

**INTERPRETING**

**HEMATOLOGY**

**RESULTS**

## 6. GENERAL

6.1 This section provides information that will help you interpret sample analysis results.

## 6.2 INTERPRETING PRINTED RESULTS

6.2.1 Table 6-1 lists the parameters reported by the HEMAVET system, their definitions, the international units of measure, the HEMAVET system units of measure, and the formulas for equivalent unit conversion.

**Table 6-1. HEMAVET System Parameter Table**

PARAMETER	DEFINITION	SI UNIT OF MEASURE	HEMAVET SYSTEM UNIT OF MEASURE	EQUIVALENT UNIT CONVERSION
<b>WBC</b> White Blood Cell (leukocyte) Count	Number of leukocytes in the specified volume of whole blood. Directly Measured.	Billions of leukocytes per liter of whole blood:  $10^9$ cells / liter	Thousands of leukocytes per microliter of whole blood:  K/ $\mu$ L	$10^9$ /liter = $10^3$ / $\mu$ L = K/ $\mu$ L
<b>RBC</b> Red Blood Cell (erythrocyte) count	Number of erythrocytes in the specified volume of whole blood. Directly measured.	Trillions of erythrocytes per liter of whole blood:  $10^{12}$ cells / liter	Millions of erythrocytes per microliter of whole blood:  M/ $\mu$ L	$10^{12}$ /liter = $10^6$ / $\mu$ L = M/ $\mu$ L
<b>Hb</b> Hemoglobin	Mass or weight of hemoglobin in the specified volume of whole blood. Directly measured.	Grams of hemoglobin per deciliter of whole blood:  g/dL	Grams of hemoglobin per deciliter of whole blood:  g/dL	$g/L = g/dL \times 10$
<b>HCT</b> Hematocrit	Relative volume of erythrocytes. Computed from RBC and MCV:  $(RBC \times MCV) \div 10$	Percent:  %	Percent:  %	$L/L = \frac{\%}{100}$

PARAMETER	DEFINITION	SI UNIT OF MEASURE	HEMAVET SYSTEM UNIT OF MEASURE	EQUIVALENT UNIT CONVERSION
<b>MCV</b> Mean Corpuscular (erythrocyte) Volume	Average volume of individual erythrocytes in whole blood. Directly measured.	Femtoliter:  fL or 10 <sup>-15</sup> liter	Femtoliter:  fL or 10 <sup>-15</sup> liter	fL = μ <sup>3</sup>
<b>MCH</b> Mean Corpuscular (erythrocyte) Hemoglobin	Mass or weight of hemoglobin in the average individual erythrocyte. Computed from Hb and RBC:  10 x (Hb ÷ RBC)	Picograms of hemoglobin per erythrocyte:  pg or 10 <sup>-12</sup> g	Picograms of hemoglobin per erythrocyte:  pg or 10 <sup>-12</sup> g	None
<b>MCHC</b> Mean Corpuscular (erythrocyte) Hemoglobin Concentration	Average mass or weight of hemoglobin in specified volume of erythrocytes. Computed from Hb and Hct:  100 x (Hb ÷ Hct)	Grams of hemoglobin per deciliter of erythrocytes:  g/dL	Grams of hemoglobin per deciliter of erythrocytes:  g/dL	g/L = g/dL x 10
<b>RDW</b> Red cell (erythrocyte volume) Distribution Width	The size-distribution spread of the erythrocyte population expressed as the coefficient of variation of the red cell distribution.	Percent %	Percent %	None
<b>RSD</b> Red Cell (erythrocyte) Standard Deviation	The size-distribution spread of the erythrocyte population expressed as the standard deviation of the red cell distribution. Directly measured.	Femtoliter:  fL or 10 <sup>-15</sup> liter	Femtoliter:  fL or 10 <sup>-15</sup> liter	fL = μ <sup>3</sup>
<b>RETICS #</b> (Reticulocytes)	Number of immature nonnucleated erythrocytes in the specified volume of whole blood. Directly measured and flagged.	Trillions of reticulocytes per liter of whole blood:  10 <sup>12</sup> cells / liter	Millions of reticulocytes per microliter of whole blood:  M/μL	10 <sup>12</sup> /liter = 10 <sup>6</sup> /μL = M/μL

PARAMETER	DEFINITION	SI UNIT OF MEASURE	HEMAVET SYSTEM UNIT OF MEASURE	EQUIVALENT UNIT CONVERSION
<b>RETICS %</b> (Reticulocytes)	Percent of immature nonnucleated erythrocytes in the specified volume of whole blood. Flagged.	Percent  %	Percent  %	None
<b>PLT</b> Platelet (thrombocyte) Count	Number of platelets (thrombocytes) in the specified volume of whole blood. Directly measured.	Billions of thrombocytes per liter of whole blood:  $10^9$ cells / liter	Thousands of thrombocytes per microliter of whole blood:  K/ $\mu$ L	$10^9$ /liter = $10^3$ / $\mu$ L = K/ $\mu$ L
<b>PCT</b> Plateletcrit	Relative volume of platelets (thrombocytes). Computed from PLT and MPV:  $(PLT \times MPV) \div 10$	Percent:  %	Percent:  %	$L/L = \frac{\%}{100}$
<b>MPV</b> Mean Platelet (thrombocyte) Volume	Average volume of individual platelets (thrombocytes) in whole blood. Directly measured.	Femtoliter:  fL or $10^{-15}$ liter	Femtoliter:  fL or $10^{-15}$ liter	fL = $\mu^3$
<b>PDW</b> Platelet (thrombocyte volume) Distribution Width	The size distribution spread of the platelet (thrombocyte) population expressed as the coefficient of variation of the platelet distribution	Percent  %	Percent  %	None

PARAMETER	DEFINITION	SI UNIT OF MEASURE	HEMAVET SYSTEM UNIT OF MEASURE	EQUIVALENT UNIT CONVERSION
NE #	Absolute number of leukocytes that are neutrophils. Directly measured.	Billions of neutrophils per liter of blood: $10^9$ cells / liter	Thousands of neutrophils per microliter of blood: K/ $\mu$ L	$10^9$ /liter = $10^3$ / $\mu$ L = K/ $\mu$ L
NE %	Percent of leukocytes that are neutrophils.	Percent %	Percent %	None
LY #	Absolute number of leukocytes that are lymphocytes. Directly measured.	Billions of lymphocytes per liter of blood: $10^9$ cells / liter	Thousands of lymphocytes per microliter of blood: K/ $\mu$ L	$10^9$ /liter = $10^3$ / $\mu$ L = K/ $\mu$ L
LY %	Percent of leukocytes that are lymphocytes.	Percent %	Percent %	None
MO #	Absolute number of leukocytes that are monocytes. Directly measured.	Billions of monocytes per liter of blood: $10^9$ cells / liter	Thousands of monocytes per microliter of blood: K/ $\mu$ L	$10^9$ /liter = $10^3$ / $\mu$ L = K/ $\mu$ L
MO %	Percent of leukocytes that are monocytes.	Percent %	Percent %	None

PARAMETER	DEFINITION	SI UNIT OF MEASURE	HEMAVET SYSTEM UNIT OF MEASURE	EQUIVALENT UNIT CONVERSION
EO #	Absolute number of leukocytes that are eosinophils. Directly measured.	Billions of eosinophils per liter of blood: 10 <sup>9</sup> cells / liter	Thousands of eosinophils per microliter of blood: K/ $\mu$ L	10 <sup>9</sup> /liter = 10 <sup>3</sup> / $\mu$ L = K/ $\mu$ L
EO %	Percent of leukocytes that are eosinophils.	Percent %	Percent %	None
BA #	Absolute number of leukocytes that are basophils. Directly measured.	Billions of basophils per liter of blood: 10 <sup>9</sup> cells / liter	Thousands of basophils per microliter of blood: K/ $\mu$ L	10 <sup>9</sup> /liter = 10 <sup>3</sup> / $\mu$ L = K/ $\mu$ L
BA %	Percent of leukocytes that are basophils.	Percent %	Percent %	None
NRBC #	Absolute number of erythrocytes that are immature nucleated red blood cells. Directly measured and flagged.	Billions of NRBC's per liter of blood: 10 <sup>9</sup> cells / liter	Thousands of NRBC's per microliter blood: K/ $\mu$ L	10 <sup>9</sup> /liter = 10 <sup>3</sup> / $\mu$ L = K/ $\mu$ L
NRBC %	Percent of erythrocytes that are nucleated red blood cells. Flagged.	Percent %	Percent %	None

**6.2.2 Leukocyte Differential.** The HEMAVET system generates a WBC differential by constructing a distribution cytogram based on the relative size and complexity of cells in a blood sample. Each cell passing through the instrument's sensing zone is analyzed, compared to known criteria, and placed in a corresponding area in the cytogram, based on these criteria. For example, a cell with the size and internal complexity of neutrophils is placed in the neutrophil "area" in the cytogram. Percentages and absolute cell numbers are then calculated.

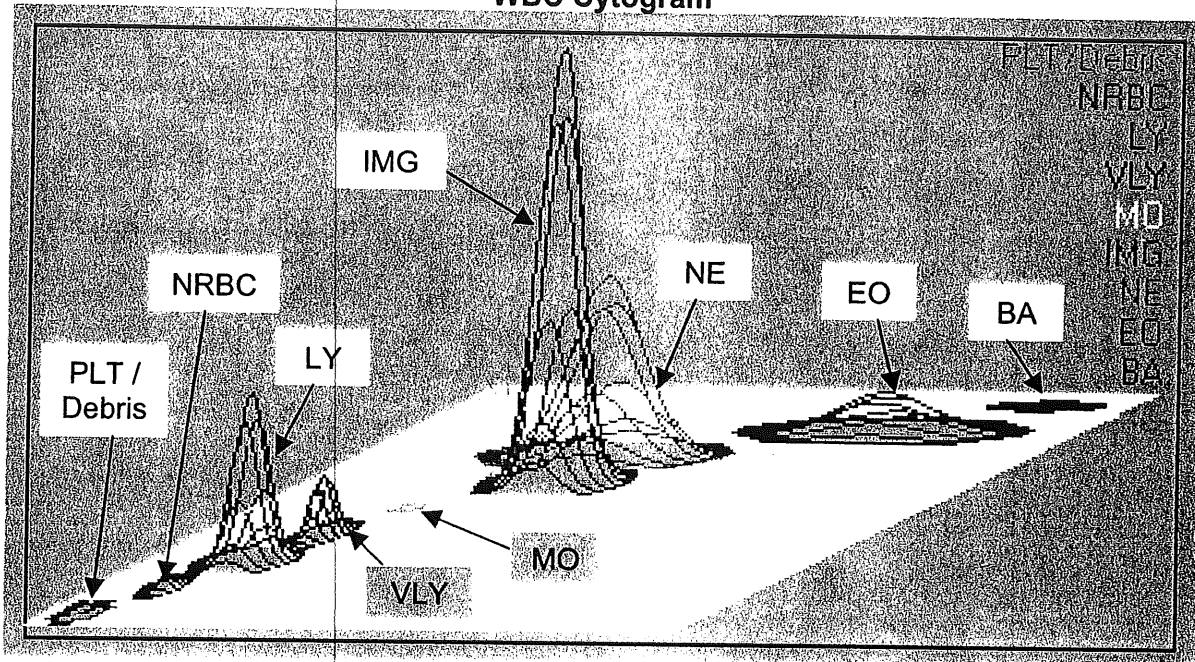
The nine leukocyte populations enumerated by this system include: less than fully mature neutrophils, mature and segmented neutrophils (NE); normal and variant lymphocytes (LY); monocytes (MO); eosinophils (EO) and basophils (BA). Figure 6-1 shows a typical WBC cytogram \* that reflects these populations in order of increasing size and complexity. The cytograms illustrate typical distribution of a "normal" blood sample. Abnormal blood samples may show a different distribution. Clumps of platelets, if present, appear on the WBC cytogram as the peak farthest to the left. They are subtracted from the total WBC count and differential analysis. Nucleated red cells (NRBC), if present, are the next largest cell type and appear as the second population slightly to the right of platelet clumps. They are also excluded from the differential and WBC count. Lymphocytes are the smallest leukocyte and are represented by the third peak on the cytogram. Variant lymphocytes are slightly larger and make up the fourth population. The fifth population represents monocytes. The sixth and seventh populations are less than mature neutrophils, mature and segmented neutrophils, respectively. Eosinophils occupy the eighth population, and basophils are the ninth. Less than mature neutrophils, mature and segmented neutrophils are combined into the NE count, with a left shift being designated by a W3 flag. (See flagging criteria below.) The LY designation contains both normal and variant lymphocytes. Cells in the NE, LY, MO, EO and BA areas are reported with numeric information for both the absolute count and percentage. NRBCs are not enumerated, but a "ELEV" flag in this parameter signals the operator to suspect the presence of these cells.

**6.2.3 Erythrocyte/Thrombocyte Analysis.** Erythrocyte and platelet enumeration is accomplished in much the same way as the WBC count and differential. Cells passing through the instrument are analyzed, placed in a corresponding area in the cytogram, and compared to known criteria for identification. See Figure 6-1 for an illustration of populations defined on the RBC/platelet cytogram \*. Mature RBCs (normocytes) and platelets are reported with numeric values. Reticulocytes are flagged for dog samples only. Reticulocytes (Retics) are not enumerated, but are indicated by an "ELEV" flag if the instrument detects the presence of these cells in numbers above the species specific normal range as shown on the Hematology Profile..

The remaining RBC parameters are either measured directly by the instrument or calculated from measured values. MCV is measured directly and represents the average volume of the erythrocytes passing through the instrument. RDW (red cell distribution width) is a measure of the variation in red cell size throughout the RBC population (i.e. increased RDW indicates more variation in cell size than normal). RBC is the number of erythrocytes per microliter of blood. Hemoglobin (Hb) is measured by lysing all the RBCs in a known quantity of blood and measuring the amount of hemoglobin liberated. HCT, MCH and MCHC are then calculated using these measured values.

\* The reported cytogram populations on the HEMAVET series hematology analyzer are not based on the morphology of humans or non-human primates, such as monkey. When running these, or any other species that is not currently optimized, it is the responsibility of the operator to determine the morphology of that species and to properly identify the various populations of the cytogram.

### WBC Cytogram



### RBC Cytogram

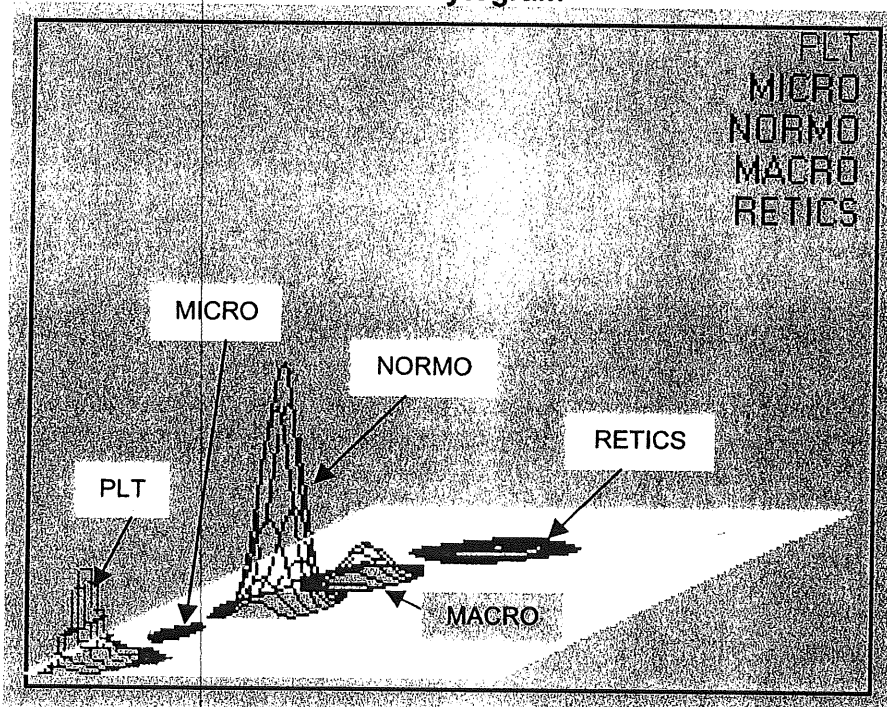


Figure 6-1.



Before reporting any patient sample analysis results, check the printout using the checklist below.

1. Is the ID number on the printout the same as the patient ID number?
2. Is the printout normal? Normal includes:
  - a. Within normal ranges, or within your laboratory's normal range.
  - b. No flags. If suspect flags are present, it is recommended that operator review the blood film.
3. Is the relationship between associated parameters possible? (RBC, Hb, Hct). For example: an Hb of 12.0 g/dL with an Hct of 50% is not "believable". Normally, there is approximately a 1:3 ratio for Hb to Hct.
4. Are the results physiologically possible? For example: an MCHC of 50.2 g/dL is highly improbable. For most mammals the MCHC ranges from 31.0 to 37.0
5. Are the results consistent with the previous reports available on the patient? If not, check the consistency of the results with the patient condition.
6. Are any of the parameters flagged, indicating results should be verified?

**6.2.4 Flagging Criteria.** Certain conditions and cell size distributions trigger the following flags to alert the operator that abnormal conditions may exist.

The following suspect flags may appear adjacent to the leukocyte parameters:

- \* Indicates that the mean of the WBC cytogram has shifted abnormally due to cell fragility. Examine blood smear.
- P1 Indicates that debris due to incomplete lysis of RBCs and/or platelet clumps are present.
- \*P1 Indicates excessive debris or cellular fragments. Examine blood smear.
- W3 Indicates that neutrophils have collapsed in vitro due to anemia or a delay in processing, or that immature granulocytes are present. Review the blood smear to evaluate RBC and WBC morphology and differential.
- W5 Indicates that very large particles or many small platelet clumps have been detected. Review the blood smear to determine cause.

The following suspect flags may appear adjacent to the erythrocyte parameters:

- \* Indicates that RDW is beyond instrument linearity limits (8% - 55%).
- R1 Indicates that platelet clumps, microcytic RBCs or RBCs that have collapsed due to autohemolysis have been detected. Review the blood smear to determine cause. R1 and P2 flags appearing together indicates difficulty in separating platelet and RBC populations because of small RBCs and/or platelet clumps. Review blood smear to determine cause.
- R5 Indicates the presence of an unusual population in the RBC cytogram.
- R7 Indicates that very large cells relative to RBCs have been detected. WBCs appearing on RBC cytogram in cases of marked leukocytosis often trigger this flag. Review blood smear to determine cause.
- RM Indicates that multiple region alarms have been triggered.

The following suspect flags can appear adjacent to the hemoglobin (Hb) parameter:

- \* Indicates that the Hb lamp is aging and will need to be replaced soon. Hb results are still valid.
- \*B Indicates that the Hb lamp is failing. Hb results are blanked out. Lamp needs to be replaced.

The following suspect flags may appear adjacent to the thrombocyte parameters:

- \*P1 Indicates that MPV is below instrument linearity limit (2.0 fL).
- P2 Indicates that very large platelets or platelet clumps are present. Examine blood smear to determine cause.
- \*P2 Indicates that MPV is above instrument linearity limit (30.0).

The following suspect flags may appear adjacent to the leukocyte, erythrocyte, or thrombocyte parameters:

- L Indicates that the flagged number or percentage is below the preset normal range for that species.
- H Indicates that the flagged number or percentage is above the preset normal range for that species.

If a particular leukocyte, erythrocyte or thrombocyte parameter is above the instrument's linearity limit, the word "HIGH" will appear in place of a numeric result.

If an error occurs in the calculation of a particular leukocyte, erythrocyte or thrombocyte parameter, dashes (----) will appear in place of the numeric result.

**6.2.5 Diagnostic Considerations.** The messages that can appear in the Diagnostic Considerations section of the hematology report are given in attachment at the end of this section.

**6.2.6 Data Checks.** As the Key Operator, you should review the patient sample analysis results. Following are suggested guidelines you may want to include in your review.