



## Technical Bulletin

### Getting the Best Results from Your Current or Future Veterinary Refractometer

In the course of engineering the Palm Abbe Veterinary Refractometer, we interviewed several veterinarians; professionals that use refractometers in their daily clinical practice. Many of the doctors we spoke with were shocked to discover that the majority of them were misusing these instruments and basing diagnostic decisions, including euthanizing animals, on inaccurate data.

For decades, refractometers have proven helpful in clinical veterinary practice for measuring urine specific gravity and blood plasma protein concentration. They have also been used successfully for measuring protein in peritoneal, pleural, and other body fluids. Few diagnostic instruments are as helpful in a veterinary practice and yet, so misunderstood.

Refractometers simply measure refractive index, or the degree to which light is slowed in a solution. The refractive index of a solution changes based on the sum of all of the dissolved solids in that solution. In the case of blood plasma, protein is the dominant solute; however, electrolytes, glucose, urea, and lipids also contribute to the total dissolved solids and, therefore, have an effect on the refractive index.

To be useful instruments, refractometers must convert the refractive index of a tested solution into a particular unit of measure that is of value to the clinician. However, the relationship between refractive index and urine specific gravity or protein concentration is not the same for all refractometers, nor is the methodology of making the measurements.

Veterinary refractometers can be divided into three main categories. The first is traditional handheld analog refractometers produced either by Atago or by other Asian companies that have copied Atago's design (collectively, "Asian refractometers"). The second group consists of traditional handheld analog instruments sold by American Optical, Reichert, and Leica. And, the last group includes the MISCO Palm Abbe Digital Veterinary Refractometer.

Most of the veterinary clinics visited in the course of developing the Palm Abbe Veterinary Refractometer had either old or very old Asian refractometers. These instruments did not have temperature compensation, had scales designed specifically for humans, and had not been calibrated in ages, if at all.

Following is information fundamental to the successful use of a veterinary refractometer along with some tips and guidelines to help you select your next refractometer.

#### **ISSUE #1: You Can't Test Feline Urine Specific Gravity on Most Refractometers.**

A common misconception among veterinarians is that the specific gravity scale on a clinical refractometer will accurately display the specific gravity of any fluid. This is NOT true. The relationship between refractive index and specific gravity is different for every fluid. Therefore, you can only measure the specific gravity of the fluid the scale was specifically designed for, i.e. urine.

In the case of Asian refractometers, the urine specific gravity scale is based on human urine. Although the human urine specific gravity scale is acceptable for dogs and large animals, it will give erroneously low readings for cats, rabbits, and guinea pigs. Instruments sold by American Optical, Reichert, and Leica have a special scale for feline urine specific gravity. The MISCO Palm Abbe has a special urine scale for cats and scales are available for rabbits, and guinea pigs.

*Recommendation:* Only measure urine on the urine specific gravity scale. Do not measure cat, rabbit, or guinea pig urine specific gravity unless the scale is specifically marked for that species.

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In the future, select a refractometer with specific gravity scales for the species you wish to test. In the meantime, you may be able to find a suitable conversion chart in the scientific literature. When measuring urine on a refractometer, the result should be reported as Urine Specific Gravity by Refractometer (“SG<sub>r</sub>”).

### **ISSUE #2: Take Special Care When Taking Protein Measurements.**

The protein scale in Asian refractometers is based on human blood serum protein concentrations determined by Atago in the early 1960s. The scales in these instruments were determined using a protein-to-nitrogen ratio of 6.25%. It has since been proven that they will always give consistently lower results compared to refractometers using a more accurate ratio of 6.54%, as determined by A. V. Wolf.<sup>1</sup>

The data from Wolf’s studies<sup>3</sup> on refractometry in the 1960s have been proven to provide the most accurate conversions between refractive index and protein concentration.

Although refractometers sold by American Optical, Reichert, and Leica purport to use a protein/nitrogen ratio of 6.54%, they use their own protein-to-refractive index conversions and do not use Wolf’s conversion. This will introduce an error into their readings compared to Wolf’s data.

Further, since protein levels in peritoneal, pleural, lymph, and other body fluids sometimes read as low as 1.0 g/dl, it is important to have an instrument with a minimum range that low. Falsely low values for peritoneal fluids with protein concentrations of less than 3 g/dL have been reported when using an Atago refractometer.

The protein scale on the MISCO Palm Abbe is based on Wolf’s data and uses a 6.54% protein-to-nitrogen ratio. The scale range is 1.0 to 14.0 g/dL.

*Recommendation:* When reading protein concentrations on an Atago or other Asian refractometer, remember that your protein readings will be lower than the true protein concentration and falsely low for readings below 3.0 g/dL.

In the future, select a refractometer with a protein scale based on Wolf’s data and a protein-to-nitrogen ratio of 6.54%. A non-Asian instrument with a minimum range of 1 g/dl is recommended when measuring body cavity fluids. When measuring protein concentrations on a refractometer, the result should be reported as Total Protein by Refractometer (“TP<sub>r</sub>”).

### **ISSUE #3: Temperature Compensation.**

Atago and most other Asian clinical refractometers do not have automatic temperature compensation. Since refractive index is extremely dependent on temperature, a non-

compensated refractometer will give erroneous readings unless they are used at or near 20 °C (68 °F).

For instance, when measuring a feline urine specific gravity with a true value of 1.0390 D20/20 at 30 °C (86 °F), a refractometer without temperature compensation would read roughly 1.0424. Since the actual temperature coefficient of fluids varies non-linearly, both by temperature and by concentration, the error would be greater for larger temperature differences and/or higher urine specific gravity.

For those few instruments that actually have temperature compensation, they compensate only linearly using a bi-metal strip, and the compensation is only accurate over a relatively small range of temperatures.

Refractometers sold by American Optical, Reichert, and Leica offer linear temperature compensation, by means of a bi-metal strip or a liquid filled prism, over a useable temperature range.

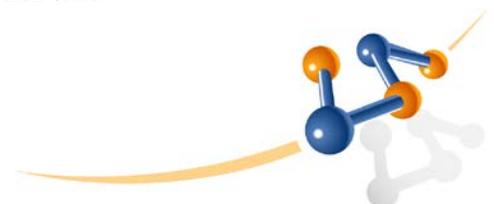
The digital nonlinear temperature compensation in the MISCO Palm Abbe is automatic and ensures that fluids read between 0 and 50 °C (+32 to 122 °F) are measured accurately.

*Recommendation:* If you do not have a refractometer with automatic temperature compensation, take all readings as close to 20 °C (68 °F) as possible. In the future, select a refractometer with temperature compensation. Digital non-linear compensation or instruments with fluid filled prisms offer the best compensation, while bi-metal strip compensation is the next best alternative.

### **ISSUE #4: Calibration is Critical.**

The simple fact is that measuring devices are only as good as their design, quality, and calibration. Calibration is essential for getting accurate readings from any refractometer. Sadly, few of the veterinarians surveyed could recall when they last calibrated their refractometer to water (zero set the low end of the scale). None had performed a span calibration or verification at the upper end of the scale with fluids traceable to the National Institute of Standards and Technology (“NIST”). In fact, Atago and other Asian refractometers can only be zero set. There is no way to adjust the span point if it is out of calibration.

Refractometers sold by American Optical, Reichert, and Leica allow for a span adjustment and can be calibrated at both ends of their scale.



The MISCO Palm Abbe automatically calibrates itself to water and is ready to use in seconds. There are no screws to turn and nothing to adjust. A NIST traceable calibration standard, available from MISCO, can be used to adjust the high end of the scale.

It is recommended that you do not use commercially prepared protein standards for instrument calibration since they contain non-protein preservatives that increase refractive index values.

*Recommendation:* Verify the zero-set of your refractometer to water daily. Send instruments out annually to a “competent” calibration laboratory that can confirm the calibration of the upper end of the scale. In the future, select an instrument that is easy to calibrate at both ends of the scale. Tag the instrument case with a tag that indicates the date of the last calibration and when the next one is due. Do not use an uncalibrated instrument.

#### **ISSUE #5: General Cautions.**

The correlation between refractive index and a particular unit of measure assumes that solutes contribute to the overall dissolved-solids content in a predictable way. Since there are times when this is not the case, there may be some error introduced in the reading.

Some examples of possible error sources are presented here and are applicable to all refractometer designs in varying degrees. This information is presented in an attempt to raise awareness of some of the limitations of refractometer measurements and is not meant as an exhausting scientific discussion. Please see the recommendations at the end of this section for a list of two exceptionally well written scientific papers from which this information is taken.

Increased levels of non-protein solids, such as cholesterol, urea, lipoproteins, and glucose can add as much as 0.5 to 1.0 g/dL to protein readings.

Excess EDTA in plasma samples from under filled blood collection tubes has been reported to produce falsely higher readings.

Hemolysis has been listed as a possible source of error, but it has been concluded that it doesn't present an error as long as the shadow line on the reticle is relatively sharp.

It does not appear that albumin to globulin (A/G) ratio produces any significant error in protein by refractometer measurements.

*Recommendation:* In order to get the most out of your veterinary refractometer in your clinical practice, it is **STRONGLY** recommended that you get a copy of the following studies published in *Veterinary Clinical Pathology*:

1. George JW. The Usefulness and Limitations of Hand-Held Refractometers in Veterinary Laboratory Medicine: An Historical and Technical Review. *Veterinary Clinical Pathology*. 2001;30(4):201-210.
2. George JW, O'Neill SL. Comparison of refractometer and biuret methods for total protein measurement in body cavity fluids. *Veterinary Clinical Pathology*. 2001;30(1):16-18.
3. Wolf AV. *Aqueous Solutions and Body Fluids: Their Concentrative Properties and Conversion Tables*. New York, NY: Harper and Row; 1966.

*Note:* MISCO is a leader in a very small world-wide community of professional refractometer manufacturers and we are very visible within that industry. We respect our competitors, and although comparison between products is inevitable, we offer here only fair and factual comparisons. The insights presented in this technical bulletin are the summation of scientific research and not our subjective opinion. Our sources of information are quoted herein, and it is strongly encouraged that the readers secure copies of these papers for themselves. In the end, it's the customer's decision to select the company they wish to honor with their business.

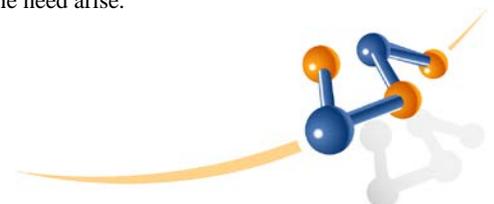
### **Benefits of Using the Palm Abbe Digital Veterinary Refractometer:**

The MISCO Palm Abbe is a fourth-generation digital handheld refractometer that puts laboratory precision in the palm of your hand.

It is fast, convenient, and easy to use. Simply place a drop or two of fluid in the stainless-steel well and press a button. The custom-designed microprocessor delivers a nearly instantaneous readout on as many as five different scales.

The large dual-line LCD display is easily read, even in dim light, and removes the subjectivity associated with interpreting where a boundary line crosses tiny scale divisions. The user interface consists of two buttons, one to take readings and the other to step through various scales or menu options.

The protein scale on the clinical veterinary instrument is based on Wolf's data and uses a 6.54% protein-to-nitrogen ratio. There are separate urine specific gravity scales for feline and for canine and large animals. Dozens of other scales are available and can be mixed and matched for a custom instrument. Instruments can also be sent back in to be reprogrammed with different scales should the need arise.



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Nonlinear temperature compensation is automatic and ensures that fluids read between 0 and 50 °C (+32 to 122 °F) are measured accurately.

The Palm Abbe refractometer automatically calibrates itself to water and is ready to use in seconds. No more screws to turn and nothing to adjust. A NIST traceable calibration standard, available from MISCO, can be used to adjust the high end of the scale.

A multilingual display allows the Palm Abbe user to elect to display prompts and measurements in English, Spanish, French, German, or Russian.

#### **VETMED01 Palm Abbe Clinical Veterinary Refractometer** (P/N 001-096-098-105)

Scale	Unit of Measure	Range	Resolution	Precision (+/-)
Refractive Index	Refractive Index nD20	1.3330 - 1.5000	0.0001	0.0001
Urine - Cat	Specific Gravity by Refractometer (D20/20)	1.0000 - 1.1200	0.0001	0.0005
Urine - Large Animal	Specific Gravity by Refractometer (D20/20)	1.0000 - 1.0650	0.0001	0.0005
Blood - Animal	Total Protein By Refractometer (TPr)	1 to 14 g/dl	0.1	0.1

*TPr scale is based directly on Wolf's data and a protein-to-nitrogen ratio of 6.54%.*

#### **VETMED02 Palm Abbe Veterinary Research Refractometer** (P/N 096-098)

Scale	Unit of Measure	Range	Resolution	Precision (+/-)
Urine - Cat	Specific Gravity by Refractometer (D20/20)	1.0000 - 1.1200	0.0001	0.0005
Urine - Large Animal	Specific Gravity by Refractometer (D20/20)	1.0000 - 1.0650	0.0001	0.0005

We encourage you to freely mix and match up to five scales per instrument from a dozen or more different veterinary scales for your own custom instrument. For more information visit the Digital Palm Abbe page at <http://www.misco.com> or call 800-358-1100, toll free. REV130626.

