C-Peptide/Insulin VAST®
Diabetes Panel Test System
Product Code: 7325-300

1.0 INTRODUCTION

Intended Use: Quantitative determination of Insulin or C-Peptide concentration levels in human serum by a Microplate Enzyme Immunoassay, Colorimetric.

2.0 SUMMARY AND EXPLANATION OF THE TEST

Diabetes is one of the leading causes of disability and death in the U.S. It affects an estimated 16 million Americans - about one third of them do not even know they have the disease. The causes of diabetes are not precisely known, but both genetic and environmental factors play a significant role. The disease is marked by deficiencies in the body's ability to produce and properly use insulin. The most common forms of diabetes are type 1, in which the body's ability to produce insulin is destroyed, and type 2, in which the body is resistant to insulin even though some amount of insulin may be produced.

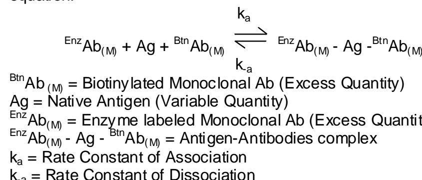
In-vitro determination of insulin and *C-Peptide* levels help in the differential diagnosis of liver disease, acromegaly, Cushing's syndrome, familial glucose intolerance, insulinoma, renal failure, ingestion of accidental oral hypoglycemic drugs or insulin induced factitious hypoglycemia. Both insulin and *C-Peptide* are produced by enzymatic cleavage of proinsulin. Proinsulin is stored in the secretory granules of pancreatic β-cells and is split into a 31 amino acid connecting peptide (*C-Peptide;* MW 3600) and insulin (MW 6000). *C-Peptide* is devoid of any biological activity but appears to be necessary to maintain the structural integrity of insulin. Although insulin and *C-Peptide* are secreted into portal circulation in equimolar concentrations, fasting levels of *C-Peptide* are 5-10 fold higher than those of insulin owing to the longer half-life of *C-Peptide.* The liver does not extract *C-Peptide*, however; it is removed from the circulation by degradation in the kidneys with a fraction passing out unchanged in urine. Hence urine *C-Peptide* levels correlate well with fasting *C-Peptide* levels in serum. The glucagon stimulated *C-Peptide* determination is often used for differential diagnosis of insulin-dependent from non-insulin-dependent diabetic patients.

The circulatory insulin can be found at much higher levels in patients with pancreatic tumors. These tumors secrete abnormally high levels of insulin and thus cause hypoglycemia. Accordingly, fasting hypoglycemia associated with inappropriately high concentrations of insulin strongly suggests an islet-cell tumor (insulinoma). To distinguish insulinomas from factitious hypoglycemia due to insulin administration, serum C-peptide values are recommended. These insulinomas can be localized by provocative intravenous doses of *tolbutamide* and *calcium.*

3.0 PRINCIPLE

Immunoenzymometric assay (TYPE 3): The essential reagents required for an immunoenzymometric assay include high affinity and specificity antibodies (Ab), (enzyme conjugated and immobilized), with different and distinct epitope recognition, **in excess,** and native antigen (Ag). In this procedure, the immobilization takes place during the assay at the surface of a microplate well through the interaction of streptavidin coated on the well and exogenously added biotinylated monoclonal Insulin antibody.

Upon mixing monoclonal biotinylated antibody, the enzyme-labeled antibody and a serum containing the native antigen, reaction results between the native antigen and the antibodies, without competition or steric hindrance, to form a soluble sandwich complex. The interaction is illustrated by the following equation:



$$^{Enz}Ab_{(M)} + Ag + {}^{Btn}Ab_{(M)} \underset{k_{-a}}{\overset{k_a}{\rightleftharpoons}} {}^{Enz}Ab_{(M)} - Ag - {}^{Btn}Ab_{(M)}$$

$^{Btn}Ab_{(M)}$ = Biotinylated Monoclonal Ab (Excess Quantity)
Ag = Native Antigen (Variable Quantity)
$^{Enz}Ab_{(M)}$ = Enzyme labeled Monoclonal Ab (Excess Quantity)
$^{Enz}Ab_{(M)} - Ag - {}^{Btn}Ab_{(M)}$ = Antigen-Antibodies complex
k_a = Rate Constant of Association
k_{-a} = Rate Constant of Dissociation

Simultaneously, the complex is deposited to the well through the high affinity reaction of streptavidin and biotinylated antibody. This interaction is illustrated below:

$^{Enz}Ab_{(M)} - Ag - {}^{Btn}Ab_{(M)}$ + Streptavidin$_{CW}$ ⇒ Immobilized complex
Streptavidin$_{CW}$ = Streptavidin immobilized on well
Immobilized complex = sandwich complex bound to the solid surface

After equilibrium is attained, the antibody-bound fraction is separated from unbound antigen by decantation or aspiration. The enzyme activity in the antibody-bound fraction is directly proportional to the native antigen concentration. By utilizing several different serum references of known antigen values, a dose response curve can be generated from which the antigen concentration of an unknown can be ascertained.

4.0 REAGENTS

Materials Provided:

A. **C-Pep/Ins Calibrators - 2ml/vial (Dried) - Icons A-F**
Six (6) vials of references for Insulin and C-Peptide antigens at levels of 0(**A**), 5(**B**), 25(**C**), 50(**D**), 100(**E**), and 300(**F**) µIU/ml for Insulin and 0(**A**), 0.2(**B**), 1.0(**C**), 2.0(**D**), 5.0(**E**), and 10.0(**F**) ng/ml for C-Peptide. Reconstitute each vial with 2ml of distilled or deionized water.
For C-Peptide, the assay should be performed immediately; reconstituted vials can be stored at 2-8°C for 8 hours then discarded. For Insulin, the reconstituted calibrators are stable for 3 days when stored at 2-8°C. In order to store for a longer period of time aliquot the reconstituted calibrators in cryo vials and store at -20°C. ***DO NOT FREEZE THAW MORE THAN ONCE.*** A preservative has been added.

Note: The human serum-based calibrators were calibrated using a reference preparation, assayed against the WHO 1st IRP 66/304 for Insulin and WHO 1st IRP 84/510 for C-Peptide.

B. **Insulin Enzyme Reagent – 13ml/vial - Icon E**
One (1) vial containing enzyme labeled affinity purified monoclonal mouse x-insulin IgG, biotinylated monoclonal mouse x-insulin IgG in buffer, dye and preservative. Store at 2-8°C.

C. **C-Peptide Enzyme Reagent – 13ml/vial - Icon E**
One (1) vial containing enzyme labeled affinity purified monoclonal mouse antibody, biotinylated monoclonal mouse IgG in buffer, dye, and preservative. Store at 2-8°C.

D. **Streptavidin Coated Plate – 96 wells – Icon ⇓**
One 96-well microplate coated with streptavidin and packaged in an aluminum bag with a drying agent. Store at 2-8°C.

E. **Wash Solution Concentrate – 20ml/vial - Icon**
One (1) vial containing a surfactant in phosphate buffered saline. A preservative has been added. Store at 2-30°C.

F. **Substrate A – 7ml/vial – Icon S^A**
One (1) vial containing tetramethylbenzidine (TMB) in buffer. Store at 2-8°C. See "Reagent Preparation."

G. **Substrate B – 7ml/vial – Icon S^B**
One (1) vial containing hydrogen peroxide (H_2O_2) in buffer. Store at 2-8°C. See "Reagent Preparation."

H. **Stop Solution – 8ml/vial - Icon STOP**
One (1) vial containing a strong acid (1N HCl). Store at 2-30°C

I. **Product Instructions**

Note 1: Do not use reagents beyond the kit expiration date.

Note 2: Opened reagents are stable for sixty (60) days when stored at 2-8°C except for calibrators.

Note 3: Above reagents are for a single 96-well microplate.

4.1 Required But Not Provided:

1. Pipette(s) capable of delivering 0.050 & 0.100ml (50 & 100µl) volumes with a precision of better than 1.5%.
2. Dispenser(s) for repetitive deliveries of 0.100 & 0.350ml (100 & 300µl) volumes with a precision of better than 1.5%.
3. Microplate washer or a squeeze bottle (optional).
4. Microplate Reader with 450nm and 620nm wavelength absorbance capability (The 620nm filter is optional)
5. Absorbent Paper for blotting the microplate wells.
6. Plastic wrap or microplate cover for incubation steps.
7. Vacuum aspirator (optional) for wash steps.
8. Timer.
9. Storage container for storage of wash buffer.
10. Distilled or deionized water.
11. Quality Control Materials.

5.0 PRECAUTIONS

For In Vitro Diagnostic Use
Not for Internal or External Use in Humans or Animals

All products that contain human serum have been found to be non-reactive for Hepatitis B Surface antigen, HIV 1&2 and HCV antibodies by FDA required tests. Since no known test can offer complete assurance that infectious agents are absent, all human serum products should be handled as potentially hazardous and capable of transmitting disease. Good laboratory procedures for handling blood products can be found in the Center for Disease Control / National Institute of Health, "Biosafety in Microbiological and Biomedical Laboratories," 2nd Edition, 1988, HHS

Safe Disposal of kit components must be according to local regulatory and statutory requirement.

6.0 SPECIMEN COLLECTION AND PREPARATION

The specimens shall be blood, serum or plasma in type, and the usual precautions in the collection of venipuncture samples should be observed. For accurate comparison to established normal values, a fasting morning serum sample should be obtained. The blood should be collected in a plain redtop venipuncture tube without additives or anti-coagulants (for serum) or evacuated tube(s) containing EDTA or heparin. Allow the blood to clot for serum samples. Centrifuge the specimen to separate the serum or plasma from the cells.

In patients receiving therapy with high biotin doses (i.e. >5mg/day), no sample should be taken until at least 8 hours after the last biotin administration, preferably overnight to ensure fasting sample.

Samples may be refrigerated at 2-8°C for a maximum period of five (5) days. If the specimen(s) cannot be assayed within this time, the sample(s) may be stored at temperatures of -20°C for up to 30 days. Avoid use of contaminated devices. Avoid repetitive freezing and thawing. When assayed in duplicate, 0.100ml (100µl) of the specimen is required.

7.0 QUALITY CONTROL

Each laboratory should assay controls at levels in the low, normal and elevated range for monitoring assay performance. These controls should be treated as unknowns and values determined in every test procedure performed. Quality control charts should be maintained to follow the performance of the supplied reagents. Pertinent statistical methods should be employed to ascertain trends. Significant deviation from established performance can indicate unnoticed change in experimental conditions or degradation of kit reagents. Fresh reagents should be used to determine the reason for the variations.

8.0 REAGENT PREPARATION

1. **Wash Buffer**
Dilute contents of wash solution to 1000ml with distilled or deionized water in a suitable storage container. Store diluted buffer at 2-30°C for up to 60 days.
2. **Working Substrate Solution –** Stable for one (1) year.
Pour the contents of the amber vial labeled Solution 'A' into the clear vial labeled Solution 'B'. Place the yellow cap on the clear vial for easy identification. Mix and label accordingly. Store at 2 - 8°C.

Note 1: Do not use the working substrate if it looks blue.
Note 2: Do not use reagents that are contaminated or have bacteria growth.

9.0 TEST PROCEDURE

Before proceeding with the assay, bring all reagents, reference calibrators and controls to room temperature (20 - 27 C).
*****Test procedure should be performed by a skilled individual or trained professional*****

1. Format the microplates' wells for calibrator, control and patient specimen to be assayed in duplicate. **Replace any unused microwell strips back into the aluminum bag, seal and store at 2-8°C.**
2. Pipette 0.050ml (50µl) of the appropriate calibrators, controls and samples into the assigned wells.
3. Add 0.100ml (100µl) of the Insulin **or C-Peptide Enzyme** Reagent to each well. **It is very important to dispense all reagents close to the bottom of the microwell.**
4. Swirl the microplate gently for 20-30 seconds to mix. Cover with a plastic wrap.
5. Incubate for 120 minutes at room temperature (20-27°C).
6. Discard the contents of the microplate by decantation or aspiration. If decanting, tap and blot the plate dry with absorbent paper.
7. Add 0.350ml (350µl) of wash buffer (see "Reagent Preparation"), decant (tap and blot) or aspirate. Repeat two (2) additional times for a total of three (3) washes. **An automatic or manual plate washer can be used. Follow the manufacturer's instruction for proper usage. If a squeeze bottle is used, fill each well to the top by squeezing the container. Avoiding air bubbles. Decant the wash and repeat two (2) additional times.**
8. Add 0.100ml (100µl) of working substrate solution to all wells (see "Reagent Preparation").

DO NOT SHAKE THE PLATE AFTER SUBSTRATE ADDITION

9. Incubate at room temperature for fifteen (15) minutes.
10. Add 0.050ml (50µl) of stop solution to each well and mix gently for 15-20 seconds. **Always add reagents in the same order to minimize reaction time differences between wells.**
11. Read the absorbance in each well at 450nm (using a reference wavelength of 620-630nm to minimize well imperfections) in a microplate reader. **The results should be read within thirty (30) minutes of adding the stop solution.**

10.0 CALCULATION OF RESULTS

A dose response curve is used to ascertain the concentration of Insulin or C-Peptide in unknown specimens.

1. Record the absorbance obtained from the printout of the microplate reader as outlined in Example 1 or Example 2.
2. Plot the absorbance for each duplicate serum reference versus the corresponding Insulin **or C-Peptide** concentration in µIU/ml or ng/ml on linear graph paper (do not average the duplicates of the serum references before plotting).
3. Draw the best-fit curve through the plotted points.
4. To determine the concentration of Insulin **or C-Peptide** for an unknown, locate the average absorbance of the duplicates for each unknown on the vertical axis of the graph, find the intersecting point on the curve, and read the concentration (in µIU/ml) from the horizontal axis of the graph (the duplicates of the unknown may be averaged as indicated). In the following example, the average absorbance (0.624) **(0.405)** intersects the dose response curve at 66.8 µIU/ml **(0.82ng/ml)** for the Insulin **(C-Peptide)** concentration (See Figure 1).

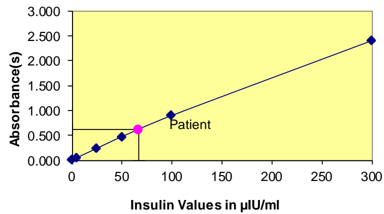
Note: Computer data reduction software designed for ELISA assays may also be used for the data reduction. If such software is utilized the validation of the software should be ascertained.

*The data presented in Example 1-2 and Figure 1-2 are for illustration only and **should not** be used in lieu of a dose response curve prepared with each assay.

EXAMPLE 1

Sample I.D.	Well Number	Abs (A)	Mean Abs (B)	Value (µIU/ml)
Cal A	A1	0.011	0.010	0
	B1	0.009		
Cal B	C1	0.054	0.054	5
	D1	0.053		
Cal C	E1	0.244	0.243	25
	F1	0.241		
Cal D	G1	0.464	0.476	50
	H1	0.488		
Cal E	A2	0.882	0.902	100
	B2	0.922		
Cal F	C2	2.467	2.405	300
	D2	2.342		
Ctrl 1	E2	0.065	0.065	6.4
	F2	0.067		
Ctrl 2	G2	1.581	1.587	188.0
	H2	1.593		
Patient 1	A3	0.597	0.624	66.8
	B3	0.651		

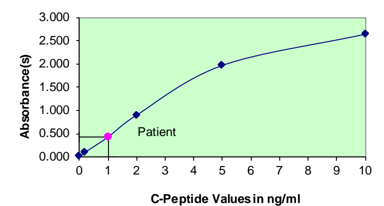
Figure 1



EXAMPLE 2

Sample I.D.	Well Number	Abs (A)	Mean Abs (B)	Value (ng//ml)
Cal A	A1	0.022	0.022	0
	B1	0.023		
Cal B	C1	0.097	0.103	0.2
	D1	0.107		
Cal C	E1	0.421	0.429	1
	F1	0.439		
Cal D	G1	0.889	0.901	2
	H1	0.910		
Cal E	A2	1.976	1.971	5
	B2	1.966		
Cal F	C2	2.717	2.643	10
	D2	2.570		
Ctrl 1	E2	0.429	0.433	1.03
	F2	0.437		
Ctrl 2	G2	1.861	1.887	4.64
	H2	1.913		
Patient 1	A3	0.388	0.405	0.82
	B3	0.421		

Figure 2



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11.0 QC PARAMETERS

In order for the assay results to be considered valid the following criteria should be met:

1. The absorbance (OD) of calibrators 0 µIU/ml should be < 0.1.
2. The absorbance (OD) of calibrators 300 µIU/ml or 10ng/ml should be > 1.3.
3. Four out of six quality control pools should be within the established ranges.

12.0 RISK ANALYSIS

The MSDS and Risk Analysis Form for this product are available on request from Monobind Inc.

12.1 Assay Performance

1. It is important that the time of reaction in each well is held constant to achieve reproducible results.
2. Pipetting of samples should not extend beyond ten (10) minutes to avoid assay drift.
3. Highly lipemic, hemolyzed or grossly contaminated specimen(s) should not be used.
4. If more than one (1) plate is used, it is recommended to repeat the dose response curve.
5. The addition of substrate solution initiates a kinetic reaction, which is terminated by the addition of the stop solution. The substrate and stop solution should be added in the same sequence to eliminate any time-deviation during reaction.
6. Plate readers measure vertically. Do not touch the bottom of the wells.
7. Failure to remove adhering solution adequately in the aspiration or decantation wash step(s) may result in poor replication and spurious results.
8. Use components from the same lot. No intermixing of reagents from different batches.
9. Patient samples with Insulin concentrations above 300µIU/ml (Insulin) or 10ng/ml (C-Peptide) may be diluted with the zero calibrator and re-assayed. Multiply the value obtained by the dilution factor to obtain the corrected value.
10. Accurate and precise pipetting, as well as following the exact time and temperature requirements prescribed, is essential. Any deviation from IFU may yield inaccurate results.
11. All applicable national standards, regulations and laws including, but not limited to, good laboratory procedures must be strictly followed to ensure compliance and proper usage.
12. It is important to calibrate all the equipment e.g. Pipettes, Readers, Washers and/or the automated instruments used with this device, and to perform routine preventative maintenance.
13. Risk Analysis- as required by CE Mark IVD Directive 98/79/EC - for this and other devices, made by Monobind, can be requested via email from Monobind@monobind.com.

12.2 Interpretation

1. ***Measurements and interpretation of results must be performed by a skilled individual or trained professional.***
2. Laboratory results alone are only one aspect for determining patient care and should not be the sole basis for therapy, particularly if the results conflict with other determinants.
3. The reagents for the test system procedure have been formulated to eliminate maximal interference; however, potential interaction between rare serum specimens and test reagents can cause erroneous results. Heterophilic antibodies often cause these interactions and have been problems for all kinds of immunoassays (Boscato LM Stuart MC. 'Heterophilic antibodies: a problem for all immunoassays' Clin Chem 1988: 3427-33). For diagnostic purposes, the results from this assay should be used in combination with clinical examination, patient history and all other clinical findings.
4. For valid test results, adequate controls and other parameters must be within the listed ranges and assay requirements.
5. If test kits are altered, such as by mixing parts of different kits, which could produce false test results, or if results are incorrectly interpreted, Monobind shall have no liability.
6. If computer controlled data reduction is used to interpret the results of the test, it is imperative that the predicted values for the calibrators fall within 10% of the assigned concentrations.

13.0 EXPECTED RANGES OF VALUES

C-Peptide values are consistently higher in plasma than in serum; Monobind advises that a serum sample be used for accurate determination. Compared with fasting values in non-obese non-diabetic individuals, C-Peptide levels are higher in obese non-diabetic subjects and lower in trained athletes. Based on the clinical data gathered by Monobind in concordance with the published literature the following ranges have been assigned. **These ranges should be used as guidelines only:**

Adult (Normal)	0.7 – 1.9 ng/ml

Insulin values are consistently higher in plasma than in serum; thus, serum is preferred. Compared with fasting values in non-obese non-diabetic individuals, insulin levels are higher in obese non-diabetic subjects and lower in trained athletes. Although proinsulin cross reacts with most competitive insulin assays, there is less than 1% cross reaction found with proinsulin using the Insulin test system. Based on the clinical data gathered by Monobind in concordance with the published literature the following ranges have been assigned. **These ranges should be used as guidelines only:**

Children < 12 yrs	< 10 µIU/ml
Adult (Normal)	0.7 – 9.0 µU/ml
Diabetic (Type II)	0.7 – 25 µIU/ml

It is important to keep in mind that establishment of a range of values, which can be expected to be found by a given method for a population of "normal" persons, is dependent upon a multiplicity of factors: the specificity of the method, the population tested and the precision of the method in the hands of the analyst. For these reasons, each laboratory should depend upon the range of expected values established by the Manufacturer only until an in-house range can be determined by the analysts using the method with a population indigenous to the area in which the laboratory is located.

14.0 PERFORMANCE CHARACTERISTICS

14.1 Precision

The within and between assay precision of the C-Pep/Ins VAST® AccuBind® ELISA Test System were determined by analyses on three different levels of pool control sera. The number, mean value, standard deviation and coefficient of variation for each of these control sera are presented in Table 1 and Table 2.

TABLE 1

Insulin (µIU/ml) or **C-Peptide (ng/ml)** within assay precision

Sample	N	X	σ	C.V.
Pool 1	24 **(20)**	10.7 **(1.43)**	0.89 **(0.11)**	8.3% **(7.7%)**
Pool 2	24 **(20)**	48.2 **(5.07)**	2.07 **(0.46)**	4.3% **(9.0%)**
Pool 3	24 **(20)**	130.1 **(7.81)**	6.64 **(0.73)**	5.1% **(9.3%)**

TABLE 2

Insulin (µIU/ml) or **C-Peptide (ng/ml)** between assay precision

Sample	N	X	σ	C.V.
Pool 1	15 **(20)**	11.8 **(1.27)**	1.33 **(0.12)**	11.3% **(9.7%)**
Pool 2	15 **(20)**	48.9 **(5.40)**	4.69 **(0.54)**	9.6% **(9.9%)**
Pool 3	15 **(20)**	145.2 **(8.18)**	10.45 **(0.50)**	7.2% **(6.1%)**

*As measured in ten experiments in duplicate over ten days.

14.2 Sensitivity

The sensitivity (detection limit) was ascertained by determining the variability of the 0 µIU/ml serum calibrator and using the 2σ (95% certainty) statistic to calculate the minimum dose. The assay sensitivity was found to be 0.182 µIU/ml for Insulin and 0.020 ng/ml for C-Peptide.

14.3 Accuracy

The C-Pep/Ins VAST® AccuBind® ELISA Test System was compared with a reference method. Biological specimens from population (symptomatic and asymptomatic) were used. The values ranged from 0.01µIU/ml – 129µIU/ml for insulin with a total number of 104 specimens. The values ranged from 0.2 ng/ml-11.8ng/ml for C-Peptide with a total number of 124 specimens. The data obtained is displayed in Tables 3 and 4.

TABLE 4 – C-Peptide

Method	Mean (x)	Least Square Regression Analysis	Correlation Coefficient
This Method (y)	1.068	y = 0.2079 + 0.8036(x)	0.962
Reference (x)	1.066		

TABLE 3 - Insulin

Method	Mean (x)	Least Square Regression Analysis	Correlation Coefficient
This Method	13.6	y = 2.6 + 0.91(x)	0.975
Reference	11.4		

Only slight amounts of bias between the C-Pep/Ins VAST® AccuBind® ELISA Test System and the reference methods are indicated by the closeness of the mean values. The least square regression equation and correlation coefficient indicates excellent method agreement.

14.3 Specificity

The cross-reactivity of the Ins/C-Pep VAST® AccuBind® ELISA Test System to selected substances was evaluated by adding the interfering substance(s) to a serum matrix at the following concentration(s). The cross-reactivity was calculated by deriving a ratio between dose of interfering substance to dose of insulin or **C-Peptide** needed to produce the same absorbance.

Insulin

Substance	Cross Reactivity	Concentration
Insulin	1.0000	-
Proinsulin	0.0078	100 ng/ml
C-Peptide	non-detectable	75 ng/ml
Glucagon	non-detectable	150 ng/ml

C-Peptide

Substance	Cross Reactivity	Concentration
C-Peptide	1.000	-
Proinsulin	0.120	100 ng/ml
Insulin	non-detectable	1.0 mIU/ml
Glucagon	non-detectable	150 ng/ml

15.0 REFERENCES

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Glossary of Symbols
(EN 980/ISO 15223)