

# COVID-19 IgM

**Enzyme Immunoassay  
for the determination of  
IgM antibodies to COVID-19  
in human serum and plasma**

- for "in vitro" diagnostic use only -



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REF COV19M.CE  
96, 192 Tests

## COVID-19 IgM

### A. INTENDED USE

Enzyme ImmunoAssay (ELISA) for the determination of IgM antibodies to COVID19 in human plasma and sera.

The kit is intended for the monitoring of the immune response to COVID-19 in the early stage of the infection as an additional marker to PCR.

For "in vitro" diagnostic use only.

### B. INTRODUCTION

Coronavirus disease 2019 (COVID-19) is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which was first identified amid an outbreak of respiratory illness cases in Wuhan City, Hubei Province, China and has since then caused a global pandemic. SARS-CoV-2 is a positive-sense single-stranded RNA virus and belongs to the Betacoronavirus Genus, which also includes SARS CoV (2003) and MERS CoV (2012). Same as all other coronaviruses, the genome of SARS-CoV-2 (2019-nCoV) encodes the spike protein, the envelope protein, the membrane protein, and the nucleocapsid protein. Those who are infected with COVID-19 may have little to no symptoms. Symptoms of COVID-19 are similar to a cold or flu and may take up to 14 days to appear after exposure to SARS-CoV-2. Symptoms have included: fever, cough, difficulty breathing, pneumonia in both lungs.

In severe cases, infection can lead to death. Current tests for SARS-CoV-2 look for genetic material of the virus in oral swabs, using the polymerase chain reaction (PCR). PCR only give a positive result when the virus RNA is still present.

Enzyme-linked immunosorbent assays (ELISAs) are more rapid, easily automatable and simple tests respect PCR, providing additional markers of early COVID-19 infection.

### C. PRINCIPLE OF THE TEST

Microplates are coated with recombinant Nucleocapsid and Spike antigens specific to COVID-19.

The dispensation of specimens and components is monitored by the DiaPro's **Sample Addition Monitoring System ("SAMS")** where the correct addition of the samples and the reagents of the assay is followed up visually by a step-wise change of colors.

The solid phase is first treated with the diluted sample in presence of a RF blocking reagent; IgM are captured, if present, by the antigens. After washing out all the other components of the sample, in the 2<sup>nd</sup> incubation bound antibodies are detected by the addition of polyclonal specific anti hIgM antibodies, labelled with peroxidase (HRP).

The enzyme captured on the solid phase, acting on the substrate/chromogen mixture, generates an optical signal that is proportional to the amount of anti COVID-19 IgM present in the sample. A cut-off value let optical densities be interpreted into COVID-19 IgM negative and positive results.

Neutralization of IgG anti-COVID and RF, carried out directly in the well, is performed in the assay in order to block such kind of interferences.

### D. COMPONENTS

Code COV19M.CE contains reagents for 96 tests.

#### Microplate **MICROPLATE**

n° 1 microplate. 12 strips of 8 microwells coated with recombinant COVID-19 Nucleocapsid and Spike antigens. Plates are sealed into a bag with desiccant.

#### Negative Control **CONTROL -**

1x2.0ml/vial. Ready to use control. It contains 1% goat serum proteins, 10 mM Na-citrate buffer pH 6.0 +/-0.1, 0.5% Tween 20,

0.09% Na-azide and 0.045% ProClin 300 as preservatives. The negative control is **yellow color coded**.

#### Positive Control **CONTROL +**

1x2.0ml/vial. Ready to use control. It contains 1% goat serum proteins, human IgM, 10 mM Na-citrate buffer pH 6.0 +/-0.1, 0.5% Tween 20, 0.09% Na-azide and 0.045% ProClin 300 as preservatives. The Positive Control is **green color coded**.

#### Enzyme Conjugate **CONJ**

1x16ml/vial. Ready to use and **pink/red color coded** reagent. It contains Horseradish Peroxidase conjugated goat polyclonal antibodies to human IgM, 5% BSA, 10 mM Tris buffer pH 6.8 +/-0.1, 0.045% ProClin 300 and 0.02% gentamicine sulphate as preservatives.

#### Chromogen/Substrate **SUBS TMB**

1x16ml/vial. Ready-to-use component. It contains 50 mM citrate-phosphate buffer pH 3.5-3.8, 4% dimethylsulphoxide, 0.03% tetra-methyl-benzidine or TMB and 0.02% hydrogen peroxide or H2O2.

**Note: To be stored protected from light as sensitive to strong illumination.**

#### Sample Diluent: **DILSPE**

2x50ml/bottle. It contains 1% goat serum proteins, 10 mM Na-citrate buffer pH 6.0 +/-0.1, 0.5% Tween 20, 0.09% Na-azide and 0.045% ProClin 300 as preservatives. To be used to dilute the sample.

**Note: The diluent changes color from olive green to dark bluish green in the presence of sample.**

#### Neutralizing Reagent **SOLN NEUT**

1x8.0ml/vial. Ready to use reagent. It contains goat anti hIgG, 10 mM tris buffered solution pH 8.0 +/-0.1 containing 0.045% ProClin 300. For blocking interference due to RF.

**Note: The liquid changes color from light yellow to dark greenish blue when the diluted sample is added.**

#### Wash buffer concentrate **WASHBUF 20X**

1x60ml/bottle. 20x concentrated solution. Once diluted, the wash solution contains 10 mM phosphate buffer pH 7.0 +/-0.2, 0.05% Tween 20 and 0.045% ProClin 300.

#### Sulphuric Acid **H<sub>2</sub>SO<sub>4</sub> 0.3 M**

1x15ml/bottle. It contains 0.3 M H<sub>2</sub>SO<sub>4</sub> solution. Attention: Irritant (H315; H319; P280; P302+P352; P332+P313; P305+P351+P338; P337+P313; P362+P363)

#### Plate sealing foils n° 2

#### Package insert n° 1

**Important note:** Only upon specific request, Dia.Pro can supply reagents for 192 tests, as reported below:

1.Microplate	n°2
2.NegativeControl	1x4.0ml/vial
3.PositiveControl	1x4.0ml/vial
4.Enz. Conjugate	2x16ml/vial
5.Chromog/Subs	2x16ml/vial
6.Sample Diluent	3x60ml/vial
8.Neutralizing Reagent	1x15ml/vial
5.Wash buff conc	2x60ml/bottle
9.Sulphuric Acid	1x32ml/vial
10.Plate seal foils	n° 4
11.Pack. insert	n° 1
<b>Number of tests</b>	<b>192</b>
<b>Code</b>	<b>COV19M.CE.192</b>

Doc.:	INS COV19M.CE/Eng	Page	3 of 7	Rev.:	6	Date:	2021/02/03
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#### E. MATERIALS REQUIRED BUT NOT PROVIDED

1. Calibrated Micropipettes (200ul and 10ul) and disposable plastic tips.
2. EIA grade water (bidistilled or deionized, charcoal treated to remove oxidizing chemicals used as disinfectants).
3. Timer with 60 minutes range or higher.
4. Absorbent paper tissues.
5. Calibrated ELISA microplate thermostatic incubator capable to provide a temperature of +37°C.
6. Calibrated ELISA microwell reader with 450nm (reading) and with 620-630nm (blinking) filters.
7. Calibrated ELISA microplate washer.
8. Vortex or similar mixing tools.

#### F. WARNINGS AND PRECAUTIONS

1. The kit has to be used by skilled and properly trained technical personnel only, under the supervision of a medical doctor responsible of the laboratory.
2. When the kit is used for the screening of blood units and blood components, it has to be used in a laboratory certified and qualified by the national authority in that field (Ministry of Health or similar entity) to carry out this type of analysis.
3. All the personnel involved in performing the assay have to wear protective laboratory clothes, talc-free gloves and glasses. The use of any sharp (needles) or cutting (blades) devices should be avoided. All the personnel involved should be trained in biosafety procedures, as recommended by the Center for Disease Control, Atlanta, U.S. and reported in the National Institute of Health's publication: "Biosafety in Microbiological and Biomedical Laboratories", ed. 1984.
4. All the personnel involved in sample handling should be vaccinated for HBV and HAV, for which vaccines are available, safe and effective.
5. The laboratory environment should be controlled so as to avoid contaminants such as dust or air-born microbial agents, when opening kit vials and microplates and when performing the test. Protect the Chromogen/Substrate from strong light and avoid vibration of the bench surface where the test is undertaken.
6. Upon receipt, store the kit at 2..8°C into a temperature controlled refrigerator or cold room.
7. Do not interchange components between different lots of the kits. It is recommended that components between two kits of the same lot should not be interchanged.
8. Check that the reagents are clear and do not contain visible heavy particles or aggregates. If not, advise the laboratory supervisor to initiate the necessary procedures for kit replacement.
9. Avoid cross-contamination between serum/plasma samples by using disposable tips and changing them after each sample. Do not reuse disposable tips.
10. Avoid cross-contamination between kit reagents by using disposable tips and changing them between the use of each one. Do not reuse disposable tips.
11. Do not use the kit after the expiration date stated on the external container and internal (vials) labels.
12. Treat all specimens as potentially infective. All human serum specimens should be handled at Biosafety Level 2, as recommended by the Center for Disease Control, Atlanta, U.S. in compliance with what reported in the Institutes of Health's publication: "Biosafety in Microbiological and Biomedical Laboratories", ed. 1984.
13. The use of disposable plastic-ware is recommended in the preparation of the liquid components or in transferring components into automated workstations, in order to avoid cross contamination.
14. Waste produced during the use of the kit has to be discarded in compliance with national directives and laws concerning laboratory waste of chemical and biological substances. In particular, liquid waste generated from the washing procedure, from residuals of controls and from samples has to be treated as potentially infective material and inactivated

before waste. Suggested procedures of inactivation are treatment with a 10% final concentration of household bleach for 16-18 hrs or heat inactivation by autoclave at 121°C for 20 min..

15. Accidental spills from samples and operations have to be adsorbed with paper tissues soaked with household bleach and then with water. Tissues should then be discarded in proper containers designated for laboratory/hospital waste.

16. The Sulphuric Acid is an irritant. In case of spills, wash the surface with plenty of water

17. Other waste materials generated from the use of the kit (example: tips used for samples and controls, used microplates) should be handled as potentially infective and disposed according to national directives and laws concerning laboratory wastes.

#### G. SPECIMEN: PREPARATION AND RECOMMANDATIONS

1. Blood is drawn aseptically by venipuncture and plasma or serum is prepared using standard techniques of preparation of samples for clinical laboratory analysis. No influence has been observed in the preparation of the sample with citrate, EDTA and heparin.
2. Avoid any addition of preservatives to samples; especially sodium azide as this chemical would affect the enzymatic activity of the conjugate, generating false negative results.
3. Samples have to be clearly identified with codes or names in order to avoid misinterpretation of results. When the kit is used for the screening of blood units, bar code labeling and electronic reading is strongly recommended.
4. Haemolysed (red) and visibly hyperlipemic ("milky") samples have to be discarded as they could generate false results. Samples containing residues of fibrin or heavy particles or microbial filaments and bodies should be discarded as they could give rise to false results.
5. Sera and plasma can be stored at +2°...+8°C in primary collection tubes for up to five days after collection. Do not freeze primary tubes of collection. For longer storage periods, sera and plasma samples, carefully removed from the primary collection tube, can be stored frozen at -20°C for at least 12 months. Any frozen samples should not be frozen/thawed more than once as this may generate particles that could affect the test result. See also Chapter S (Limitations).
6. If particles are present, centrifuge at 2.000 rpm for 20 min or filter using 0.2-0.8u filters to clean up the sample for testing.
7. As the Sample Diluent (DILSPE) contains a strong virus-inactivating substance, diluted samples may be stored at +2..8°C only for 48 hrs.

#### H. PREPARATION OF COMPONENTS AND WARNINGS

A study conducted on an opened kit has not pointed out any relevant loss of activity up to 6 re-use of the device and up to 6 months.

##### Microplates:

Allow the microplate to reach room temperature (about 1 hr) before opening the container. Check that the desiccant is not turned to dark green, indicating a defect of manufacturing. In this case call Dia.Pro's customer service.

Unused strips have to be placed back into the aluminum pouch, in presence of desiccant supplied, firmly zipped and stored at +2°..8°C. When opened the first time, residual strips are stable till the indicator of humidity inside the desiccant bag turns from yellow to green.

##### Negative Control:

Ready to use. Mix well on vortex before use.

##### Positive Control:

Ready to use. Mix well on vortex before use.

##### Wash buffer concentrate:

The 20x concentrated solution has to be diluted with EIA grade water up to 1200 ml and mixed gently end-over-end before use.

As some salt crystals may be present into the vial, take care to dissolve all the content when preparing the solution. In the preparation avoid foaming as the presence of bubbles could give origin to a bad washing efficiency.

**Note:** Once diluted, the wash solution is stable for 1 week at +2..8° C.

**Enzyme conjugate:**

Ready to use. Mix well on vortex before use.

Be careful not to contaminate the liquid with oxidizing chemicals, air-driven dust or microbes.

If this component has to be transferred use only plastic, possibly sterile disposable containers.

**Chromogen/Substrate:**

Ready to use. Mix well on vortex before use.

Be careful not to contaminate the liquid with oxidizing chemicals, air-driven dust or microbes.

Do not expose to strong illumination, oxidizing agents and metallic surfaces.

If this component has to be transferred use only plastic, possible sterile disposable container.

**Neutralizing Reagent:**

Ready to use. Mix well on vortex before use.

**Sample Diluent:**

Ready to use. Mix well on vortex before use.

**Sulphuric Acid:**

Ready to use. Mix well on vortex before use.

Attention: Irritant (H315; H319; P280; P302+P352; P332+P313; P305+P351+P338; P337+P313; P362+P363).

**Legenda:**

**Warning H statements:**

**H315** – Causes skin irritation.

**H319** – Causes serious eye irritation.

**Precautionary P statements:**

**P280** – Wear protective gloves/protective clothing/eye protection/face protection.

**P302 + P352** – IF ON SKIN: Wash with plenty of soap and water.

**P332 + P313** – If skin irritation occurs: Get medical advice/attention.

**P305 + P351 + P338** – IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

**P337 + P313** – If eye irritation persists: Get medical advice/attention.

**P362 + P363** – Take off contaminated clothing and wash it before reuse.

**I. INSTRUMENTS AND TOOLS USED IN COMBINATION WITH THE KIT**

- 1. Micropipettes** have to be calibrated to deliver the correct volume required by the assay and must be submitted to regular decontamination (household alcohol, 10% solution of bleach, hospital grade disinfectants) of those parts that could accidentally come in contact with the sample. They should also be regularly maintained in order to show a precision of 1% and a trueness of +/-2%. Decontamination of spills or residues of kit components should also be carried out regularly.
- The **ELISA incubator** has to be set at +37°C (tolerance of +/-0.5°C) and regularly checked to ensure the correct temperature is maintained. Both dry incubators and water baths are suitable for the incubations, provided that the instrument is validated for the incubation of ELISA tests.
- The **ELISA washer** is extremely important to the overall performances of the assay. The washer must be carefully validated in advance, checked for the delivery of the right dispensation volume and regularly submitted to maintenance according to the manufacturer's instructions for use. In particular the washer, at the end of the daily workload, has to be extensively cleaned out of salts with

deionized water. Before use, the washer has to be extensively primed with the diluted Washing Solution.

The instrument weekly has to be submitted to decontamination according to its manual (NaOH 0.1 M decontamination suggested).

**5 washing cycles** (aspiration + dispensation of 350ul/well of washing solution + 20 sec soaking = 1 cycle) are sufficient to ensure the assay with the declared performances.

If soaking is not possible add one more cycle of washing.

An incorrect washing cycle or salt-blocked needles are the major cause of false positive reactions.

4. Incubation times have a tolerance of ±5%.
5. The **ELISA microplate reader** has to be equipped with a reading filter of 450nm and with a second filter of 620-630nm, mandatory for blanking purposes. Its standard performances should be (a) bandwidth ≤ 10 nm; (b) absorbance range from 0 to ≥ 2.0; (c) linearity to ≥ 2.0; (d) repeatability ≥ 1%. Blanking is carried out on the well identified in the section "Assay Procedure". The optical system of the reader has to be calibrated regularly to ensure that the correct optical density is measured. It should be regularly maintained according to the manufacturer 's instructions.
6. The use of **ELISA automated work stations** is recommended when screening a quite high number of samples (> 50 samples). When using an ELISA automated workstation, all critical steps (dispensation, incubation, washing, reading, data handling) have to be carefully set, calibrated, controlled and regularly serviced in order to match the values reported in the section O "Internal Quality Control". The assay protocol has to be installed in the operating system of the unit and validated as for the washer and the reader. In addition, the liquid handling part of the station (dispensation and washing) has to be validated and correctly set. Particular attention must be paid to avoid carry over by the needles used for dispensing and for washing. This must be studied and controlled to minimize the possibility of contamination of adjacent wells. When using automatic devices, in case the vial holder of the instrument does not fit with the vials supplied in the kit, transfer the solution into appropriate containers and label them with the same label peeled out from the original vial. This operation is important in order to avoid mismatching contents of vials, when transferring them. When the test is over, return the secondary labeled containers to 2..8°C, firmly capped.

Dia.Pro's customer service offers support to the user in the setting and checking of instruments used in combination with the kit, in order to assure compliance with the requirements described. Support is also provided for the installation of new instruments to be used with the kit.

**L. PRE ASSAY CONTROLS AND OPERATIONS**

1. Check the expiration date of the kit printed on the external label of the kit box. Do not use if expired.
2. Check that the liquid components are not contaminated by naked-eye visible particles or aggregates. Check that the Chromogen/Substrate is colorless or pale blue by aspirating a small volume of it with a sterile transparent plastic pipette. Check that no breakage occurred in transportation and no spillage of liquid is present inside the box. Check that the aluminum pouch, containing the microplate, is not punctured or damaged.
3. Dilute all the content of the 20x concentrated Wash Solution as described above.
4. Allow all the other components to reach room temperature (about 1 hr) and then mix as described.
5. Set the ELISA incubator at +37°C and prepare the ELISA washer by priming with the diluted washing solution,

according to the manufacturers instructions. Set the right number of washing cycles as reported in the specific section.

- Turn on the ELISA reader at least 20 minutes before the reading operation.
- If using an automated workstation, turn it on, check settings and be sure to use the right assay protocol.
- Check that the micropipettes are set to the required volume.
- Check that all the other equipment is available and ready to use.
- In case of problems, do not proceed further with the test and advise the supervisor.

#### M. ASSAY PROCEDURE

The assay has to be carried out according to what reported below, taking care to maintain the same incubation time for all the samples in testing.

#### AUTOMATED ASSAY:

In case the test is carried out automatically with an ELISA system, follow the instruction below for programming the instrument:

- Dilute samples 1:41 in a proper tube according to the instruction of use of the instrument. As an example: 10 ul sample + 400 ul DILSPE). Mix by aspiration&dispensation.
- The well A1 is used for blanking operations.
- Dispense 50 ul of Neutralizing Reagent (SOL NEUT) in all the wells of the microplate except A1 for blanking.

**Important note:** *The Neutralizing Reagent is able to block false positive reactions due to RF. Positive samples in internal QC panels might be detected negative if such samples were tested positive with an IVD that does not carry out any RF blocking reaction.*

- Dispense 200 ul Negative Control in triplicate and 200 ul Positive Control in single in the appropriate control wells (ex.: B1+C1+D1 for the negative control and E1 for the positive control). Do not dilute Controls as they are pre-diluted, ready to use!
- Dispense 200 ul of the prediluted samples in the proper sample wells.
- For the next operations follow the operative instructions reported below for the Manual Assay.

**Important Note:** *Visually monitor that samples have been dispensed into appropriate wells. This is simply achieved by checking that the color of the well turns to intense blue.*

It is strongly recommended to check that the time lap between the dispensation of the first and the last sample will be calculated by the instrument and taken into consideration by delaying the first washing operation accordingly.

#### MANUAL ASSAY

- In proper test tubes dispense 400 ul of sample diluent (DILSPE); then add 10 ul sample to have a final dilution of 1:41. Mix the sample on vortex. Check that the color turns from light green to bluish green.
- Place the required number of wells in the microwell holder. Leave the 1<sup>st</sup> well empty for the operation of blanking.
- Add 50 ul of Neutralizing Reagent (SOL NEUT) in each well of the plate, except in A1.
- Dispense 200 ul of Negative Control in triplicate and 200 ul Positive Control in single in properly identified control wells. Do not dilute Controls as they are pre-diluted, ready to use!
- Finally dispense 200 ul of diluted samples to all the sample wells.

**Important note:** *Check that the color of the well turns upon addition of the diluted sample from bluish green to dark blue.*

- Mix gently the plate manually, avoiding overflowing and contaminating adjacent wells.
- Incubate the microplate for **45 min at +37°C**.

**Important note:** *Strips have to be sealed with the adhesive sealing foil, supplied, only when the test is carried out manually. Do not cover strips when using ELISA automatic instruments.*

- Wash the microplate with an automatic washer by delivering and aspirating 350ul/well of diluted washing solution as reported previously (section I.3).
- Pipette 100 µl Enzyme Conjugate into each well, except the 1<sup>st</sup> blanking well, and cover with the sealer. Check that this pink/red colored component has been dispensed in all the wells, except A1.

**Important note:** *Be careful not to touch the plastic inner surface of the well with the tip filled with the Enzyme Conjugate. Contamination might occur.*

- Incubate the microplate for **45 min at +37°C**.
- Wash microwells as in step 8.
- Pipette 100 µl Chromogen/Substrate mixture into each well, the blank well included. Then incubate the microplate at **room temperature (18-24°C) for 15 minutes**.

**Important note:** *Do not expose to strong direct illumination. High background might be generated.*

- Pipette 100 µl Sulphuric Acid into all the wells using the same pipetting sequence as in step 10 to stop the enzymatic reaction. Addition of acid will turn the positive control and positive samples from blue to yellow/brown.
- Measure the color intensity of the solution in each well, as described in section I.5, at 450nm filter (reading) and at 620-630nm (background subtraction), blanking the instrument on A1 (mandatory).

#### Important notes:

- Ensure that no finger prints are present on the bottom of the microwell before reading. Finger prints could generate false positive results on reading.
- Reading has to be carried out just after the addition of the Stop Solution and anyway not any longer than 20 minutes after its addition. Some self oxidation of the chromogen can occur leading to high background.

#### N. ASSAY SCHEME

An example of dispensation scheme is reported below:

		Microplate											
		1	2	3	4	5	6	7	8	9	10	11	12
A	BLK	S4											
B	NC	S5											
C	NC	S6											
D	NC	S7											
E	PC	S8											
F	S1	S9											
G	S2	S10											
H	S3	S11											

Legenda: BLK = Blank NC = Negative Control PC = Positive Control S = Sample

In the table below the volumes and the procedures are summarized for the Manual Method.

Manual Method	Operations
Samples + DILSPE	10 ul + 400 ul (dilution 1:41)
Neutralizing Reagent	50 ul
Controls	200 ul
Diluted samples	200 ul
<b>1<sup>st</sup> incubation</b>	<b>45 min</b>
Temperature	+37°C
Wash step	n° 5 cycles with 20" of soaking OR n° 6 cycles without soaking
Enzyme conjugate	100 ul
<b>2<sup>nd</sup> incubation</b>	<b>45 min</b>
Temperature	+37°C
Wash step	n° 5 cycles with 20" of soaking OR n° 6 cycles without soaking
TMB/H2O2	100 ul
<b>3<sup>rd</sup> incubation</b>	<b>15 min</b>
Temperature	r.t.
Sulphuric Acid	100 ul
Reading OD	450nm / 620-630nm

#### O. INTERNAL QUALITY CONTROL

A check is carried out on the controls any time the kit is used in order to verify whether their OD450nm/620-630nm values are as expected and reported in the table below.

Check	Requirements
Blank well	< 0.100 OD450nm value
Negative Control (NC)	< 0.150 mean OD450nm value after blanking
Positive Control	S/Co > 1.1

If the results of the test match the requirements stated above, proceed to the next section.

If they do not, do not proceed any further as data are invalid.

#### P. CALCULATION OF THE CUT-OFF

The tests results are calculated by means of a cut-off value determined with the following formula on the mean OD450nm/620-630nm value of the Negative Control (NC):

$$NC + 0.250 = \text{Cut-Off (Co)}$$

The value found for the test is used for the interpretation of results as described in the next paragraph.

**Important note:** When the calculation of results is done by the operative system of an ELISA automated work station be sure that the proper formulation is used to calculate the cut-off value and generate the right interpretations of results.

#### Q. INTERPRETATION OF RESULTS

Test results are interpreted as ratio of the sample OD450nm/620-630nm and the Cut-Off value (or S/Co) according to the following table.

In the follow-up of COVID-19 **suspected infections** the following interpretation applies:

S/Co	Interpretation
< 0.9	Negative
0.9 - 1.1	Gray-zone
> 1.1	Positive

A **negative** result indicates that the subject has not developed IgM to COVID-19.

Any subject showing an **equivocal** result (Gray zone) should be tested again on a second sample taken 1-2 weeks later.

A **positive** result is indicative of presence of IgM to COVID-19.

#### Important notes:

- The right interpretation of results should be done anyway under the supervision of the responsible of the laboratory looking in addition at other clinical parameters to reduce the risk of judgment errors and misinterpretations.**
- Any positive result should be confirmed by an alternative method capable to detect IgM antibodies (example: confirmation/typing test Dia.Pro) before a diagnosis is formulated. The presence of IgM cannot be used when alone to formulate a diagnosis of COVID-19 infection.**
- In the exceptional case the kit is used for the screening of Health Care Workers at risk of COVID-19 infection or for the evaluation of the acquired immune status of individuals from normal population, the following interpretation applies:**

S/Co	Interpretation
< 0.9	Negative
0.9 – 1.1	Gray-zone
1.1 – 2.0	Low Positive
> 2.0	Positive

and a "Confidence Index" (or grade of reliability) is used in the interpretation of data, as follows:

- for values in the range  $1.1 < S/Co < 2$ , positivity has a low index of confidence. If however IgG antibodies, when tested in combination to IgM, show a positive or equivocal result, further diagnostic investigations are suggested on a sample collected after 7-10 days from the first.
  - for  $S/Co > 2$ , at contrary, the confidence index is high and in this case it is suggested to submit the sample to the DiaPro's Confirmatory Assay, as reported already. If IgG antibodies, when tested in combination, are positive as well, the person should be tested for COVID-19 RNA, and/or submitted to a computed tomography (CAT).
- When test results are transmitted from the laboratory to an informatics Centre, attention has to be done to avoid erroneous data transfer.

#### R. PERFORMANCES

Whole performances are still under evaluation considering the difficulty to evaluate in particular specimens coming from infected hospitalized patients.

#### Diagnostic specificity:

The assay was tested on hundreds of samples collected before the outbreak of COVID-19, gently provided by a national Blood Center.

A value of  $\geq 98\%$  was found.

Potential crossreactions with other respiratory infective agents were studied on samples positive for antibodies to: PIV1-3, Influenza A and B, H.influenzae, hCoV 229E, hCoV OC43, hCoV HKU1, hCoV NL63, Rhinovirus, RSV, Adenovirus, M.pneumoniae and C.pneumoniae.

No crossreaction was observed.

In addition antibodies, commonly present in human sera and plasma, to unrelated infective agents were also tested. Antibodies positive to CMV, EBV, HSV1&2, Toxoplasma, Rubella, H.pylori, Malaria sps, Coxsackie virus, Parvovirus B19 and HCV, HIV, Syphilis and HBsAg did not crossreacted.

Data are summarized in the following tables:

### Other respiratory infective microbes and viruses (pre-pandemic samples)

Category	gender	age	COVID-19 IgM		
			N° of samples tested	Pos	Neg
PIV 1-3 Ab+	Male&female	25-40	11	0	11
Influenza A+B (vaccinated 10/2019)	Male&female	25-40	12	0	12
Anti H. influenza Ab+	Male&female	25-40	5	0	5
hCoV 229E Ab+	Male&female	25-40	2	0	2
hCoV OC43 Ab+	Male&female	25-40	8	0	8
hCoV HKU1 Ab+	Male&female	25-40	3	0	3
hCoV NL63 Ab+	Male&female	25-40	1	0	1
hCoV HKU1/NL63 Ab+	Male&female	25-40	5	0	5
SARS-CoV 1 Ab+	Male&female	25-40	1	0	1
Rinovirus Ab+	Male&female	25-40	1	0	1
RSV Ab+	Male&female	25-40	9	0	9
Adenovirus Ab+	Male&female	25-40	10	0	10
M.pneumoniae Ab+	Male&female	25-40	10	0	10
C.pneumoniae Ab+	Male&female	25-40	3	0	3

### Unrelated microbes

Category	gender	age	COVID-19 IgM		
			N° of samples tested	Pos	Neg
CMV IgM+	Male&female	25-40	4	0	4
CMV IgG+	Male&female	25-40	4	0	4
EBV EBNA IgG+	Male&female	25-40	5	0	5
EBV VCA IgM+	Male&female	25-40	5	0	5
HSV1&2 IgG+	Male&female	25-40	5	0	5
Toxo IgG+	Male&female	25-40	3	0	3
Rub IgG+	Male&female	25-40	3	0	3
H.Pylori IgG+	Male&female	25-40	3	0	3
HCV Ab+	Male&female	25-40	3	0	3
HIV Ab&Ag +	Male&female	25-40	4	0	4
HBsAg+	Male&female	25-40	2	0	2
HBsAb+	Male&female	25-40	5	0	5
Syphilis Ab+	Male&female	25-40	1	0	1
Malaria Ab+	Male&female	25-40	3	0	3
Coxsackye virus Ab+	Male&female	25-40	5	0	5
Parvovirus B19 Ab+	Male&female	25-40	2	0	2

Common autoantibodies (thyroid, liver, ANA and ENA mostly) in Autoimmune Diseases did not generate false positive results.

No interferences were observed in pregnant women, abnormal levels of liver enzymes and other common organ-specific pathologies.

Past infections of SARS-CoV-1 may cause interference and IgM response due to the high level of genetic homology between the two viruses. Other Coronavirus strain may cause a light IgM response in view of similarity of different strains.

Well-known potentially interfering samples in EIA were studied. Results are reported in the table below:

Substances	Concentrations	Score
Haemoglobin	Up to 500 mg/dl	negative
Bilirubin	Up to 20 mg/dl	negative
Triglyceride (milky samples)	Up to 3000 mg/dl	negative
Serum proteins	Up to 15g/dl	negative
RF+	Up to 2500 U/ml (Cobas)	negative
Anti E-Coli Ab+	Highly positive	negative

No false reactivity due to the method of analysis was found.

The same potential interfering samples were spiked with a specimen highly positive for IgM to COVID-19 Nucleocapsid Core. No false negative result was found assuring no interference of such substances in positive samples testing.

Both plasma, derived with different standard techniques of preparation (citrate, EDTA and heparin), and sera were used to determine the value of specificity. Frozen specimens were tested, as well, to check for interferences due to collection and storage. No interference was observed provided that the sample was clear and free of particles/aggregates.

Interferences were seen when fibrin aggregates, visible particles and lipid layers were present in the sample, giving usually a

false positive result. These samples have to be cleared by filtration on a 0.22 µ filter (lipid layers) or centrifuged for 30 min at 4000 rpm (aggregates) before testing, or discarded as not suitable for testing.

### Diagnostic Sensitivity

A multicentric international study (several COVID-19 hospitals in Italy, UK, France, Spain, Ecuador), was carried out in the context of the Public Health Emergency.

Samples from a cohort of infected patients, some followed up to recovery, showed a sensitivity better than 98%.

A good correlation of IgM positivity in PCR+ patients tested at the offset of symptoms was observed.

In some cases IgM were revealed later than IgG, as reported by the specific Literature for COVID-19 seroconversions.

Such correlation reached almost 100% respect to PCR+ results in the course of follow-up of the patient. Some cases are present in the study of PCR- patients having symptoms of infection that showed up a COVID-19 specific seroconversion.

The whole study is available upon request; its results are briefly summarized below.

In internal studies, all the samples that were detected positive for IgM were confirmed positive in the DiaPro's Confirmatory Assay for IgM to Nucleocapsid Core. In some cases IgM were also positive to Spike antigens but none was positive only to them, confirming that seroconversion to antibodies starts up first to Nucleocapsid Core.

When COVID-19 IgM patients were tested later in the course of infection and after full recovery IgM antibodies show the tendency to remain positive even for several weeks after recovery, but with tendency to decrease in their S/Co; IgG at contrary have the tendency to increase in such values.

NIBSC/WHO recently released a panel - anti SARS-CoV-2 Verification Panel for Serology Assays code 20/B770 – aimed at providing data of performances in such IVD.

Results are reported in the table below in reference to the data presented by NIBSC in its data sheet for IgG to NCP+SPIKE (code COV19G.CE):

Sample #	Dia.Pro COV19M.CE S/Co	DIA IgG S/Co	Sample #	Dia.Pro COV19M.CE S/Co	DIA IgG S/Co
1	2.2	8.1	20	4.6	8.9
2	3.0	10.5	21	10.0	10.7
3	11.5	11.1	22	11.1	9.4
4	6.1	9.4	23	6.5	10.2
5	8.5	11.3	24	0.1	0.1
6	2.5	7.0	25	0.1	0.2
7	2.3	4.2	26	0.1	0.5
8	8.5	11.2	27	0.1	0.3
9	11.1	11.3	28	0.1	0.1
10	11.7	11.1	29	0.1	0.3
11	0.9	3.9	30	0.1	0.2
12	5.8	7.3	31	0.2	0.4
13	7.0	9.6	32	0.1	0.4
14	3.7	8.3	33	0.1	0.2
15	5.7	10.1	34	0.1	0.9
16	2.0	8.0	35	0.1	0.2
17	6.5	9.6	36	0.2	0.5
18	12.0	11.1	37	0.1	0.2
19	8.8	10.1			

### Precision:

Repeatability (intra-assay) was studied on 3 samples, one negative, one low positive and one high positive, examined in 16 replicates.

Results showed values of CV in the range 4-20% depending on their OD450nm

Reproducibility (inter-assay) was studied on the same 3 samples tested in 16 replicates for 3 times.

The variability found of 4-20 % depending on the sample OD450nm did not lead in sample misclassification.

## S. LIMITATIONS

As reported in the proper section highly lipemic (“milky”) and haemolized (“red”) samples may generate false positive reactions.

Very high titers of Rheumatoid Factor over 2500 U/ml might lead to a false positive result.

When testing frozen samples, in particular those that:

- (a) were submitted to several cycles of freezing&thawing;
- (b) were already “dirty” in origin when aliquoting;
- (c) were aliquoted in a small volume, due to tendency to get jellified by evaporation;
- (d) are composed of plasma because of their tendency to form aggregates of fibrin upon thawing;
- (e) contain thermal sensitive IgM samples that by nature tends to aggregate upon freezing&thawing and become “sticky”,

some false positive reaction it's quite likely to come out.

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All the IVD Products manufactured by the company are under the control of a certified Quality Management System in compliance with ISO 13485 rule. Each lot is submitted to a quality control and released into the market only if conforming with the EC technical specifications and acceptance criteria.

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