Introduction

The Forensic Chemistry Unit utilizes a Mettler PE24 platform balance for determining net and gross weights of large items of evidence, typically weighing over 200 grams. The maximum weighing capacity for this balance is 24 kilograms. This is a common use balance.

The Forensic Chemistry Unit performs forensic drug analysis on samples impounded at the San Diego Police Department. Part of the analytical process is the determination of the net or gross weights of individual items of evidence. The net weight of evidence is of particular concern when it is specifically addressed in legislation.

It is standard practice to obtain and record the kilogram weight to three decimal places, then convert the kilogram weight to a gram weight reported with no decimal places. For example, an observed weight of 1.234 kilograms is reported as 1,234 grams.

Forensic Chemistry Unit personnel evaluated data collected through routine calibration testing of this balance, which was performed by contracted service providers. This was conducted to establish an uncertainty of measurement determination for the use of this balance, and to incorporate the uncertainty of measurement of this balance in the reporting of weights for forensic samples.

Method

In order to establish measurement uncertainty for the balance, the following contributing factors were evaluated:

- **Readability:** The incremental changes the balance will display. This value is reported as the decimal place the balance is capable of reading.
- **Repeatability:** The instrument's ability to consistently deliver the same reading of a known object. This measurement can be established using the standard deviation of repeated measurements.
- **Linearity:** The instrument's ability to measure weights accurately throughout the capacity range (minimum values to maximum values). This value can be established by measuring the amount of deviation from a straight line.
- **Sensitivity to Drift:** The instrument's ability to measure accurately with temperature change. This value is relevant with micro-balances and is negligible for this electronic precision balance. This value will not be included in the overall uncertainty of measurement calculation.

The specifications set forth by the manufacturer for the Mettler PE24 electronic precision balance are the following:

Weighing Capacity	**24 kg**
Readability	**1 g**
Repeatability	**0.3 g**
Linearity	**1 g**

Two separate outside agencies contracted by the SDPD measured 7 different NIST traceable weights ranging from 1 kg to 24 kg. Six years of data was compiled. (See appendix 1 for the excel spreadsheet.)

Readability: The readability used for the uncertainty of measurement calculation is the manufacturer's reported value of 1 gram.

Repeatability: For each column of repeated measurements, standard deviations were calculated. The maximum standard deviation reported from all 6 years was used in the uncertainty of measurement calculation.

Linearity: The maximum difference between the actual NIST traceable weights and the measured values was determined across the range of weights and was used in the uncertainty of measurement calculation.

Results

Results were compiled to evaluate measurement data obtained. The standard deviation of weight values were calculated for each individual weight value. (See Appendix 2 for the result worksheets.)

The Uncertainty Budget Table summarizes the maximum calculated results of repeatability and linearity from the Mettler PE24 balance. Readability was established through manufacture specifications and the decimal-place readings of weight values in our study.

Uncertainty Budget Table (in grams)

Factors	Value (x)	Standard Uncertainty (u)	Distribution	Relative contribution
Readability[1]	1 g	$\frac{x/2}{\sqrt{3}} = 0.2887$ g	Rectangular	18.44%
Repeatability[2]	0.7 g	0.7g	Normal	44.70%

Linearity	2 g	$\frac{x/2}{\sqrt{3}} = 0.5773$	Rectangular	36.86%

[1] Manufacturer's literature
[2] Maximum Standard deviation

Calculation of Combined Standard Uncertainty:

$$U_c = \sqrt{u(\text{readability})^2 + u(\text{repeatability})^2 + u(\text{linearity})^2}$$

$$U_c = \sqrt{(0.2887)^2 + (0.7)^2 + (0.5773)^2}$$ **= 0.9522 g**

Calculation of Expanded Uncertainty:

$U = k * u_c$ Where U is the expanded uncertainty and k is the coverage factor.

Approximate 95% where k= 2 +/- 1.9044 g
Approximate 99.7% where k= 3 +/- 2.8566 g

Conclusions

A standard uncertainty of measurement was calculated for the Mettler PE24 balance used in the Forensic Chemistry Unit. Measurement results for casework in the Forensic Chemistry Unit, using this balance only, are reported to 0-decimal places. The balance displays a 3-decimal place result in kilograms, which is then converted by the analyst to grams, and reported with no decimal places. Therefore, the expanded uncertainty cannot be incorporated directly into the measured result.

Integrating the uncertainty of measurement at the 99.7% confidence interval into our reported results creates a maximum uncertainty of +/- 3 g.

Measurements utilizing the PE24 balance will be reported with no decimal places, in grams. A statement of the effect of the expanded uncertainty at the 99.7% confidence interval on results will be incorporated into the report.

A new uncertainty of measurement will be calculated only when the balance is subject to repair which would potentially affect its measurability.

Technical Review R. Jurado 8611 Date 2-16-12

Administrative Review [signature] Date 2/16/12

Quality Assurance Manager J. M. Simms Date 2-17-12

APPENDIX 1 - Measurement Data: Mettler PE24 Balance

Date	Parameter	Weight Used	Measured	Max Diff	Tolerance	Stated Tolerance
12/15/2010	Corners	5 kilograms	5.000	0.000	+/- 0.005 kg	
12/15/2010	1st Point	500 grams	0.500	0.000	+/- 0.001 kg	
12/15/2010	2nd Point	2 kilograms	2.000	0.000	+/- 0.002 kg	
12/15/2010	3rd Point	4 kilograms	4.000	0.000	+/- 0.003 kg	
12/15/2010	4th Point	10 kilograms	10.000	0.000	+/- 0.005 kg	
12/15/2010	5th Point	15 kilograms	14.999	0.001	+/- 0.005 kg	
12/15/2010	6th Point	20 kilograms	19.999	0.001	+/- 0.005 kg	
12/15/2009	Corners	5 kilograms	5.000	0.000	+/- 0.005 kg	
12/15/2009	1st Point	500 grams	0.500	0.000	+/- 0.001 kg	
12/15/2009	2nd Point	2 kilograms	2.000	0.000	+/- 0.002 kg	
12/15/2009	3rd Point	4 kilograms	4.000	0.000	+/- 0.003 kg	
12/15/2009	4th Point	10 kilograms	10.000	0.000	+/- 0.005 kg	
12/15/2009	5th Point	15 kilograms	14.999	0.001	+/- 0.005 kg	
12/15/2009	6th Point	20 kilograms	19.998	0.002	+/- 0.005 kg	
12/5/2007	Corners	10 kilograms	10.000	0.000	+/- 0.003 kg	+/- 3d
12/5/2007	1st Point	2 kilograms	2.000	0.000	+/- 0.003 kg	
12/5/2007	2nd Point	5 kilograms	5.000	0.000	+/- 0.003 kg	
12/5/2007	3rd Point	8 kilograms	8.000	0.000	+/- 0.003 kg	
12/5/2007	4th Point	11 kilograms	11.000	0.000	+/- 0.003 kg	
12/5/2007	5th Point	18 kilograms	18.000	0.000	+/- 0.003 kg	
12/5/2007	6th Point	23 kilograms	23.000	0.000	+/- 0.003 kg	
12/14/2006	Corners	10 kilograms	10.000	0.000	+/- 0.003 kg	+/- 3d
12/14/2006	1st Point	2 kilograms	2.000	0.000	+/- 0.003 kg	
12/14/2006	2nd Point	5 kilograms	5.000	0.000	+/- 0.003 kg	
12/14/2006	3rd Point	8 kilograms	8.000	0.000	+/- 0.003 kg	
12/14/2006	4th Point	12 kilograms	12.000	0.000	+/- 0.003 kg	
12/14/2006	5th Point	18 kilograms	18.000	0.000	+/- 0.003 kg	
12/14/2006	6th Point	23 kilograms	23.000	0.000	+/- 0.003 kg	
12/14/2005	Corners	10 kilograms	10.000	0.000	+/- 0.003 kg	+/- 3d
12/14/2005	1st Point	2 kilograms	2.000	0.000	+/- 0.003 kg	
12/14/2005	2nd Point	5 kilograms	5.000	0.000	+/- 0.003 kg	
12/14/2005	3rd Point	8 kilograms	8.000	0.000	+/- 0.003 kg	
12/14/2005	4th Point	12 kilograms	12.000	0.000	+/- 0.003 kg	
12/14/2005	5th Point	18 kilograms	18.000	0.000	+/- 0.003 kg	
12/14/2005	6th Point	24 kilograms	23.999	0.001	+/- 0.003 kg	
9/18/2002	Corners	10 kilograms	10.001	0.001	+/- 0.003 kg	
9/18/2002	1st Point	2 kilograms	2.000	0.000	+/- 0.003 kg	
9/18/2002	2nd Point	5 kilograms	5.000	0.000	+/- 0.003 kg	
9/18/2002	3rd Point	8 kilograms	8.000	0.000	+/- 0.003 kg	
9/18/2002	4th Point	12 kilograms	12.000	0.000	+/- 0.003 kg	
9/18/2002	5th Point	18 kilograms	18.000	0.000	+/- 0.003 kg	
9/18/2002	6th Point	24 kilograms	24.000	0.000	+/- 0.003 kg	

Appendix 2 - Calculation of Standard Deviation: Mettler PE24 Balance

	Weight Used							
Date	**500 grams**	**2 kg**	**4 kg**	**5 kg**	**8 kg**	**10 kg**	**11 kg**	**12 kg**
12/15/2010	0.500	2.000	4.000	5.000		10.000		
12/15/2009	0.500	2.000	4.000	5.000		10.000		
12/5/2007		2.000		5.000	8.000	10.000	11.000	
12/14/2006		2.000		5.000	8.000	10.000		12.000
12/14/2005		2.000		5.000	8.000	10.000		12.000
9/18/2002		2.000		5.000	8.000	10.001		12.000
Standard Dev	0.000	0.000	0	0.000	0.000	0.000408	0.000	0.000

Date	**15 kg**	**18 kg**	**20 kg**	**23 kg**	**24 kg**
12/15/2010	14.999		19.999		
12/15/2009	14.999		19.998		
12/5/2007		18.000		23.000	
12/14/2006		18.000		23.000	
12/14/2005		18.000			23.999
9/18/2002		18.000			24.000
Standard Dev	0.000	0.000	0.000707	0.000	0.000707