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Operator's Manual
Balance Automation Software for the
NIST Mass Calibration Laboratory

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  Division
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NIST

Forward

This operator's manual was written primarily for the use of current and future providers of NIST mass calibration services. Other audiences may include current and future reviewers/inquirers of the NIST mass quality manual, upper echelon U.S. mass labs, states weights and measures labs, and national metrology institutes providing mass calibration services.

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Introduction

This manual contains instructions on using the mass measurement software with the AT20, AT21, AT106, and AT1005 Mettler electronic balances in the mass calibration laboratory[1]. It is assumed that the user of this automation software is knowledgeable in the use of these balances as well as in the calibration of weight standards. This knowledge should include the measurement designs used[2] as well as weighing procedures. Also, the user should also be familiar with the existing, separate statistical program, referred to as the Mass Code[3] used at NIST.

Equipment Set Up

Shown in Figure 1 is the set up of the equipment in the automation. There are four workstations, each consisting of a balance and a computer. Installed within the balance is a temperature probe. Each probe is connected to the precision thermometer. Also in the set up are a hygrometer, barometer and two "COMS". A "COMS" is a code-operated matrix switch. It allows a computer to individually connect to its corresponding balance, thermometer, barometer and hygrometer as needed while the others simultaneously do the same.
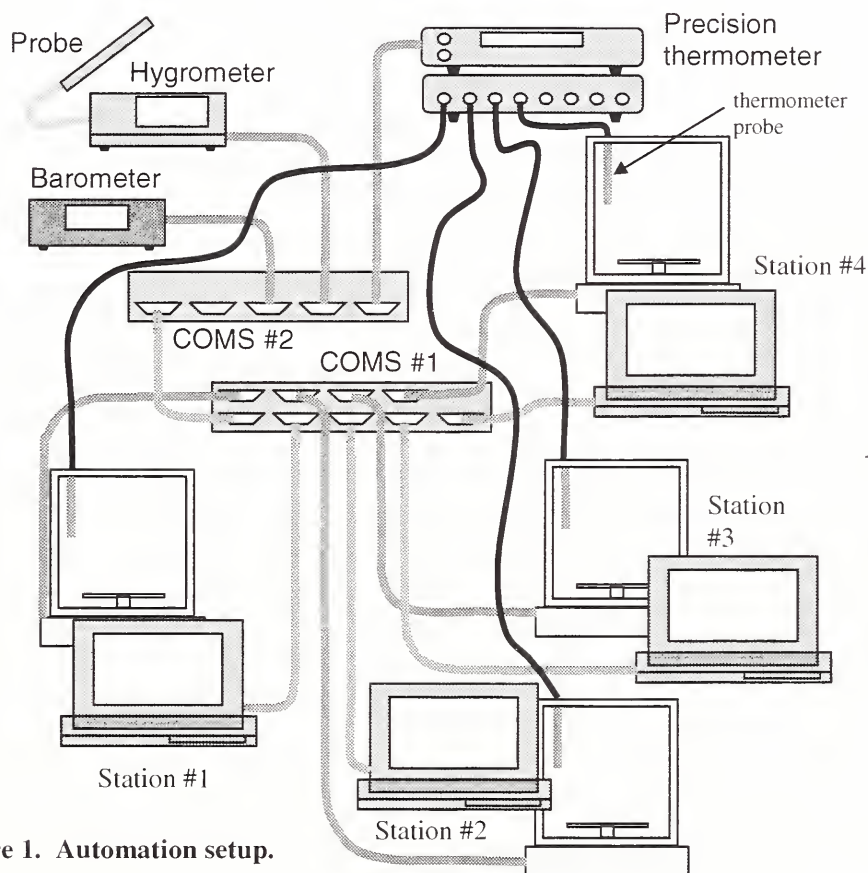

Figure 1. Automation setup.

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[1] Disclaimer: Commercial instruments are identified in this paper for the purpose of describing the experimental setup. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology. Nor does it imply that the equipment identified is necessarily the best available for the purpose or the only equipment that can be used.

[2] See NBS Technical Note 952, "Designs for the Calibration of Standards of Mass", J. M. Cameron, M. C. Croarkin, and R. C. Raybold, June 1977.

[3] See NBS Technical Note 1127, "National Bureau of Standards Mass Calibration Computer Software", R. N. Varner & R. C. Raybold, July 1980.

The only equipment the user deals with when performing measurements is the computer and balance. The software controls the measurement sequence of the weights (according to the user-specified design) and the measurement and recording of the environmental variables and balance readings. The user is instructed by the program to enter the required customer and measurement information and to load and unload weights on the balance.

Measurement Designs

The measurement designs coded into the software include:

> 31S (or 1,1,1),
> 41S (or 1,1,1,1),
> 51S (or 1,1,1,1,1),
> 16A (or 5,2,2,1,1,1),
> 52J (or 5,3,2,1,1),
> R62C (or 5,3,2,1,1,1),
> 5221111, and
> 5321111.

The 31S, 41S, and 51S designs are each run as single, stand-alone series. Designs 16A, 52J, and R62C are run as a set of seven series starting with a 41S or 51S design with the remaining in their respective designs. For example, a 16A set may start with the first series using the 41S design and use for series two through seven the 16A design. Measurements using the 5221111 and 5321111 designs use these designs for all seven series in the set. Table 2 (shown later) lists the names of these designs as individual series in a set.

Summary of Procedure

The basic steps in using the automation software consist of:
- gathering customer, weight, and measurement information,
- inserting a data disk into the floppy disk drive,
- starting the software,
- entering the gathered information, and
- placing weights on the balance in sequence as instructed.

Detailed Procedures

1. Gather customer, weight, and measurement information using the form on pages 12 and 13. Required by the Mass Code, this information consists of:
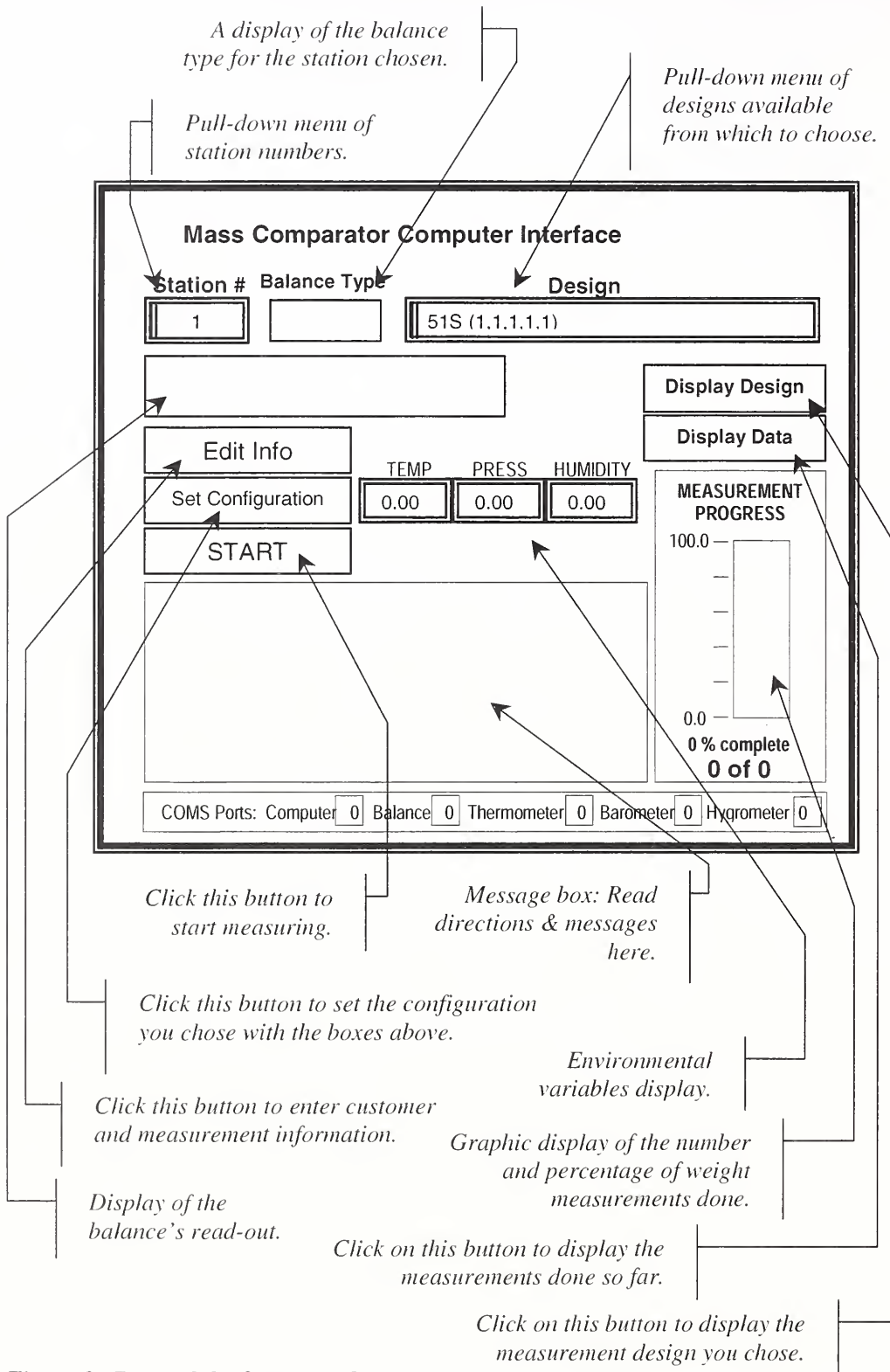
- customer name
- customer address (up to 2 lines)
- measurement description (up to 2 lines)
- balance number
- operator number
- test number
- report file name (all data files in this measurement are given this name with different extensions)
- type B uncertainty in the restraint
- nominal temperature, °C (default value is 20 °C)
- starting restraint identification number
- standard deviation of balance, mg
- accepted between standard deviation of the process, mg
- sensitivity value used
- multiplier for computed A's

- check standard number
- for each weight:
  - name or description (up to 15 characters long)
  - nominal weight value, g
  - material density, g/cm^3
  - material volumetric coefficient of thermal expansion, per °C
  - accepted mass correction, mg
  - standard-weight flag
- restraint vector
- check standard vector
- restraint vector for next series (as applicable)
- report items vector

Photocopy the "Customer/measurement Information Worksheet" at the end of this document for planning the information that you will enter into the program for each measurement you make.

2. After the laptop computer has been powered on and is ready to run, insert a formatted floppy disk into the laptop computer's disk drive. The program will use this to store all the measurements and data that you take. Use the same disk for subsequent measurements in the same set. These remaining series will look for data (from the first series you measured) on this disk. Use a blank floppy disk for each set of measurements. After you're done measuring, copy the data to a safe location.

3. Start the software by double clicking the icon labeled "bal". The front panel will appear. It looks like:

A display of the balance type for the station chosen.

Pull-down menu of designs available from which to choose.

Pull-down menu of station numbers.

Mass Comparator Computer Interface

Station #   Balance Type   Design

| 1 | | | 51S (1,1,1,1,1) |

Display Design

Display Data

Edit Info

| | TEMP | PRESS | HUMIDITY |
| | 0.00 | 0.00 | 0.00 |

Set Configuration

MEASUREMENT PROGRESS

START

100.0 —

—

—

—

0.0 —

0 % complete

0 of 0

COMS Ports: Computer | 0 | Balance | 0 | Thermometer | 0 | Barometer | 0 | Hygrometer | 0 |

Click this button to start measuring.

Message box: Read directions & messages here.

Click this button to set the configuration you chose with the boxes above.

Environmental variables display.

Click this button to enter customer and measurement information.

Graphic display of the number and percentage of weight measurements done.

Display of the balance's read-out.

Click on this button to display the measurements done so far.

Click on this button to display the measurement design you chose.

Figure 2. Parts of the front panel.

Follow the directions that appear in the message box. The first instructions are shown below.

Mass Comparator Computer Interface

Station #   **Balance Type**   **Design**

| 1 | | | | 51S (1,1,1,1,1) |

Display Design

Display Data

Edit Info

TEMP (deg. C)   PRESS (mm Hg)   HUMIDITY (%)

Set Configuration | 0.0000 | | 0.0000 | | 0.0000 |

MEASUREMENT PROGRESS

START

100.0 —

Choose the station number you're at and the design you want to use. Then click on the [EDIT INFO] button to enter the measurement information.

0.0 —

**0 % complete
0 of 0**

COMS Ports: Computer | 0 | Balance | 0 | Thermometer | 0 | Barometer | 0 | Hygrometer | 0 |

Figure 3. The front panel with first instructions.

Choose the station you are using with the **Station #** pull-down menu. After picking the station, the balance type will appear in the adjacent display box. The following table shows the station numbers assigned to the balances in the mass lab.

Table 1. Stations and corresponding balance type

Station number	Balance type
1	AT1005
2	AT106
3	AT20
4	AT21

Next, choose the design you want to use by using the **Design** pull-down menu. By clicking once on this menu box, the entire list of designs will appear. Move the mouse cursor up or down to the desired design type and then release to choose. The chosen design name will appear in the menu box.

Below is a list of the designs available from which to choose grouped by design in the pull-down **Design** menu. For each design, there are seven series and some have two versions of series I (choose only one of these). Each of these must be performed in sequence before the final data file is generated and run with the Mass Code.

Table 2. Listing of measurement designs.

4-1 used with 16A (5,2,2,1,1,1) series
5-1 used with 16A (5,2,2,1,1,1) series
16A (5,2,2,1,1,1) series II
16A (5,2,2,1,1,1) series III
16A (5,2,2,1,1,1) series IV
16A (5,2,2,1,1,1) series V
16A (5,2,2,1,1,1) series VI
16A (5,2,2,1,1,1) series VII
31s (1,1,1) standalone
41s (1,1,1,1) standalone
51s (1,1,1,1,1) standalone
4-1 used with 52J (5,3,2,1,1) series
5-1 used with 52J (5,3,2,1,1) series
52J (5,3,2,1,1) series II
52J (5,3,2,1,1) series III
52J (5,3,2,1,1) series IV
52J (5,3,2,1,1) series V
52J (5,3,2,1,1) series VI
52J (5,3,2,1,1) series VII
5221111 series I
5221111 series II
5221111 series III
5221111 series IV
5221111 series V
5221111 series VI
5221111 series VII
5321111 series I
5321111 series II
5321111 series III
5321111 series IV
5321111 series V
5321111 series VI
5321111 series VII
4-1 used with R62C (5,3,2,1,1,1) series
5-1 used with R62C (5,3,2,1,1,1) series
R62C (5,3,2,1,1,1) series II
R62C (5,3,2,1,1,1) series III
R62C (5,3,2,1,1,1) series IV
R62C (5,3,2,1,1,1) series V
R62C (5,3,2,1,1,1) series VI
R62C (5,3,2,1,1,1) series VII

4. After making your choices, click on the **Edit Info** button to enter the customer, weight, and measurement information. A series of screens will then appear to ask you for information. The first of which looks like:

Are you starting the first (or only) series of a job or continuing with the next series of an existing job?

First series   **Next series**
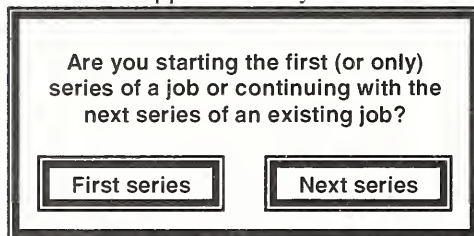
Figure 4. Dialog box with buttons.

If you are starting the first series for a set of weights, click on the **First series** button. If this is not the first series click on the **Next series** button. The **First series** button will bring up the screen where you enter all the customer and measurement information – information that is repeated for the subsequent series. The **Next series** button skips over the first window and goes on to the next.

If you are starting a new set of measurements, the first screen that prompts for information looks like this:

Figure 5. Customer data entry screen.

Enter the items listed on the screen by clicking the mouse cursor into the boxes or using the tab key to move the cursor into the boxes. Enter the customer's name, limiting it to 15 characters. Enter the customer's address using two lines and the description of the measurement in up to two lines. Enter the balance number, your operator number and a test number. Finally enter a name for the report, unique to this measurement. It will be reused for the remaining series in the measurement of the weight set. When done entering all items, click on the **Next Page** button to move on to the next screen.

The program compares the report name you specify to see if there is a pre-existing name. If there is a duplicate and this is your first series you will be prompted to enter a new name. If this is a continuation of the series, you are prompted to choose the related one from the list of existing filenames.

In the next screen enter the requested items in the same manner as before. Click on the **Next Page** button when done.

Figure 6. Screen prompting for more measurement information.

The screen illustrated by Figure 7 appears for each of the weights to be measured in this design. Note that the first line in the screen that reads "Enter information for each of the ... weights." indicates the number of weights there are. This example indicates four. The second (the first entry box) indicates which weight you are entering information for. Enter the weight's name (a 15-character description), nominal value, density, etc. in the boxes. Move among the boxes with the tab key or mouse cursor. After you are done entering the information for the weight, click on the **Go to next weight** button to proceed to the next weight or to the next screen if all the weight information was entered.

Figure 7. Screen for entering weight information.

After entering the weight information. the "vectors" screen appears. Enter the vectors by typing in their representation with ones, minus ones. or zeros delimited by spaces. Use the tab key to move between the fields in the screen or use the mouse. Use a mouse click at the **Check if no following series** check box item as needed. When done at this screen click the **ENTER** button to continue.

Restraint vector (e.g. 1 1 0 0) [   ]

Check standard vector (e.g. 1 −1) [   ]

Vectors of restraint items in next series [   ]
☐ *Check if no following series*

Report items vector [   ]

Use the [TAB] key to move from field to field.
Click on the [ENTER] button when done.   [ENTER]

Figure 8. Screen for entering vector information.

After you enter all the customer and measurement information the front panel screen re-appears with the message **Click on [SET CONFIGURATION] to initialize the instruments** in the message box of the front panel. Click on the button and the program will begin to initialize/test the barometer. hygrometer. and thermometer. When that is done. you are instructed to click on the **START** button when you are ready to make measurements. The message in the message box for this is **Click on the [START] button when you are ready to make measurements.**

5. After clicking on the **START** button. the program displays a dialog window with instructions to place the first weight (or weights) on the balance pan. The balance door will have automatically opened. a **PLACE...** message is displayed on the balance LED readout. and a beep would have sounded. The message in the dialog box would read:

**Place weight(s) "number 1"
on pan then click on the [PROCEED] button
to close the door and continue
OR
click on [RE-MEASURE] to weigh the previous weight again.**

[PROCEED]   [RE-MEASURE]

Figure 9. Dialog box with weighing instructions.

After placing the weight. use the mouse to click on the **PROCEED** button in the dialog box. The balance door will close and the balance will stabilize. Meanwhile. the thermometer. barometer and hygrometer are automatically read and their values recorded in the data file. After the balance is stable. its value is displayed on the front panel (along with the temperature. pressure. and humidity) and automatically recorded.

If you want to measure the weight again (if you're not satisfied with the measurement or used the wrong weight) you can click on the **RE-MEASURE** button without exchanging the weight. The program will

perform the measurement again for this weight and mark the already-recorded unsatisfactory measurement as rejected with the letter, "R".

After any measurement, the program will prompt you to decide to accept or reject the measurement. If the measurement is satisfactory, click on the **PROCEED** button in the dialog window. The program will proceed to the next weight. If you want to reject the measurement, click on the **RE-MEASURE** button and the program will re-weigh the weight as described above.

Data Files

Note that for all the measurement series you perform a data file is created to hold all the measurements. This file includes the name of the weight, the temperature, humidity, and air pressure at the time of the weighing, the balance reading and the date and time of the weighing. Also included is your decision on whether or not to accept the measurement. These items are all included in one line of the data file and are delimited by commas. The file may be imported into a spreadsheet program to work with. This measurement data file is one of three made during the course of one series. This first file has the extension ".dat" and contains all the data. Another file with the extension ".dt2" contains these items in the same format excluding the ones that you rejected. A third file contains the measurements in a format understood by the Mass Code. It has the extension, ".dt3".

All the files created for a series use the same filename (with differentiating extensions). At the end of it all the only file you are concerned with is the final report which has the extension ".ipt". It is used as the input file for the Mass Code.

Displaying Measurement Data

While you are measuring the weights you can see the measurements made in tabular form. Do this by clicking on the **Display Data** button on the right side of the front panel. The screen looks like:
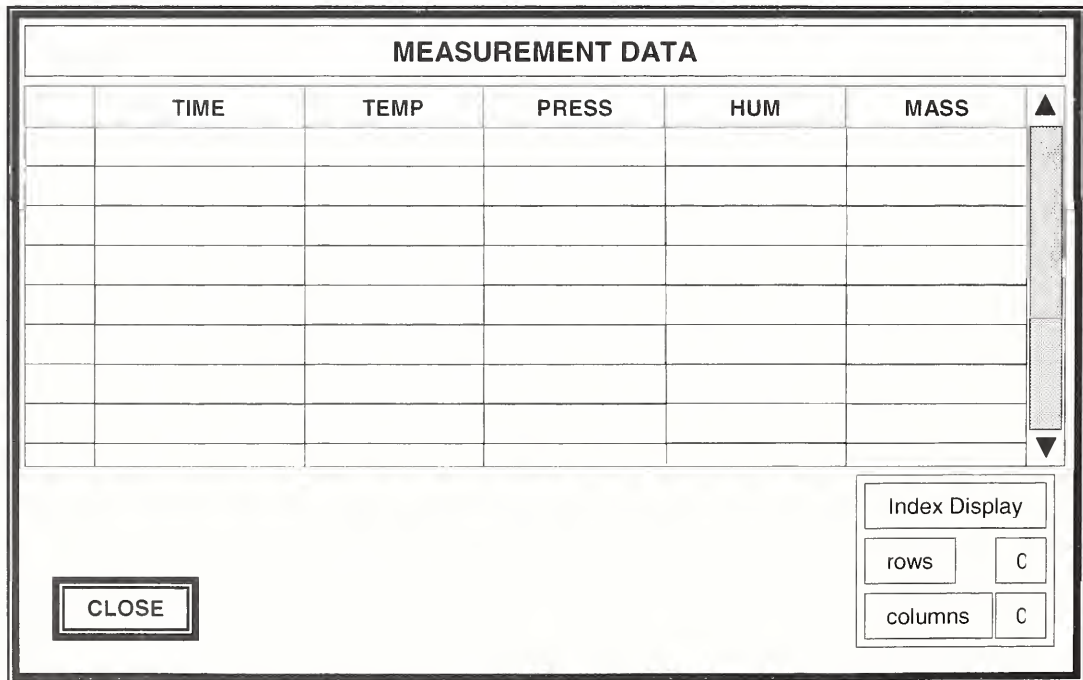

Figure 10. Screen for displaying current measurements.

As needed, use the scrollbar on the right to move up and down the listing. This information is the same as that saved in the data file. It shows the measurements made in chronological order. Clicking on the CLOSE button returns you to the front panel.

Customer/measurement Information Worksheet
Use this form to collect the information needed by the balance automation program.

customer name _____

customer address _____

_____

measurement description _____

_____

balance number _____

operator number _____

test number _____

report file name _____

type B uncertainty in the restraint _____

nominal temperature 20.0_____

starting restraint identification number _____

standard deviation of balance _____

accepted between standard deviation of the process _____

multiplier for computed A's _____

check standard number _____

restraint vector _____

check standard vector _____

restraint vector for next series (as applicable) _____

report items vector _____

for each weight:

name (up to 15 characters long) _____

nominal weight value, g _____

density, g/cm^3 _____

volumetric coefficient of thermal expansion, per °C _____

accepted mass correction, mg _____

standard weight flag _____

name (up to 15 characters long) _____

nominal weight value, g _____

density, g/cm^3 _____

volumetric coefficient of thermal expansion, per °C _____

accepted mass correction, mg _____

standard weight flag _____

name (up to 15 characters long) _____

nominal weight value, g _____

density, g/cm^3 _____

volumetric coefficient of thermal expansion, per °C _____

accepted mass correction, mg _____

standard weight flag _____

name (up to 15 characters long) _____

nominal weight value, g _____

density, g/cm^3 _____

volumetric coefficient of thermal expansion, per °C _____

accepted mass correction, mg _____

standard weight flag _____

*test number:*_____

report filename: _____

name (up to 15 characters long) _____
nominal weight value, g _____
density, g/cm^3 _____
volumetric coefficient of thermal expansion, per °C _____
accepted mass correction, mg _____
standard weight flag _____

name (up to 15 characters long) _____
nominal weight value, g _____
density, g/cm^3 _____
volumetric coefficient of thermal expansion, per °C _____
accepted mass correction, mg _____
standard weight flag _____

name (up to 15 characters long) _____
nominal weight value, g _____
density, g/cm^3 _____
volumetric coefficient of thermal expansion, per °C _____
accepted mass correction, mg _____
standard weight flag _____

name (up to 15 characters long) _____
nominal weight value, g _____
density, g/cm^3 _____
volumetric coefficient of thermal expansion, per °C _____
accepted mass correction, mg _____
standard weight flag _____

name (up to 15 characters long) _____
nominal weight value, g _____
density, g/cm^3 _____
volumetric coefficient of thermal expansion, per °C _____
accepted mass correction, mg _____
standard weight flag _____

name (up to 15 characters long) _____
nominal weight value, g _____
density, g/cm^3 _____
volumetric coefficient of thermal expansion, per °C _____
accepted mass correction, mg _____
standard weight flag _____

name (up to 15 characters long) _____
nominal weight value, g _____
density, g/cm^3 _____
volumetric coefficient of thermal expansion, per °C _____
accepted mass correction, mg _____
standard weight flag _____