Automated Force Calibration System

Instruction Manual

For controlling Morehouse UCMs & SCMs
Patent Pending

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Table of Contents

1 Introduction 3
2 General Safety Warnings 3
3 Referenced Documents 4
4 System Overview 4
4.1 General Specifications: 6
4.2 Capabilities 6
4.3 Safety System Overview 6
5 Operating Instructions 7
5.1 Setup 7
5.1.1 Reference Meter Setup 7
5.1.2 Physical Setup 8
5.1.3 Program Setup 9
5.2 Calibration 9
5.3 Screens 10
5.3.1 Top Banner 10
5.3.2 Load Cell Selection 11
5.3.3 Test Details 13
5.3.4 Active Test 15
5.3.5 Results 16
5.3.6 Settings 17
5.3.7 Sequence Builder 19
5.3.8 Reference Cell Editor 20
5.3.9 Machine Editor 21
5.3.10 Help 22
6 Maintenance 22
6.1 Necessary Maintenance 22
6.2 Oil Recommendations 23
6.3 Software Updating 23
7 Troubleshooting 27
8 Glossary 27
9 Appendix 1: 4215 Limit Switch Setting 29

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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.
- Hardware and software modifications should only be made under the direction of Morehouse Instrument Company. When powered on, the cabinet contains high voltage. 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:
    - Insufficient number of threads engaged for a given force value.
    - Fixtures are used beyond their rated capacities.
    - Fixtures are used below the rated capacity.
    - Using fixtures that are visibly damaged or bent.
    - Using a smaller pin size than needed on a Tension Link
    - Using fixtures that have been modified without the approval of a cognizant engineer.
    - Using fixtures in a way they were not designed for.
    - Using fixturing with small cracks or insufficient welds.

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- It is recommended not to modify settings in the reference standard (including, but not limited to, taking 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. Contact Morehouse to discuss the possibility of using a different meter with your reference load cell. 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 Wi-Fi capability to interface with a network if desired. The system can be requested without Wi-Fi 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 hard-wired keyboard, 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 at a comfortable height while standing.

There are images of the system indicating the locations of the important components on the next page.

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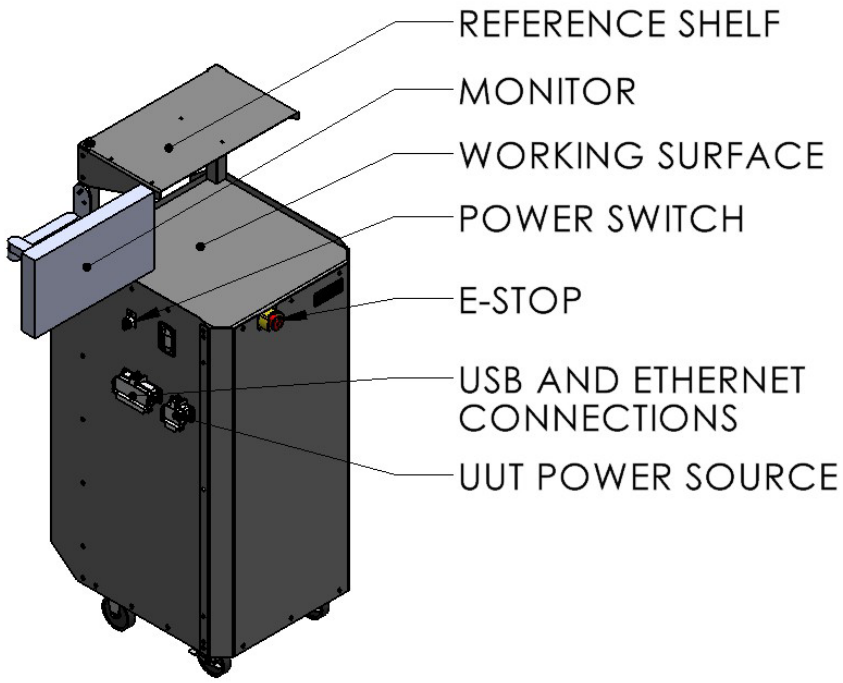

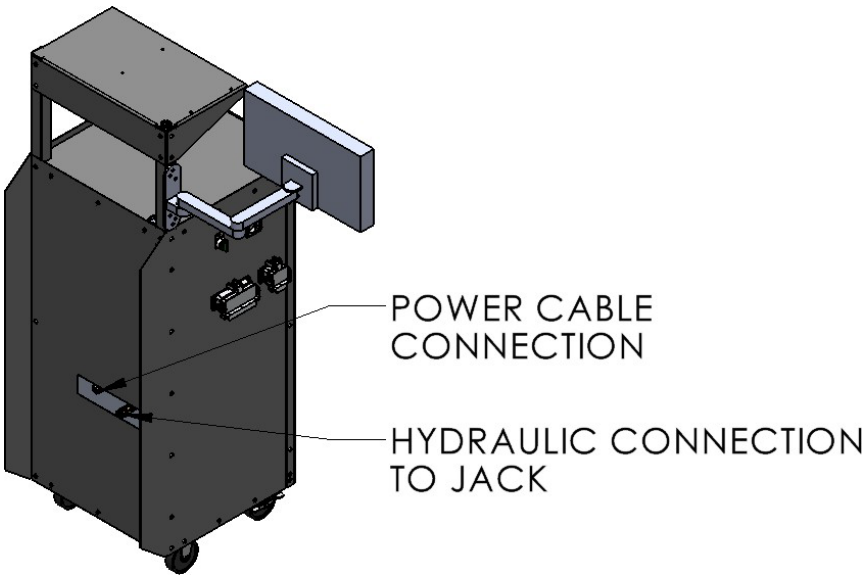

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4.1 General Specifications:

- 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. Existing 10 klbf UCMs must be sent in for retrofit with a 30 klbf jack.
- Capable of applying loads from 1 %-100 % of hydraulic jack capacity.
- System can exercise to specified loads and number of cycles. Automates calibration sequences with an unlimited number of points.
- The system can be commanded to hold a set force indefinitely, and readings can be 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, which will be recorded manually later.
- Individual calibration points can be held for specified times, and multiple readings can be held 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 measures intended to prevent damage that each issue could cause.

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

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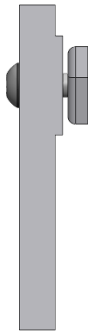
Program crash	System removes pressure if connection lost with program; limit switch in meter set to shut system off if higher than overload for lowest capacity item: pressure relief valve set to protect load frame
Program malfunction	System removes pressure if connection lost with program; limit switch 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

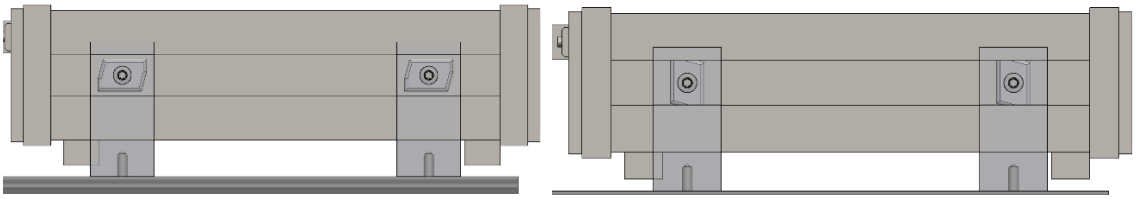
5.1 Setup

5.1.1 Reference Meter Setup

5.1.1.1 4215 Setup



- 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 is clamped between the upright part of the bracket and the nut. This will require the nut to rotate inside the rail, as shown below.
- Once all four brackets have been mounted on the 4215, mount them on the top shelf of the automation unit. This will likely require loosening the brackets and sliding them into place.



5.1.1.2 Other Meters

If a reference meter other than a 4215 is being used, connect the communications for the meter to the system. Connect the reference meter bypass connector to the connector on the top of the automation system.

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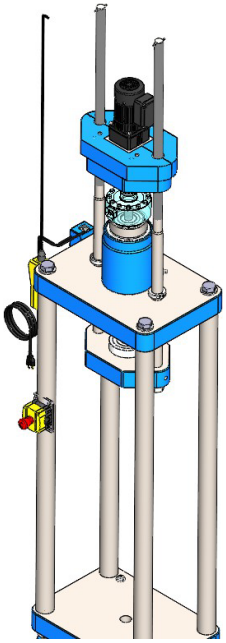
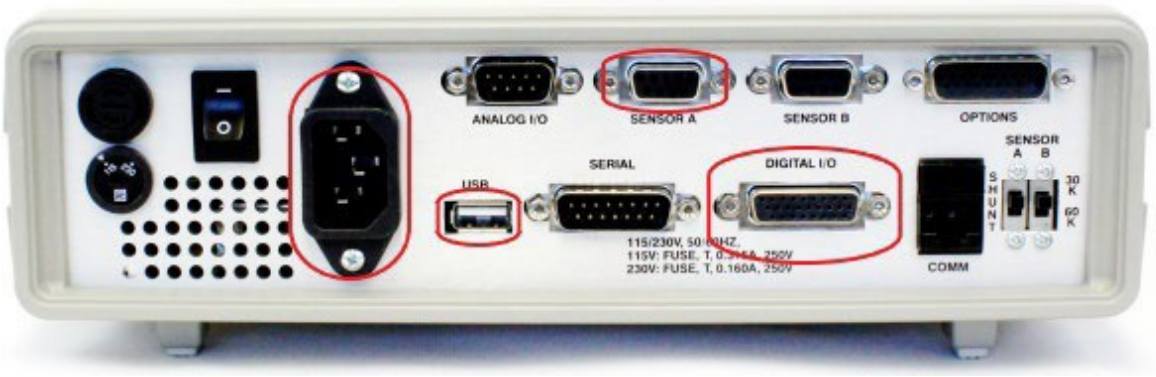
5.1.2 Physical Setup

- Install remote e-stop to UCM using the included bracket and U-bolt, as shown below. Make sure it is mounted in a spot that is easily accessible while operating and loading/unloading from the UCM. If the system is to be used on more than one UCM, additional remote e-stop modules should be purchased and mounted to each machine with which the system is to be used. The system can then be plugged into the e-stop on whatever machine it uses.



- 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 (circled below).



- Plug the system into a power outlet and turn power switch to the on position. The system should power up automatically.

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5.1.3 Program Setup

To start using the automation system, two main things must be configured: the machine settings and the reference cell. The machine settings pertain to the UCM or USC to which the automation system is connected. The reference cell is the load cell that the system will use as a reference for calibration.

- Ensure that the e-stop is released, and the front e-stop light is not on. If the e-stop is released and the light is still on, consult the troubleshooting Section 6. Or see Help screen.
- Start the HCS program and navigate to the Machine Editor page using the hamburger button in the top left corner of the program.
- Enter the information for the machines the system will use. Select the machine being used in the upper left corner and restart HCS. For detailed instructions, see Section 5.3.9.
- Navigate to the Reference Cell Editor screen and add information for the reference cells to be used with the system. For detailed instructions, see Section 5.3.8 Reference Cell Editor.
- Navigate to the Settings page and set settings as desired. For detailed instructions, see Section 5.3.6.
- Follow the instructions in Section 5.3.2 to connect to the reference standard in the Load Cell Selection screen and select the reference cell currently connected.
- Continue to the next section to perform a calibration. Once the user is comfortable with the machine and has loaded it a few times to make sure things are configured properly, it is recommended to perform a pressure sensor calibration. Using a reference cell with a capacity that is at least 1/3 of the machine's capacity, run a pressure sensor calibration from the settings screen. See the section on pressure sensor calibrations in the Settings section of this manual. ***Make sure that the reference cell is correctly configured before running this routine as there is an increased chance of an overload if things are not configured properly.***

5.2 Calibration

If this is the first time using the system, set it up in accordance with the previous section.

- Place the reference load cell in the UCM and connect it to the reference meter.
- Place the UUT in the UCM and prepare it for calibration. See Section 2 General Safety Warnings.
- Start HCS if it has not already been started.
- Confirm that the proper machine (UCM or USC to which the automation system is connected) and reference cell are selected in the top left corner of the screen. See Section 5.3.1 for more information. If the correct reference cell is not shown, navigate to the Load Cell Selection screen and connect to it. See Section 5.3.2 for more information.
- Navigate to the Load Cell Selection page and connect to (and select) any UUT meters used in the calibration. If the instrument being used is one for which the user will be manually entering data, a Manual Entry "meter" can be used. This will pop up a dialog box for the user to enter data from the UUT once the system has stabilized. Be sure to select Apply before navigating away from the page. For more details, see Section 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 Section 5.3.3.

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- To start exercise runs, press the Start Exercise button. 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 10% Exercise Safety Point check box is checked, the system will stop at 10% of the capacity of the UUT on the first exercise run and ask the user to confirm that everything is correct before proceeding.
- To start a calibration run, press the Start Run. Once any run has started, all controls for changing the meters, UUTs, or calibrations runs will be locked. For more information, see Section 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 (or will pop up a dialog box for the user to enter and Manual Entries). 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 Section 5.3.6.
- The Manual Set Point Control can also command the system to go to a specified load indefinitely until a new one is given. This can be useful for programming dynamometers and load links where the instrument needs to be held at a given load. Take Reading will capture and record data from all connected UUTs.
- Data that is gathered will be displayed on the Results screen and can be exported from there.
- 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.

5.3 Screens

5.3.1 Top Banner

A banner is always at the top of the window, allowing controls and displays to be always available.

Description of items on screen:

1. On the left is a display of the currently selected machine, reference cell, and meter to which the reference cell is connected. This allows the user to check that the system is correctly configured at any time. The machine refers to the UCM or USC to which the automation system is connected to. If the correct machine is not selected, it can be changed here.
2. The Stop Run button, when pressed, stops the current run. A run cannot be restarted, and the data for that run will be lost.

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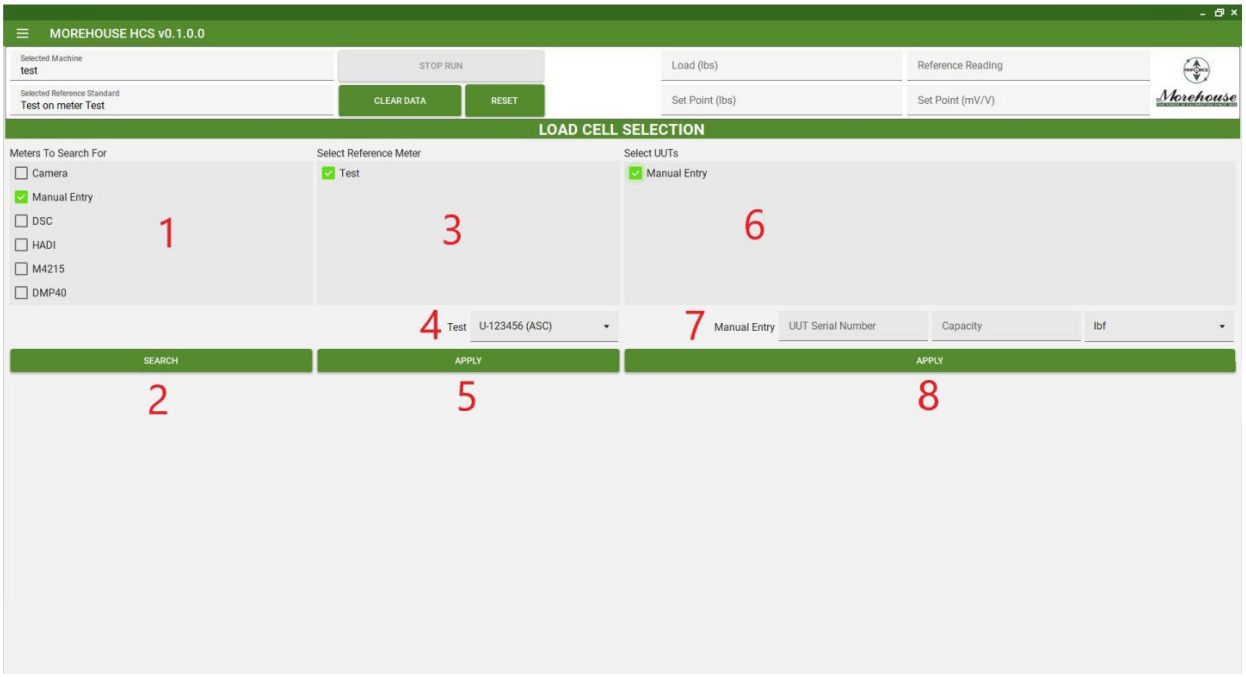
3. The Clear Data and Reset buttons have similar functions but differ slightly. The reset button is intended to be used when a new instrument is calibrated or the calibration to be run is changed. This unlocks the controls for setting up the UUT and calibration runs. The Clear Data button does not unlock any of the controls but clears all data that has been gathered.
4. A display shows the current reading from the reference standard in mV/V and the system's target set point in mV/V. The reference display filter in the settings page does not affect this display.
5. The Display Units dropdown allows users to change the units used in all displays.
6. The Set Point display shows the system's target set point in force units.
7. The Current Load display shows the system's current load in force units. The settings page allows you to change the resolution of this display and set simple averaging filtering. When the system gets a reading, it will record the unfiltered load at full resolution.
8. The Offset From Set Point shows how far the current load on the system is from its target as a % of the target value.

5.3.2 Load Cell Selection



The load cell selection screen allows users to connect the system to meters to get readings from load cells.

Description of items on screen:

1. The Meters To Search For region lists possible meters that can be connected to.
2. The search button searches for any meters selected in the Meters To Search For field.
3. The Select Reference Meters region is where the user selects which meter is connected to the reference cell.

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4. Once a meter is selected in the Select Reference Meters region, a dropdown menu will appear below for the user to select the reference cell that is connected to the meter.
5. The Apply button below the reference meter selection area will apply any changes made.
6. The Select UUTs region is where the user selects which meter is connected to the UUT.
7. Once a meter is selected in the Select UUTs region, a menu will appear below. This will allow the user to enter the serial number and capacity of the UUT. Some meters will allow the user to select which units should be read. For example, a 4215 can display the reading from a load cell in mV/V or a converted value in force units (lbf, kN, etc). This system allows the user to capture readings from a 4215 in either mV/V or a variety of force units.
8. The Apply button below the UUT selection area will apply any changes made.

The typical workflow for this screen would be as follows:

Connecting to the reference meter:

- If the system has already been connected to the reference meter, it will automatically attempt to connect to the meter again on startup, so this step is typically unnecessary once the system is set up.
- First, select the type of meter from the Meters To Search For field (1).
- Select Search (2).
- The serial number for any meters found will appear in the Select Reference Meter and Select UUTs regions (3 & 6). Select the reference meter's serial number in the Select Reference Meter region (3). Select the appropriate reference cell from the dropdown menu that appears (4) and select Apply (5).

Connecting to a UUT:

- First, select the type of meter from the Meters To Search For field (1).
- Select Search (2).
- The serial number for any meters found will appear in the Select UUTs region (6). Select the reference meter's serial number and enter the instrument's serial number, capacity, and units used for capacity.
- Some meters will allow the user to select which units to read. For example, a 4215 can display the reading from a load cell in mV/V or a converted value in force units (lbf, kN, etc). This system allows the user to capture readings from a 4215 in either mV/V or a variety of force units.
- Select Apply (5).

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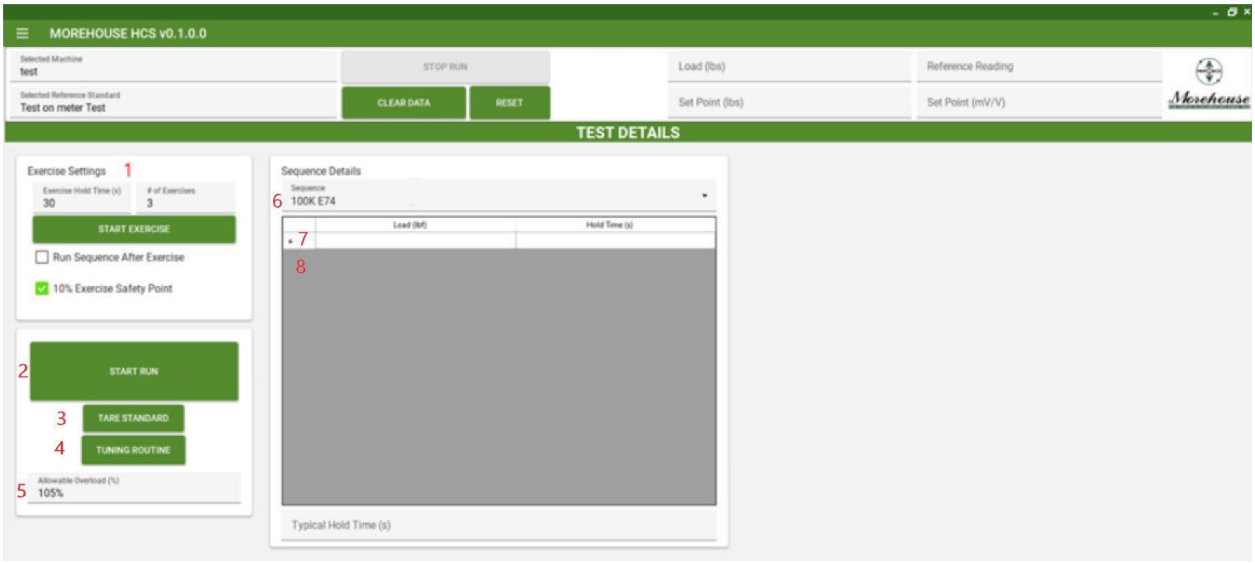
5.3.3 Test Details



The Test Details page contains the controls for setting up and starting exercise sequences and calibration runs.

Description of items on screen:

1. The exercise settings are grouped in the top left of the screen. 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 exercise hold time. It will then return to no load and hold it there for the specified exercise hold time. The system will automatically run the exercise the specified number of times. The load that the system exercises will be the lowest of the machine, reference cell, and UUT capacities. For example, a 50klbf UUT in a 100klbf machine with a 100klbf reference cell will exercise to 50klbf. However, a 200klbf UUT in the same machine will only exercise to 100klbf. If the Run Sequence After Exercise check box is clicked, the system will automatically run one calibration run as specified in the Sequence Details chart (8) after completing all the exercise runs. 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 feature 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.
2. When the Start Run button is pressed, the sequence displayed in the Sequence Details chart (8) will be run.
3. The Tare Standard button tares all attached reference meters.

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4. 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.
5. 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. The program, internal pressure sensor, and reference 4215 (if used) will monitor the system for an overload and are independently able to stop the run. The value entered here should be greater than 100%.
6. The dropdown at the top of the Sequence Details section of the screen allows the user to load a sequence previously built in the Sequence Builder screen. See Section 5.3.7 for more information. Selecting a sequence from the dropdown will populate the sequence chart (8) with the prebuilt sequence.
7. To delete a row from the sequence chart (8), select the whole row using the left header column and press delete.
8. The sequence chart shows the sequence of loads the system will apply in a run and the amount of time it will hold those loads. See below for how to generate sequences.

There are three ways to create a sequence to be run. The first is creating a run manually from scratch. This can be done by entering the desired loads and hold times directly into the sequence chart. 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 using the dropdown above the sequence chart (6). The third way to create a sequence is to modify a saved sequence. Once a previously created sequence is selected from the dropdown, it can be modified directly in the sequence chart 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.

Changing the Typical Hold Time entry below the sequence chart at any time will change all entered rows to a common hold time.

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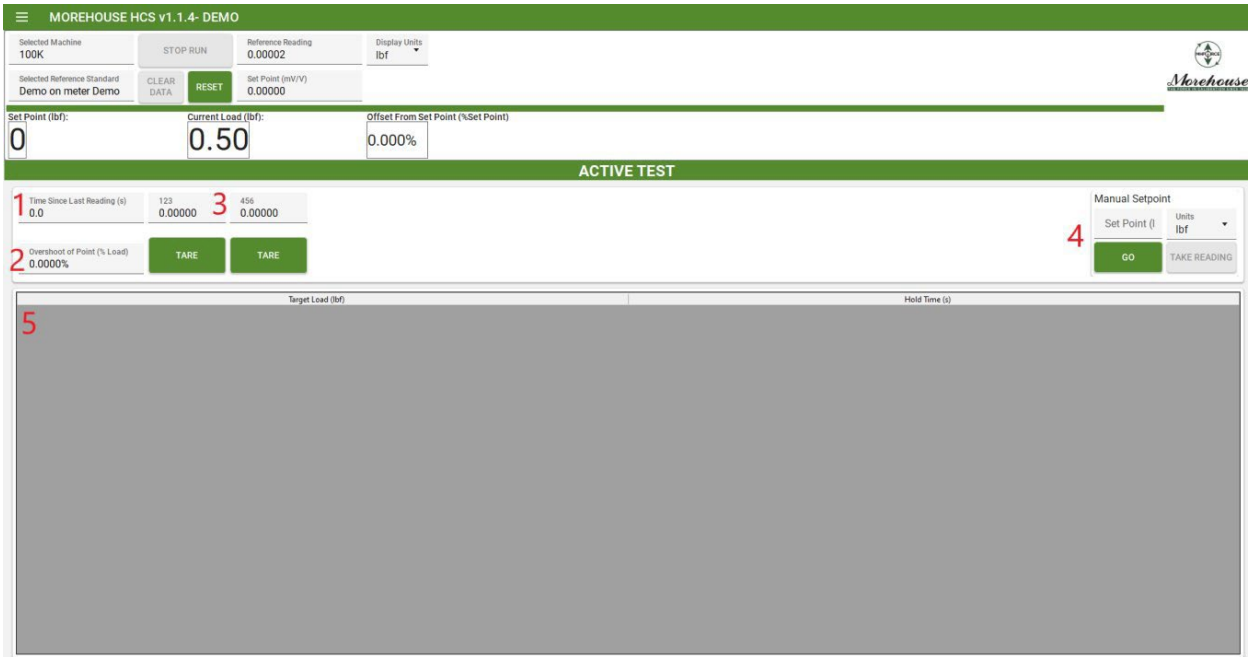
5.3.4 Active Test



The active test screen displays information pertaining to the test currently being run.

Description of items on screen:

1. The Time Since Last Reading displays how long it has been since a reading was taken.
2. 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 on the Settings page, it will alert the user and give them the option to stop the run.
3. A display showing the current reading for each UUT labeled with its serial number (the example screenshot shows two UUTs) and a tare button under its reading display is also available.
4. The Manual Setpoint controls 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.
5. The Active Test screen displays each point's target force and hold time. For each run, it displays the reading from each UUT and the actual measured force when the UUT readings were taken.

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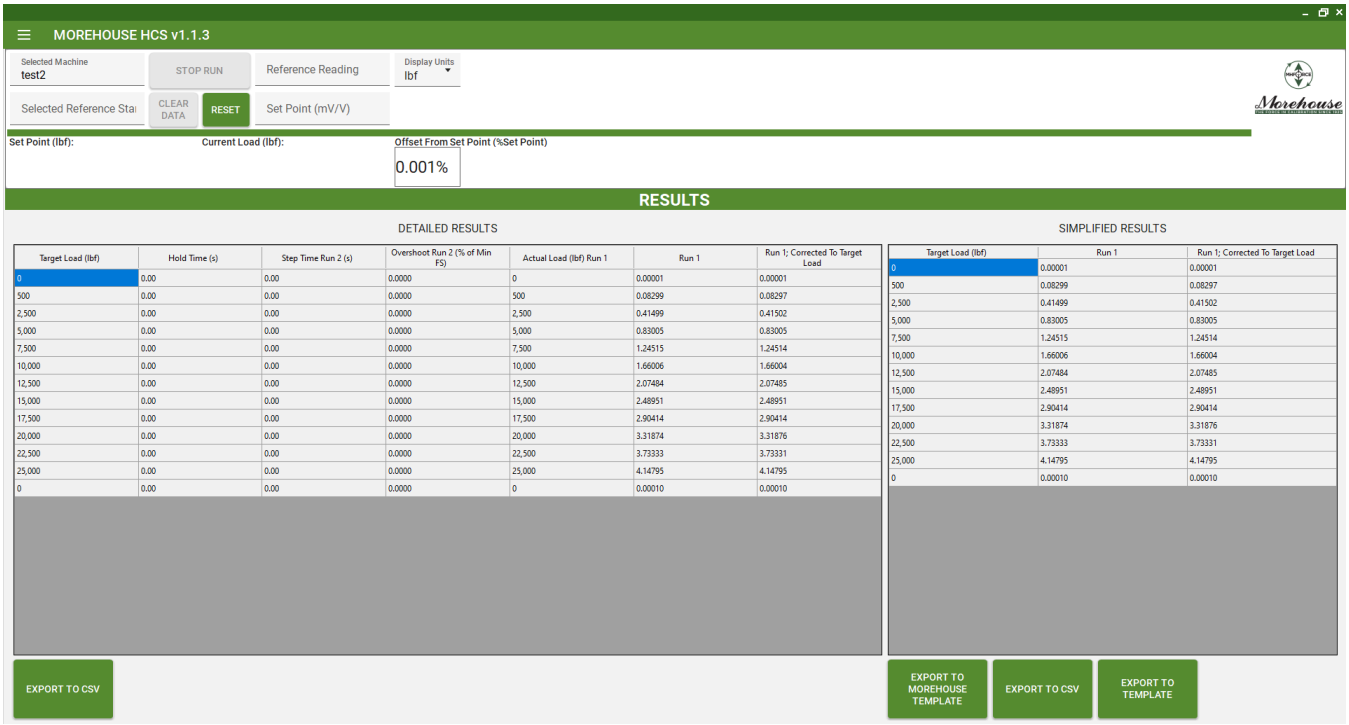
5.3.5 Results



Target Load (lbf)	Hold Time (s)	Step Time Run 2 (s)	Overshoot Run 2 (% of Min FS)	Actual Load (lbf) Run 1	Run 1	Run 1; Corrected To Target Load
0	0.00	0.00	0.0000	0	0.00001	0.00001
500	0.00	0.00	0.0000	500	0.08299	0.08297
2,500	0.00	0.00	0.0000	2,500	0.41499	0.41502
5,000	0.00	0.00	0.0000	5,000	0.83005	0.83005
7,500	0.00	0.00	0.0000	7,500	1.24515	1.24514
10,000	0.00	0.00	0.0000	10,000	1.66006	1.66004
12,500	0.00	0.00	0.0000	12,500	2.07484	2.07485
15,000	0.00	0.00	0.0000	15,000	2.48951	2.48951
17,500	0.00	0.00	0.0000	17,500	2.90414	2.90414
20,000	0.00	0.00	0.0000	20,000	3.31874	3.31876
22,500	0.00	0.00	0.0000	22,500	3.73333	3.73331
25,000	0.00	0.00	0.0000	25,000	4.14795	4.14795
0	0.00	0.00	0.0000	0	0.00010	0.00010

Target Load (lbf)	Run 1	Run 1; Corrected To Target Load
0	0.00001	0.00001
500	0.08299	0.08297
2,500	0.41499	0.41502
5,000	0.83005	0.83005
7,500	1.24515	1.24514
10,000	1.66006	1.66004
12,500	2.07484	2.07485
15,000	2.48951	2.48951
17,500	2.90414	2.90414
20,000	3.31874	3.31876
22,500	3.73333	3.73331
25,000	4.14795	4.14795
0	0.00010	0.00010

The results page shows all results from the calibration runs for the current instrument. Below is an explanation for each column:

- Target Load: Load that the user had selected to apply.
- Hold Time: Amount of time the user had selected to hold the target load.
- Step Time: Amount of time between the previous reading being taken and the reading in this row being taken.
- Overshoot: How far over the target load the load on the system went. Expressed as a % of target load.
- Actual Load: Actual load applied according to the reference load cell when the UUT reading was taken. This is corrected based on the Initial and/or final zero readings of the reference load cell according to the Reference Zero Correction setting on the Settings screen.
- UUT Reading: Reading taken from UUT.
- UUT Reading, Corrected to Target Load: UUT reading corrected to what the UUT may have read if the target load had been applied instead of the actual load. This assumes the UUT is linear.

A chart on the left side of the screen shows all these results, and a chart on the right side shows only the target load, UUT reading, and UUT reading corrected to the target load. The full results chart can be exported to a CSV. The simplified results can be exported to a CSV or a template supplied by Morehouse to generate a certificate. The data can also be exported to a user-made template by selecting a file and then selecting what sheet and starting location, the data is to be

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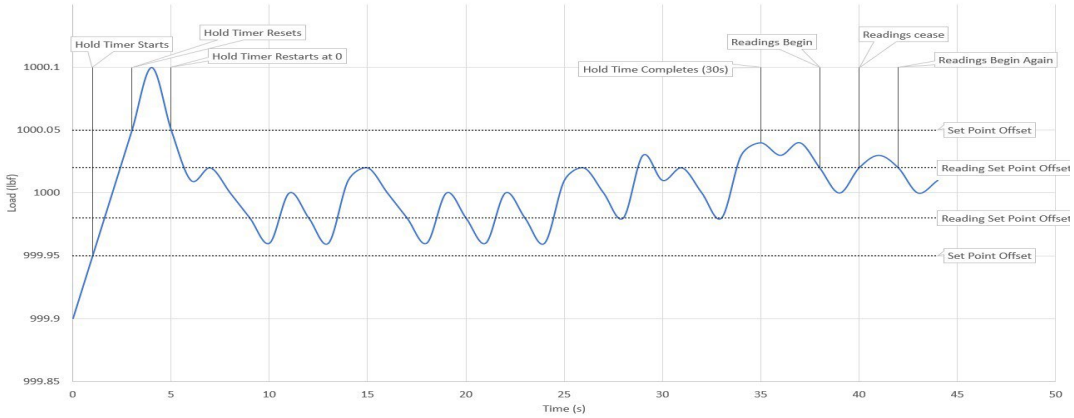
written to. This allows users to export data to a known place in a spreadsheet to be used however they see fit.

5.3.6 Settings

The Settings page allows users to change various settings that persist when the program is restarted. They are described below in detail.

- Default Units: The units are automatically selected when the program starts.
- Max Overshoot: If the system is attempting to reach a force (F) and an ascending force reaches F + the unacceptable overshoot (or for a descending force, F – unacceptable overshoot), the system will alert the user and give them the option to 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 Wait Until Set Point Is Reached to Take Reading check box conditions 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 at which the system will take readings. If the applied load has been within the Set Point Offset for the 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.
- 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 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.

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



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- Number of averaged readings: The number of readings the system will take from the UUT meter and then average together to get one reading.
- Pressure Build Timeout: How long it takes 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 as long as specified before it errors out. This safety feature prevents 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.
- 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.
- Reference Zero Correction: This allows the user to set how the system corrects the reference load cell's readings based on the initial and final zero readings. For example, most of Morehouse's customers get their reference standards calibrated according to ASTM E74 using Method B zero correction (which takes into account initial and final zeros). Selecting the Initial & Final Zero selection here would best reflect how the reference load cell was calibrated and would reduce the uncertainty associated with these corrections.
- Enable Manual Controls: This enables some jogging controls on the Active Test screen, allowing the user to control the system manually.
- Tare UUTs at Beginning of Run: Selecting this will cause the system to tare all UUTs at the beginning of each calibration run.
- Final Reference Reading Delay: Sets the amount of time after returning to zero until the final reference zero reading is recorded.
- Pressure Sensor Calibration: This will perform a routine to calibrate the internal pressure sensor of the system against the reference standard. To perform this calibration, set the machine up with a reference standard and a solid block in the compression area of the machine that can withstand the full capacity of the machine. It is recommended that the calibration be performed to full scale of the machine being used. It is not recommended to perform this below 1/3 of the machine's capacity. This should be performed once when the system is first commissioned and at regular intervals afterward. See maintenance section for more information. ***Make sure that the reference cell is correctly configured before running this routine as there is an increased chance of an overload if things are not configured properly.***

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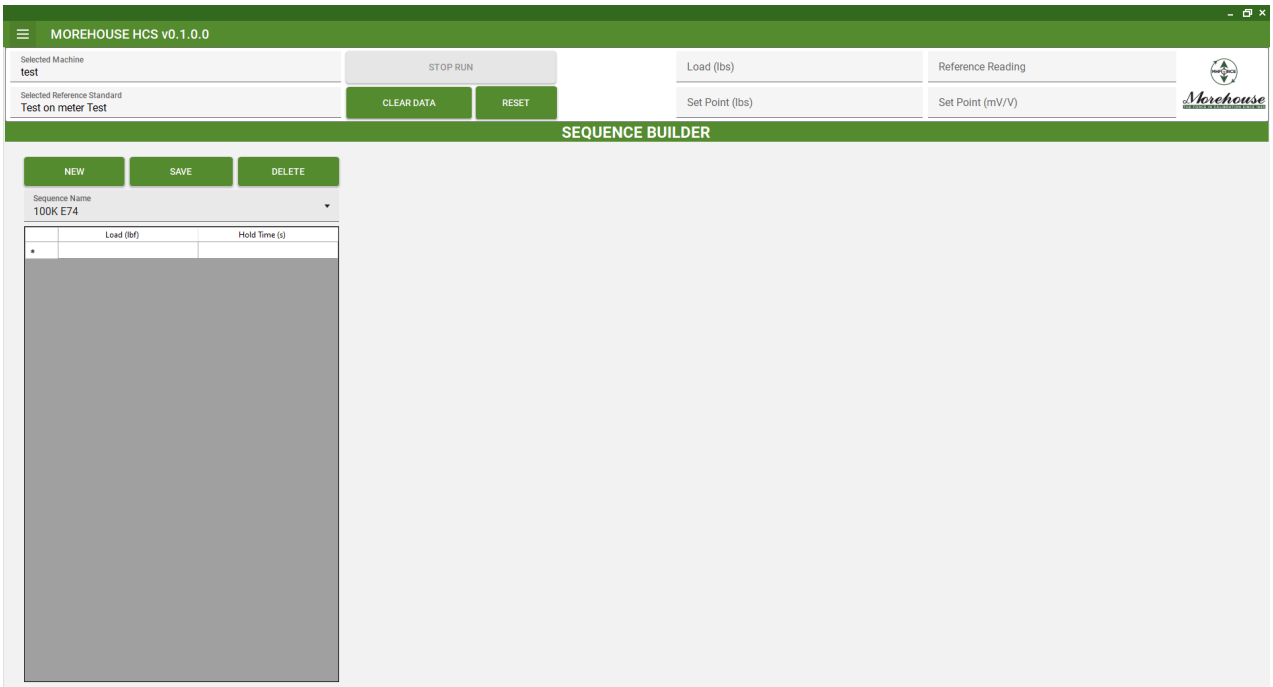
5.3.7 Sequence Builder



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.

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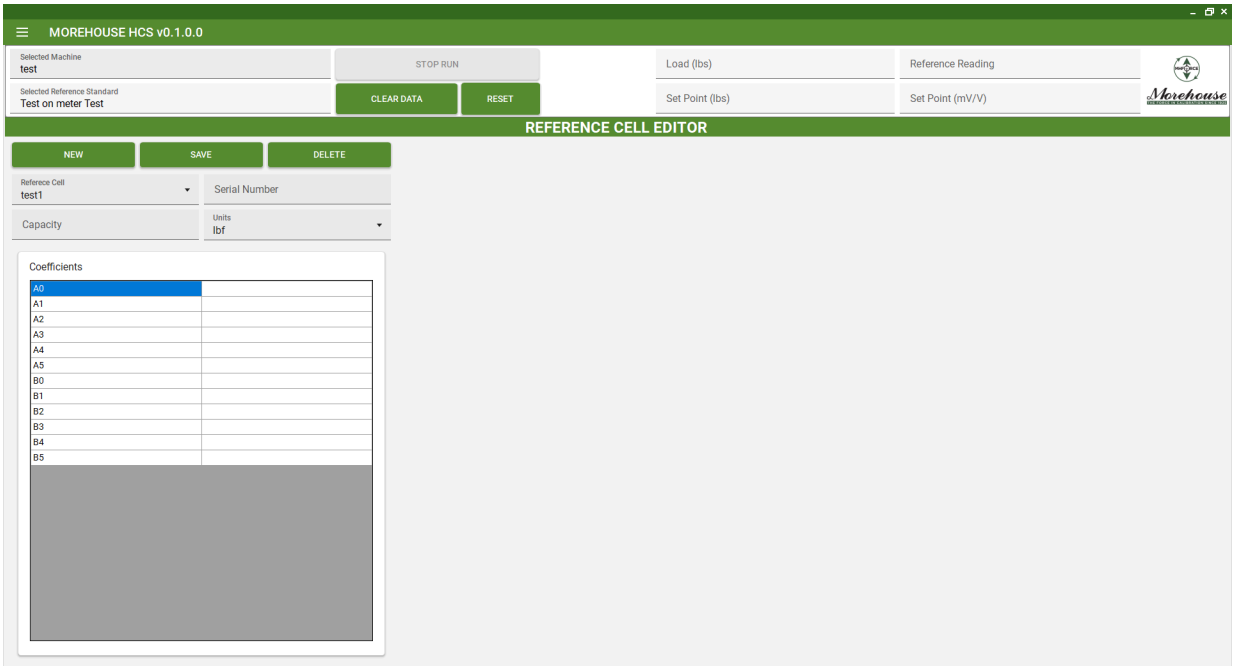
5.3.8 Reference Cell Editor



The Reference Cell Editor screen allows the user to enter the calibration coefficients for reference cells.

To create a new reference cell or modify an existing one:

- To create a new cell, press the New button, enter the desired name, and press OK. To modify an existing cell, select it from the dropdown.
- Enter Serial Number, Capacity, and Units. The units apply to both the capacity and the calibration coefficients.
- Enter the calibration coefficients of the cell. 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. A0-A5 are the coefficients associated with the polynomial for calculating the applied load based on the response of the load cell. B0-B5 are the coefficients associated with the polynomial for calculating the load cell's response for a given applied load. Calibration providers may use different nomenclature for these coefficients. Below is a demonstration of what these coefficients represent. If a lower-order calibration equation is used, the unused coefficients can be left as 0.

$$\text{Response (mV/V)} = A_0 + A_1F + A_2F^2 + A_3F^3 + A_4F^4 + A_5F^5$$
where: F = Force (kN)

$$\text{Force (kN)} = B_0 + B_1R + B_2R^2 + B_3R^3 + B_4R^4 + B_5R^5$$
where: R = Response (mV/V)

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- Press Save to save your changes. 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. Check the predicted response values against your calibration certificate.
- An existing cell can also be deleted by selecting it from the drop-down and pressing delete.

5.3.9 Machine Editor

The Machine Editor screen allows the user to enter the parameters for machines (UCM or USC) that the system will be connected to.

To create a new machine or modify an existing one:

- If creating a new machine: press the New button, enter the desired name, and press ok. If modifying an existing machine, select the machine from the dropdown.
- Enter the serial number, capacity, units, and jack size. Jack size refers to the size of the hydraulic jack on the UCM or USC that the automation system is connected to. If the machine's jack does not have a label, a table of approximate outer diameters of different jack sizes is listed below. Measure the outer diameter of the jack and compare it to the chart. The jack is likely the same as the machine's capacity, but some machines have jacks that are larger than the machine's capacity.

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Jack Size	Outer Diameter (in)
30KLBF	4
60KLBF	5.5
100KLBF	7
150KLBF	8.5
200KLBF	9.75
300KLBF	11
500KLBF	16
600KLBF	17
675KLBF	17
1,000KLBF	23
2,000KLBF	27

- Press Save to save your changes.
- An existing machine can also be deleted by selecting it from the drop-down and pressing delete. The currently selected machine for the system cannot be deleted.

5.3.10 Help

The Help screen aids in getting the system working as well as troubleshooting through common issues.

The Initial Setup tab walks the user through the steps to get the system set up.

The Your First Calibration tab walks the used through the steps of the first calibration with the system.

The Common Errors screen addresses some common issues that might be encountered and how to troubleshoot them.

6 Maintenance

Contact Morehouse for replacement part diagrams or schematics.

6.1 Necessary Maintenance

A pressure sensor calibration should be performed once a year to avoid nuisance alarms due to drift in the sensor. This may need to be done more frequently (about every 3 months) if calibrations are performed on instruments with capacities less than ~5% of the hydraulic jack's capacity. See instructions in Settings screen section 5.3.6 for more details.

The system has been designed to be low maintenance and does not need any regular physical maintenance aside from checking for leaks periodically by examining the floor underneath the machine. In the unlikely event of a leak, there is a sensor that will detect when the oil reservoir

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has gotten to a critically low state but visually checking for leaks is recommended to ease cleanup in the event of a leak.

If hydraulic oil must be added, the reservoir can be accessed by removing the front cover. The reservoir should be filled approximately half full. For oil recommendations, see the section below.

6.2 Oil Recommendations

The reservoir of the system was filled with approximately 1.5 gallons of petroleum-based hydraulic fluid (Kendall, Four Seasons AW 32 is recommended) prior to shipping. If hydraulic fluid must be added, be sure to use petroleum base anti-wear hydraulic fluid with an ISO Viscosity Grade of 22 or 32, which meets DIN 51524. The following hydraulic fluids are recommended, but any equal hydraulic fluid may also be used:

Drydene Oil Co . . . . . Paradene 22AW
Exxon . . . . . Nuto H 32
Gulf . . . . . Harmony 32 AW
Mobil . . . . . DTE 24
Texaco . . . . . Rando HD 32

When choosing a hydraulic fluid, be certain it is equal to one of the above-listed recommendations. Many formulations may lack certain additives or are formulated for special reasons, such as lower cost, high detergency, leakage control, etc. Some of these specialty fluids can be used successfully; however, others may prompt malfunctions and high rates of wear.

6.3 Software Updating

Systems that come with software version 1.1.10.0 or later will automatically check for software updates if connected to the internet. The user will be prompted if they want the update before installing it and the update can be denied; however, the user will be prompted again to update after a week. Contact Morehouse if you do not want your system to check for updates.

Any version before version 1.1.10.0 will not automatically check for updates.

Follow the instructions below if:

- Your system's software is earlier than version 1.1.10.0
- You have software version 1.1.10.0 or later and you need to manually update the software (either because it is not connected to the internet or another reason)

HCS Update Instructions:

1. Download the latest software at:
   https://github.com/mhforce/HCS-Releases/releases/latest/download/HCS_Release.zip
2. If this file was downloaded on a computer other than the automation system, it will need to be moved onto the automation system somehow; one option would be using a flash drive. Put the downloaded zip file into the downloads folder.

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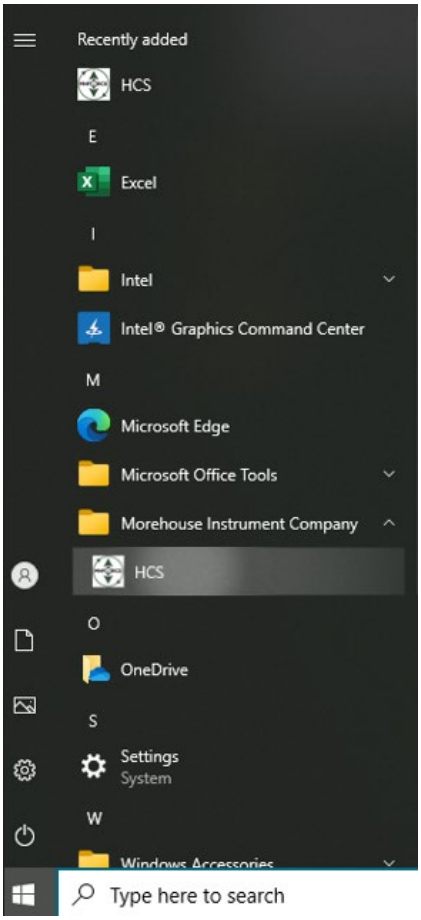
3. If you have software version 1.1.10.0 or later you do not need to uninstall the current version so you can skip to step 7.
4. Go to the start menu and find HCS under Morehouse Instrument Company. Right click and select Uninstall.



5. In the window that opens, find HCS. Right click and select Uninstall/Change.

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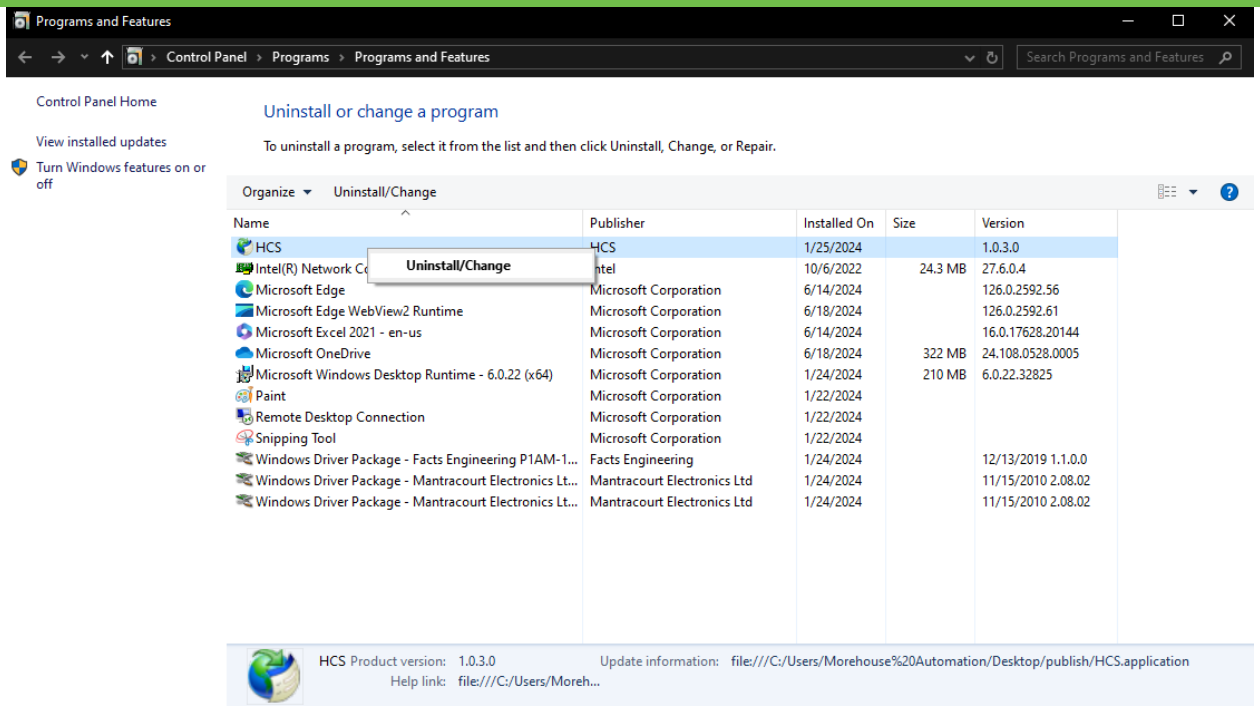
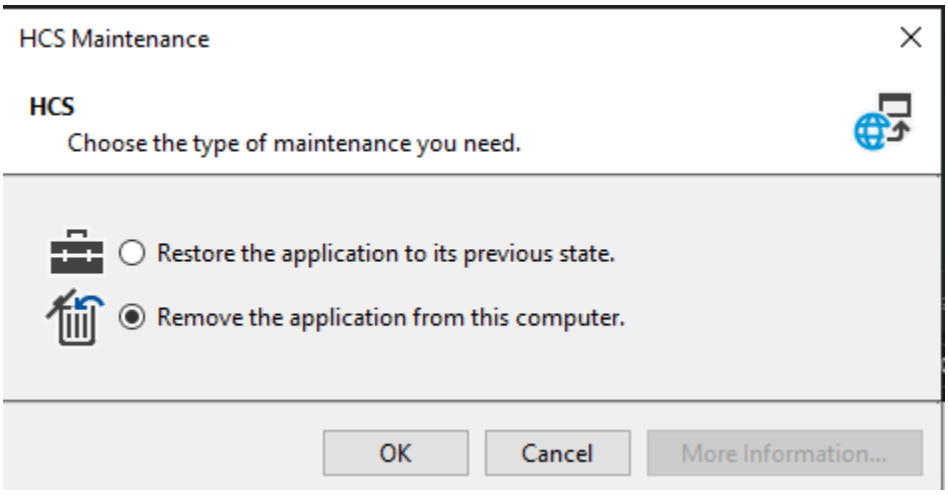


6. In the window that opens, select Remove the application from this computer and click OK.



7. Find the zip file that was downloaded in step 1 then right click on it. Extract all into the downloads folder.

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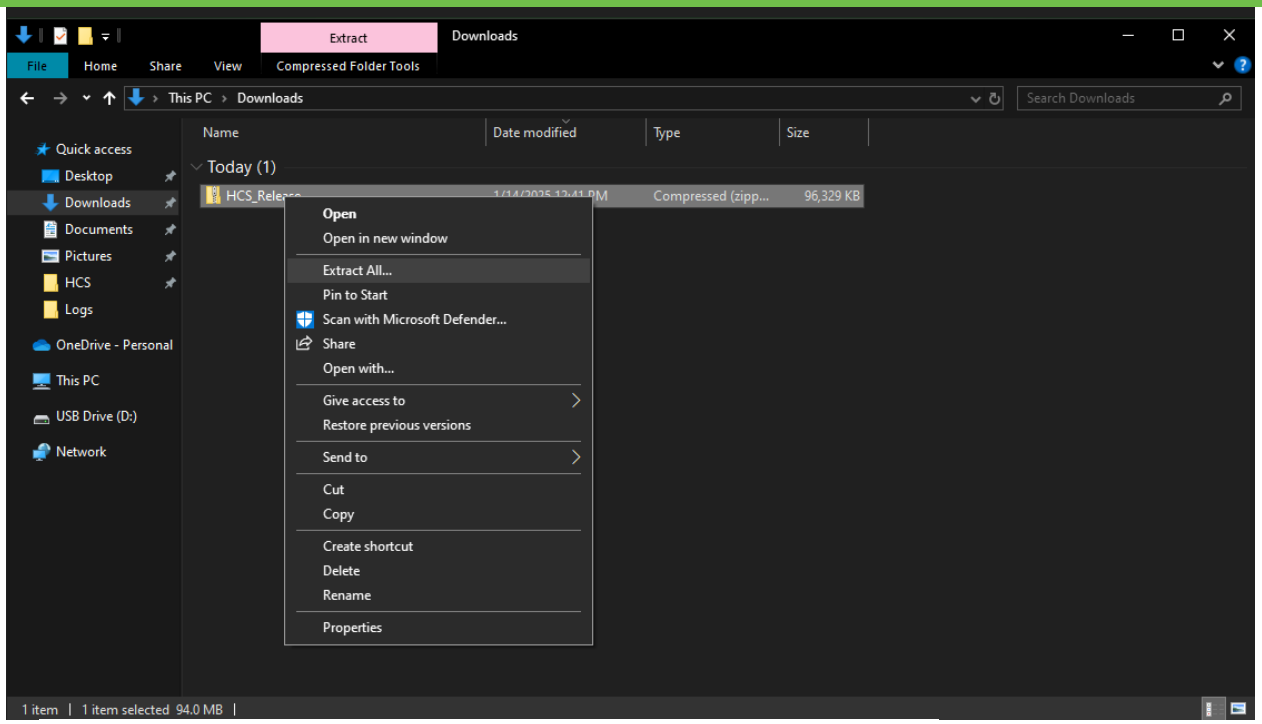

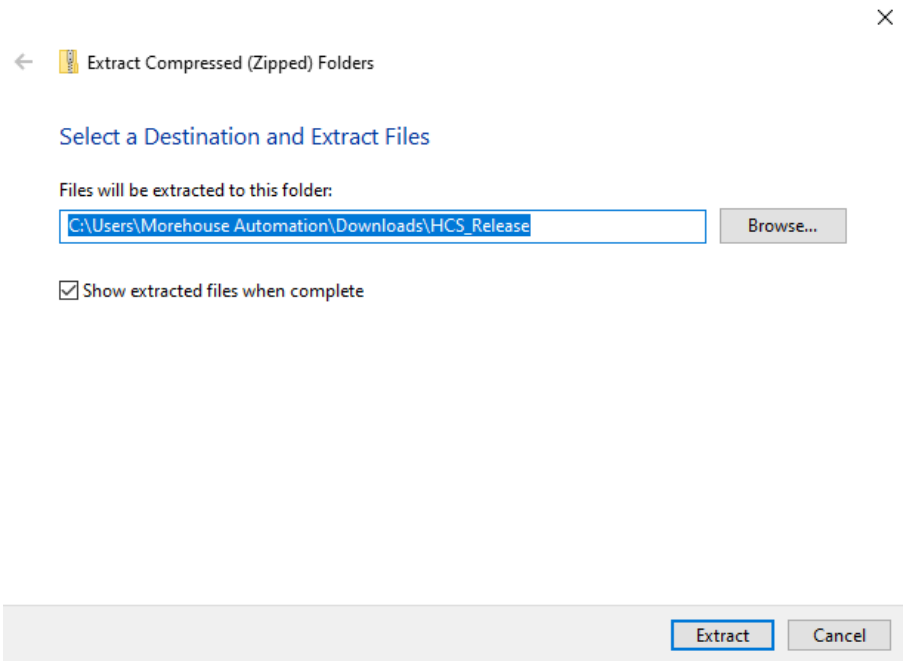

8. The extracted folder should open. Run the setup file and step through the dialogs to install the new version.

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7 Troubleshooting

Issue	Possible Cause	Solution
System will not initialize	Safety system fault	See below
	Reference meter issue	Make sure the reference meter is on and the USB is connected.
E-stop light is lit (safety system fault)	E-stop is pressed	Release e-stop (check both).
	The safety system needs to be reset.	Press e-stop for 5-10 seconds and release it.
	The reference meter limit was triggered.	Make sure the reference meter is on.
		Make sure the reference meter IO cable is plugged in.
		Make sure there is no load on the system and tare reference meter.
		If not using 4215 as a reference meter, make sure the bypass connector is connected to the reference IO connector on top of the unit.
		Configure meter limit value by following steps in Help Screen.
		If the above fails, reset the meter limit value manually (see Appendix in Section 9).

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

8 Glossary

Meter – Device that reads the output from a load cell. Also known as an indicator.

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Reference Cell – Load cell used to measure the load applied to the UUT.

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 is being calibrated.

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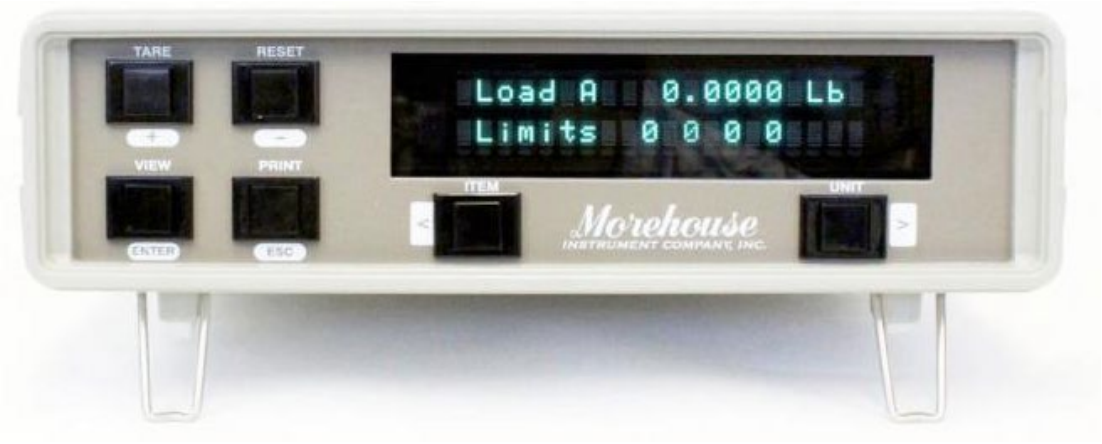
9 Appendix 1: 4215 Limit Switch Setting

The 4215 meter has a functionality called a "limit switch." This is a set of relays in the meter that can be set to trigger if it reads a mV/V over or under a certain amount. The automation system uses this functionality as a safety check that allows the 4215 to shut the system down if a certain load is exceeded. If using a 4215 that was not supplied with your automation system, it may be necessary to set these limits manually switches the first time the 4215 is used with the automation system. If the e-stop light on the front stays on despite the e-stop not being pressed, this may be the case (see the troubleshooting section 6).



Above is an image of the faceplate of a 4215. Throughout these instructions, the buttons will be referred to by the labels surrounded in white (+, -, ENTER, ESC, LEFT, and RIGHT).

1. After bootup, press the LEFT and RIGHT buttons simultaneously to enter the menu.
2. Using the RIGHT button, scroll to Limiters.
3. Press ENTER.
4. Press ENTER on Select Limiter 1.
5. Select Normally Closed and press ENTER.
6. Select Limit 1 Enabled and press ENTER.
7. Select Source: Load A and press ENTER.
8. Select Units: mV/V and press ENTER.
9. Enter 4.0000 mV/V Set using LEFT and RIGHT keys to select digits + and – keys to change values. The value can be toggled between positive and negative by pressing the + and – keys together. Press ENTER.
10. Select Trip if Load A>Set and press ENTER.
11. Select Latching Off and press ENTER.
12. Enter 3.000 mV/V Reset and press ENTER.
13. You should now be back in the main menu at Limiters. Press ENTER to reenter the Limiters menu.
14. Select Limiter 2 and press ENTER.
15. Follow steps 5 through 12 for Limiter 2.

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16. You should now be back in the main menu at Limiters. Press ESC to exit the menu.
17. Tare the meter.
18. At this point, the limiters should be off. This can be confirmed by scrolling through the display using the ITEM button (same as the LEFT button) until the Limits are displayed. The first to numbers should be zero.
19. If the e-stop light has still not turned off, try pressing the e-stop for about 10 seconds and releasing it. If it is still on, see the troubleshooting section 6.

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