

**PROPER MAINTENANCE**

For optimal results, refractometers should be calibrated daily and cleaned after each use.

**SKILLS CHECK: CLINICAL PATHOLOGY**

Measuring Urine Specific Gravity With a Clinical Refractometer

Barbie Papajeski, MS, LVT, RLATG, VTS (Clinical Pathology)
Murray State University, Murray, Kentucky

Abstract

Urine specific gravity (USG) is useful for evaluating a patient's kidney function, hydration status, and other physiologic functions. USG is a comparison of the concentration of urine with that of serum; thus, units of measure are not used. USG can be measured in the clinic by using either an analog or digital refractometer. Some refractometer scales apply to only 1 species; others, to multiple species. Measurement of specific gravity involves calibrating the refractometer, taking the reading, and interpreting the reading. The refractometer prism should be cleaned after every use.



Take-Home Points

- There are 2 types of refractometers: analog and digital.
- Some refractometer scales are specific for 1 species; others work with multiple species.
- The steps of refractometer use are calibration, reading, and interpretation.
- Refractometer calibration varies by type of refractometer but should be done daily.
- Refractometers should be cleaned between each use.
- Small volumes of urine can yield valuable information regarding an animal's health status.

Clinical refractometers are common in-house screening tools for measuring urine specific gravity (USG) with a minute volume of urine.¹ Veterinarians use USG to determine the concentrating ability of the kidneys, pinpoint the anatomic location of any abnormalities, and assess hydration status.¹⁻³ This article describes how refractometers work, refractometer types and maintenance, and the steps to follow when measuring USG.

HOW REFRACTOMETERS WORK

Refractometers compare the gravity of urine with that of distilled water, measuring solid particles in the sample as the refractive index.³ The refractive index correlates with increasing solids within a sample; as light waves pass through the solution, the light is bent depending on the amount of solute within the sample.³ As light is bent through a prism, the optical density is

measured on a scale designed for urine gravity. This scale increases with increased urine concentration and provides a visual indication of the urine:distilled water ratio (**FIGURE 1**).³

TYPES OF REFRACTOMETERS

There are many types of refractometers on the market today, including analog and digital models (**FIGURE 2**). Results are typically accurate, although they may be altered by certain factors (**BOX 1**). Some models offer separate scales for samples from different species (multispecies refractometers) (**FIGURES 3 AND 4**), but the advantage over single-scale models is questionable.⁵⁻⁷ Multispecies refractometers will have one scale for dogs/large animals and a separate scale for cats.^{6,7} Compared with multispecies scales, single-scale refractometers tend to provide higher specific gravity values for cats.³ Both analog and digital refractometer

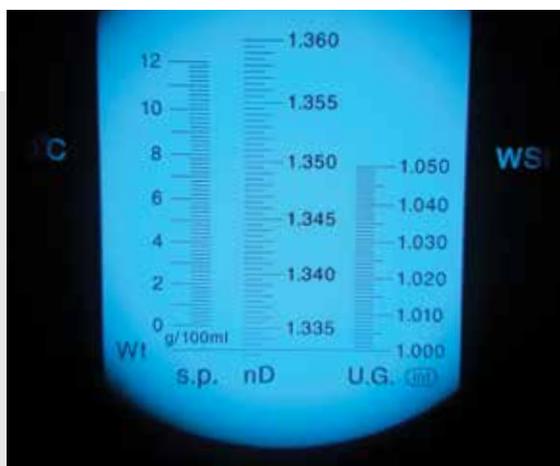


FIGURE 1. Scale of an analog refractometer. Before a sample is added, scales should be visualized and the eyepiece adjusted to bring the numbers into better view. The urine specific gravity scale, designated U.G., is on the right.

BOX 1

Common Causes of Altered Urine Specific Gravity Readings¹⁻⁴

- Inadequate sample volume
- Calibration error
- Reading incorrect scales (Brix or protein)
- Misreading numbers
- Failure to close cover
- High temperature
- Glucosuria
- Proteinuria



specific gravity readings correlate well with urine osmolality, the gold standard for evaluating dissolved particles in a sample.^{2,5,8} To get the most reliable and accurate measurements, always refer to calibration recommendations set forth in the instruction manual for the specific refractometer used. Some refractometers are temperature compensated and do not require frequent calibration.⁷ Patient factors that may affect USG results include glucosuria and marked proteinuria (**BOX 1, FIGURE 5**).^{2,3,5}

STEPS FOR MEASURING URINE SPECIFIC GRAVITY

Step 1: Calibrate

For analog models, before applying the sample to the prism, bring the scale into clearer view by turning the eyepiece while holding the refractometer in the direction of a light source.⁹ Environmental

temperatures outside the range of 16 °C to 38 °C (60 °F to 100 °F) may affect the accuracy of readings.^{1,2,4,10} If the environmental (workplace) temperature fluctuates more than -15 °C (5 °F), some models may require recalibration⁴; however, sample temperature rarely affects USG readings.^{4,6,7} The author's facility calibrates refractometers daily to adjust for any room temperature changes.

To calibrate the refractometer, first gather the necessary supplies (**BOX 2, FIGURE 6**). Then place a sample-equivalent volume of distilled water on the prism and close the cover before checking the reading. On an analog model, if the reading is not on the 1.000 line of specific gravity (**FIGURE 7**), use a screwdriver on the calibration screw to set the line exactly on the mark while viewing the scale (**FIGURE 8**).^{4,7,9} Digital models are calibrated with the press of a button.^{6,10} After calibration is complete, wipe the prism dry with a soft cloth or optical tissue paper.^{6,7,9,10}



FIGURE 2. Various types of refractometers. Left to right: Reichert multispecies analog (reichert.com), Westover analog, Jorvet analog (jorvet.com), Fisher digital (fishersci.com).

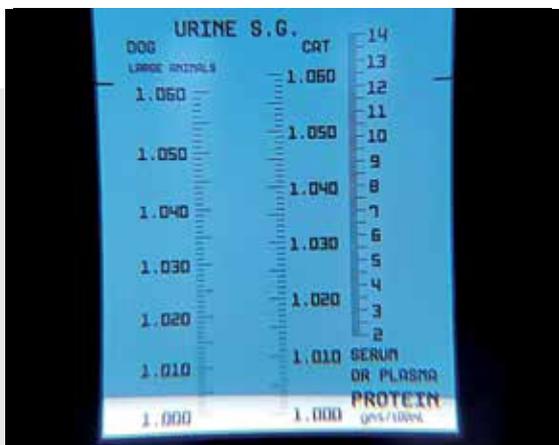


FIGURE 3. Reichart analog model refractometer (reichert.com) showing separate scales for different species. The dog and large animal scales are to the far left and the cat scales are in the middle.

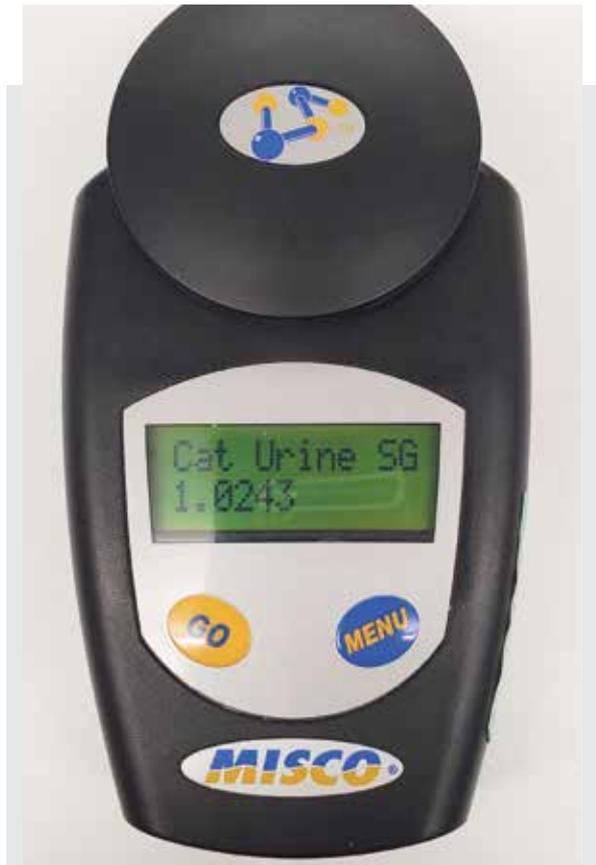


FIGURE 4. Misco digital model refractometer (misco.com), showing separate cat-specific scales. This reading of 1.024 may indicate inadequate concentrating ability, depending on the hydration status of the cat.

Step 2: Reading Urine Specific Gravity

When taking a sample reading, place 1 to 5 drops of urine on the refractometer prism, similar to the distilled water in the calibration step. For accurate readings, be sure to add an adequate amount of sample to the prism (**FIGURE 9**).⁴ Urine samples may be well mixed by gently swirling or inverting the sample, or the supernatant of a centrifuged sample may be used for measurement.^{5,8} To read analog models, close the sample cover and read the interface between the blue and white color; for digital models, read the numbers displayed.^{4,6,7,9,10} The advantage of digital models is minimization of recording errors.⁸ For samples that exceed the USG scale, dilute the sample by adding 1 drop of distilled water to 1 drop of urine, mix well, and then multiply the results past the decimal point by 2. Commonly, USG is merely reported as greater than the scale limit (i.e., >1.060).³ The cutoff value will vary by model. Most models have a USG range from 1.000

BOX 2

Materials Required for Refractometer Calibration^{4,6,7,9,10}

- Refractometer
- Disposable gloves for protection against potential zoonotic disease
- 1–5 drops of urine, depending on refractometer model requirements
- Distilled water for calibration, cleaning, and/or diluting specimen (if required)
- Transfer pipettes for dispensing samples
- Soft cloth or optical tissue for cleaning
- Light source

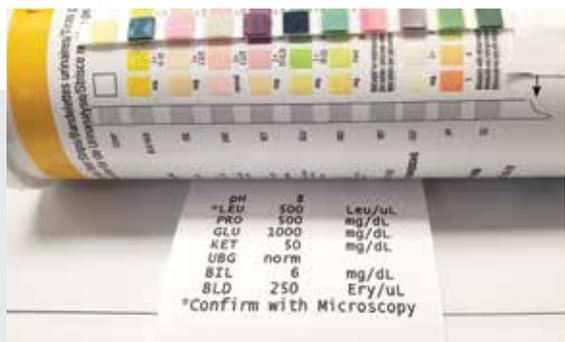


FIGURE 5. Chemical evaluation of a urine sample with elevated glucose and proteinuria, which can falsely elevate urine specific gravity (USG) values. Note that even if USG values are provided on urinalysis chemistry strips, the refractometer measurement is more accurate.



FIGURE 7. Calibrated refractometer scale of the Jorvet analog refractometer (jorvet.com).



FIGURE 6. Materials required for measuring urine specific gravity: refractometer, distilled water, calibration screwdriver for analog models, urine sample, transfer pipette, laboratory optical tissue or a soft cloth, gloves, and natural or artificial light.



FIGURE 8. Calibration screw. While distilled water under the prism is viewed, the calibration screw is turned to adjust the calibration according to the refractometer instructions.



FIGURE 9. An adequate volume of urine is required. Right: Proper sample volume. Left: Inadequate sample volume. An inadequate sample volume will result in a blurred interface between the white and blue areas, leading to the potential for reporting inaccuracies. Either more sample can be applied to the prism or the cover can be gently pressed to ensure complete coverage of the prism with the sample.

to 1.060, and on some digital models, USG on the feline setting can be read up to 1.120.^{4,6,7,9,10}

After each use, clean the refractometer with a soft cloth or laboratory optical tissue and distilled water. Do not use abrasive cleaners or cloths on the prism as doing so will damage the surface and impede readings.^{4,6,7,9,10}

Step 3: Reporting and Interpreting Urine Specific Gravity Results

Because USG is a ratio of urine to distilled water, no



FIGURE 10. Isosthenuric specific gravity reading of 1.012 on a digital refractometer scale.

TABLE 1 Urine Specific Gravity interpretation¹⁻³

READING	INTERPRETATION
<1.008	Hyposthenuria
1.008-1.012	Isosthenuria
>1.012	Hypersthenuria

units of measure are used. USG is described both in terms of concentrating ability compared with the expected specific gravity of plasma or glomerular ultrafiltrate. USG references ranges vary widely. Categories of USG are as follows (TABLE 1)¹⁻³:

- Hyposthenuric indicates dilute urine, often resulting from renal tubule inability to concentrate or from excessive water consumption by the patient.
- Isosthenuric (FIGURE 10) may result from renal dysfunction in dehydrated and azotemic animals, indicating an inability to either dilute or concentrate urine.
- Hypersthenuric (FIGURE 11) indicates concentrated urine, usually resulting from dehydration.

SUMMARY

Refractometers are valuable tools for accurately determining USG readings for veterinary patients. Small volumes of urine can yield valuable information

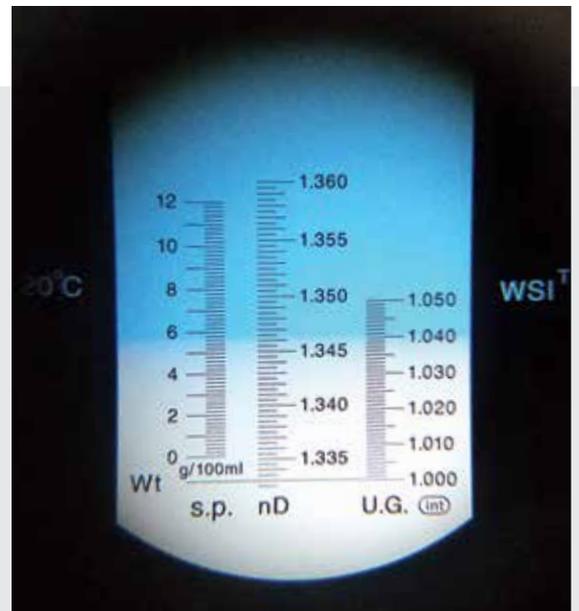


FIGURE 11. Hypersthenuric specific gravity reading of 1.040 on an analog refractometer scale. The urine specific gravity scale is on the right. The line between the blue and white and numbers is clear, making the result easy to read.

regarding an animal's health status. Veterinary nurses increase the value of results by properly calibrating, reading, and maintaining refractometers. **TVN**

References

1. Thrall M, Weiser G, Allison RW, Campbell TW. Laboratory evaluation of renal function. In: *Veterinary Hematology and Clinical Chemistry*. Wiley Blackwell; 2012:333-346,366.
2. Latimer KS. Urinary system. In: *Duncan & Prasse's Veterinary Laboratory Medicine Clinical Pathology*. 5th ed. Wiley Blackwell; 2011:255-257.
3. Sink CA, Weinstein NM. Routine urinalysis: physical properties. In: *Practical Veterinary Urinalysis*. Wiley Blackwell; 2012:19-25.
4. Westover. RHC-200 Refractometer for Clinical Use Operation Manual; 2001.
5. Mösch M, Reese S, Weber K, Hartmann K, Dorsch R. Influence of preanalytic and analytic variables in canine and feline urine specific gravity measurement by refractometer. *J Vet Diagn Invest*. 2020;32(1):36-43. doi:10.1177/1040638719896785
6. Misco. Misco Veterinary Refractometer - Veterinary Urine Scales - Dog & Cat Urine Specific Gravity, Total Protein, & Refractive Index - MISCO VETMED01 Refractometer. Accessed July 14, 2022. <https://www.misco.com/product/veterinary-refractometer-cat-dog-urine-specific-gravity-protein-refractive-index-vetmed01>
7. Reichert Technologies Analytical Instruments. Reichert Vet 360 Instruction Manual; 2003.
8. Bennett AD, McKnight GE, Dodkin SJ, Simpson KE, Schwartz AM, Gunn-Moore, DA. Comparison of digital and optical hand-held refractometers for the measurement of feline urine specific gravity. *J Feline Med Surg*. 2011;3(2):152-154. doi:10.1016/j.jfms.2010.09.012
9. Jorgenson Laboratories. Instruction Manual J-351 Clinical Refractometer. Accessed July 14, 2022. http://jorvet.com/wp-content/uploads/2012/01/J351_Refractometer.pdf
10. Fisher Scientific. Fisherbrand Digital Handheld Refractometer User Manual; 2017.

Barbie Papajeski

Barbie teaches clinical pathology and laboratory animal courses in the veterinary technology program at Murray State University as well as continuing education at state and national conferences. Before full-time teaching, she worked at the Breathitt Veterinary Center diagnostic laboratory. She currently serves as secretary of the Academy of Veterinary Clinical Pathology Technicians. She resides in western Kentucky where she loves to hike with her 2 sons and husband. She shares her home with 2 dogs, 4 cats, and an assortment of feathered and scaled animals.



Reconcile[®]

(fluoxetine hydrochloride)

Affordable. Reliable. Chewable.

RECONCILE[®] (fluoxetine hydrochloride) Chewable Tablets For complete prescribing information, see full package insert. **Caution:** Federal law restricts this drug to use by or on the order of a licensed veterinarian. **Indications:** RECONCILE chewable tablets are indicated for the treatment of canine separation anxiety in conjunction with a behavior modification plan. **Contraindications:** RECONCILE chewable tablets should not be used in dogs with epilepsy or history of seizures, nor given concomitantly with drugs that lower the seizure threshold (e.g., phenothiazines). RECONCILE chewable tablets should not be given in combination with, or within 14 days of discontinuing, a monoamine oxidase inhibitor (MAOI). RECONCILE chewable tablets are contraindicated in dogs with a known hypersensitivity to fluoxetine HCl or other SSRIs. Observe a 6-week washout interval following discontinuation of therapy with RECONCILE chewable tablets prior to the administration of any drug that may adversely interact with fluoxetine or its metabolite, norfluoxetine. **Human Warnings:** Not for use in humans. Keep out of reach of children. In case of accidental ingestion seek medical attention immediately. **Precautions:** RECONCILE chewable tablets are not recommended for the treatment of aggression and have not been clinically tested for the treatment of other behavioral disorders. Studies in breeding, pregnant or lactating dogs and in patients less than 6 months of age have not been conducted. Seizures may occur in dogs treated with RECONCILE chewable tablets, even in dogs without a history of epilepsy or seizures (see **Adverse Reactions**). Before prescribing RECONCILE chewable tablets, a comprehensive physical examination should be conducted to rule out causes of inappropriate behavior unrelated to separation anxiety. RECONCILE chewable tablets have not been evaluated with drugs that affect the cytochrome P450 enzyme system and should be used with caution when co-administered with any drug that affects this system. Studies to assess the interaction of RECONCILE chewable tablets with tricyclic antidepressants (TCAs) (e.g., amitriptyline, clomipramine) have not been conducted. The minimum washout period to transition dogs from TCAs to RECONCILE chewable tablets has not been evaluated. Data demonstrate that TCAs are cleared 4 days following discontinuation.^{1,2} **Adverse Reactions:** In two North American field studies involving 427 dogs, the following adverse reactions were observed at a rate of $\geq 1\%$ in dogs treated with RECONCILE chewable tablets (n=216): calm/lethargy/depression (32.9%), decreased appetite (26.9%), vomiting (17.1%), shaking/shivering/tremor (11.1%), diarrhea (9.7%), restlessness (7.4%), excessive vocalization (including whining) (6.0%), aggression (4.2%), otitis externa (2.8%), disorientation (2.3%), incoordination (2.3%), constipation (1.4%) and excessive salivation (1.4%). **Other adverse reactions: Seizures:** One of 112 dogs in the control group and three of 117 dogs that received RECONCILE chewable tablets experienced the serious adverse reaction of seizures during or after the end of the treatment period. One dog that was treated with RECONCILE chewable tablets experienced two seizures 10 days after the end of therapy and, despite escalating phenobarbital doses, died in status epilepticus approximately six months after the first seizure. In the second study, one of 99 dogs treated with RECONCILE chewable tablets and one of 99 dogs treated with the control tablet experienced the serious adverse reaction of seizures. Lastly, in a European multi-site study, one dog treated with a daily dose of 0.4 mg/kg for one month experienced one seizure one week after discontinuing therapy. **Weight loss:** In field studies, a weight loss $\geq 5\%$ (relative to pre-study body weight) was observed in 58 (29.6%) of dogs treated with RECONCILE chewable tablets and 24 (13.0%) of control dogs. No dogs were withdrawn from clinical studies due to weight loss alone. **Dose reduction:** Twenty dogs in the RECONCILE chewable tablet group and five control dogs required a dose reduction due to unacceptable adverse reactions, the majority intermittent and mild, generally anorexia, vomiting, shaking and depression. Lowering the dose eliminated or reduced the severity of these reactions in the RECONCILE chewable tablet group only, while resumption of the full dose resulted in a return of the initial adverse reactions in approximately half the affected dogs. One dog experienced recurrence of severe adverse reactions, which necessitated withdrawal from the study. Additionally, two dogs required a second dose reduction of RECONCILE chewable tablets. **Post Approval Experience (Rev. 2010):** The following adverse events are based on post-approval adverse drug experience reporting with RECONCILE[®] chewable tablets. Not all adverse reactions are reported to FDA CVM. It is not always possible to reliably estimate the adverse event frequency or establish a causal relationship to product exposure using this data. The following adverse events are listed in decreasing order of reported frequency: decreased appetite, depression/lethargy, shaking/shivering/tremor, vomiting, restlessness and anxiety, seizures, aggression, diarrhea, mydriasis, vocalization, weight loss, panting, confusion, incoordination and hypersalivation. For a copy of the Safety Data Sheet (SDS) or to report suspected adverse drug events, contact Pegasus Laboratories at 1-800-874-9764. For additional information about adverse drug experience reporting for animal drugs, contact FDA at 1-888-FDA-VETS or www.fda.gov/reportanimalae. **Effectiveness:** In one randomized multi-centered, double-blinded, vehicle-controlled study of 8 weeks' duration, 229 dogs were evaluated at 34 investigative sites in the United States and Canada. One hundred seventeen dogs were randomized to 1-2 mg/kg/day of RECONCILE chewable tablets and 112 dogs were randomized to the control group. Both groups underwent concurrent behavior modification. In seven of the eight weeks, the percentage of dogs with improved overall separation anxiety scores was significantly higher ($p < 0.05$) among dogs treated with RECONCILE chewable tablets compared to dogs that received the control tablet. At the end of the study, 73% of dogs treated with RECONCILE chewable tablets showed significant improvement ($p=0.010$) as compared to 51% of dogs treated with behavior modification alone. Dogs treated with RECONCILE chewable tablets also showed improvement in destructive behavior, excessive vocalization and restlessness over dogs that received the control tablet. In addition, dogs in both groups experienced improvement in inappropriate urination, inappropriate defecation, excessive salivation, excessive licking/grooming, shaking/shivering and depression. Overall separation anxiety severity scores improved more rapidly for dogs taking RECONCILE chewable tablets than those dogs receiving the control tablet. The same effect was also noted for the individual scores for excessive vocalization and depression. **To obtain full product information please call 800-874-9764 or visit Reconcile.com • 10-20175 • Approved by FDA under NADA #141-272 • Pegasus Laboratories, Inc.**

¹ Plumb DC. Amitriptyline. *Veterinary Drug Handbook 5th Edition (Pocket Edition)*. Iowa State Press. Ames, IA. Page 39, 2002.

² Hewson CJ, et al. The pharmacokinetics of clomipramine and desmethylclomipramine in dogs: parameter estimates following a single oral dose and 28 consecutive daily doses of clomipramine. *J Vet Pharmacol Therap* 21 :214-222, 1998.



PRN[®] and Reconcile[®] are registered trademarks of Pegasus Laboratories, Inc.