国家计量技术规范规程制修订

《尿比重计校准规范》

实验报告

2025年2月

实验报告

1. 实验目的

验证《尿比重计校准规范》的适用性和可行性。

1. 实验地点

验证实验均在实验室完成。

1. 环境条件

实验过程中环境温度均在（20±2）℃，相对湿度≤85%。

1. 实验仪器与实验设计

在验证实验中，对金科利达仪器有限公司、华勤众远仪器有限公司和Anton Paar等公司生产的6台不同型号尿比重计进行了验证实验，覆盖了国内家用和医院临床科室常用的刻度式和数显式尿比重计类型。

1. 测量标准

5.1 METTLER TOLEDO XSR205DU电子天平

测量范围为0.01mg~220g，级。

5.2 Fluke 1524数字温度计

测量范围（0～50）℃，最大允许误差为±0.1 ℃。

5.3 GBW(E)060024氯化钠纯度标准物质

以氯计的质量分数为100.00%，*U*=0.02%（*k*=2）。

5.4纯水

电阻率不小于18.2 MΩ·cm（25 ℃）。

5.5其他设备

A级容量瓶若干，烧杯、搅拌器、滴管、镜头纸等。

5.6 比重标准溶液

在环境温度20 ℃下，用电子天平精确称取氯化钠纯度标准物质（NaCl，分子量58.44277），精确称取纯水（H2O，分子量18.0153）溶解，分别配置5种覆盖各质量浓度水平的氯化钠溶液各1份，如下表所示。

|  |  |  |  |
| --- | --- | --- | --- |
| 质量浓度/% | 比重（20 ℃） | NaCl（g） | H2O（g） |
| 1 | 1.00534 | 0.50267 | 49.76433 |
| 2 | 1.01246 | 1.01246 | 49.61054 |
| 4 | 1.02680 | 2.0536 | 49.2864 |
| 6 | 1.04127 | 3.12381 | 48.93969 |
| 8 | 1.05589 | 4.22356 | 48.57094 |

1. 实验结果

6.1 金科利达NS-40验证实验

根据校准规范的要求和方法，对数显式金科利达NS-40进行验证实验，验证后的结果如下表所示。

表1 NS-40温度示值误差校准结果

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 尿比重计/℃ | | | | 数字温度计/℃ | | | | 温度示值误差/℃ |
| 测量值 | | | 平均值 | 测量值 | | | 平均值 |
| 20.1 | 20.2 | 20.1 | 20.1 | 20.2 | 20.2 | 20.3 | 20.2 | -0.1 |

表2 NS-40比重示值误差校准结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 质量浓度水平 | 比重测量结果 | | | | | 示值误差 |
| 标准值 | 尿比重计 | | | |
| *T* | 1 | 2 | 3 | *M* |
| 1% | 1.00534 | 1.006 | 1.006 | 1.006 | 1.006 | 0.001 |
| 2% | 1.01246 | 1.012 | 1.012 | 1.012 | 1.012 | -0.001 |
| 4% | 1.02680 | 1.021 | 1.021 | 1.021 | 1.021 | -0.006 |
| 6% | 1.04127 | 1.029 | 1.029 | 1.029 | 1.029 | -0.012 |
| 8% | 1.05589 | 1.037 | 1.037 | 1.037 | 1.037 | -0.019 |

表3 NS-40比重重复性校准结果

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 质量浓度水平 | 比重测量结果 | | | | | | | | 重复性*SD* |
| 标准值 | 尿比重计 | | | | | | |
| *M* | 1 | 2 | 3 | 4 | 5 | 6 | *T* |
| 4% | 1.02680 | 1.021 | 1.020 | 1.019 | 1.020 | 1.021 | 1.021 | 1.020 | 0.0008 |

6.2华勤众远DR501验证实验

根据校准规范的要求和方法，对数显式华勤众远DR501进行验证实验，验证后的结果如下表所示。

表4 DR501温度示值误差校准结果

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 尿比重计/℃ | | | | 数字温度计/℃ | | | | 温度示值误差/℃ |
| 测量值 | | | 平均值 | 测量值 | | | 平均值 |
| 20.2 | 20.2 | 20.1 | 20.2 | 20.2 | 20.3 | 20.3 | 20.3 | -0.1 |

表5 DR501比重示值误差校准结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 质量浓度水平 | 比重测量结果 | | | | | 示值误差 |
| 标准值 | 尿比重计 | | | |
| *T* | 1 | 2 | 3 | *M* |
| 1% | 1.00534 | 1.004 | 1.004 | 1.004 | 1.004 | -0.001 |
| 2% | 1.01246 | 1.009 | 1.009 | 1.009 | 1.009 | -0.003 |
| 4% | 1.02680 | 1.019 | 1.019 | 1.019 | 1.019 | -0.008 |
| 6% | 1.04127 | 1.027 | 1.027 | 1.027 | 1.027 | -0.014 |
| 8% | 1.05589 | 1.035 | 1.035 | 1.035 | 1.035 | -0.021 |

表6 DR501比重重复性校准结果

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 质量浓度水平 | 比重测量结果 | | | | | | | | 重复性*SD* |
| 标准值 | 尿比重计 | | | | | | |
| *M* | 1 | 2 | 3 | 4 | 5 | 6 | *T* |
| 4% | 1.02680 | 1.019 | 1.018 | 1.019 | 1.020 | 1.018 | 1.019 | 1.019 | 0.0008 |

6.3华勤众远RHC-300ATC验证实验

根据校准规范的要求和方法，对刻度式华勤众远RHC-300ATC进行验证实验，验证后的结果如下表所示。

表7 RHC-300ATC温度示值误差校准结果

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 尿比重计/℃ | | | | 数字温度计/℃ | | | | 温度示值误差/℃ |
| 测量值 | | | 平均值 | 测量值 | | | 平均值 |
| 20.1 | 20.2 | 20.1 | 20.1 | 20.3 | 20.4 | 20.4 | 20.4 | -0.3 |

表8 RHC-300ATC比重示值误差校准结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 质量浓度水平 | 比重测量结果 | | | | | 示值误差 |
| 标准值 | 尿比重计 | | | |
| *T* | 1 | 2 | 3 | *M* |
| 1% | 1.00534 | 1.003 | 1.003 | 1.003 | 1.003 | -0.002 |
| 2% | 1.01246 | 1.008 | 1.008 | 1.008 | 1.008 | -0.004 |
| 4% | 1.02680 | 1.018 | 1.018 | 1.018 | 1.018 | -0.009 |
| 6% | 1.04127 | 1.027 | 1.027 | 1.027 | 1.027 | -0.014 |
| 8% | 1.05589 | 1.035 | 1.035 | 1.035 | 1.035 | -0.021 |

表9 RHC-300ATC比重重复性校准结果

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 质量浓度水平 | 比重测量结果 | | | | | | | | 重复性*SD* |
| 标准值 | 尿比重计 | | | | | | |
| *M* | 1 | 2 | 3 | 4 | 5 | 6 | *T* |
| 4% | 1.02680 | 1.018 | 1.017 | 1.016 | 1.015 | 1.017 | 1.017 | 1.017 | 0.0010 |

6.4 华勤众远HT312ATC验证实验

根据校准规范的要求和方法，对刻度式华勤众远HT312ATC进行验证实验，验证后的结果如下表所示。

表10 HT213ATC温度示值误差校准结果

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 尿比重计/℃ | | | | 数字温度计/℃ | | | | 温度示值误差/℃ |
| 测量值 | | | 平均值 | 测量值 | | | 平均值 |
| 20.2 | 20.2 | 20.1 | 20.2 | 20.4 | 20.4 | 20.3 | 20.4 | -0.2 |

表11 HT213ATC比重示值误差校准结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 质量浓度水平 | 比重测量结果 | | | | | 示值误差 |
| 标准值 | 尿比重计 | | | |
| *T* | 1 | 2 | 3 | *M* |
| 1% | 1.00534 | 1.005 | 1.005 | 1.005 | 1.005 | -0.0003 |
| 2% | 1.01246 | 1.010 | 1.010 | 1.010 | 1.010 | -0.003 |
| 4% | 1.02680 | 1.020 | 1.020 | 1.020 | 1.020 | -0.007 |
| 6% | 1.04127 | 1.030 | 1.030 | 1.030 | 1.030 | -0.011 |
| 8% | 1.05589 | 1.040 | 1.040 | 1.040 | 1.040 | -0.016 |

表12 HT213ATC比重重复性校准结果

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 质量浓度水平 | 比重测量结果 | | | | | | | | 重复性*SD* |
| 标准值 | 尿比重计 | | | | | | |
| *M* | 1 | 2 | 3 | 4 | 5 | 6 | *T* |
| 4% | 1.02680 | 1.020 | 1.019 | 1.018 | 1.018 | 1.020 | 1.021 | 1.019 | 0.0012 |

6.5 Anton Paar公司 DMA 5001验证实验

根据校准规范的要求和方法，对Anton Paar公司 DMA 5001进行验证实验，验证后的结果如下表所示。

表13 DMA 5001温度示值误差校准结果

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 尿比重计/℃ | | | | 数字温度计/℃ | | | | 温度示值误差/℃ |
| 测量值 | | | 平均值 | 测量值 | | | 平均值 |
| 20.1 | 20.0 | 20.1 | 20.1 | 20.1 | 20.2 | 20.2 | 20.2 | -0.1 |

表14 DMA 5001比重示值误差校准结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 质量浓度水平 | 相对密度测量结果 | | | | | 示值误差 |
| 标准值 | 尿比重计 | | | |
| *M* | 1 | 2 | 3 | *T* |
| 1% | 1.00534 | 1.00718 | 1.00718 | 1.00718 | 1.00718 | 0.002 |
| 2% | 1.01246 | 1.01430 | 1.01430 | 1.01431 | 1.01430 | 0.002 |
| 4% | 1.02680 | 1.02865 | 1.02866 | 1.02865 | 1.02865 | 0.002 |
| 6% | 1.04127 | 1.04316 | 1.04316 | 1.04317 | 1.04316 | 0.002 |
| 8% | 1.05589 | 1.05770 | 1.05770 | 1.05771 | 1.05770 | 0.002 |

表15 DMA 5001比重重复性校准结果

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 质量浓度水平 | 相对密度测量结果 | | | | | | | | 重复性*SD* |
| 标准值 | 尿比重计 | | | | | | |
| *M* | 1 | 2 | 3 | 4 | 5 | 6 | *T* |
| 4% | 1.02680 | 1.02865 | 1.02861 | 1.02875 | 1.02858 | 1.02855 | 1.02851 | 1.02861 | 0.00008 |

6.6 Anton Paar公司 DMA 35验证实验

根据校准规范的要求和方法，对Anton Paar公司 DMA 35进行验证实验，验证后的结果如下表所示。

表16 DMA 35温度示值误差校准结果

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 尿比重计/℃ | | | | 数字温度计/℃ | | | | 温度示值误差/℃ |
| 测量值 | | | 平均值 | 测量值 | | | 平均值 |
| 20.1 | 20.0 | 20.1 | 20.1 | 20.1 | 20.2 | 20.2 | 20.2 | -0.1 |

表17 DMA 35比重示值误差校准结果

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 质量浓度水平 | 相对密度测量结果 | | | | | 示值误差 |
| 标准值 | 尿比重计 | | | |
| *M* | 1 | 2 | 3 | *T* |
| 1% | 1.00534 | 1.0098 | 1.0095 | 1.0096 | 1.0096 | 0.005 |
| 2% | 1.01246 | 1.0173 | 1.0172 | 1.0171 | 1.0172 | 0.005 |
| 4% | 1.02680 | 1.0315 | 1.0317 | 1.0316 | 1.0316 | 0.005 |
| 6% | 1.04127 | 1.0465 | 1.0467 | 1.0461 | 1.0464 | 0.005 |
| 8% | 1.05589 | 1.0607 | 1.0605 | 1.0604 | 1.0605 | 0.005 |

表18 DMA 35比重重复性校准结果

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 质量浓度水平 | 相对密度测量结果 | | | | | | | | 重复性*SD* |
| 标准值 | 尿比重计 | | | | | | |
| *M* | 1 | 2 | 3 | 4 | 5 | 6 | *T* |
| 4% | 1.02680 | 1.0315 | 1.0317 | 1.0316 | 1.0311 | 1.0310 | 1.0321 | 1.0315 | 0.0004 |

1. 实验结论

通过对金科利达NS-40，华勤众远DR501，华勤众远RHC-300ATC，华勤众远HT312ATC，Anton Paar DMA 5001，Anton Paar DMA 35等公司生产的6台不同型号尿比重计进行验证，证明制定的《尿比重计校准规范》能够很好的评价仪器温度示值误差、比重示值误差和比重重复性等计量特性，从而实现量值传递，保证尿比重计校准结果的准确可比。