



Asphalt Mixture Automated Testing System with Zero Intervention (AMAZE): Revised User Manual

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**ASPHALT MIXTURE AUTOMATED TESTING SYSTEM WITH
ZERO INTERVENTION (AMAZE):
REVISED USER MANUAL**

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Disclaimer

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This report is not intended for construction, bidding, or permit purposes. The researcher in charge of the project was Fujie Zhou.

The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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Space Requirements

The Asphalt Mixture Automated Testing System with Zero Intervention (AMAZE) requires a minimum space of 12 ft × 12 ft. Figure 1 shows the top view of the system.



Figure 1. Top View of System

Electrical Requirements

AMAZE requires two different power sources, one for the main system's components and the other for the central computer, as detailed below.

- System:
 - Power input requirements: 125V AC—50 amps, isolated circuit.
 - Receptacle outlet: NEMA 14-50r.
- Central computer:
 - Power input requirements: 100–240V AC—1.8 amps.

System Description

AMAZE is a cutting-edge solution designed to revolutionize the asphalt mixture testing process. The goal of the system is to increase consistency and accuracy of test results, eliminate human error, improve efficiency, and reduce testing times. AMAZE is engineered to automatically measure four essential asphalt mixture properties: bulk specific gravity (i.e., air voids with the condition of known rice value), cracking resistance, rutting resistance, and indirect tensile strength.

The system is comprised of six main units that are arranged tightly around a central robotic arm, a UR-5e robot with a gripper (see Figure 1). This robotic arm grabs an asphalt specimen and moves it through the various stages of the testing process to measure essential properties of asphalt mixtures.

AMAZE has multiple components that work together to perform the desired tests for asphalt specimens. The system is composed of six different units. Each unit within the AMAZE system is not only distinct in function but also designed for mobility, such that each unit can be moved for maintenance or transportation. This mobility feature is particularly beneficial for adapting the system layout to different operational environments or specific testing requirements. The subsequent subsections provide a detailed exposition of each unit, delineating the individual roles and functionalities within the AMAZE system.

Radio-Frequency Identification (RFID) Unit

The RFID system integrated into AMAZE serves as a pivotal component for enhancing sample identification, substantially diminishing the risk of conducting incorrect tests on given samples. This system leverages RFID technology to accurately ascertain the identity of each sample, thereby ensuring that the appropriate test is performed.

This RFID system is composed of two primary elements:

- Desktop RFID Staging Unit (Figure 2): This unit plays a crucial role in the initial stages of the testing process. It is utilized for individually registering each sample, a process that involves creating a testing profile file. This file is pivotal for the AMAZE system because it guides the subsequent testing procedures by providing detailed information about each sample.



Figure 2. Desktop RFID Staging Unit

- Sample RFID Reader (Figure 3): Positioned within the AMAZE system, this reader operates during the testing phase. Its function is to identify each sample as it is about to undergo testing. By reading the RFID tags attached to the samples, the reader ensures that each specimen is correctly identified, thus aligning the testing process with the information outlined in the testing profile file.



Figure 3. Sample RFID Reader

In essence, the RFID system in AMAZE enhances the testing accuracy by providing a reliable method of sample identification, which is essential in maintaining the integrity of the testing process and the validity of the test results.

Carousel Unit

The carousel unit in the AMAZE system is integral for feeding asphalt specimens into the testing process. It is designed to hold up to two samples across its three-tiered structure, with each sample position clearly numbered to prevent misplacement. Users are advised to load the samples sequentially without skipping any numbered spot, ensuring an orderly and efficient testing procedure.

This unit is directly docked to the air voids unit, facilitating a smooth transition of samples into the initial phase of testing. Its operation is driven by a powered rotary table, which accurately rotates the tiers to align the samples for pickup by the robotic arm. This precision in rotation is crucial for the consistent and reliable transfer of samples for testing. The overall functionality of the carousel unit, as shown in Figure 4, enhances the efficiency and accuracy of the AMAZE system's testing process.

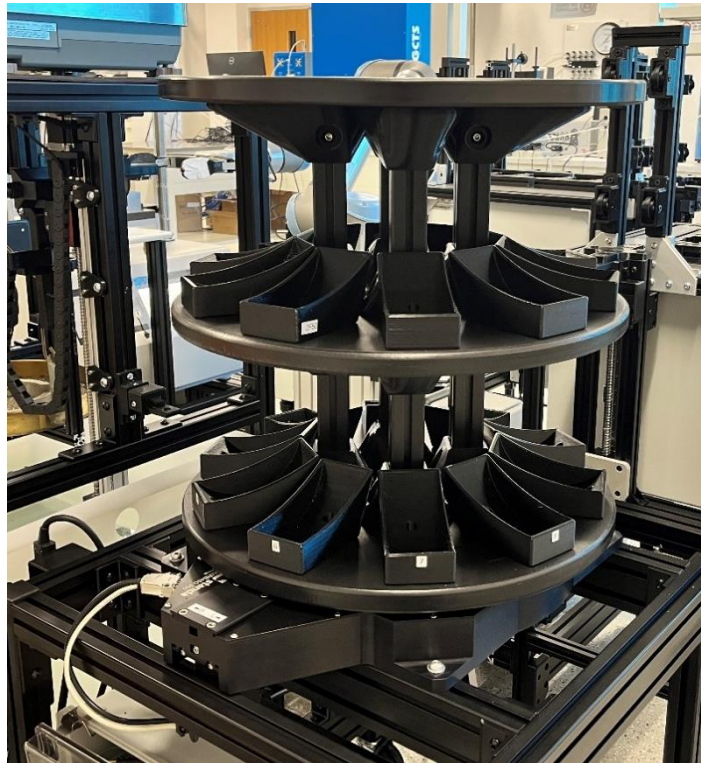


Figure 4. Carousel Unit

Air Voids Unit

The air voids unit is composed of two key components: weight measurement and saturated surface dry (SSD). The weight measurement component measures the dry weight of an asphalt specimen, the weight of the specimen submerged in the water, and the weight of the SSD of the specimen out of water. The air voids unit is equipped with two linear actuators, which lower an asphalt specimen into the water and lift it out of the water. Figure 5 shows the weight measurement component of the air voids unit.

Another part of the air voids unit is the SSD component (see Figure 6). The major function of the SSD component is to dry the surface of an asphalt specimen with a dampened towel so that SSD is achieved.



Figure 5. Weight Measurement Component



Figure 6. Saturated Surface Dry Component

Specimen Conditioning Units

The AMAZE system includes two specimen conditioning units specifically designed to address the temperature sensitivity of asphalt mixtures. These units are integral for preparing test specimens for the indirect tension asphalt cracking test (IDEAL-CT) and IDEAL rutting test (IDEAL-RT). Although both units share identical designs, they are designated for different conditioning temperatures. The first unit conditions specimens at a standard room temperature of 25 °C (77 °F), suitable for the IDEAL-CT. In contrast, the second unit is tailored for the IDEAL-RT, conditioning specimens at a higher temperature of 50 °C (122 °F). Each conditioning unit possesses the capacity to accommodate up to eight specimens simultaneously, ensuring efficient and uniform conditioning for multiple samples. This feature is especially useful for handling bulk testing scenarios, enhancing productivity and consistency in test results. Figure 7 specifically showcases the specimen conditioning unit designated for either the IDEAL-CT or the IDEAL-RT.



Figure 7. Specimen Conditioning Unit for IDEAL-CT (or IDEAL-RT)

Specimen Storage Unit

In some cases, users may choose to simply measure air voids of an asphalt specimen and then store it for later use. The specimen storage unit shown in Figure 8 is designed to save and store the specimen. It is connected to the main body of the system via the docking system.



Figure 8. Specimen Storage Unit

Loading Frame Unit

The loading frame unit is engineered to perform three tests: IDEAL-CT, IDEAL-RT, and indirect tensile strength. At the heart of this unit is the Humboldt 5040 loader, which applies an axial compressive load to the specimens and records the time, load, and displacement data. Furthermore, this loading frame unit is enhanced with a conveyor belt, a two-in-one fixture, and a self-cleanup system to allow for automatically cleaning up the tested specimen. Figure 9 shows the loading frame unit.



Figure 9. Loading Frame Unit

Robot Arm Unit

The robotic arm unit is the central component within the AMAZE system. It transfers the asphalt specimens among different units during the testing process. It is equipped with a specialized gripper capable of holding the specimen in any orientation.

Furthermore, the robotic arm frame is seamlessly integrated into the AMAZE system's power infrastructure. It is directly connected to the system's power distribution panel, which encompasses essential electrical components such as breakers, surge protectors, and cables of the appropriate gauge to handle expected loads. This integration underscores the unit's reliability and safety during operation. Surrounding the frame of the robotic arm are five receptacles, each dedicated to different units of the AMAZE system. This strategic placement facilitates efficient power distribution and connectivity for the entire system. Figure 10 shows the robotic arm unit.



Figure 10. Robot Arm

Central Computer Unit

The central computer unit is the system's control center, coordinating the testing sequence, processing data from the machines, and sending the test results to the users. Figure 11 shows the central computer.



Figure 11. Central Computer Unit

Seven Testing Options

AMAZE offers seven different testing options, giving users testing flexibility based on their needs. These seven testing options are described below.

- Option 1: Air Voids Only. When this option is chosen, AMAZE measures the bulk specific gravity of the specimen and then calculates its air voids. After the bulk specific gravity measurement is complete, the specimen is stored in the specimen storage unit. The robotic arm moves to the next task.
- Option 2: IDEAL-CT Only. If users want to skip the air voids measurement and directly perform the IDEAL-CT, they can choose this option. In this case, the robotic arm picks up the specimen and loads it into the loading frame unit for the IDEAL-CT testing. After testing is complete, the loading frame unit automatically pushes the broken specimen to a conveyor belt, transferring the specimen to a trash can.
- Option 3: Air Voids and IDEAL-CT with Specimen Conditioning. This option is designed for users who want to measure the specimen's air voids and condition the specimen in a water bath to the target temperature before running the IDEAL-CT.
- Option 4: Air Voids and IDEAL-RT with Specimen Conditioning. This option allows users to measure the specimen's air voids first and then condition the specimen in a water bath to the target temperature before running the IDEAL-RT. For all IDEAL-RT specimens, conditioning the specimens to the target testing temperature is required.
- Option 5: Air Voids and IDEAL-CT. This option is designed for scenarios where users want to measure the air voids of the specimen and then run the IDEAL-CT. This option provides users with the flexibility to skip the specimen conditioning stage.
- Option 6: IDEAL-CT with Specimen Conditioning. This option directly conditions the specimen in a water bath without performing the air voids measurement. After the specimen reaches its target testing temperature, the robotic arm picks it up, and then the IDEAL-CT is performed.
- Option 7: IDEAL-RT with Specimen Conditioning. This option directly conditions the specimen in a water bath without performing the air voids measurement. After the specimen reaches its target testing temperature, the robotic arm picks it up, and then the IDEAL-RT is performed.

Pre-Testing Preparation

Prior to initiating tests with the AMAZE system, users must complete certain preparatory steps to ensure accurate and efficient testing. These steps are outlined below:

1. **Select Testing Mode:** Users must choose between two distinct operating modes.
 - a. **RFID Mode:** This mode is chosen when RFID is used for sample identification. The desktop RFID staging unit, as depicted in Figure 2, is utilized to create the testing profile file. In this mode, the sequence of sample placement in the testing carousel is not constrained by the order in the testing profile file, offering flexibility for the user.
 - b. **Non-RFID Mode:** This mode is comparatively simpler, requiring no additional tagging of the samples. The critical requirement in this mode is the alignment of the sample order in the carousel with that in the testing profile file, ensuring consistency between the physical setup and the testing input.
2. **Prepare Specimen.** AMAZE can test either laboratory compacted specimens or field cores as long as they are 150 mm in diameter by 62 mm in height. For samples used in RFID mode, an RFID tag must be affixed to each sample. This is achieved using a thin layer of silicone, preferably a low-strength silicone, to secure the tag in place. It is imperative to allow the silicone to dry completely before proceeding with testing to ensure tag stability and integrity during the testing process. Figure 12 shows an RFID tag on an asphalt specimen.



Figure 12. RFID Tag on Asphalt Specimen

3. **Prepare Testing Profile File for AMAZE.** To initiate the testing process, it is imperative to create a testing profile file using the AMAZE registrar software specifically designed to guide users through the creation of a testing profile file. This step is mandatory for each test, regardless of the number of samples being evaluated—even for individual sample testing. Figure 13 shows the AMAZE registrar graphical user interface (GUI).

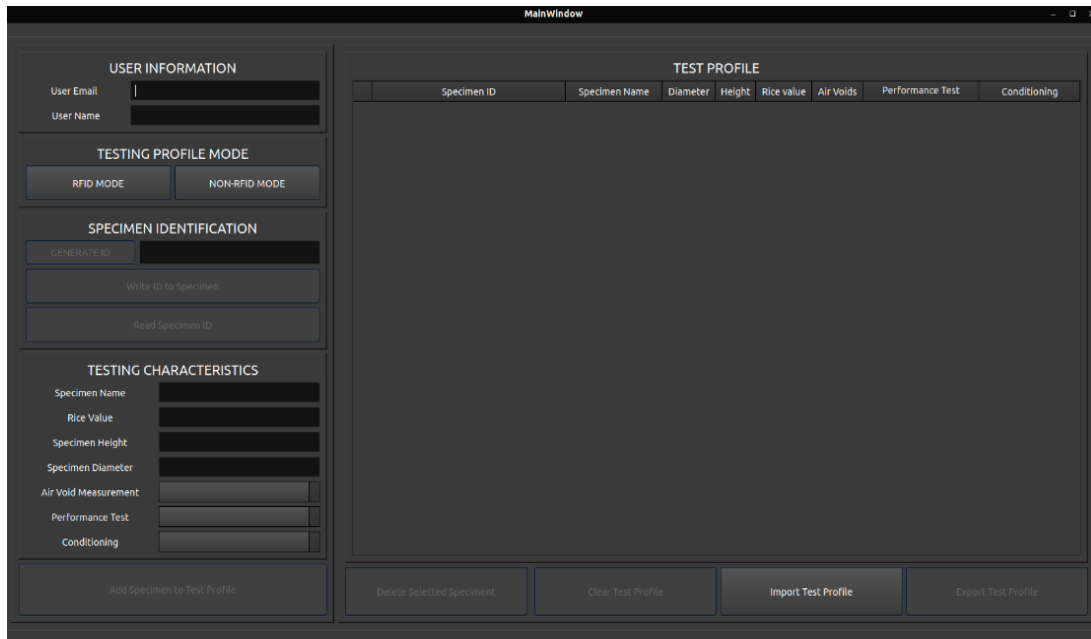


Figure 13. AMAZE Registrar Software

Upon opening the AMAZE registrar GUI, users should follow the subsequent steps to prepare a testing profile file:

- a. **User Information Entry:** Begin by entering the user’s information into the system. This step is crucial for maintaining a record of who is conducting the test.
- b. **Testing Profile Mode Selection:** Choose the appropriate testing profile mode from the available options.
- c. **Specimen Information Input:** Input detailed information about each specimen, including its name, rice value, and physical dimensions like height and diameter. Accurate entry of these data is essential for the precise analysis of the specimen.
- d. **Test Combination Selection:** For each specimen, select the combination of tests to be conducted. This step is crucial for tailoring the testing procedure to the specific requirements of the specimen.
- e. **Addition of Specimen to Test Profile:** After inputting all necessary information for a specimen, add it to the test profile file. This action registers the specimen for the upcoming test.
- f. **Repeating for Additional Samples:** Repeat steps c through e for each additional sample that needs to be tested. Ensure that each specimen is accurately registered with its respective information.
- g. **Exporting of the Test Profile:** Once all specimens are registered and the test profile is complete, use the “Export Test Profile” button to save the file to a desired location on the computer. This exported file will be used by the AMAZE testing software to conduct the tests.

Following these steps ensures that each specimen is accurately recorded and the testing parameters are set correctly in the AMAZE system. The exported test profile file is a

critical component for the AMAZE testing software to perform the tests as per the specified requirements.

4. **Prepare Robotic Arm.** The robotic arm is used in AMAZE to transfer asphalt specimens among different testing units. To prepare the robotic arm for testing operations, follow these steps:
 - a. Turn on the robot by pressing the power button on the robot's tablet, as shown in Figure 14.



Figure 14. Robot Arm Power Button

- b. Press the POWER OFF button located on the bottom left of the robot's tablet to start the initialization process, as shown in Figure 15.

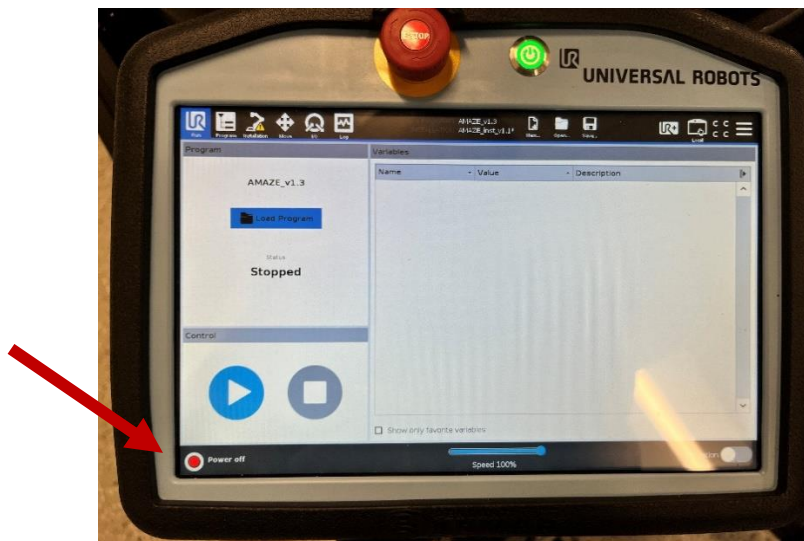


Figure 15. Starting Robot Initiation

c. Press the ON button, as shown in Figure 16.

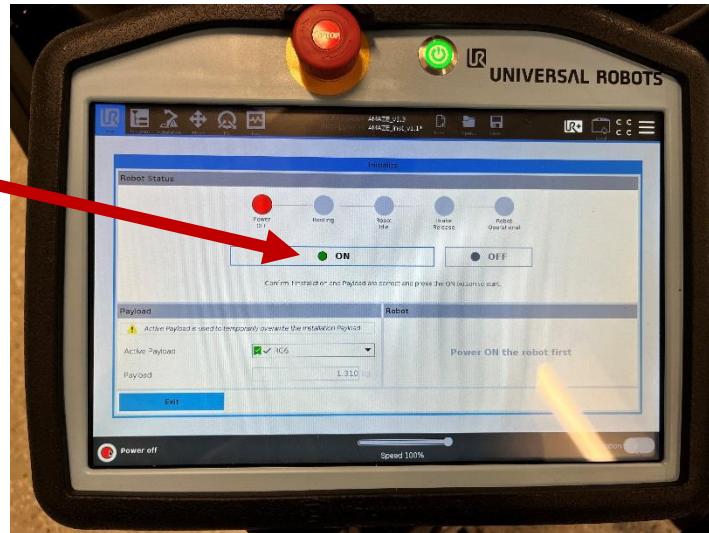


Figure 16. Turning On Robot

d. After the robot boots up, press the START button, as shown in Figure 17.

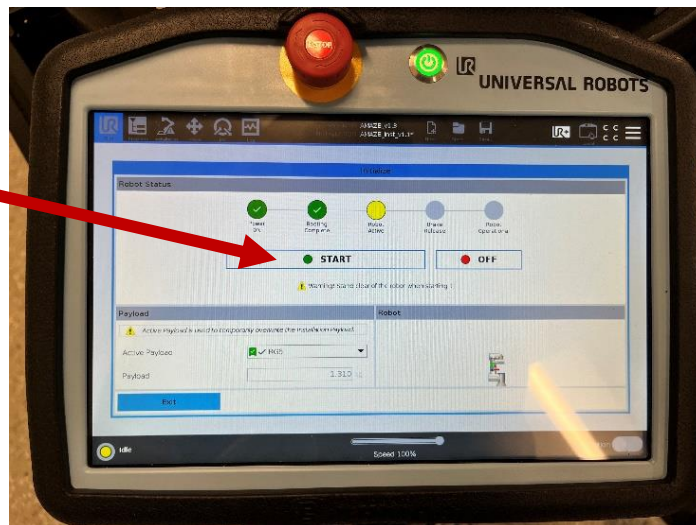
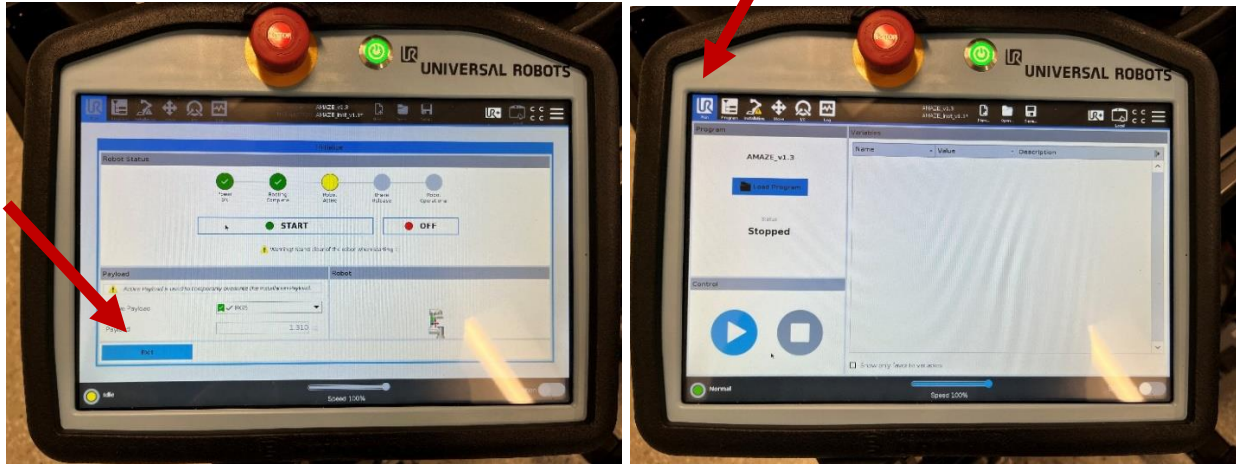


Figure 17. Starting Robot

- e. Exit the initialize screen and go to the RUN tab on the robot's tablet, as shown in Figure 18.



a. Exit button

b. Run tab

Figure 18. Exit Button and Run Tab

- f. Press the PLAY button (Figure 19), and the robot program should begin playing. Figure 20 shows the RUN tab when the program is playing. When needed, users can manually stop the robot's program by pressing the STOP button (Figure 21).

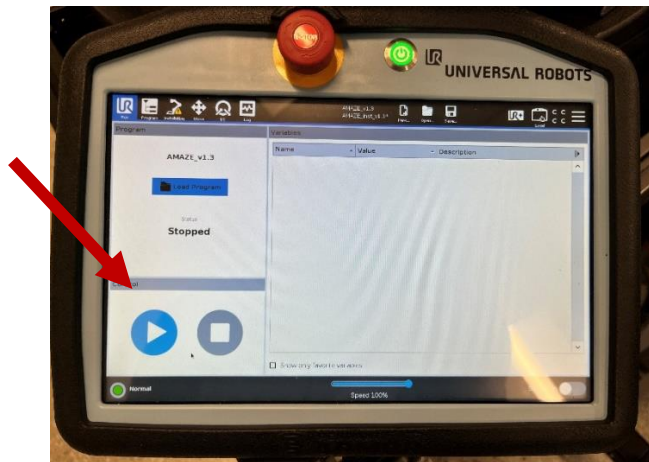


Figure 19. Play Button

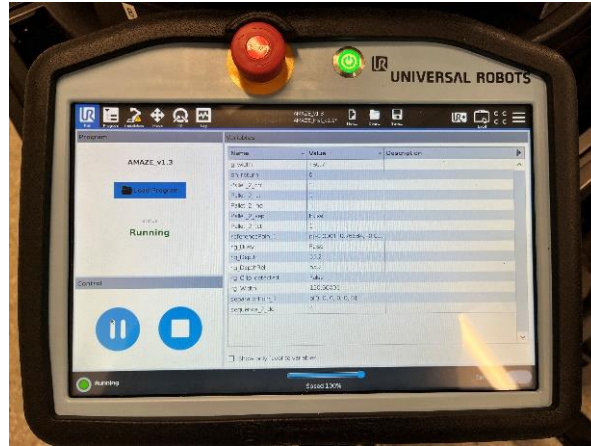


Figure 20. Robot Program Playing

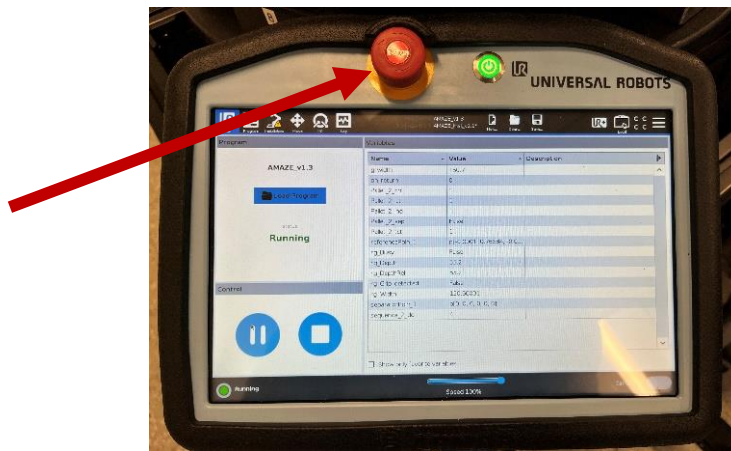


Figure 21. Stop Button

5. **Prepare AMAZE System.** Before starting automated testing, ensure that the rest of the testing units are ready by taking the following steps:
 - a. Check that the specimen storage unit is empty. If not, empty the storage area.
 - b. Check that the carousel unit is empty. If not, remove all remaining specimens/other items.
 - c. Check that both conditioning units are empty. If not, remove all remaining specimens.
 - d. Check that the loading frame is all the way down to its original position and the RT fixture is clear. If not, set it to the original position and clear the RT fixture.

Testing Operation Procedure

After completing the pre-testing preparation, proceed to the testing phase with the following steps.

1. **Launch the AMAZE Testing Software.** Double-click the AMAZE icon (Figure 22) located on the laptop desktop to launch the AMAZE testing software. Once launched, the screen shown in Figure 23 will be displayed. This GUI is instrumental in controlling individual machines, initiating and stopping tests, and displaying test results.

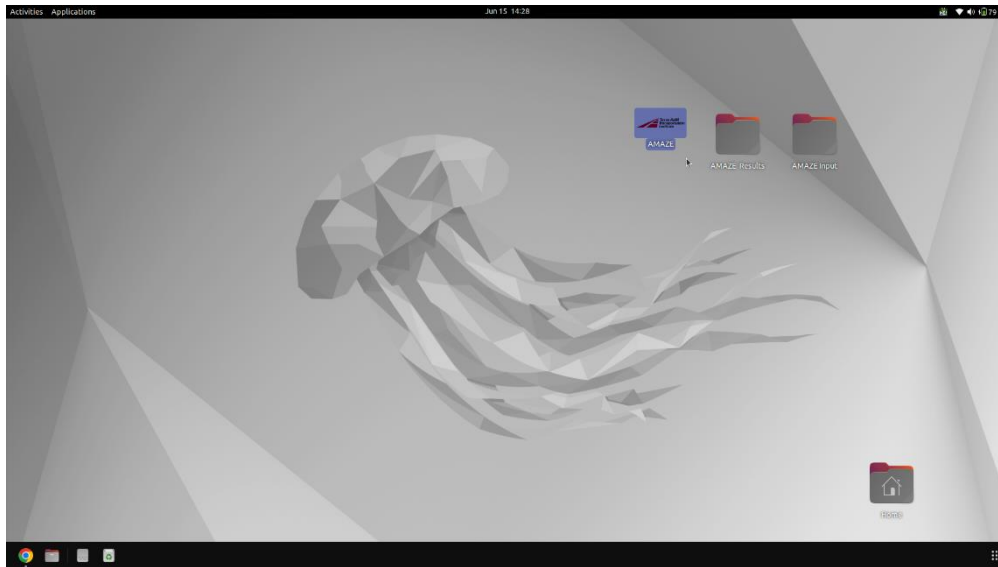


Figure 22. AMAZE Icon

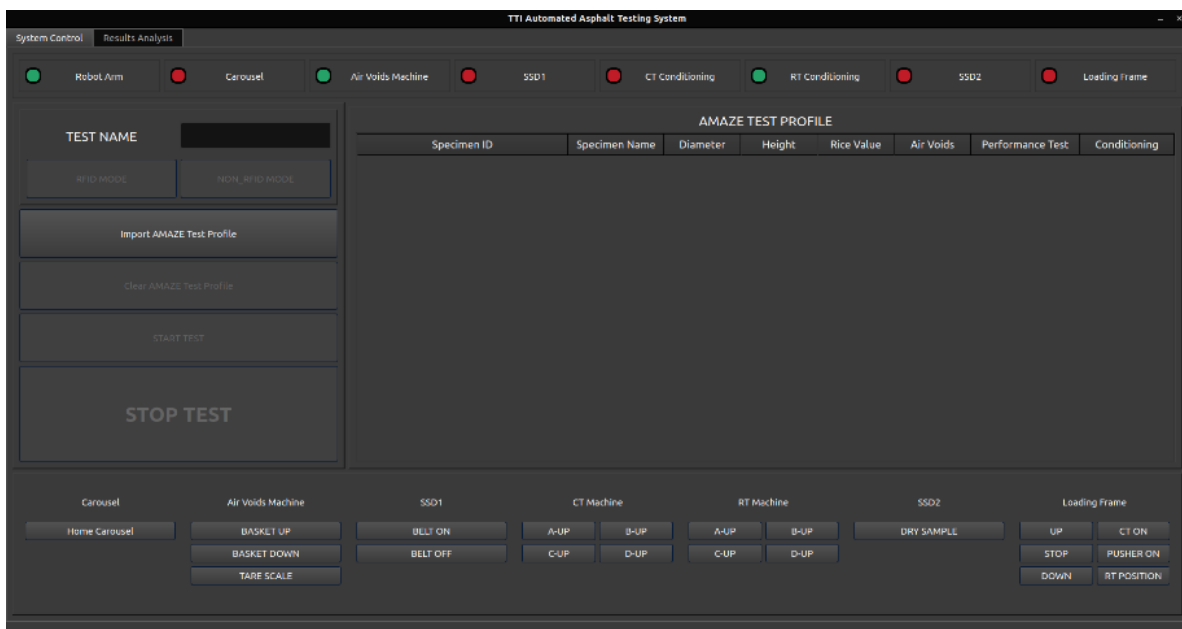


Figure 23. AMAZE System Control Screen

2. **Import the AMAZE Test Profile File.** Within the GUI, click on the “Import AMAZE Test Profile” button. Select the test profile file previously created using the AMAZE registrar software. This file contains all the necessary configurations and specimen details for the test. Figure 24 shows the testing profile after importing the file.

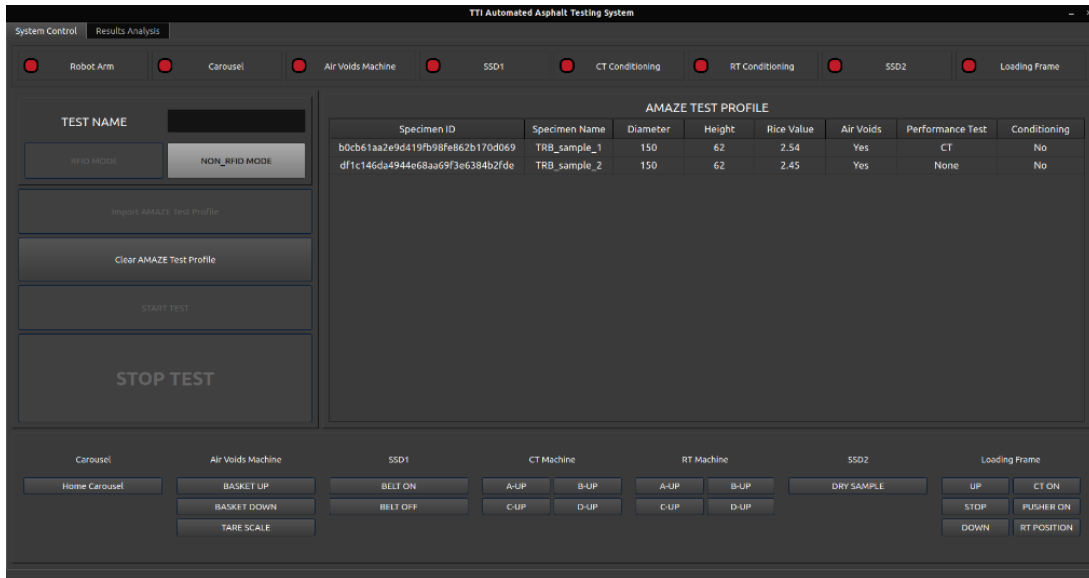


Figure 24. Importing Test Profile

3. **Assign a Name to the Test.** Assign a unique and identifiable name to the test. This step is crucial for record-keeping and future reference. Figure 25 shows the GUI after adding a test name.

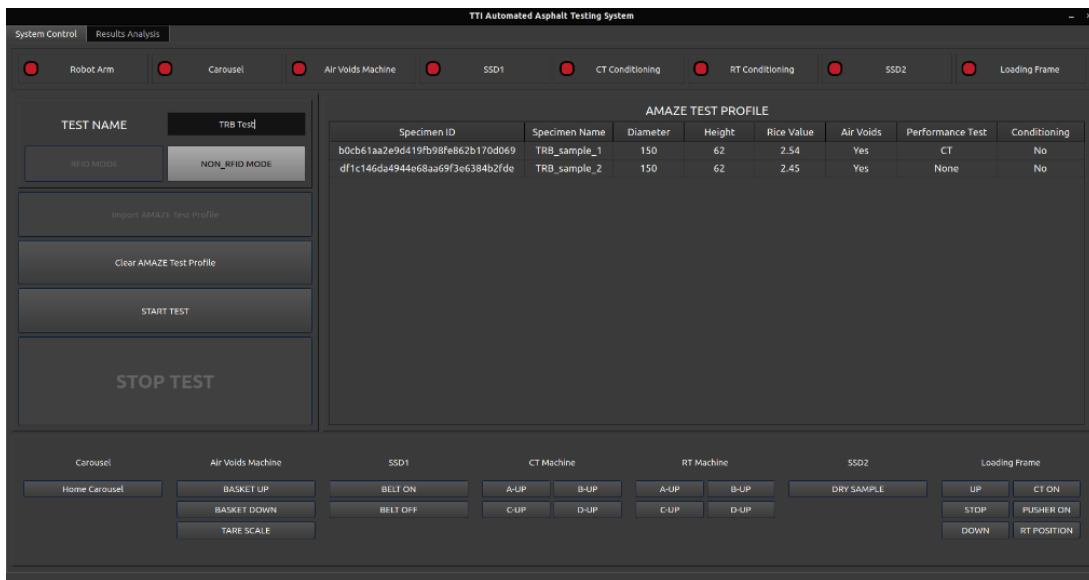


Figure 25. Screen for Assigning a Test Name

- Verify Machine Status.** Ensure that all the machine status LEDs displayed at the top of the GUI are green. This indicates that each machine is operational and ready for testing. If any LED is red, indicating an issue, reboot the corresponding machine and wait until the LED turns green, signaling readiness. Figure 26 shows all the machine status LEDs as green.

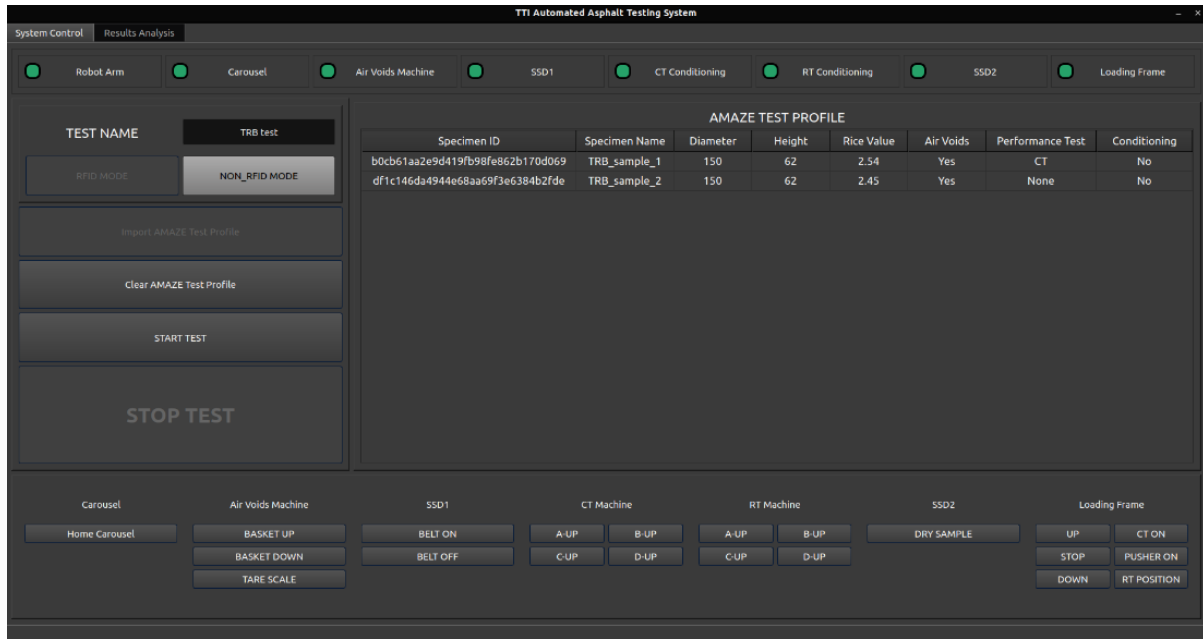


Figure 26. Screen of Machine Status

- Start Test.** Once all LEDs are green, a test name is assigned, and the test profile file is successfully loaded, the START TEST button will become active. Press this button to commence the testing process.
- Present Test Results.** Once the testing process is initiated using the AMAZE testing software, the system will automatically conduct tests on each specimen. As each specimen is tested, its results are immediately recorded and displayed in the results table, which can be found under the Results Analysis tab. Figure 27 shows the tab. In addition to the results being displayed on the Results Analysis tab, all of the raw data are saved to a folder named Result Folder under the AMAZE folder.

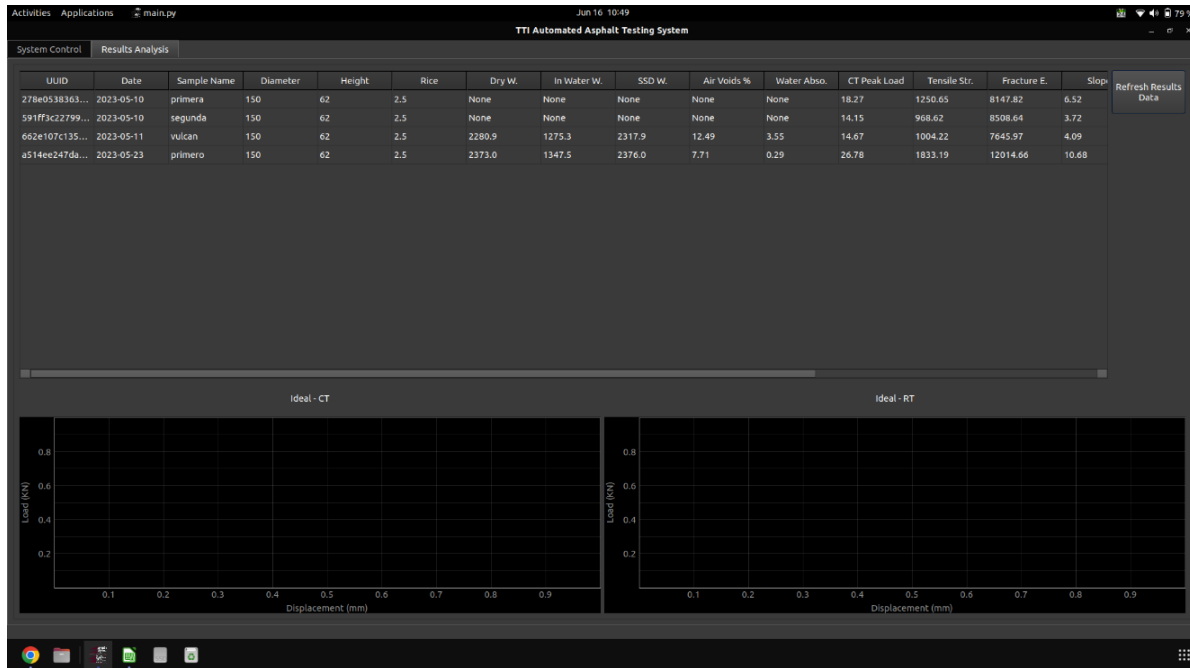


Figure 27. Presentation of Test Results

Post-Testing Operation

Once all the specimens are tested, users should receive a notification on the screen that the test is complete. Following are the post-testing operation steps to then take:

1. Load a new testing profile and assign a new test name if starting another test.
2. If another test does not need to be started, complete the following steps for the correct turn-off procedure.
 - a. Close the AMAZE application.
 - b. Turn off all the machines via their ON/OFF switch.
 - c. Clean up the specimen trash and the specimen storage unit.
 - d. Turn off the robotic arm.
 - e. Save results on a removable flash drive.

