

Version 3a Last updated 20 November 2024

# ab223586 Human Vitamin D Binding Protein SimpleStep ELISA<sup>®</sup> Kit

For the quantitative measurement of Vitamin D Binding Protein in serum, plasma, saliva, urine, milk, and cell culture supernatants.

This product is for research use only and is not intended for diagnostic use.

# Table of Contents

1. Overview	1
2. Protocol Summary	2
3. Precautions	3
4. Storage and Stability	3
5. Limitations	4
6. Materials Supplied	4
7. Materials Required, Not Supplied	5
8. Technical Hints	5
9. Reagent Preparation	7
10. Standard Preparation	8
11. Sample Preparation	9
12. Plate Preparation	12
13. Assay Procedure	13
14. Calculations	15
15. Typical Data	16
16. Typical Sample Values	17
17. Assay Specificity	23
18. Species Reactivity	23
19. Troubleshooting	24
20. Notes	25

## 1. Overview

Vitamin D Binding Protein *in vitro* SimpleStep ELISA® (Enzyme-Linked Immunosorbent Assay) kit is designed for the quantitative measurement of Vitamin D Binding Protein in serum, plasma, saliva, urine, milk, and cell culture supernatant.

The SimpleStep ELISA® employs an affinity tag labeled capture antibody and a reporter conjugated detector antibody which immunocapture the sample analyte in solution. This entire complex (capture antibody/analyte/detector antibody) is in turn immobilized via immunoaffinity of an anti-tag antibody coating the well. To perform the assay, samples or standards are added to the wells, followed by the antibody mix. After incubation, the wells are washed to remove unbound material. TMB Development Solution is added and during incubation is catalyzed by HRP, generating blue coloration. This reaction is then stopped by addition of Stop Solution completing any color change from blue to yellow. Signal is generated proportionally to the amount of bound analyte and the intensity is measured at 450 nm. Optionally, instead of the endpoint reading, development of TMB can be recorded kinetically at 600 nm.

Vitamin D Binding Protein, also known as gc-globulin, is a 458 - amino acid, glycosylated protein encoded by the gene GC, which is in the albumin gene family. The primary function of this protein is to bind Vitamin D and its metabolites and to transport them to tissue. Vitamin D Binding protein is highly expressed and secreted into serum primarily from hepatic cells. There are three common alleles of the protein (Gc1f, Gc1s, and Gc2), and several minor polymorphisms. Different glycosylation sites are found on the isoforms of Vitamin D binding protein, a selectively deglycosylated form produced by B cell  $\beta$ -galactosidase and T cell sialidase is known as Macrophage Activating Factor. MAF has been found to block angiogenic effects of several proteins on vascular endothelial cells.

## 2. Protocol Summary

Prepare all reagents, samples, and standards as instructed



Add 50  $\mu$ L standard or sample to appropriate wells



Add 50  $\mu$ L Antibody Cocktail to all wells



Incubate at room temperature for 1 hour



Aspirate and wash each well three times with 350  $\mu$ L 1X Wash Buffer  
PT



Add 100  $\mu$ L TMB Development Solution to each well and incubate  
for 10 minutes.



Add 100  $\mu$ L Stop Solution and read OD at 450 nm

### 3. Precautions

**Please read these instructions carefully prior to beginning the assay.**

- All kit components have been formulated and quality control tested to function successfully as a kit.
- We understand that, occasionally, experimental protocols might need to be modified to meet unique experimental circumstances. However, we cannot guarantee the performance of the product outside the conditions detailed in this protocol booklet.
- Reagents should be treated as possible mutagens and should be handled with care and disposed of properly. Please review the Safety Datasheet (SDS) provided with the product for information on the specific components.
- Observe good laboratory practices. Gloves, lab coat, and protective eyewear should always be worn. Never pipet by mouth. Do not eat, drink or smoke in the laboratory areas.
- All biological materials should be treated as potentially hazardous and handled as such. They should be disposed of in accordance with established safety procedures.

### 4. Storage and Stability

**Store kit at +4°C immediately upon receipt. Kit has a storage time of 1 year from receipt, providing components have not been reconstituted.**

Refer to list of materials supplied for storage conditions of individual components.

## 5. Limitations

- Assay kit intended for research use only. Not for use in diagnostic procedures.
- Do not mix or substitute reagents or materials from other kit lots or vendors. Kits are QC tested as a set of components and performance cannot be guaranteed if utilized separately or substituted.

## 6. Materials Supplied

Item	Quantity	Storage Condition
Human Vitamin D Binding Protein Capture Antibody 10X	600 µL	+4°C
Human Vitamin D Binding Protein Detector Antibody 10X	600 µL	+4°C
Human Vitamin D Binding Protein Lyophilized Recombinant Protein	2 Vials	+4°C
Antibody Diluent 5BI	6 mL	+4°C
Wash Buffer PT 10X	20 mL	+4°C
TMB Development Solution	12 mL	+4°C
Stop Solution	12 mL	+4°C
Sample Diluent NS	50 mL	+4°C
Pre-coated microplate (12 x 8 well strips)	96 Wells	+4°C
Plate Seal	1	+4°C

## 7. Materials Required, Not Supplied

These materials are not included in the kit, but will be required to successfully perform this assay:

- Microplate reader capable of measuring absorbance at 450 or 600 nm.
- Method for determining protein concentration (BCA assay recommended).
- Deionized water.
- Multi- and single-channel pipettes.
- Tubes for standard dilution.
- Plate shaker for all incubation steps.
- Optional: Phenylmethylsulfonyl Fluoride (PMSF) (or other protease inhibitors).

## 8. Technical Hints

- Samples generating values higher than the highest standard should be further diluted in the appropriate sample dilution buffers.
- Avoid foaming or bubbles when mixing or reconstituting components.
- Avoid cross contamination of samples or reagents by changing tips between sample, standard and reagent additions.
- Ensure plates are properly sealed or covered during incubation steps.
- Complete removal of all solutions and buffers during wash steps is necessary to minimize background.
- As a guide, typical ranges of sample concentration for commonly used sample types are shown below in Sample Preparation (section 11).
- All samples should be mixed thoroughly and gently.
- Avoid multiple freeze/thaw of samples.
- Incubate ELISA plates on a plate shaker during all incubation steps.
- When generating positive control samples, it is advisable to change pipette tips after each step.

- To avoid high background always add samples or standards to the well before the addition of the antibody cocktail.
- This kit is sold based on number of tests. A 'test' simply refers to a single assay well. The number of wells that contain sample, control or standard will vary by product. Review the protocol completely to confirm this kit meets your requirements. Please contact our Technical Support staff with any questions.

## 9. Reagent Preparation

- Equilibrate all reagents to room temperature (18-25°C) prior to use. The kit contains enough reagents for 96 wells. The sample volumes below are sufficient for 48 wells (6 x 8-well strips); adjust volumes as needed for the number of strips in your experiment.
- Prepare only as much reagent as is needed on the day of the experiment. Capture and Detector Antibodies have only been tested for stability in the provided 10X formulations.

### 9.1 1X Wash Buffer PT:

Prepare 1X Wash Buffer PT by diluting Wash Buffer PT 10X with deionized water. To make 50 mL 1X Wash Buffer PT combine 5 mL Wash Buffer PT 10X with 45 mL deionized water. Mix thoroughly and gently.

### 9.2 Antibody Cocktail:

Prepare Antibody Cocktail by diluting the capture and detector antibodies in Antibody Diluent 5BI. To make 3 mL of the Antibody Cocktail combine 300  $\mu$ L 10X Capture Antibody and 300  $\mu$ L 10X Detector Antibody with 2.4 mL Antibody Diluent 5BI. Mix thoroughly and gently.

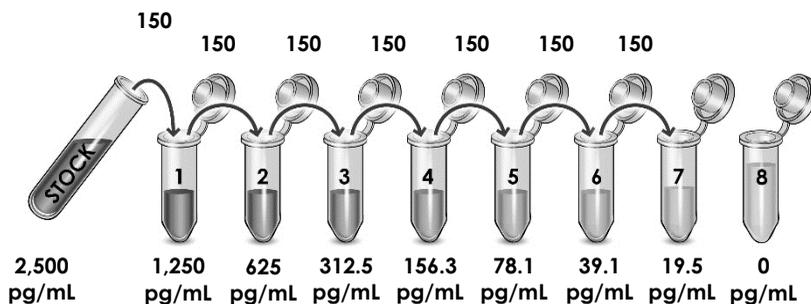
## 10. Standard Preparation

- Always prepare a fresh set of standards for every use.
- Discard working standard dilutions after use as they do not store well.
- The following section describes the preparation of a standard curve for duplicate measurements (recommended).

**10.1 IMPORTANT:** If the protein standard vial has a volume identified on the label, reconstitute the Vitamin D Binding Protein by adding that volume of Sample Diluent NS indicated on the label. Alternatively, if the vial has a mass identified, reconstitute the Vitamin D Binding Protein standard by adding 1,000  $\mu\text{L}$  Sample Diluent NS. Hold at room temperature for 10 minutes and mix gently. This is the 2,500  $\text{pg/mL}$  **Stock Standard** Solution.

**10.2** Label eight tubes, Standards 1– 8 and add 150  $\mu\text{L}$  Sample Diluent NS into each tube.

**10.3** Use the Stock Standard to prepare the following dilution series. Standard #8 contains no protein and is the Blank control:



## 11. Sample Preparation

Typical Sample Dynamic Range	
Sample Type	Range
Human Plasma - Heparin	1:16,000,000-1: 500,000
Human Plasma - EDTA	1:16,000,000-1: 500,000
Human Plasma - Citrate	1:16,000,000-1: 500,000
Human Serum	1:16,000,000-1: 500,000
Human Saliva	1:12,800 -1: 800
Human Urine	1: 3,200- 1: 100
Human Milk	1:128,000 -1: 8,000
RPMI+10% Fetal Bovine serum	1.56-50%

### 11.1 Plasma:

Collect plasma using citrate, EDTA or heparin. Centrifuge samples at 2,000 x g for 10 minutes. Dilute samples into Sample Diluent NS and assay. Store un-diluted plasma samples at -20°C or below for up to 3 months. Avoid repeated freeze-thaw cycles.

### 11.2 Serum:

Samples should be collected into a serum separator tube. After clot formation, centrifuge samples at 2,000 x g for 10 minutes and collect serum. Dilute samples into Sample Diluent NS and assay. Store un-diluted serum at -20°C or below. Avoid repeated freeze-thaw cycles.

**Δ Note:** Due to the high dilutions required for certain Human serum and plasma samples, we recommend initially diluting your samples in 1X Wash Buffer and then performing the final dilution in Sample Diluent NS. As an example, the table below demonstrates the steps suggested to generate a final sample dilution of 1: 500,000:

Tube #	Sample to Dilute	Volume of Sample (µL)	Volume of 1X Wash Buffer (µL)	Volume of Sample Diluent NS (µL)	Starting Conc.	Final Conc.
1	Neat serum/plasma	5	995	-	Neat	1:200
2	Tube #1	5	495	-	1:1,000	1:20,000
3	Tube #2	5	-	120	1:20,000	1:500,000

### 11.3 Cell Culture Supernatants:

Centrifuge cell culture media at 2,000 x g for 10 minutes to remove debris. Collect supernatants and assay. Or dilute samples into Sample Diluent NS and assay. Store un-diluted samples at -20°C or below. Avoid repeated freeze-thaw cycles.

### 11.4 Urine:

Centrifuge urine at 2,000 x g for 10 minutes to remove debris. Collect supernatants, dilute in Sample Diluent NS and assay. Store un-diluted samples at -20°C or below. Avoid repeated freeze-thaw cycles.

### **11.5 Saliva:**

Centrifuge saliva at 800 x g for 10 minutes to remove debris. Collect supernatants and assay OR Dilute samples into Sample Diluent NS and assay. Store un-diluted samples at -20°C or below. Avoid repeated freeze-thaw cycles.

### **11.6 Milk:**

De-fat milk samples as follows. Centrifuge milk samples at 500 x g for 15 minutes at 4°C and collect the aqueous fraction using syringe attached to needle. Centrifuge the aqueous fraction at 3,000 x g for 15 minutes at 4°C and collect the final aqueous fraction (de-fatted milk) using syringe attached to needle. Dilute the de-fatted milk samples at least 1.5 X in Sample Diluent NS and assay. Store un-diluted de-fatted milk at -20°C or below. Avoid repeated freeze-thaw cycles.

## 12. Plate Preparation

- The 96 well plate strips included with this kit are supplied ready to use. It is not necessary to rinse the plate prior to adding reagents.
- Unused plate strips should be immediately returned to the foil pouch containing the desiccant pack, resealed and stored at 4°C.
- For each assay performed, a minimum of two wells must be used as the zero control.
- For statistical reasons, we recommend each sample should be assayed with a minimum of two replicates (duplicates).
- Differences in well absorbance or “edge effects” have not been observed with this assay.

## 13. Assay Procedure

- Equilibrate all materials and prepared reagents to room temperature prior to use.
  - We recommend that you assay all standards, controls and samples in duplicate.
- 13.1** Prepare all reagents, working standards, and samples as directed in the previous sections.
  - 13.2** Remove excess microplate strips from the plate frame, return them to the foil pouch containing the desiccant pack, reseal and return to 4°C storage.
  - 13.3** Add 50 µL of all sample or standard to appropriate wells.
  - 13.4** Add 50 µL of the Antibody Cocktail to each well.
  - 13.5** Seal the plate and incubate for 1 hour at room temperature on a plate shaker set to 400 rpm.
  - 13.6** Wash each well with 3 x 350 µL 1X Wash Buffer PT. Wash by aspirating or decanting from wells then dispensing 350 µL 1X Wash Buffer PT into each well. Wash Buffer PT should remain in wells for at least 10 seconds. Complete removal of liquid at each step is essential for good performance. After the last wash invert the plate and tap gently against clean paper towels to remove excess liquid.
  - 13.7** Add 100 µL of TMB Development Solution to each well and incubate for 10 minutes in the dark on a plate shaker set to 400 rpm.

*Given variability in laboratory environmental conditions, optimal incubation time may vary between 5 and 20 minutes.*

*Note: The addition of Stop Solution will change the color from blue to yellow and enhance the signal intensity about 3X. To avoid signal saturation, proceed to the next step before the high concentration of the standard reaches a blue color of O.D.600 equal to 1.0.*
  - 13.8** Add 100 µL of Stop Solution to each well. Shake plate on a plate shaker for 1 minute to mix. Record the OD at 450 nm. This is an endpoint reading.
  - 13.9** Alternative to 13.7 – 13.8: Instead of the endpoint reading at 450 nm, record the development of TMB Substrate kinetically. Immediately after addition of TMB Development Solution begin recording the blue color development with elapsed

time in the microplate reader prepared with the following settings:

<b>Mode</b>	<b>Kinetic</b>
Wavelength:	600 nm
Time:	up to 20 min
Interval:	20 sec - 1 min
Shaking:	Shake between readings

**Δ Note:** that an endpoint reading can also be recorded at the completion of the kinetic read by adding 100  $\mu$ L Stop Solution to each well and recording the OD at 450 nm.

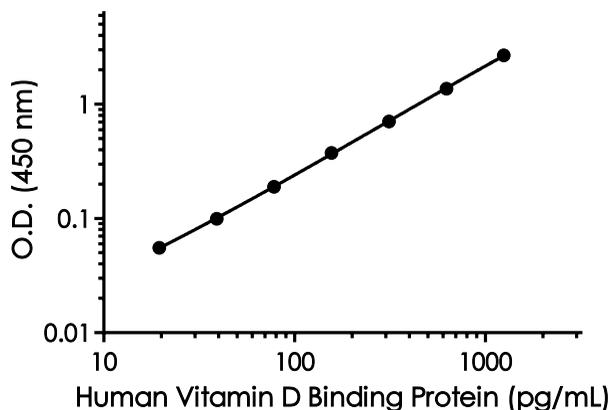
**13.10** Analyze the data as described below.

## 14. Calculations

- 14.1 Calculate the average absorbance value for the blank control (zero) standards. Subtract the average blank control standard absorbance value from all other absorbance values.
- 14.2 **Create a standard curve** by plotting the average blank control subtracted absorbance value for each standard concentration (y-axis) against the target protein concentration (x-axis) of the standard. Use graphing software to draw the best smooth curve through these points to construct the standard curve.
  - Δ **Note:** Most microplate reader software or graphing software will plot these values and fit a curve to the data. A four parameter curve fit (4PL) is often the best choice; however, other algorithms (e.g. linear, semi-log, log/log, 4 parameter logistic) can also be tested to determine if it provides a better curve fit to the standard values.
- 14.3 Determine the concentration of the target protein in the sample by interpolating the blank control subtracted **absorbance values against the standard curve**. Multiply the resulting value by the appropriate sample dilution factor, if used, to obtain the concentration of target protein in the sample.
- 14.4 Samples generating absorbance values greater than that of the highest standard should be further diluted and reanalyzed. Similarly, samples which measure at an absorbance values less than that of the lowest standard should be retested in a less dilute form.

## 15. Typical Data

Typical standard curve – data provided for demonstration purposes only. A new standard curve must be generated for each assay performed.



Standard Curve Measurements			
Concentration (pg/mL)	O.D 450 nm		Mean O.D
	1	2	
0	0.074	0.068	0.071
19.53	0.123	0.130	0.126
39.06	0.176	0.165	0.171
78.13	0.255	0.266	0.260
156.25	0.445	0.448	0.447
312.5	0.760	0.797	0.779
625	1.439	1.442	1.441
1,250	2.705	2.779	2.742

**Figure 1.** Example of human Vitamin D Binding Protein standard curve in Sample Diluent NS. The Vitamin D Binding Protein standard curve was prepared as described in Section 10. Raw data values are shown in the table. Background-subtracted data values (mean +/- SD) are graphed.

## 16. Typical Sample Values

### SENSITIVITY –

The calculated minimal detectable dose (MDD) is 2.8 pg/mL. The MDD was determined by calculating the mean of zero standard replicates (n=8) and adding 2 standard deviations then extrapolating the corresponding concentration.

### RECOVERY –

Three concentrations of Vitamin D Binding Protein were spiked in duplicate to the indicated biological matrix to evaluate signal recovery in the working range of the assay.

Sample Type	Average % Recovery	Range (%)
Serum (1:4,000,000)	95	91-99
Plasma- EDTA (1:4,000,000)	101	94-105
Plasma- Citrate (1:4,000,000)	98	94-102
Plasma- Heparin (1:4,000,000)	92	88-96
Milk (1:32,000)	102	93-108
Saliva (1:1,600)	99	86-107
Urine (1:800)	102	99-108
RPMI+10% FBS (25%)	95	95-95

## Linearity of Dilution

Linearity of dilution is determined based on interpolated values from the standard curve. Linearity of dilution defines a sample concentration interval in which interpolated target concentrations are directly proportional to sample dilution.

Native Vitamin D Binding Protein was measured in the following biological samples in a 2-fold dilution series. Sample dilutions are made in Sample Diluent NS.

Dilution Factor	Interpolated value	1:500,000 Human Serum	1:500,000 Human Plasma (Citrate)	1:500,000 Human Plasma (EDTA)	1:500,000 Human Plasma (Heparin)
Undiluted	pg/mL	835	741	1004	532
	<b>% Expected value</b>	100	100	100	100
2	pg/mL	438	378	550	269
	<b>% Expected value</b>	105	102	109	101
4	pg/mL	203	189	276	134
	<b>% Expected value</b>	97	102	110	101
8	pg/mL	110	94	137	67
	<b>% Expected value</b>	105	102	110	101
16	pg/mL	55	48	72	35
	<b>% Expected value</b>	102	104	114	105

NL – Non-Linear

Native Vitamin D Binding Protein was measured in the following biological samples in a 2-fold dilution series. Sample dilutions are made in Sample Diluent NS.

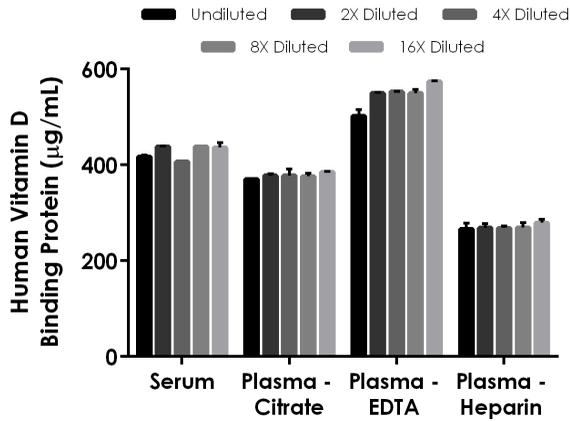
Recombinant Vitamin D Binding Protein was spiked into RPMI media containing 10% fetal bovine serum and diluted in a 2-fold dilution series in Sample Diluent NS.

Dilution Factor	Interpolated value	1:8,000 Human Milk	1:800 Human Saliva	1% Human Urine	50% RPMI+10% FBS
Undiluted	pg/mL	744	383	575	638
	% Expected value	100	100	100	100
2	pg/mL	329	179	272	301
	% Expected value	88	94	95	94
4	pg/mL	159	87	134	154
	% Expected value	86	90	93	96
8	pg/mL	78	44	68	77
	% Expected value	84	92	95	96
16	pg/mL	40	23	35	41
	% Expected value	87	95	96	102

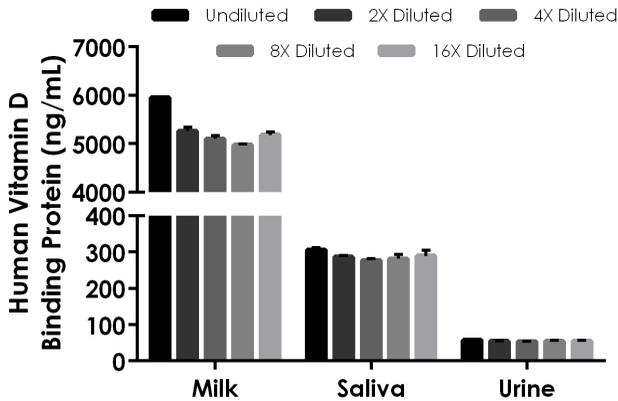
## PRECISION –

Mean coefficient of variations of interpolated values from Vitamin D Binding Protein within the working range of the assay.

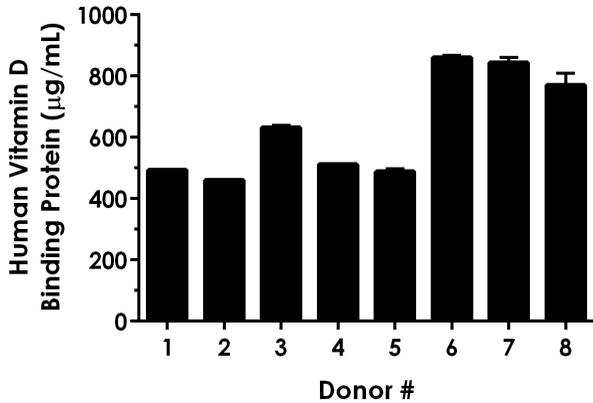
	Intra-Assay	Inter-Assay
n =	6	3
CV(%)	3	4.3



**Figure 2.** Interpolated concentrations of native Vitamin D Binding Protein in human serum and plasma samples. The concentrations of Vitamin D Binding Protein were measured in duplicates, interpolated from the Vitamin D Binding Protein standard curves and corrected for sample dilution. All undiluted samples start at 1:500,000 in Sample Diluent NS. The interpolated dilution factor corrected values are plotted (mean +/- SD, n=2). The mean Vitamin D Binding Protein concentration was determined to be 427 µg /mL in neat serum, 380 µg /mL in neat plasma (citrate), 552 µg /mL in neat plasma (EDTA), and 271 µg/mL in neat plasma Heparin.



**Figure 3** Interpolated concentrations of native Vitamin D Binding Protein in human milk, saliva, and urine samples. The concentrations of Vitamin D Binding Protein were measured in duplicates, interpolated from the Vitamin D Binding Protein standard curves and corrected for sample dilution. All undiluted samples start at 1:500,000 in Sample Diluent NS. The interpolated dilution factor corrected values are plotted (mean +/- SD, n=2). The mean Vitamin D Binding Protein concentration was determined to be 5,280 ng /mL in neat milk, 288 ng/mL in neat saliva, and 56 ng /mL in neat urine.



**Figure 4.** Serum from ten individual healthy human female donors was measured in duplicate. Interpolated dilution factor corrected values are plotted (mean +/- SD, n=2). The mean Vitamin D Binding Protein concentration was determined to be 632 µg/mL with a range of 460 – 866 µg/mL.

## 17. Assay Specificity

This kit recognizes both native and recombinant human Vitamin D Binding Protein in serum, plasma, milk, urine, saliva, and cell culture supernatant samples only. This kit uses monoclonal antibodies raised against the canonical sequence of human Vitamin D Binding Protein, which have overlapping regions with the other major isoforms of the protein.

Cell extracts samples have not been tested with this kit.

### CROSS REACTIVITY

Recombinant mouse Vitamin D Binding Protein was prepared at 2 ng/mL and assayed for cross reactivity. No cross-reactivity was observed.

## 18. Species Reactivity

This kit recognizes native and recombinant human Vitamin D Binding Protein.

Other species reactivity was determined by measuring a 1: 250,000 dilution serum samples of various species, interpolating the protein concentrations from the human standard curve, and expressing the interpolated concentrations as a percentage of the protein concentration in human serum assayed at the same dilution.

Reactivity < 3% was determined for the following species:

- Mouse
- Rat
- Cow
- Rabbit

Please contact our Technical Support team for more information.

## 19. Troubleshooting

Problem	Reason	Solution
<b>Poor standard curve</b>	Inaccurate Pipetting	Check pipettes
	Improper standard dilution	Prior to opening, briefly spin the stock standard tube and dissolve the powder thoroughly by gentle mixing
<b>Low Signal</b>	Incubation times too brief	Ensure sufficient incubation times; increase to 2 or 3 hour standard/sample incubation
	Inadequate reagent volumes or improper dilution	Check pipettes and ensure correct preparation
	Incubation times with TMB too brief	Ensure sufficient incubation time until blue color develops prior addition of Stop solution
<b>Large CV</b>	Plate is insufficiently washed	Review manual for proper wash technique. If using a plate washer, check all ports for obstructions.
	Contaminated wash buffer	Prepare fresh wash buffer
<b>Low sensitivity</b>	Improper storage of the ELISA kit	Store your reconstituted standards at -80°C, all other assay components 4°C. Keep TMB substrate solution protected from light.
<b>Precipitate in Diluent</b>	Precipitation and/or coagulation of components within the Diluent.	Precipitate can be removed by gently warming the Diluent to 37°C.

# 20. Notes

# Technical Support

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