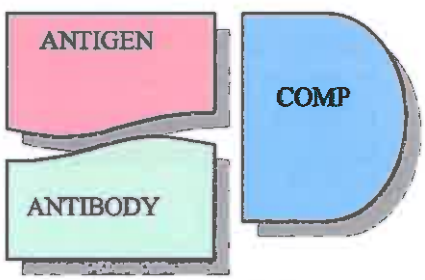
Addition of Test Serum to Test Antigen

NEGATIVE SAMPLE

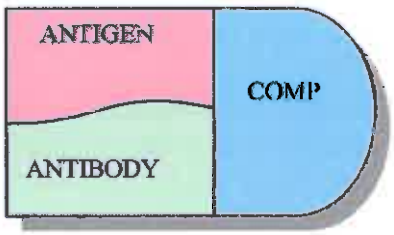
Unbound Antibodies

Addition of Complement



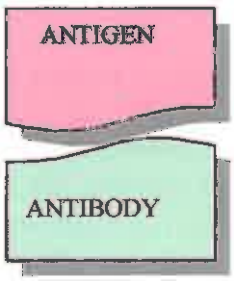


Fixation of Complement by Immune Complexes

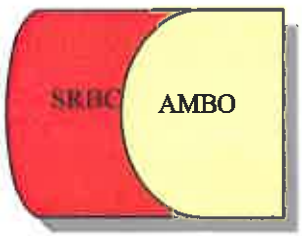


Indicator Reaction:

Unbound Complement

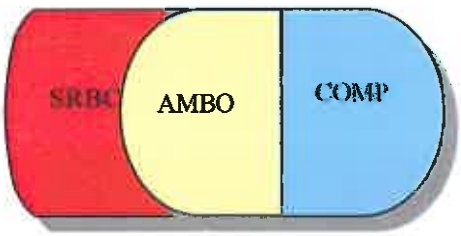


Addition of SRBC and Amboceptor



Sedimentation of SRBC

RESULT



Lysis of SRBC by Activated Complement

The *Brucella abortus* antigen and the test serum (its complement inactivated by heating at 58 °C ± 2 °C for 30 min) are brought into contact with each other. If the antibodies in the test serum are specific to the added antigen, an immune complex is formed. If the antibodies are not specific to the antigen, the antibodies and antigen remain unbound.

If these immune complexes are now incubated with normal guinea-pig serum, which provides a source of unbound complement, fixation of the complement with the immune complexes takes place. If there are no complexes for the complement to fixate to, the complement stays unbound.

An indicator system, consisting of sheep red blood cells (SRBC) and amboceptor (haemolysin) is added. The SRBC and amboceptor form an immune complex. Since there is no unbound complement in the positive test sample, the SRBC-amboceptor complex remains unaffected, resulting in sedimentation of the SRBC. The negative test sample however, has unbound complement, which will now bind to the SRBC-amboceptor immune complex. This binding to the erythrocyte surfaces will result in the erythrocytes being disrupted and haemolysis occurs.

2. PERSONNEL

The person/s performing the procedure shall be declared competent by relevant procedures e.g. witnessing, repeat testing, inter-laboratory/proficiency testing etc.

3. SAFETY/ PRECAUTIONARY MEASURES

3.1 Safety measures

3.1.1 All blood samples should be regarded as potentially capable of transmitting diseases.
3.1.2 Wear personal protective equipment (PPE) at all times i.e. laboratory coat and gloves.
3.1.3 Disinfect the bench before the test is done and after the test is completed.
3.1.4 Spills must be cleaned by spraying over the spill with disinfectant and wiping down with paper towels. Paper towels must be discarded into a biohazard bag.
3.1.5 Amboceptor contains sodium azide as a preservative. Avoid swallowing and contact with the skin or mucous membranes.
3.1.6 Never pipette by mouth.

3.2 Precautionary measures

3.2.1 All reagents must be stored at 4 °C ± 2 °C at all times when not in use.
3.2.2 CFT Buffer, Antigen, Complement, Red Blood Cell suspension, test and control sera to be mixed well before use.
3.2.3 Remove only a sufficient amount of reagents from refrigerator for use.
3.2.4 New tips must be used for each test serum.

4. LIMITATIONS AND PRECISION OF THE TEST METHOD

4.1 Complement factors and other factors, inducing anti-complementary effects inherent in the test sera, have to be inactivated before performing the CFT.

4.2 The various biological reagents used in the CFT must all be standardized in order to yield optimal results.

4.3 The test is both a sensitive and specific test.

4.4 Only serum samples should be tested.

4.5 The test cannot differentiate between reactions caused by field strains of *Brucella abortus*, or the vaccine strain, S19. It is thus important that the history (vaccination and previous test results) of the herd is taken into account when interpretations of results are made. The

recombinant vaccine strain, RB 51, does not elicit immune responses that are detected by the CFT test.

4.6 Haemolysed samples, due to excessive agitation or too high temperature, are rejected and cannot be tested.

5. EQUIPMENT

5.1 Multi-channel micropipette (5 µl to 50 µl/300 µl) and single channel micropipette (10 µl to 100 µl/1000 µl; 1-10 ml)
5.2 Incubator (37 °C ± 2 °C)
5.3 Timer
5.4 Refrigerator (4 °C ± 2 °C), Freezer (-20 °C ± 5 °C, Ultrafreezer (-70 °C - -80 °C).
5.5 Water bath **or** Hot Air Oven/Incubator (37 °C ± 2 °C and 58 °C ± 2 °C)
5.6 Centrifuges (one standard for blood and one to spin micro titre plates at 1 000x g)
5.7 Dispenser (25 µl to 50 µl)
5.8 Shaker
5.9 X-ray viewing box **or** magnifying mirror
5.10 Spectrophotometer **or** Wintrobe Tubes
5.11 Biological Safety Cabinet
5.12 Balance
5.13 Thermometers
5.14 Magnetic stirrer
5.15 Pasteur pipettes

6. MATERIALS

6.1 Permanent marker pen
6.2 Test tubes
6.3 Pipette tips
6.4 Beaker
6.5 96-well microtitre plate filled with 1.2 ml polypropylene cluster tubes
6.6 96-well U-bottom micro titre plates
6.7 Reagent bottles and reservoirs
6.8 Centrifuge tubes
6.9 Measuring cylinder
6.10 Wintrobe tubes
6.11 Sealing film or plate lids

7. REAGENTS

NB: Reagents should be re-constituted according to manufacturer's instructions. Any deviations should be validated.

7.1 *Brucella abortus* complement fixation antigen supplied by Onderstepoort Biological Products (OBP) should be thoroughly mixed and then diluted 1/10 with CFT Buffer (1 part antigen to 9 parts CFT Buffer) as indicated on the bottle. The antigen is stored at 4 °C ± 2 °C.

Note If a large number of tests are to be done, equal volumes of diluted complement and diluted antigen (C'/Ag) can be mixed so that 50 µl of C'/Ag can be added to the wells instead of 25 µl of the complement and 25 µl of the antigen. In the same way equal volumes of diluted complement and CFT buffer (C'/2) can be mixed for 50 µl to be added to the anti-complementary control row.

7.2 *Brucella abortus* standardized positive control serum (Onderstepoort National Standard - OPNS), supplied by OBP should be reconstituted as per manufacturer's instruction. i.e. Reconstitute the freeze dried serum by adding 1 ml sterile distilled water. Allow to stand for 30 minutes at room temperature (22 ± 3 °C) for powder to completely dissolve. To serve as a control in the CFT, dilute the reconstituted serum 1/7.24 by adding 6.24 ml CFT buffer. The diluted serum then contains 1050 ÷ 7.24 = 145 IU/ml (++ (50 %) at a 1/32 serum dilution). Store at 4 °C ± 2 °C. A volume of this serum should be inactivated together with the test sera every time the test is done.

7.3 *Brucella abortus* negative serum (Any serum from a herd that consistently tests negative and has been externally verified by a DAFF or SANAS approved laboratory).

7.4 Guinea-pig Complement for CFT (e.g. Siemens or Alere), according to titration, see.

7.5 Amboceptor from Rabbit (e.g. Siemens or Alere) Use 5 Minimum Haemolytic Doses in the CFT (see 8.2.2).

7.6 CFT buffer (see Appendix 1.

7.7 Sheep red blood cells (SRBC) 3%suspension (see 8.2.1).

7.8 Test sera, positive and negative control sera must be inactivated together at 58 °C ± 2 °C for 30 minutes.

7.9 Cyanmethaemoglobin standard can be obtained from BDS International Diagnostics (spectrophotometric method).

7.10 Drabkin's reagent can be obtained from Sigma (spectrophotometric method).

8. PROCEDURE

8.1 Collection and preservation of sheep red blood cells (SRBC)

8.1.1 Donor animals should test negative for *Brucella abortus, Brucella ovis and Brucella melitensis* antibodies in the CFT test.

8.1.2 Select sheep that give red blood cells which consistently react well in the test. At least two sheep must be kept for this specific purpose. (Use the 10 minute haemolysis test for selection, see Appendix 3).

8.1.3 A maximum of 500 ml blood can be drawn at six-week intervals.

8.1.4 Blood is collected at a ratio of 50% blood to 50% Alsever's solution (See Appendix 2) or in Fenwal Blood packs which are used as per manufacturer's instructions (e.g. Adcock Ingram).

8.1.5 Mix the blood thoroughly when collecting by gently rotating the container. Work in a biological safety cabinet when dispensing into smaller volumes. Label bottles with sheep number and date of collection and expiry date.

8.1.6 Blood is stored at 4 °C ± 2 °C for a period of no longer than six weeks.

8.1.7 Blood can only be used at least 5 days after collection (Alton *et al.* 1988:89)

8.2 Preparation of reagents

Reagents must reach room temperature (22 °C ± 3 °C) before use, with the exception of the complement, which is heat labile and should be kept at 4 °C ± 2 °C until needed for dilution.

8.2.1 Preparation of 3% SRBC suspension

There are two methods: the Wintrobe tube method (see 8.2.1.2) and the spectrophotometric method (see 8.2.1.3).
Both methods start with the washing of SRBC.

8.2.1.1 Washing SRBC

1. Pour sufficient blood into two conical graduated centrifuge tube and centrifuge at 1 000x g to 3 000x g for 5 minutes.
2. Remove supernatant and buffy coat layer.
3. Re-suspend the cells in CFT Buffer, by gentle agitation and centrifuge at 1 000x g to 3 000x g for 5 minutes.
5. Remove supernatant and buffy coat layer and repeat Step 3 except the centrifugation is for 10 minutes and not 5 minutes. This the final wash.
7. The supernatant after the final wash must be crystal clear and colourless.
8. Remove the supernatant and for the Wintrobe method fill the centrifuge tubes with CFT buffer. Gently mix suspension and pour the volumes of the tubes into a graduated measuring cylinder to prepare a 3% suspension from packed red blood cells (RBC).

8.2.1.2 Wintrobe Tube Method

1. Prepare a 20% RBC suspension in CFT buffer from washed cells as in 8.2.1.1.
2. Mix thoroughly but gently.
3. With the aid of a Pasteur pipette fill two Wintrobe tubes to the 10-graduation mark.
4. Centrifuge for 15 minutes at 1 000x g.
5. Read packed cell volume (PCV) on the graduated Wintrobe tubes.
6. In order to prepare a 3% RBC suspension, use the following formula to calculate the volume of VB to add to a chosen volume of the original 20% suspension e.g.
   PCV = 18
   Chosen volume (20% suspension) = 20 ml

$$\frac{\text{Vol. (20\% suspension)} \times \text{PCV}}{3} - (\text{Vol. 20\% susp.}) = \text{Vol. CFT Buffer}$$

$$\frac{20 \times 18}{3} - 20 = 100 \text{ ml}$$

Thus add 100 ml CFT buffer to 20 ml of 20% suspension to give a 3% RBC suspension.

8.2.1.3 Spectrophotometric method

(i) Calibration of the spectrophotometer

1. A 3% suspension contains 0.96 g haemoglobin (Hb) per 100 ml (Alton *et al.* 1988:91).
2. All readings are done at 540 nm wavelength.
3. Allow the machine to warm up for 15 min.
4. Bring the cyanmethaemoglobin standard to room temperature.
5. Read the optical density (OD) of this standard on the spectrophotometer using Drabkin's reagent as a blank.
6. Calculate the OD for a 3% RBC suspension diluted 1/16 in Drabkin's reagent from the following formula:

$$\text{OD (3\% suspension)} = \frac{0.96 \times \text{OD (standard)} \times 1\,000}{\text{Concentration of standard (mg/100 ml)} \times 16}$$

7. Prepare a ± 4% RBC suspension from washed, packed cells.
8. Mix 1 ml of this suspension with 15 ml Drabkin's reagent.
9. Allow to stand for 10 min and then read OD.
10. Make a 3% RBC suspension from the original 4% RBC suspension by applying the following formula:

$$\text{Vol. (CFT Buffer to be added)} = \frac{\text{OD(4\%) - OD(3\%)}}{\text{OD(3\%)}} \times \frac{\text{Vol.(4\%)}}{1}$$

E.g. If the OD calculated in step 6 above is 0.5 and the OD of the 4% suspension is 0.58 and the volume of the 4% suspension to be diluted is 80 ml then:

Vol. (CFT Buffer to be added) $= \frac{0.58 - 0.5}{0.5} \times \frac{80}{1}$

Thus add 12.8 ml CFT buffer to 80 ml of 4% RBC suspension and this will give a 3 % RBC suspension.

11. Lyse 1 ml of the 3% RBC suspension with 15 ml Drabkin's reagent. Allow to stand for 10 min and read the OD. It should equal the OD calculated in step 6.
12. Distilled water is used routinely to lyse the RBC suspension, the final target OD (TOD) is obtained by lysing 1 ml of this 3% RBC suspension with 15 ml of distilled water, waiting 10 min and then reading the OD using distilled water as a blank.
13. This is the target OD (TOD) used in daily calculation. The target OD is generally near 0.5, Alton et al. 1988:93).

(ii) An alternative method for calibration of the spectrophotometer

In the absence of facilities for the cyanmethaemoglobin method the spectrophotometer may be standardised as follows:

1 Take up to 10 ml of sheep blood, stored in Alsever's solution, and add about 40 ml of CFT buffer: mix well, then centrifuge to pellet the erythrocytes.
2 Discard the supernatant, re-suspend the erythrocytes in about 40 ml of diluent and centrifuge again.
3 Discard the supernatant, re-suspend the erythrocytes in about 40 ml of diluent and centrifuge again.
4 Discard the supernatant, re-suspend the erythrocytes, this time in a 15 ml graduated centrifuge tube and centrifuge at 1 000x g to 3 000x g for 10 minutes.
1.5 Note the volume of the pellet accurately, discard the supernatant, then suspend the whole of the pellet in 32.3 times its volume in CFT buffer to produce a 3% suspension. For reproducible results it is recommended that sufficient erythrocytes be washed to give a final deposit of about 1 to 2 ml.
2. Add 1 ml of this suspension to 15 ml distilled water and mix. Allow to stand for 10 min for lysis to complete.
3. As soon as lysis is complete, measure the OD.
4. Repeat steps 1, 2 and 3 several times and calculate the mean OD. This is the target OD used in daily calculation (See table above).

(iii) Routine calculation for the preparation of a 3% SRBC suspension

1. Prepare an initial 4% suspension by taking 4 ml packed SRBC (from the washing procedure) and 96 ml CFT buffer.
2. From this 4% suspension, prepare a 1:16 dilution by adding 1 ml of 4% SRBC to 15 ml distilled water. Allow to stand for 10 min in order to completely lyse the RBCs.

3. Use two cuvettes: one filled with distilled water (to use as a blank), and the second to fill with the 1:16 dilution of lysed RBCs.
4. Read the absorbance value at 540 nanometre (nm): Each laboratory shall calibrate their instrument with each batch of blood collected.
5. Use the following formula to calculate the volume of CFT buffer to be added to the suspension:

$$\frac{\text{OD reading of initial 4\% - Target OD}}{\text{Target OD}} \times \text{The volume that is left after 1ml has been taken out to make 1:16}$$

For example:
If the OD reading was 0.58 and the TOD was 0.5 the formula would be applied as follows:

$$\frac{0.58 - 0.5}{0.5} \times 99 = 15.8\text{ml (round off to 16 ml)}$$

Thus, 16ml CFT buffer must be added to the initial 4% suspension to make a 3% suspension. After the CFT buffer is added, repeat steps 3 and 4. The reading should equal the TOD of the donor used. If this is not the case discard the suspension and start again

8.2.2 Titration of Haemolysin (Amboceptor). To be done for each new batch.

1. Set up 2 racks of 10 tubes (11 x 75 mm), one for the serial dilution of haemolysin and the other for the titration.
2. Prepare a 3% RBC suspension in CFT buffer.
3. Prepare a 1/1 000 dilution of haemolysin in CFT buffer (0.1 ml haemolysin in 99.9 ml buffer).
4. Make further dilutions of haemolysin in the first rack according to the following schedule:

Table 1. Dilutions of haemolysin used in the haemolysin titration.

Tube No.	Dilution	1/1 000 Master dilution (ml)	CFT Buffer (ml)
1	1/1 000	1.0	-
2	1/2 000	1.0	1.0
3	1/3 000	0.5	1.0
4	1/4 000	0.5	1.5
5	1/5 000	0.5	2.0
6	1/6 000	0.5	2.5
7	1/7 000	0.5	3.0
8	1/8 000	0.2	1.4
9	1/9 000	0.2	1.6
10	1/10 000	0.2	1.8

5. In addition 2 control tubes are set up at the start of the test as follows:

Tube No. 11	Complement 1/20	0.4 ml
	3% RBC suspension	0.4 ml
	CFT buffer	1.2 ml
Tube No. 12	Haemolysin 1/1000	0.4 ml
	3% RBC suspension	0.4 ml
	CFT buffer	1.2 ml

These 2 tubes pass through the same incubation (steps 8 and **11**) process as the titration tubes and no other reagents are added. Neither must show any sign of haemolysis.

6. Mix each dilution starting with the highest dilution (Tube No. 10) and transfer 0.4 ml to the appropriate tube in the titration rack.
7. Add 0.4 ml of the 3% RBC suspension to each tube and mix immediately.
8. Shake and place in a water bath at 37 °C ± 2 °C for 30 min to sensitize the red blood cells.
9. Add 0.4 ml of complement with a final dilution of 1/20 to each tube.
10. Add 0.8 ml CFT buffer to each tube.
11. Shake and incubate for 30 min in a water bath a 37 °C ± 2 °C.
12. Remove from the water bath and read.
13. The unit of haemolysin referred to as 1 MHD (minimal haemolytic dose) is the highest dilution showing complete haemolysis.
14. Use 5 MHDs in the CFT.
15. Store as per manufacturer's instructions and avoid contamination.

Note Haemolysin with a titre of less than 1/2 000 should not be used.

Calculation of 5 MHDs

If the haemolysin titration is1/2 000 then 1 MHD is contained in a 1/2000 dilution. Thus 5 MHDs are contained in a 5/2 000 = 1/400 dilution. Therefore 0.25/100 is the correct dilution for 100 ml haemolytic system to contain 5 MHDs. Thus to supply 5 MHDs in 100 ml haemolytic system one must add 0.25 ml of haemolysin with a titre of 1/2 000 to 50ml of CFT buffer.

8.2.3 Preparation of Sensitized Haemolytic System

First determine the volume of blood needed to run the entire test by taking into account the number of test samples, then following the guidance given in 8.2.2 above determine the dilution of the haemolysin to be used.

Add the haemolysin (5 MHDs) to the CFT buffer. Mix the correct volume of the haemolysin-added CFT buffer (5 MHDs) with an equal volume of 3% SRBC to make the haemolytic system. This is achieved by pouring each volume simultaneously into a third container and agitating for a short while. Alternatively, a magnetic stirrer can be used as follows: place a volumetric flask containing the CFT buffer plus haemolysin on a magnetic stirrer set at a medium speed. Slowly add the 3% SRBC suspension to the flask and stir for 5 minutes. Incubate the haemolytic system for 30 minutes at 37 °C ± 2 °C in a water bath/incubator before use to allow for the sensitisation of the SRBCs. Gently mix the haemolytic system twice during the incubation i.e. at 10 minutes and 20 minutes.

8.2.4 Titration of complement. To be done for each new batch.

1 Prepare the haemolytic system (sensitized SRBC according to 8.2.3 above).
2 Prepare a 1/40 dilution of complement in cold CFT buffer.
3 Dispense the 1/40 dilution of complement into 10 tubes in the quantities shown in Table 2.

Table 2. Volumes of complement (1/40) and CFT buffer used in the complement titration.

Tube No.	Complement 1/40 (ml)	CFT Buffer (ml)	Incubation	Sensitized sheep red blood cells (ml)
1.	0.03	0.72	30 minutes in the water bath at 37 °C ± 2 °C	0.25
2	0.04	0.71		0.25
3.	0.05	0.7		0.25
4.	0.06	0.69		0.25
5.	0.075	0.675		0.25
6.	0.1	0.65		0.25
7.	0.125	0.625		0.25
8.	0.15	0.6		0.25
9.	0.2	0.55		0.25
10.	0.25	0.5		0.25

4 Add the appropriate quantities of CFT buffer, as shown in Table 2.

5 Shake the tubes to mix the contents and place in the water bath at 37 °C ± 2 °C for 30 minutes.

6 Add 0.25 ml of the haemolytic system to all the tubes, mix well and replace in the water bath at 37 °C ± 2 °C for another 30 minutes.

7 Remove the tubes from the water bath and read the result. The quantity of complement in the first tube to show complete haemolysis is 1 exact unit and the quantity in the next tube containing more complement, 1 full unit; 2 full units are used in the diagnostic test. Calculate the dilution of complement to use in the diagnostic test using the formula:

$$\frac{40}{4 \times 2 \ \textit{full units}}$$

For example, if haemolysis is absent or incomplete in tubes 1 to 4, and complete in tubes 5 to 10, the exact unit is 0.075 and the full unit is 0.1. Then the dilution factor will be:

$$\frac{40}{4 \times 0.2} = 50$$

i.e. a dilution of 1/50 will be used in the diagnostic test.

8.2.5 Chequerboard titration of *B. abortus* CFT antigen

Antigen is commercially available from OBP and is used as per manufacturer's instructions. The working dilution of the antigen may be verified according to the following method:

1. Prepare a 1/2 master dilution as follows: 3 ml CFT buffer + 3 ml antigen.

2. Prepare the antigen dilutions in Table 3 from the 1/2 master dilution:

Table 3. Dilutions of antigen used in the antigen titration.

Dilution	1/2 Master Dilution (ml)	CFT Buffer (ml)
1/2	0.5	-
1/4	0.5	0.5
1/6	0.5	1.0
1/8	0.5	1.5
1/10	0.5	2.0
1/12	0.5	2.5
1/14	0.5	3.0
1/16	0.5	3.5

3. Use a medium titre positive serum (OPNS 4.3 reconstituted according to the manufacturer's instruction) inactivated at 58 °C ± 2 °C for 30 min.
4. Place 50 µl of inactivated positive serum in each of the first 8 wells of row A of a microtitre plate. Add 25 µl CFT buffer to wells 1 to 8 of rows B-H. (See Table 4).
5. Draw up 25 µl of serum in row A using an 8-channel pipette and dispense it into row B wells 1-8 and do doubling dilutions with CFT buffer through rows B to H leaving 25 µl diluted serum in each well. The last 25 µl of serum after diluting in row H must be discarded.
6. Add 25 µl of the correctly diluted complement to wells 1 to 8 of rows B to H.
7. Add 25 µl of the different antigen dilutions, as per Table 4, to wells 1 (1/2) to 8 (1/16) starting from row C to row H. Row B gets no antigen as it acts as the anti-complementary control.
8. Add 25 µl CFT buffer to wells 1 to 8 in row B in lieu of antigen.
9. Proceed with the complement fixation test in the routine manner. Record the results with numbers for each well representing the percentage haemolysis:

   - = 100 % haemolysis
   1 = 75 % haemolysis
   2 = 50 % haemolysis
   3 = 25 % haemolysis
   4 = 0 % haemolysis

Table 4. Plate layout for the antigen titration indicating volumes of medium titre serum and CFT buffer to be added to each dilution of antigen.

Dilutions of medium titre serum OPNS 4.3		Antigen dilutions											
ROW		1	2	3	4	5	6	7	8	9	10	11	12
		1/2	1/4	1/6	1/8	1/10	1/12	1/14	1/16				
A	Undiluted sera	50µl	50µl	50µl	50µl	50µl	50µl	50µl	50µl				
B	1 / 2	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer				
C	1 / 4	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer				
D	1 / 8	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer				
E	1 / 16	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer				
F	1 / 32	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer				
G	1 / 64	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer				
H	1 / 128	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer	25µl CFT buffer				

See Table 5 below for the results of a typical titration.

Table 5. An example of a chequerboard titration of the antigen.

Dilutions of medium titre serum (OPNS 4.3)		Antigen Dilutions											
		1/2	1/4	1/6	1/8	1/10	1/12	1/14	1/16				
	Row	1	2	3	4	5	6	7	8	9	10	11	12
	A	Used for the deposition of a medium titre serum											
1/2	B*	-	-	-	-	-	-	-	-				
1/4	C	4+	4+	4+	4+	4+	3+	2+	2+				
1/8	D	4+	4+	4+	3+	2+	-	-	-				
1/16	E	4+	4+	3+	-	-	-	-	-				
1/32	F	2+	4+	-	-	-	-	-	-				
1/64	G	-	1+	-	-	-	-	-	-				
1/128	H	-	-	-	-	-	-	-	-				

* Anti-complementary row
4+ = 0% haemolysis; 3+ = 25% haemolysis; 2+ = 50% haemolysis; 1+ = 75% haemolysis; - = 100% haemolysis

In the example, the highest titre is recorded for the antigen dilution of 1/4 and this is the dilution to be used. Any anti-complementary activity in the antigen is detected by a similar titration using a negative serum.

8.3 Inactivation of test serum

1 Prepare a 96-well microtitre plate filled with 1.2 ml polypropylene cluster tubes or test tubes in a test tube rack, in the test procedure format for the day. The wells of a 96-well microtitre plate may also be used and the plate sealed with sealing film before inactivation in a hot air oven.

2 Test serum should be clear before being pipetted into the cluster tubes or microtitre plate. Haemolysed sera cannot be tested.

3 Inactivate the test and control (positive and negative) sera in a water bath or a hot air oven, at 58 °C ± 2 °C for 30 minutes. It is important when a water bath is used that the water level covers the level of the serum.

8.4 Test Procedure (Serum dilution, reagent dispensing and incubation):

1 Dispense 25 µl CFT buffer into U-bottomed microtitre plates, beginning with row B (column 1 – 8) and proceeding to row H (column 1-8). See Figure 1, for orientation of the plate. (The plate may be orientated vertically if preferred, refer to Appendix 6).

2 For each microtitre plate row B (column 1) is used for the positive control sera, row B (column 2) is used for the negative control sera and row B (column 3 -8) is used for the test sera. (Eight sera are tested on each plate including the positive and negative controls).

3 Draw up a 25 µl volume of inactivated serum from the cluster tubes or serum microtitre plate using a 8-channel micropipette and dispense it into row B (column 1-8) of the test plate. Mix the serum and the CFT buffer in row B (column 1-8). Draw up a 25 µl volume from row B (column 1-8) and dispense it into row C (column 1-8). Draw up a 25 µl volume from row C (column 1-8) and dispense it into row D (column 1-8). Continue this serial dilution to row H (column 1-8) of the test plate. Draw up a 25 µl volume from row H (column 1-8) and discard it. This accomplishes a 1/2 serial dilution, leaving dilutions of 1/4, 1/8, 1/16, 1/32, 1/64 and 1/128 in rows C to H.

4 Repeat the procedure for the next batch of sera on a new microtitre plate.

5 Use new tips for each batch of 8 sera (including the positive and negative control sera) and for dispensing the other reagents.

6 Dispense 50 µl complement/CFT buffer into Row B (column 1-8).

7 Dispense 50 µl Complement/Antigen into the test plate from Row C (column 1-8) to Row H (column 1-8).

8 Tap the plates gently to ensure mixing of the test sera and reagents.

9 Incubate the plates at 37 °C ± 2 °C for 30 minutes. Plates must not be stacked during incubation to ensure even distribution of heat to all wells. If possible, cover the plates.

10 Dispense 50 µl haemolytic system (mix well before dispensing) into all wells of the test plates (Row B to H, Column 1-8).

11 Incubate the plates at 37 °C ± 2 °C for 30 min on a shaker and again avoid stacking the plates. If possible, cover the plates.

12 Remove the plates from the incubator and centrifuge at 1 000x g for 1 minute or leave on the work bench at room temperature for two to three hours to allow the pellets to settle. Cover the plates with lids or stack the plates, with one empty plate on top, to avoid moisture loss. Centrifugation is the preferred method.

13 Read the plates over a magnifying mirror or light box as 0 - 4+ (0 = 100% haemolysis and 4+ = 0% haemolysis) in the last dilution with a reaction and record the results in IU ml^{-1} according to Table 6.

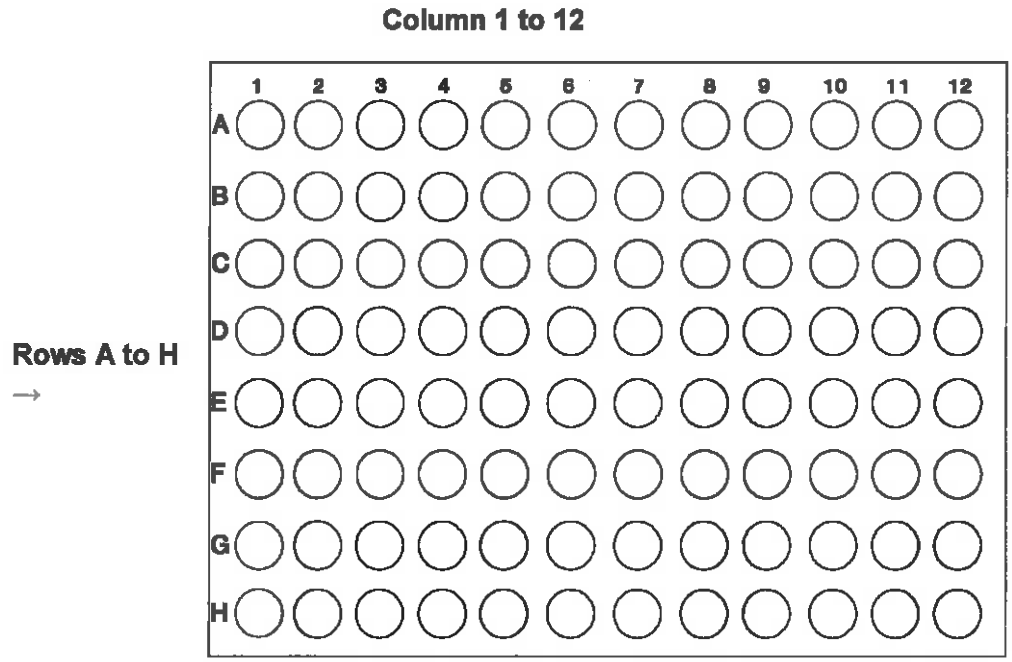


Figure 1. Orientation of the micro titre plate.

8.5 Results

1 A negative result is where no sedimentation of SRBC is present, i.e. complete haemolysis.

2 A positive result is where sedimentation of SRBC is present as a distinct button at the bottom of the well, and is scored between 1 and 4. The final dilution is determined as the dilution showing more than 0% haemolysis and is converted to international units/ml ($IUml^{-1}$) using the prescribed conversion chart (Table 6).

3 The anti-complementary well should be negative, otherwise the test for that particular serum must be repeated (with and without antigen) or the result recorded as anti-complementary.

4 The positive control on each plate should give the correct titre. (± 2 IU titres on either side are still acceptable). The negative control should always be negative.

Interpretation of CFT results scores 1 - 4

- 0 = 100 % haemolysis of SRBC. No button/pellet of SRBC at bottom, uniformly red supernatant.
- 1 = 75 % haemolysis of SRBC. Small button/pellet of SRBC at bottom of well, lighter supernatant.
- 2 = 50 % haemolysis of SRBC. Bigger button/pellet of SRBC, medium red supernatant, midway between 0 and 4.
- 3 = 25 % haemolysis of SRBC. Still bigger button/pellet of SRBC, still lighter, almost clear supernatant.
- 4 = 0 % haemolysis of SRBC. Large button/pellet of SRBC, supernatant clear, like water.

SRBC = sheep red blood cells

Table 6. The conversion of CFT endpoint reactions to IU ml^{-1} on a scale where 50% haemolysis in a 1/220 serum dilution is equivalent to 1000 IU ml^{-1}

Row	Serum Dilution[a]	Final Dilution[b]	Endpoint Reading		IU ml^{-1}[c]
			% Haemolysis	Reaction	
C	1/4	1/20	100	0 or-	0
			75	1 or +	15
			50	2 or ++	18
			25	3 or +++	21
			0	4 or ++++	24
D	1/8	1/40	75	1 or +	30
			50	2 or ++	36
			25	3 or +++	43
			0	4 or ++++	49
E	1/16	1/80	75	1 or +	60
			50	2 or ++	72
			25	3 or +++	86
			0	4 or ++++	98
F	1/32	1/160	75	1 or +	120
			50	2 or ++	145
			25	3 or +++	172
			0	4 or ++++	196
G	1/64	1/320	75	1 or +	240
			50	2 or ++	290
			25	3 or +++	344
			0	4 or ++++	392
H	1/128	1/640	75	1 or +	480
			50	2 or ++	581
			25	3 or +++	688
			0	4 or ++++	784
	1/220	1/1100	50	2 or ++	1000

a Serum dilution = dilution factor with CFT Buffer only
b Final dilution = final dilution factor after all reagents are added
c IU ml^{-1} = International Units per millilitre

9. QUALITY CONTROL

Do not test unsuitable samples – haemolysed samples due to excessive agitation or high temperatures. Only serum samples should be tested, not whole blood (e.g. EDTA or heparin tubes). Each plate is valid when the positive and negative controls on the plate produce the expected results.

9.1 Sources of Measurement Uncertainty (MU)

When a method is used to test a sample and a result is obtained, the result is likely to have an error associated with it relating to various uncertainties occurring in the sampling and testing process. The significance of these various uncertainties should be assessed. A test result is liable to deviate from the true result for a variety of reasons. The potential sources of measurement uncertainty are the following: sampling, handling and storage of samples, personnel, environmental conditions, limitations of the method, equipment, reference standards. Potential sources of measurement uncertainty can be identified by repeat testing of the same sample within and between personnel as well as with, proficiency testing.

1 Test Samples

Blood samples are taken by customers and submitted to the laboratory. Thus sampling and transport procedures are not under the control of the laboratory. Samples should be taken using Vacutest tubes, kept under 10 °C ± 2 °C during transport and reach the laboratory within 2-3 days. Once at the laboratory samples are stored at 4 °C ± 2 °C and tested within 5 days. Poor sample quality such as haemolysis or contamination could be a source of MU.

2 Personnel

Personnel carrying out the test must be trained and found to be competent by witnessing of the test procedure. Potential sources of measurement of uncertainty can be identified by repeat testing of the same samples within and between personnel as well as with inter-laboratory and proficiency testing.

3 Environmental conditions

The temperature under which the test is carried out must be within a consistent range of 22 °C ± 3 °C. The temperature of the laboratory is monitored daily. The plates used in the test should be clean and free of dust.

4 Equipment

All equipment must be calibrated/verified or serviced by approved suppliers using traceable standards where applicable.

5 Reagents

Each batch of complement, antigen and amboceptor must be titrated to ensure optimal performance. SRBC must be standardised according to accepted procedures. The

haemolytic system must be prepared carefully ensuring thorough mixing of SRBC and amboceptor. The pH of the CFT buffer should be within range.

10 Troubleshooting

10.1 Inconsistent Endpoints

- Incomplete inactivation process of the serum.
- Partial blockage in dispenser, pipette or tip.
- Viscous serum.
- Carry over.
- Stacking of plates during incubation or inactivation in hot-air oven.
- Inaccurate pipetting technique.

10.2 Incomplete Haemolysis

- Inadequate sensitization of SRBC e.g. time, temperature, mixing and haemolysin titre.
- Dirty apparatus.
- Insufficient complement.
- Anti-complementary activity (see below).
- Insufficient mixing during incubation periods.
- Insufficient incubation (time, temperature).

10.3 Anti-complementary activity

- Contaminated sera.
- Foreign antibody, antigen or their complexes in any of the reagents.
- Incomplete inactivation process (temperature, time).
- Where the anti-complementary activity decreases with dilution the serum must be involved as part of the problem (see Appendix 4). Uniform deviations exclude the involvement of the serum.

11. WASTE DISPOSAL

Laboratory waste is discarded according to the laboratory's waste disposal procedure.

12. FORMS

1 All raw data shall be captured on the relevant forms/work sheets and retained for a minimum of 5 years.
2 CA 5 form (G.P.-S.013-0215; LEB 12/132) to be used for sample registration.
3 All result entries should be clearly legible in permanent ink.
4 Use Laboratory Information Management System (LIMS) if available.

13. REPORTING

1 Report results on CA 5 form (G.P.-S.013-0215; LEB 12/132)
2 Copies of reports are to be kept for 5 years
3 In case of errors, do not use correction fluid, instead strike through the wrong entry once, write the correct entry and initialize and date.
4 Original test results are sent to the relevant State Veterinarian.

14. SPECIMEN RETENTION

1 Short term storage: Done according to different Laboratory procedures or samples are kept refrigerated 4 °C ± 2 °C for 10 working days, from time of release of results, in case a repeat test is required.
2 Long term storage: Done according to different Laboratory procedures. Some selected samples may be transferred to the serum bank and stored at -20 °C to -70 °C, depending on the duration.

THE STANDARD METHOD SHOULD BE FOLLOWED AS FAR AS POSSIBLE BUT IN CASE OF VARIATION, VALIDATION RECORDS MUST BE AVAILABLE.

15. REFERENCES

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South African National Standard, 2005, *General requirements for the competence of testing and calibration laboratories*, (ISO/IEC 17025:2005, Edition 2), Standards South Africa, Pretoria.

16. APPENDICES

APPENDIX 1 : CFT Buffer - Virion - Commercially available from Alere Healthcare and used as per manufacturer's instructions **OR** prepared by using Appendix 1a **OR** a 0.85% solution of Sodium Chloride containing Calcium and Magnesium ions can be used by following Appendix 1b.

APPENDIX 1a: Veronal Buffer

			x2 (4 litres)
Barbitone ($C_8H_{12}N_2O_3$) (5,5 Diethylbarbituric acid)	MM 184.20	5.75 g	11.5 g
Barbital-Sodium ($C_8H_{11}N_2NaO_3$)	MM 206.18	3.75 g	7.50 g
Calcium chloride ($CaCl_2.6H_2O$)	MM 219.09	0.33 g	0.66 g
or ($CaCl_2.2H_2O$)	MM 147.02	0.22 g	0.44 g
Magnesium chloride ($MgCl_2.6H_2O$)	MM 203.31	1.02 g	2.04 g
Sodium chloride (NaCl)	MM 58.44	85.00 g	170.00 g

1. Dissolve the barbitone (barbituric acid) in 1 800 ml (or 3 600 ml) hot distilled water near boiling point (80 – 90 °C).
2. Dissolve the remaining reagents.
3. Cool to room temperature and make up to 2 000 ml (or 4 000 ml) with distilled water.
4. The pH should be 7.3 - 7.4. No pH adjustment is permitted. If the pH is not within limits the buffer must be discarded.
5. This stock solution may be stored for up to 3 months at 4 °C ± 2 °C .For use in the CFT dilute the stock solution 1/5 with distilled water (1 part stock + 4 parts cold distilled water). This is prepared freshly every day.

APPENDIX 1b: 0.85% Solution of Sodium Chloride containing Calcium and Magnesium Ions.

Barbital buffered saline is the standard diluent for the CFT test, but satisfactory results are also obtained with a 0.85% solution of sodium chloride containing calcium and magnesium ions,

provided the pH lies between 7.3 and 7.4. This latter solution is prepared by adding 1 ml of the stock solution of calcium and magnesium salts to each litre of saline solution. If 0.25 ml of a 5 % solution of sodium azide is added per litre to control bacterial contamination, the solution can be stored at room temperature.

Stock solution

Anhydrous Magnesium Chloride	9.5 g
Anhydrous Calcium Chloride	3.7 g
Made up to 100ml distilled water	
Store in refrigerator at 4 °C ± 2 °C	

0.85% Solution of sodium chloride

Sodium chloride (NaCl)	8.5 g
Distilled water	1.0 litre

Working solution

Add 1 ml of the stock solution containing calcium and magnesium ions to 1.0 litre of saline solution.
Store in the refrigerator at 4 °C ± 2 °C

APPENDIX 2: Anti-coagulants Alsever's solution

Glucose D+ ($C_6H_{12}O_6$)	MM 180.16	20.50 g
Sodium chloride (NaCl)	MM 58.44	4.18 g
Sodium citrate ($Na_3C_6H_5O_7.2H_2O$)	MM 294.12	8.00 g
Citric acid ($H_3C_6H_5O_7.H_2O$)	MM 210.15	0.55 g
Distilled water		1 ℓ

1. Mix glucose in 100 ml distilled water.
2. Do not autoclave, instead filter through a 0.20 µm Millipore filter in laminar flow cabinet.
3. Add remainder of ingredients to 900 ml distilled water.
4. Autoclave at 70 kPa for 20 min.
5. Allow to cool.
6. Add glucose mixture.
7. Store at 4 °C ± 2 °C.
8. The pH should be 6.1.

The following appendices are practical aids to the test:

APPENDIX 3: 10 min Haemolysis Test for Reagents used in the CFT

APPARATUS

- Test tube rack
- Test tubes (5)
- Pipettes
- Water bath at 37 °C ± 2 °C.

REAGENTS

- Complement diluted according to the titration.
- Complement diluted 1/10. (1 ml Complement+9 ml CFT Buffer)
- Haemolytic system
- CFT Buffer

PROCEDURE

- Add the reagents to the test tubes as indicated in the table below:

Table 7. Volumes of reagents used in the 10 minute haemolysis test.

REAGENTS	TUBE NO.				
	1	2	3	4	5
Diluted complement (ml)	0.6	0.4	0.2	-	-
Complement 1/10 (ml)	-	-	-	-	0.4
CFT Buffer (ml)	0.6	0.8	1.0	1.2	0.8
Haemolytic system (ml)	0.8	0.8	0.8	0.8	0.8
Total volume (ml)	2	2	2	2	2

Incubate for 5 min in a water bath at 37 °C ± 2 °C.
Check and incubate for a further 5 min if necessary.

INTERPRETATION

- Usually complete haemolysis is seen in tube Nrs 1 (1.5 doses of complement), 2 (full dose of complement) and 5 (complement in excess) and partial haemolysis in tube Nr 3 (0.5 dose of complement), after 5 min incubation.

- If this is not seen, incubate for a further 5 min when this pattern will be seen if all the reagents are optimal.
- No haemolysis should occur in tube Nr 4 (no complement).
- Haemolysis in tube Nr 4 indicates that some factor other than complement is active e.g. i) old RBC in the H/S, or ii) hypotonicity of the CFT Buffer.
- Incomplete haemolysis in tube Nrs 1 and 2 but complete in tube Nr 5 indicates that the complement dilution used is too weak.
- Incomplete haemolysis in tube Nrs 1, 2 and 5 indicates that there is a fault with either the complement or the H/S e.g. i) complement almost totally inactive; ii) H/S not properly sensitized.

APPENDIX 4: Re-testing of Anti-complementary sera

1. Where anti-complementary activity occurs and the titre exceeds 98 IU a retest may be carried out.
2. This retest is done in duplicate excluding the antigen from the one sample and replacing it with 25 µl CFT buffer.
3. The difference in titre of the test without antigen must be three dilutions or greater lower than the test with antigen before the serum can be regarded as positive and the titre is then as read.

Example A

Table 8. Example where the difference between the test with antigen and the test without antigen is more than 3 dilutions.

ROW	Original Test Result	Repeat test with Antigen	Repeat test Without Antigen
B (Anti-complementary Control)	4	4	4
C	4	4	2
D	4	4	-
E	4	4	-
F	4	4	-
G	4	4	-
H	-	-	-
Titre Recorded	A/C	422 IU/ µl	> 3 dilution difference

A/C = Anti-complementary

Example B

Table 9. Example where the difference between the test with antigen and the test without antigen is less than 3 dilutions.

ROW	Original Test Result	Repeat test with Antigen	Repeat test Without Antigen
B (Anti complementary Control)	4	4	4
C	4	4	4
D	4	4	4
E	4	4	4
F	4	4	4
G	4	4	-
H	-	-	-
Titre Recorded	A/C	A/C	Single dilution difference

APPENDIX 5: Guidelines for the Interpretation of IU ml^{-1} Titres in Bovine Brucellosis

Table 10. Guidelines for the interpretation of IU ml^{-1} titres in bovine brucellosis in South Africa (Herr *et al.* 1985)

Vaccination history	IU ml^{-1}	Interpretation
Unvaccinated, calf hood vaccinated (< 8 months) or unknown	≤ 15 18 - 24 ≥ 30	Negative Suspicious Positive
Adult vaccinated (> 8 months)	≤ 24 30 - 49 ≥ 60	Negative Suspicious Positive

APPENDIX 6: Test procedure for reading plate in a vertical position

1. Dispense 25 µl CFT buffer into U-bottomed microtitre plates, beginning with row A (column 1 – 7) and proceeding to row H (column 1-7).
2. For each microtitre plate row G (column 1) is used for the positive control sera, row H (column 1) is used for the negative control sera and row 1A-F is used for the test sera. (Eight sera are tested on each plate including the positive and negative controls).
3. Draw up a 25 µl volume of inactivated serum and controls from the cluster tubes or serum microtitre plate using a 8-channel micropipette and dispense it into column 7A-H of the test plate. Mix the serum and the CFT buffer in column 7A-H. Draw up a 25 µl volume from column 7A-H and dispense it into column 1A-H. Draw up a 25 µl volume from column 1A-H and dispense it into column 2A-H. Continue this serial dilution to column 6A-H of the test plate. Draw up a 25 µl volume from column 6A-H and discard it.
4. Repeat the procedure for the next batch of sera on a new microtitre plate.
5. Use new tips for each batch of 8 sera (including the positive and negative control sera) and for dispensing the other reagents. If a dispenser is used for dispensing of reagents the dispenser must be rinsed with de-ionized water after each reagent used.
6. Dispense 25 µl CFT buffer into column 7A-H.
7. Dispense 25 µl Antigen into the test plate from column 1A-H to column 6A-H.
8. Dispense 25 µl Complement into the test plate from column 1A-H to column 7A-H.
9. Tap the plates gently to ensure mixing of the test sera and reagents.
10. Incubate the plates at 37 °C ± 2 °C for 30 minutes. Plates must not be stacked during incubation to ensure even distribution of heat to all wells. If possible, cover the plates.
11. Dispense 50 µl haemolytic system (mix well before dispensing) into all wells of the test plates (column 1A-H to column 7A-H).
12. Incubate the plates at 37 °C ± 2 °C for 30 min on a shaker and again avoid stacking the plates. If possible, cover the plates.
13. Remove the plates from the incubator and centrifuge at 1 000x g for 1 minute or leave on the work bench at room temperature for two to three hours to allow the pellets to settle. Cover the plates with lids or stack the plates, with one empty plate on top, to avoid moisture loss. Centrifugation is the preferred method.
14. Read the plates over a magnifying mirror or light box as 0 - 4+ (0 = 100% haemolysis and 4+ = 0% haemolysis) in the last dilution with a reaction and record the results in IU ml^{-1} according to Table 6. For results refer to point 8.5.