Morehouse Instrument Company
1742 Sixth Ave.
York, PA 17403-2675
(717) 843-0081

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Automated Force Calibration System

Instruction Manual

For controlling Morehouse UCMs & SCMs

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1   Introduction

Morehouse is a family-owned company whose passion for metrology has passed from generation to generation for over 100 years. Here, company culture ensures we constantly raise the standard regarding our products and services. Every day, Morehouse collaborates with the government, standards institutes, accreditation bodies, and customers to promote best practices in force calibration and measurement.

As a part of that tradition, Morehouse has manufactured Universal Calibrating Machines (UCM) for over 70 years as hydraulic load frames used to calibrate various instruments. The Automated Force Calibration System (AFCS) is designed to automate and simplify the operation and data gathering of UCMs.

2   General Safety Warnings

- This system is designed to automate the control of hydraulic load frames that can apply large force loads. These machines do not move quickly but can move without warning. Ensure that the control system is not running and use care when putting hands or other body parts in a position where they could be crushed, especially if there is a small gap.
- Modification to hardware and software should only be done under the direction of Morehouse Instrument Company. The cabinet contains high voltage when powered on, disconnect all sources of electrical power before opening the cabinet.

- Morehouse UCMs and USCs are designed to have approximately 1" of stroke. Do not use setups where the combined deflection of the instrument and fixturing (including the gap between fixturing and the machine) exceeds 1".
- Operators must ensure proper installation of all fixtures per documentation and markings. If documentation is not available, parts should not be used until evaluated.
- No list of fixturing errors can be complete, but common errors include:
  o   Insufficient number of threads engaged for a given force value.
  o   Fixtures are used beyond their rated capacities.
  o   Fixtures are used below the rated capacity.
  o   Using fixtures that are visibly damaged or bent.
  o   Using a smaller pin size than needed on a Tension Link
  o   Using fixtures that have been modified without the approval of a cognizant engineer.
  o   Using fixtures in a way they were not designed for.
  o   Using fixturing with small cracks or insufficient welds.

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- It is recommended to not modify settings in the reference standard (including, but not limited to; taring the meter manually, changing displayed units, etc.) while the program is running. This may cause issues and possibly damage to equipment.
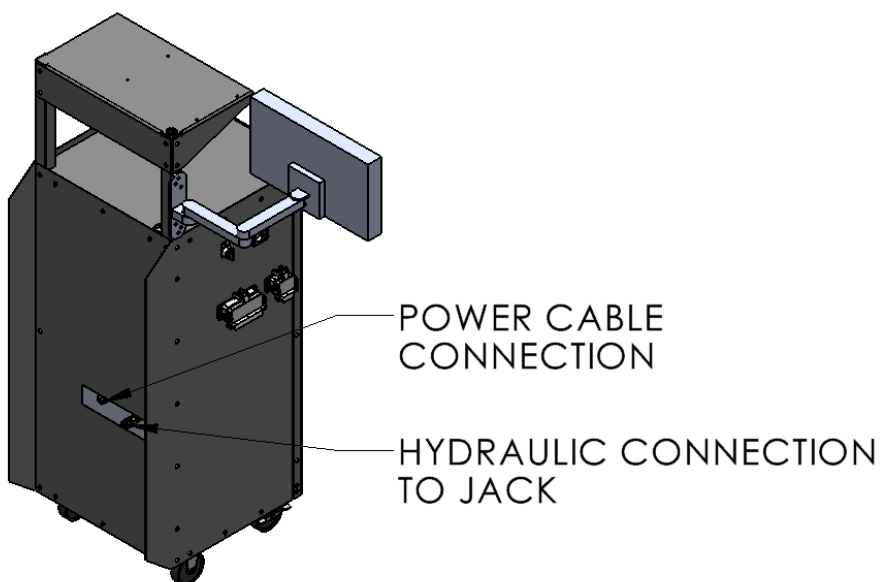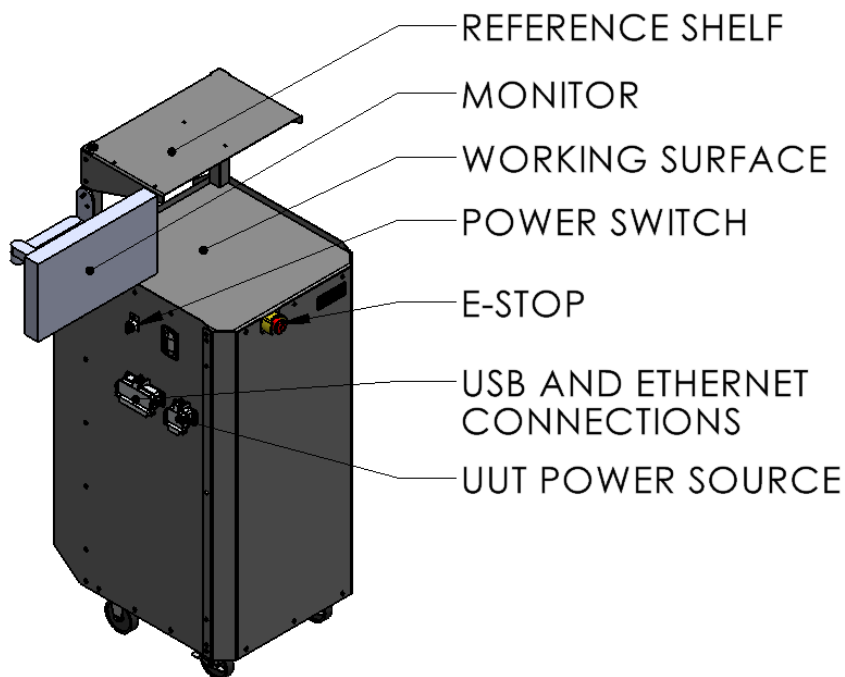
3   Referenced Documents

- PM-5201: UCM Operation and Instruction Manual
- PM-5301: USC Operation and Instruction Manual
- PG-5950: Force Calibration Setups and Adapters
- PG-5901: Quick Change Adapters for Force Tension Calibration
- PG-5943: Compression and Tension Adapters

4   System Overview

The HCS system is designed to control Morehouse UCMs (Universal Calibration Machines) and USCs (Universal Scale Calibrators) and automate data collection. The system can be connected to an existing system with minimal effort or provided with a new system. All that is required to connect to a machine is to connect the hydraulic connection on the back of the system to the machine's jack and connect the system to the reference meter. The system is designed to work with a reference load cell calibrated with a Morehouse M4215. This can be a standard, HS, or plus model. There is a shelf on the top of the machine designed to hold the reference meter and some space to hold another meter for the UUT if desired. The side of the system has a 120VAC socket and 3 female USB A connections for operator convenience to power and communicate with UUTs (units under test) and an RJ45 ethernet connection and WiFi capability to interface with a network if desired. The system can be requested with no WiFi if desired.

The system is controlled by a PC running Windows IoT and so has all the functionality of a typical Windows computer. It is controlled through the hand-wired keyboard and mouse and monitor supplied with the system. There is also an emergency stop on the front of the machine and a remote e-stop designed to be mounted to the UCM, should the operator need to shut it down in an emergency. There is a working surface for the keyboard and mouse (or any other work) designed to be a comfortable height while standing.

Below are images of the system indicating the locations of the important components.

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REFERENCE SHELF

MONITOR

WORKING SURFACE

POWER SWITCH

E-STOP

USB AND ETHERNET
CONNECTIONS

UUT POWER SOURCE

POWER CABLE
CONNECTION

HYDRAULIC CONNECTION
TO JACK

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4.1   General Specifications:

- Width: 39" (1,000mm)
- Width without a monitor: 22" (560mm)
- Depth: 25" (640mm)
- Height: 60" (1530mm)
- Weight: 400 lbs (180kg)
- Max 60dB during normal operation (measured 6" from the front of the machine).
- Required electrical power supply: 6A @ 120VAC or 3A @ 240VAC.
- Requires reference cells calibrated with Morehouse M4215 meters.
- Maximum system pressure: 5,000psi (34MPa) – Maximum oil capacity: 2 U.S. gallons (7.5L).

4.2   Capabilities

- Capable of controlling USCs and UCMs with capacities from 10 klbf through 2,500 klbf
- Capable of applying loads from 1 %-100 % of load frame capacity.
- System can exercise to specified loads and number of cycles. Automates calibration sequences with an unlimited number of points.
- System can be commanded to hold a set force indefinitely and readings triggered manually. This can be useful for programming scales, dynamometers, etc.
- Capable of gathering data from an unlimited number of UUTs. The system can automatically gather data from certain meters; others may be added on request. Meters that cannot be communicated with can be entered manually or recorded using a camera to be recorded manually later.
- Individual calibration points can be held for specified times, and multiple readings can simultaneously to automate creep tests, etc.

4.3   Safety System Overview

The HCS system is designed with many safety features in place to prevent damage caused by operator or program errors. However, operators should always stay attentive and ensure proper setup and data entry.

Below is a list of possible operator errors and system issues along with the safety measure that is intended to prevent damage that could be caused by the issue.

| Issue	Safety measure(s)
Incorrect UUT capacity entered	Prompt asking operator to confirm UUT capacity before applying load; on the first exercise, the system applies 10% of the entered capacity and prompts the user to confirm that it is correct. This can be disabled.
Reference cell not connected	System compares pressure in system to pressure expected and stops if outside acceptable limit; pressure relief valve set to protect load frame
Wrong reference cell connected	System compares pressure in system to pressure expected and stops if outside acceptable limit; pressure relief valve set to protect load frame

| Program crash	System removes pressure if connection lost with program; limit switch in meter set to shut system off if higher than overload for lowest capacity item; pressure relief valve set to protect load frame
Program malfunction	System removes pressure if connection lost with program; limit switch in meter set to shut system off if higher than overload for lowest capacity item; pressure relief valve set to protect load frame
No UUT installed	System stops running if contact is not made after a certain amount of time.

5   Operating Instructions

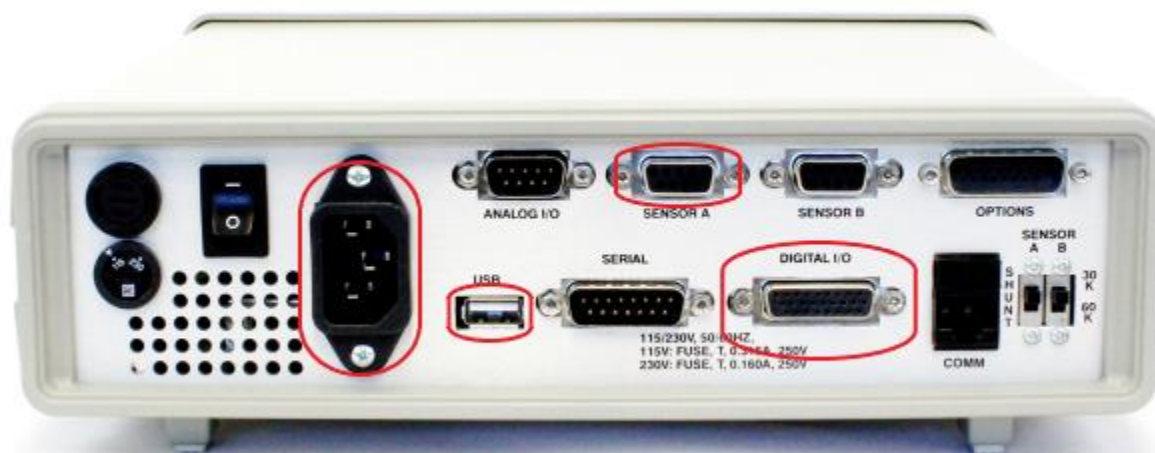### 5.1   Setup

5.1.1   4215 mounting
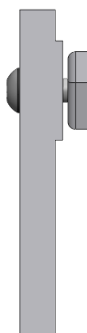
- Assemble 4215 mounting brackets as shown. Leave screws loose so that there is about 1 thread worth of engagement.
- Insert the nuts into the side rail of the 4215 as shown below and tighten so that the rail on the 4215 is clamped between the upright part of the bracket and the nut. This will require the nut to rotate inside of the rail as shown below.
- Once all four of the brackets have been mounted to the 4215, mount the brackets to the top shelf of the automation unit. This will likely require loosening the brackets and sliding them into place.
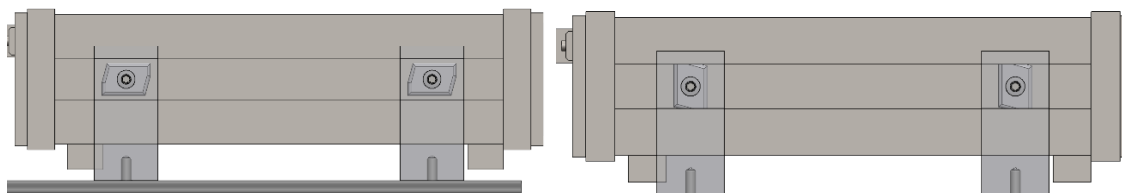
5.1.2   Physical Setup

- Install remote e-stop to UCM using the included bracket and U-bolt as shown below. Make sure that it is mounted in a spot easily accessible while operating and loading/unloading from the UCM.
- Connect the system to the jack of the machine using a hose rated for at least 5,000 psi.
- Connect the reference indicator power, USB, digital IO, and sensor cables.

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- Plug the system into a power outlet. The system should power up automatically.

5.1.3   Program Setup

- Ensure that the e-stop is released and the e-stop light is not on. If the e-stop is released and the light is still on, consult the troubleshooting section.
- Start the HCS program and navigate to the Reference Cell Editor page using the hamburger button in the top left corner of the program.
- Add information for the reference cells to be used with the system. For detailed instructions, see 5.3.8 Reference Cell Editor.
- Navigate to the Machine Editor page and enter the information for the machines that the system will be used with. For detailed instructions, see 5.3.9.
- The Reference Cell Editor screen allows the user to enter the calibration coefficients for reference cells. To create a new cell, press the **New** button, enter the desired name, and press ok. Make sure the new cell is selected from the dropdown, enter the desired parameters, and press Save. An existing cell can be modified by selecting it from the dropdown, making the desired changes, and pressing Save.
- A dialog will appear with the loads at 10 % capacity and capacity and mV/V values calculated for loads. This is to check that the coefficients were entered correctly. An existing cell can also be deleted by selecting it from the drop-down and pressing delete. If a Morehouse PDF certificate is available for the load cell, it can be dragged and dropped onto the Coefficient display, and the coefficients will automatically load.
- Navigate to the Settings page and select the machine to be used as well as other settings desired. For detailed instructions, see 5.3.6 Settings.

5.2   Calibration

- Place UUT in the machine and prepare it for calibration. See 2 General Safety Warnings. If the UUT is connected to a supported meter, connect it to the USB port on the side of the system.

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- Navigate to the Load Cell Selection page and connect to (and select) any meters used in the calibration, including the reference standard. Select which reference cell is connected to which meter and enter information for the UUTs. Be sure to select Apply for both the references and UUTs before navigating away from the page. For more details, see 5.3.2 Load Cell Selection.
- Navigate to the Test Details page and enter information for desired exercise cycles and allowable overload, and either select a sequence or enter one manually. For more details, see 5.3.3 Test Details.
- Press the Start Exercise button to start the exercise runs. If the Run Sequence After Exercise check box is checked, the system will automatically run the first calibration run after the exercise runs are complete.
- If the system is not running, to start the next calibration run, pressing the Start Run button will start a new calibration run. Once any run has started, all controls for changing the meters, UUTs, or calibrations runs will be locked. For more information, see 5.3.3 Test Details.
- Once the system has reached the target load +/- the acceptable set point offset and has been within that range for the specified hold time, the system will start collecting readings from all the UUTs. If the check box to wait until the set point has been reached is checked on the Settings page, the system also waits until the actual set point has been reached to take readings from the UUTs. This does not mean, however, that all readings will be taken at the set point. Readings will be taken when the load is within the Reading Set Point Offset defined on the Settings page. Once it has collected as many readings as are specified to be averaged on the Settings page, it averages them, records them, and moves to the next point. For more information on these settings, see 5.3.6 Settings.
- During any runs, if manual entries are required, the system will hold the current load until the input is received. Examples would be if any UUTs are tied to a Manual Entry meter or if the 10 % Exercise Safety Point check box is checked when running the first exercise run.
- Data that is gathered can be exported to the Results screen.
- Once a calibration is completed and the results exported, press the Reset button to clear data and unlock controls to set up the next calibration.
- If the Manual Control is used, the system will hold the specified load indefinitely until given a new one. Take Reading will capture and record data from all connected UUTs.
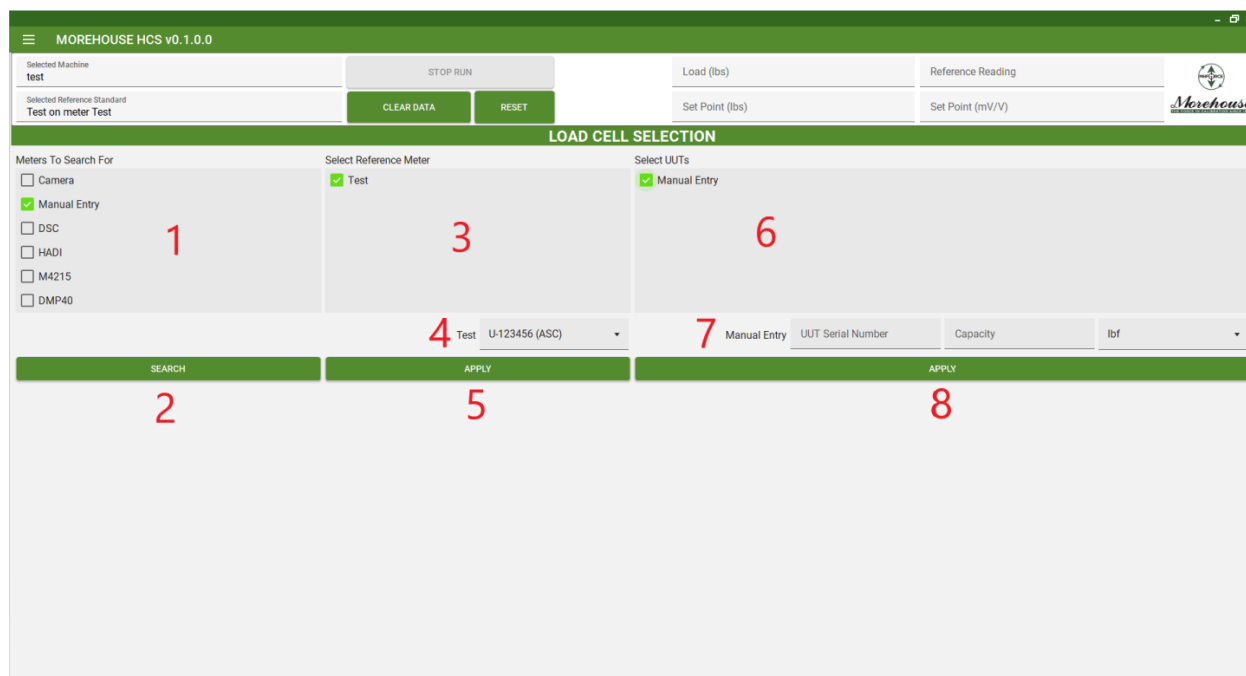
5.3   Screens

5.3.1   Top Banner

A banner is always on the top of the window, allowing controls and displays to be always available. On the left is a display of the currently selected machine, reference cell, and meter to which the reference

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cell is connected (1). This allows the user to check that the correct reference cell is connected at any time. There is a Stop Run button (2) which, when pressed, stops the current run. A run cannot be restarted, and the data for that run will be lost. The Clear Data (3) and Reset (4) buttons have similar functions but are slightly different. The reset button is intended to be used when a new instrument is calibrated or the calibration to be run is changed. This unlocks the controls for setting up the UUT and calibration runs. The Clear Data button does not unlock any of the controls but clears all data that has been gathered. Finally, there is a display showing the current load on the system, reference reading in mV/V, and the setpoint the system is working at reaching in lbs and mV/V.

5.3.2   Load Cell Selection

The load cell selection screen allows the user to connect the system to meters to get readings from load cells. The typical workflow on this screen would be to select the types of meters the user wants to search for (1) and press the search button (2). Once the system is done searching for the selected types of meters, it will display the serial numbers of those it found in (3) and (6). Only meters capable of being used as a reference (generally Morehouse M4215s) will display in (3). For UUTs that are connected to meters that are not supported, select a Manual Entry, and the user will be prompted during calibration to enter the indicated value for that instrument. It is also possible to connect a camera to the system to record the reading on the instrument to be recorded manually later. These videos can be accessed at C:\ProgramData\Morehouse Instrument Company\HCS\Videos.
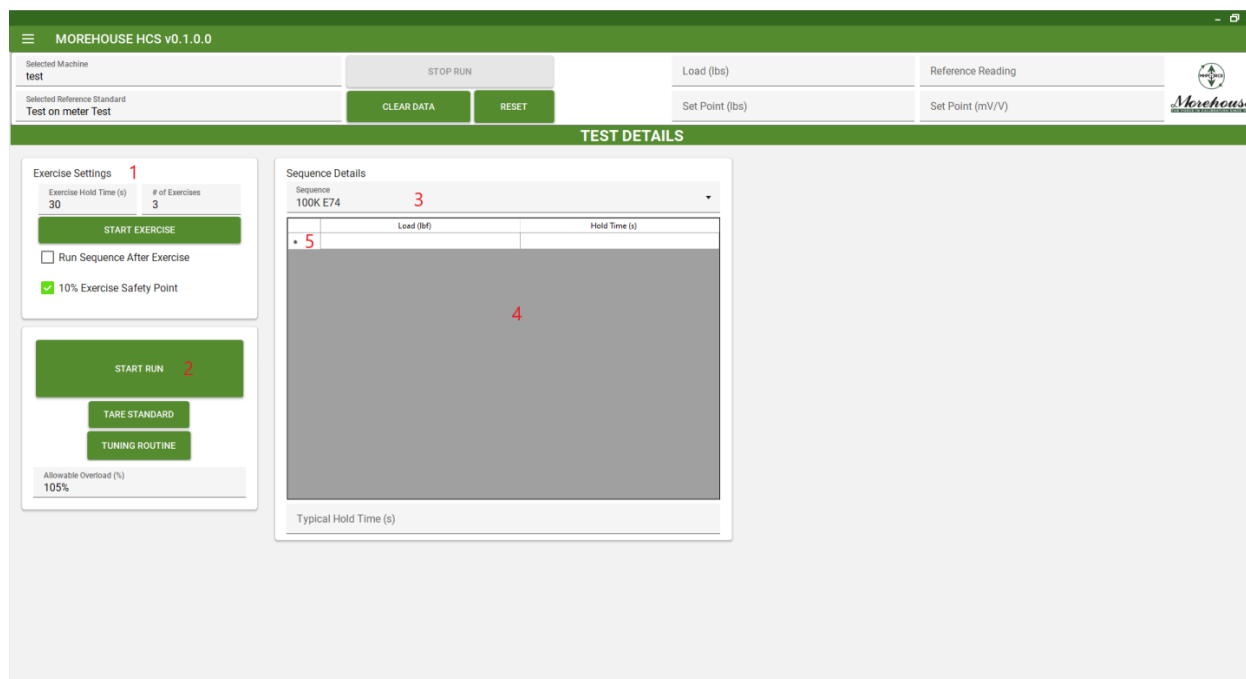
Next, the user would select the meter(s) connected to the reference load cell in (3), pick the reference cell that is connected to that meter (4), and press Apply (5). When the system first starts up, it will attempt to connect to the last used reference meter and link it to the last used reference cell. If

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successful, this will be reflected on this screen. The user should make sure that the correct meter and reference cell are shown here.

Next, the user would select the meter(s) connected to the UUTs to be calibrated in (6). Each meter selected will be populated in (7). The user must enter the capacity of each UUT selected, as well as the readability of the indicator and units to read (if applicable) and should then press Apply. If the user leaves this page before pressing apply on either of these steps, they will be prompted to confirm that they want to discard the unapplied changes.

To remove or change UUTs or references, simply make the changes and press Apply.

5.3.3   Test Details

The Test Details page contains the controls for setting up and starting exercise sequences and calibration runs. The exercise settings are grouped at (1). Once an exercise sequence is started with the Start Exercise button, the system will load the machine to the exercise load and hold it there until it has continuously held it at that load (± the Acceptable Set Point Offset specified in the Settings Page) for the specified hold time. The exercise load will be the lowest of the machine, reference cell, and UUT capacities. The system will automatically run the exercise the specified number of times. If the Run Sequence After Exercise check box is clicked after all the exercise runs have been completed, the system will automatically run one calibration run as specified in the Sequence Details section (4). This will be explained later in this section. If the 10% Exercise Safety Point check box is clicked, the system will apply 10% of the exercise load and prompt the user with a dialog box and auditory alarm to confirm that it should continue with the exercise sequence. This is a safety intended to prevent damage to equipment.

If the user confirms that the system should continue with the exercise sequence, the check will only be performed on the first exercise run and will not be performed again until the Reset button is pressed.

When the Start Run button (2) is pressed, the sequence displayed in the Sequence Details section (4) will be run. There are three ways to create a sequence to be run. The first is creating a run manually from scratch. When data is entered in the bottom row with a * in the left header column (5), a new row will be added. A row can be deleted by selecting the whole row by clicking on the left header column and pressing delete. Changing the Typical Hold Time entry will change all entered rows to a commonhold time. The second way to create a sequence is by going to the Sequence Builder screen and creating a sequence. Any sequence created in that screen will be saved for future use and can be selected on the test details screen. This will load the saved sequence. The third way to create a sequence is to modify a saved sequence. Once a previously created sequence is selected from the drop-down, it can be modified on this screen and subsequently run. Any changes made on this screen will not affect the saved sequence, it can be loaded, unchanged, for runs in the future.

The remaining controls on this page are Tare Standard, which tares all attached standard meters; Tuning Routine; and Allowable Overshoot. The Tuning Routine button will run a routine that will tune the system to the instrument currently in the machine. This can be useful if the system has difficulty holding a point steady or taking a long time to reach a point with the current instrument. This may happen with instruments that have either very low or very high amounts of deflection. The tuning parameters will be reset to default values once the Reset button is pressed. If this is a common ongoing problem, running a tuning routine for the whole machine may make sense.   The Allowable Overshoot entry allows the user to set the allowable overshoot for the UUTs in the machine. If the load overshoots the capacity of any UUTs (plus the allowable overshoot), the system will stop the run. Both the program and reference 4215 will monitor the system for and reference cell overload and are independently able to stop the run. The value entered here should be greater than 100%.

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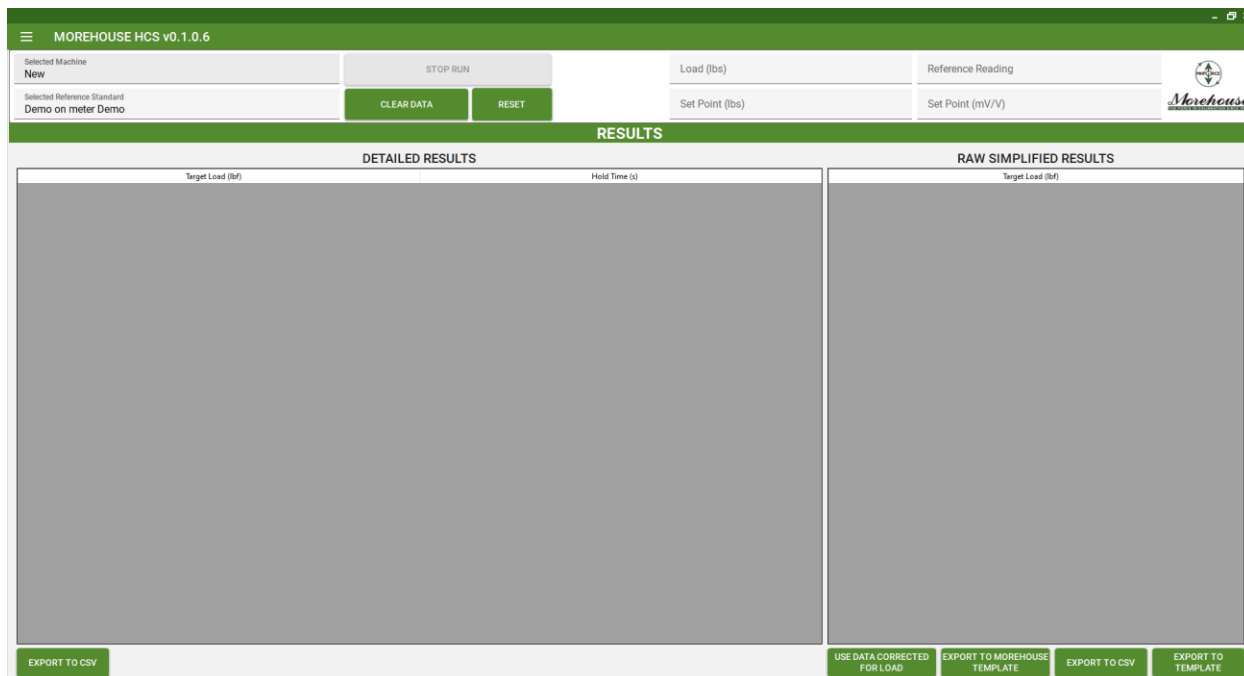
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5.3.4   Active Test

The active test screen displays the current UUT readings (1), the state of the system, and results from past and ongoing calibration runs (3). It also contains controls for a manual run (2).

The Time Since Last Reading displays how long it has been since a reading was taken. This is recorded for each point in the Results screen. The Overshoot of Point displays how far the set point has been overshot as a percent of load. For an ascending point, this is how far over the system has gone; for a descending point, this is how far under the system has gone. If the system overshoots by more than the Acceptable Overshoot setting in the Settings page, it will automatically stop the run.

The results display (3) will display the target force and hold time for each point. For each run, it will display the reading from each UUT, and the actual measured force when the UUT readings were taken.

The manual controls (2) allow the user to command the system to go to a specified force and hold it there indefinitely. It also allows the user to trigger the system to take a reading from all connected UUTs. To do this, enter a load to go to, and press the Go button. To change the load, enter a new load and press the Go button. The system will hold the last specified load indefinitely. To stop using the manual controls, press the Stop Run button.

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5.3.5 Results

The results page shows all results from the calibration runs for the current instrument, including the time between readings and overshoot. These results can be exported to a CSV. The actual load applied when taking the readings is also recorded. Data can be exported to a CSV for analysis, or a template supplied by Morehouse to generate a certificate. The data can also be exported to a user-made template by first selecting a file and then selecting what sheet and starting location the data is to be written to. This allows a user to export data to a known place in a spreadsheet to be used however they see fit.

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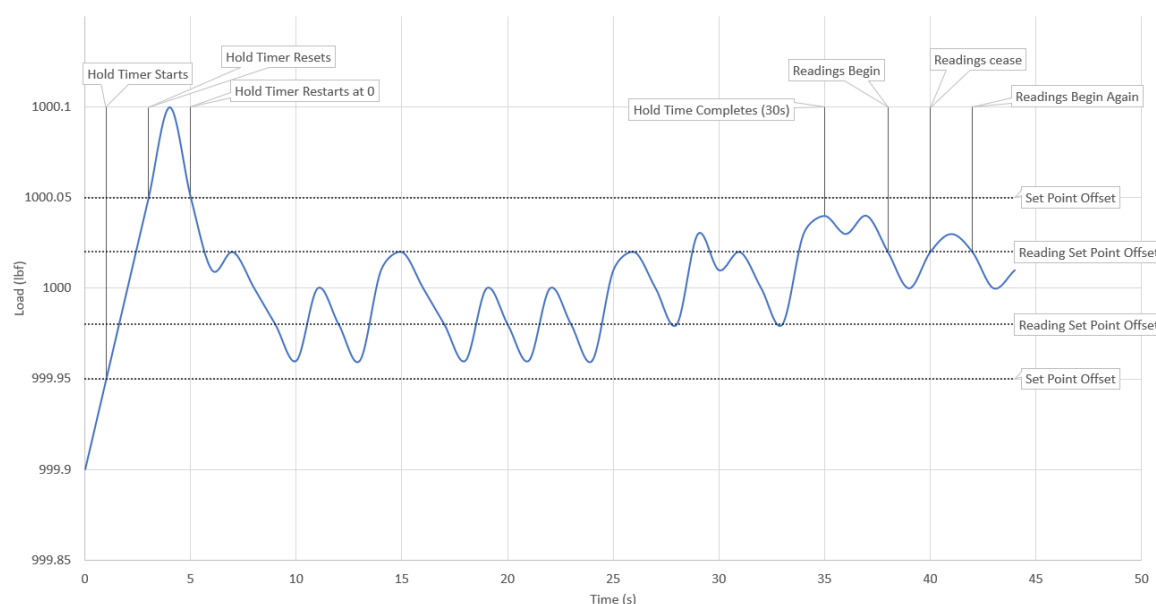
5.3.6   Settings

The Settings page allows the user to change a variety of settings that persist when the program is restarted. They are described in detail below.

- Machine: The machine the system is currently connected to. This is also displayed at the top of the screen.
- Default Units: The units automatically selected when the program starts.
- Number of averaged readings: The number of readings the system will take from the UUT meter and then average together to get one reading.
- Unacceptable overshoot: If the system is attempting to reach a force (F) and for an ascending force reaches F + the unacceptable overshoot (or for a descending force, F – unacceptable overshoot), the system will automatically cancel the run.
- Set Point Offset: The amount that the load can be off from the set point where the system will begin the timer for the hold time specified in the sequence. Once the system is within the target force +/- the acceptable offset, the system begins a timer. Once that timer has reached the hold time specified in the sequence, it will continuously check whether it is within the Reading Set Point Offset and that the conditions for the Wait Until Set Point Is Reached To Take Reading check box are met. If both are true, it will gather readings from the UUT. If, however, the load passes back outside of the Set Point Offset threshold, the timer for the hold time will be reset.
- Reading Set Point Offset: The amount that the load can be off from the set point in which the system will take readings. If the applied load has been within the Set Point Offset for the

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specified hold time and within the Reading Set Point Offset, the system will gather readings until it has the required number of readings to average.

- Pressure Build Timeout: How long it will take the system to error out due to not building pressure. If the system is running at no load and trying to build pressure, it will only try if this setting is specified before it errors out. This is a safety feature to prevent jack-over travel if the user left too large of a gap, forgot to put in an adapter, etc. However, some larger machines may take longer to build pressure under normal circumstances and this timeout may need to be adjusted.
- Wait Until Set Point Is Reached to Take Reading: Whether the system waits until the actual set point has been reached to take readings from the UUTs. This does not guarantee that the applied force is exactly the target force when readings are taken, only that it has in fact reached that target force at some point. This may result in readings taken closer to the target load if the hold times are set low enough that the system would otherwise not have reached the Reading Set Point Offset. For example, if the hold time is set to 0 seconds, the system will start taking readings as soon as it crosses that acceptable offset threshold. However, if the check box is checked, it will start taking readings as soon as it reaches the actual set point.
- Use Default Resolution: When selected, the reference display's resolution will match the indicator's resolution based on the mV/V.
- Reference Display Resolution: The user can select a resolution for the reference load display.
- Reference Display Filter Time: Allows the user to select the amount of time that the reference readings are averaged over to filter the display.

Below is a graphical representation of an example to demonstrate how the system would handle the different set point offsets.

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5.3.7 Sequence Builder

The Sequence Builder screen allows the user to create sequences that can be called up later to perform a calibration. An existing sequence can be modified by selecting it from the dropdown, making the required changes, and pressing save. It can also be deleted by pressing delete. A new sequence can be created by pressing new, entering the desired name, and pressing ok. Make sure the new sequence is selected from the drop-down before making changes and pressing save.

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5.3.8 Reference Cell Editor

The Reference Cell Editor screen allows the user to enter the calibration coefficients for reference cells. To create a new cell, press the New button, enter the desired name, and press ok. Make sure the new cell is selected from the dropdown, enter the desired parameters, and press Save. An existing cell can be modified by selecting it from the dropdown, making the desired changes, and pressing Save. A dialog will appear with the loads at 10% capacity and capacity and the mV/V values calculated for those loads. This is to check that the coefficients were entered correctly. An existing cell can also be deleted by selecting it from the drop-down and pressing delete. If a Morehouse PDF certificate is available for the load cell, it can be dragged and dropped onto the Coefficient display, and the coefficients will be automatically loaded in.

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5.3.9   Machine Editor

The Machine Editor screen allows the user to enter the parameters for machines that the system will be connected to. To create a new machine, press the New button, enter the desired name, and press ok. Make sure the new machine is selected from the dropdown, enter the desired parameters, and press Save. An existing machine can be modified by selecting it from the dropdown, making the desired changes, and pressing Save. An existing machine can also be deleted by selecting it from the drop-down and pressing delete.

6   Troubleshooting

Issue	Possible Cause	Solution
System will not initialize	Safety system fault	See below
	Reference meter issue	Make sure reference meter is on and the USB is connected
E-stop light is lit (safety system fault)	E-stop is pressed	Release e-stop
	Reference meter limit triggered	Make sure reference meter is on
		Make sure reference meter IO cable is plugged in
		Make sure there is no load on the system and tare reference meter
		Reset meter limit value (see below)

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		Make sure the reference cell is connected to the meter.
System keeps saying there is a pressure mismatch	Reference cell issue	Make sure the correct cell and meter are selected in the program
		Make sure the cell coefficients are correct.
	Incorrect machine selected	Make sure correct machine is selected in the program
		Make sure that the correct jack size is assigned to the machine.
	Hydraulics not connected	Make sure system is connected to jack.
System keeps saying it is taking too long to build pressure	Too large of a gap is left	Reduce gap between adapters to 1/16" – 1/8"

7   Glossary

UCM – Universal Calibration Machine. A hydraulic load frame manufactured by Morehouse for calibrating load cells, dynamometers, proving rings, crane scales, etc.

USC – Universal Scale Calibrator. A hydraulic load frame manufactured by Morehouse for calibrating truck scales, aircraft scales, etc.

UUT – Unit under test. The instrument being calibrated.