Owner’s/Operator’s Manual for Rat Treadmill

Instructions for Use, Maintenance, and Safety

Revision C

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1. Introduction

Welcome to the Owner's/Operator's Manual for the Rat Treadmill, a specialized research device designed to facilitate controlled exercise and locomotion studies in laboratory rodents. This treadmill's advanced harness system, adjustable belt speed, and integrated data collection features enable researchers to study a range of physiological and behavioral parameters under standardized, reproducible conditions. Whether you are investigating muscle function, bone density changes, or aerobic capacity, the Rat Treadmill is engineered to help you gather accurate and consistent data while maintaining high standards of animal welfare.

This manual provides comprehensive guidance on setting up, operating, and maintaining the Rat Treadmill to ensure optimal performance and reliability. You will find safety instructions, technical specifications, and best practices for routine and preventative maintenance. Adherence to these guidelines not only helps protect the animals and operators but also contributes to the integrity and repeatability of your research findings.

By familiarizing yourself with the contents of this manual, you will gain an understanding of:

1. **Safe Operation**: Essential safety measures to protect both lab personnel and animals, including correct harness usage and emergency stop procedures.
2. **Installation and Setup**: Step-by-step instructions on how to calibrate and prepare the treadmill for use.
3. **Daily Use and Study Protocols**: Best practices for monitoring the animal's condition and adjusting exercise parameters
4. **Maintenance and Troubleshooting**: Guidelines for regular cleaning, inspection, and repairs to maintain accuracy, prolong the lifespan of the equipment, and reduce downtime.

Please read this manual thoroughly before using the Rat Treadmill and keep it readily available for reference. Together, we can uphold the highest standards of care, safety, and scientific rigor in every research endeavor.

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2. Safety Guidelines

- General Safety Reminder
    - Although the Rat Treadmill is designed for ease of operation, safety must remain a priority. Only handle the treadmill by the areas that are color-coded in **blue**, as these sections are specifically intended for user interaction. Avoid touching or bypassing any other parts—particularly those marked with warning labels or guarded compartments—while the device is running. If you need to load or handle the aggregate, use a suitable respirator to protect against airborne particles and use the treadmill in a suitable environment. Always power down and wait for all motion to stop before clearing any obstructions or performing any maintenance tasks.
- Warnings and Precautions
    - Proper Harness Use: Always ensure the harness is correctly fitted to the animal before operation. A loose or poorly adjusted harness can lead to injury or compromised research data. If in doubt, consult the harness fitting guidelines in this manual.
    - Preventing Aerosolization of Regolith: Handle regolith gently and within a fume hood to minimize dust generation. A fume hood is required for usage of the system with aggregate. Avoid shaking, pouring, or dumping regolith in a way that creates airborne particles.
- Emergency Stop and Safety Features
    - Unlike many traditional machines, the Rat Treadmill's **emergency stop (E-stop)** feature initiates a **gradual deceleration** rather than an immediate halt. This prevents sudden jolts or stress on the rat, helping maintain its well-being during unexpected stops. Once the E-stop is engaged, the harness system **automatically lifts** the rat slightly above the belt and then sets the rat back down, ensuring the animal is safely out of contact with any moving parts.
    - To further protect users and animals, all **approved interaction points are color-coded in blue**. Areas prone to pinch or crush injuries are equipped with **warning decals and protective grates/covers**, discouraging contact with moving mechanisms. Always avoid reaching into any section not marked in **blue**, and do not bypass guards or safety covers.

- **Warning Decals (ISO 7010)**

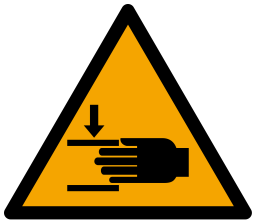
- **P015 – No reaching in**

- Aggregate used in the treadmill may collect or clump in the hoppers, especially during heavy or prolonged use. While it might be tempting to manually guide or clear these accumulations, doing so places hands and fingers at risk of being trapped or pinched by the moving mechanical components.
- **Do not** insert hands, fingers, or tools into the hopper area while the treadmill is running. Always **power down** the treadmill before attempting any maintenance or cleaning.
- If you observe a clog or excessive buildup of aggregate, refer to the "Maintenance and Cleaning" section of this manual for instructions on safely clearing the blockage.

- **P016 – Do not spray with water**

- Spraying or misting water can cause the aggregate to clump, disrupting the treadmill's functionality and potentially damaging seals, leading to mechanical failure.
- **Do not** spray or apply water in or around the treadmill. Keeping the system dry is essential to maintain proper operation and prolong equipment life.
- If dust generation is a concern, operate the treadmill **inside a fume hood**. This ensures both operator safety and the prevention of moisture-related damage to the system.

- **W024 – Crushing of hands/Danger of crush injuries**



- The continuous motion of the treadmill belt and other internal mechanisms can **pinch, crush, or entangle** hands and fingers if they come into contact with these areas while the system is operational.
- **Do not** touch or reach into the belt area or any moving components while the treadmill is running. Always ensure the treadmill is powered off and fully stopped before performing any cleaning, adjustments, or maintenance tasks.
- If foreign objects fall onto the belt or inside the treadmill, **Shut Down** the unit and wait until all moving parts come to a complete stop before carefully removing them. Keep all guards, covers, and safety features in place to help prevent accidental contact. If there is an emergency, refer to “Emergency Stops” in “Operating Instructions”

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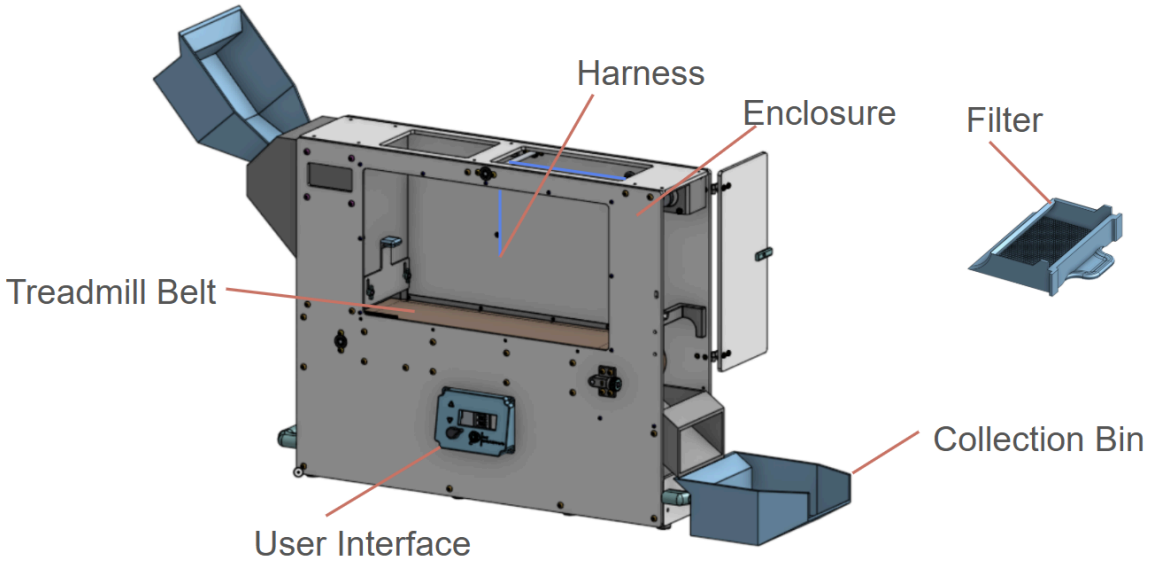
3. System Components

- **Treadmill Overview**



- **Key Components**
  - Harness - suspends the rat to create a synthetic reduced gravity.
  - Belt - Surface that aggregate is placed on to create an ambulatory surface
  - Waste Filter - Collects rat waste to prevent recirculation
  - User Interface - allows user to interact with and control the system
  - Enclosure - ties the subsystems together and encloses the space for the Rat.
  - Collection Bin - Collects aggregate for recirculation.

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4. Installation and Setup

- **Inspection**
  - **Check for Damage or Missing Parts**
    Inspect for visible damage or missing components. Ensure all parts match those listed in the “Parts List” section of this manual.

    - **Inspect the GT2 Belts (Behind Clear Covers)**
      Locate and visually check the GT2 drive belts behind the clear covers. Confirm they are free from cracks, tears, or misalignment. If a belt appears damaged or excessively loose refer to the "Maintenance" section for replacement and tensioning instructions.
    - **Check the Treadmill Belt Alignment**
      Before powering on, confirm the treadmill belt runs true (i.e., it does not drift to one side). If the belt is off-center, refer to the "Troubleshooting" or "Maintenance" sections for alignment and tension adjustment procedures.
    - **Check for Potential Jams**
      Carefully examine the belt, hoppers, and any visible moving parts for obstructions. If you notice foreign objects or misaligned components, remove or correct them before using the treadmill.
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- **Placement Requirements**
    - **Fume Hood or Tabletop Use**
        - **For Experiments with Aggregate**: Place the treadmill inside a **fume hood** to help extract any aerosolized dust and maintain a safe working environment.
        - **For Experiments without Aggregate**: You may safely position the treadmill on a **sturdy table** capable of supporting its weight and operation.
    - Clearance and Ventilation
        - Allow for **900 × 400 × 600 mm (L × W × H) [35.4" × 15.7" × 23.6]** of clear space around the device to ensure smooth operation, with a preferred clearance of **1400 × 650 × 660 mm (55.12 in × 25.59 in × 25.98 in)** if possible.
        - If you are using a fume hood, position the top of the treadmill to align with the hood's exhaust for optimal dust extraction and airflow.
    - **Initial Calibration**
        - **Belt Tensioning**
          Before first use, confirm that the treadmill belt is properly tensioned. This helps prevent slippage, ensures consistent speed, and prolongs belt life. Refer to the "Maintenance" or "Troubleshooting" sections for specific tensioning instructions.
    - **Testing Aggregate Circulation**
      If you will run tests involving aggregate, perform a brief dry run to observe aggregate flow and check for clogging or uneven distribution. Make any necessary adjustments before conducting formal experiments.

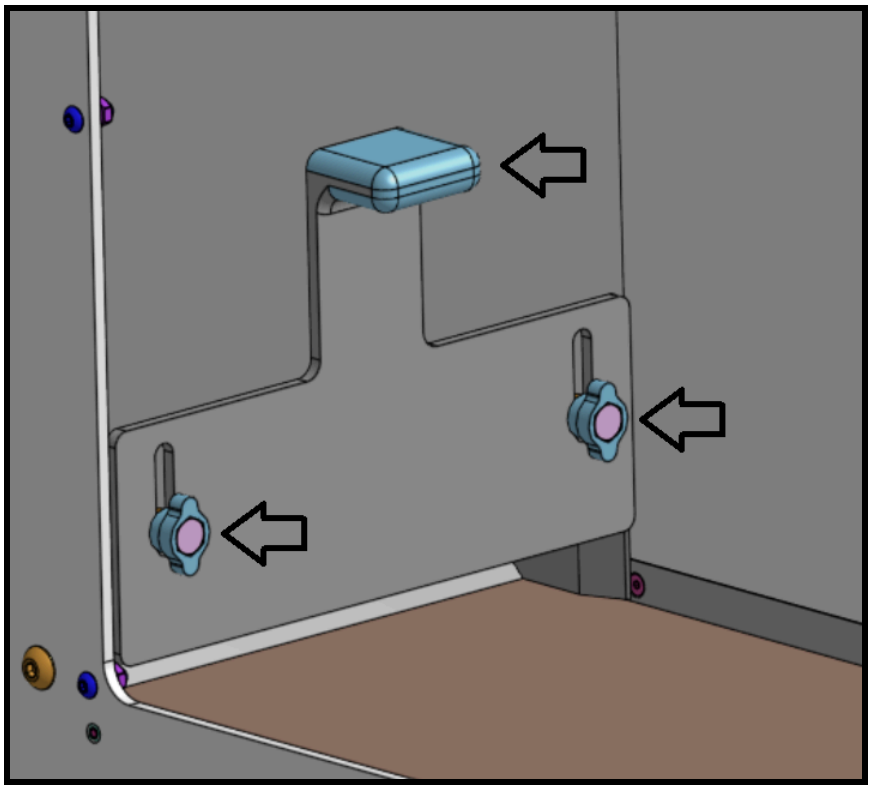
5. Operating Instructions

- **Starting the System**
    - Powering On
        1. Ensure the system is clear of any debris, no animal is loaded into the system, and that the system is in an appropriate location of operation.
        2. Ensure the system is plugged into 120V AC wall power.
        3. Flip the green power switch on the left hand side of the enclosure
        4. Disengage the emergency stop
        5. You will be greeted on the screen and the system is ready for use.
    - Selecting Settings (Speed, Weight Simulation)
        1. Rotate the rotary encoder to select the sub menu that you desire. Once over the submenu desired, click the rotary encoder by pressing it in.
            a. Weight Simulation - Use the arrow buttons to raise and lower the rat until in a desired position. Click the rotary encoder to navigate back to the main menu.
            b. Speed - Use the rotary encoder to select a desired speed. Clockwise increases the speed while counter clockwise lowers the speed. **To go back to the main menu, the speed must be at 0m/s.** Click the rotary encoder to navigate back to the main menu.

               Note: The Speed on the screen takes 1 second to update.

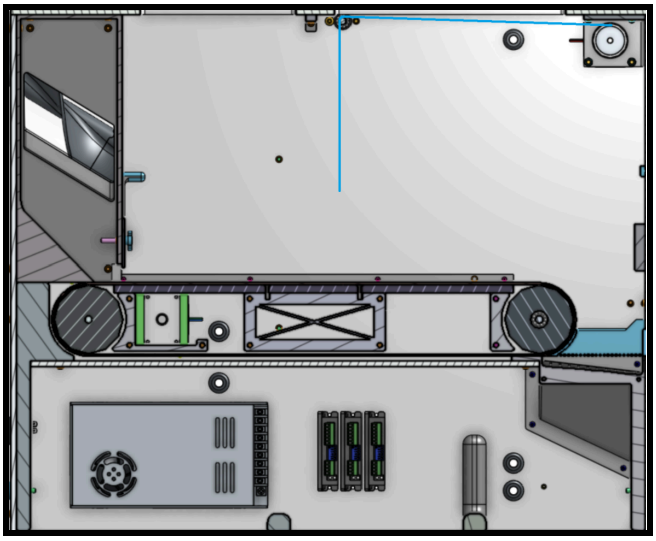
    - Loading Aggregate
        1. Load the upper hopper using the fill port on the top of the left panel and the bins.
        2. Power on the treadmill as per "Powering On" instructions.
        3. Run the treadmill's speed mode.
    - Removing Aggregate
        1. Remove the Filter
        2. Run the treadmill's speed mode until a majority of the aggregate is removed from the system while collecting the aggregate in the bins
    - Setting Aggregate Height (assuming the system is filled with aggregate)
        1. Roughly estimate the height of the leveling bar
            a. Loosen the **blue** thumbscrews.

b. Lift the leveling bar to the height desired using the **blue** handle.
c. Tighten the thumbscrews.



2. Turn on the treadmill using the powering on procedures
3. Run the treadmill for a few seconds to let the aggregate disperse through the system and add aggregate as needed per the aggregate loading instructions
4. Measure the thickness of the aggregate layer and make adjustments to the leveling bar accordingly.

- **Loading the Rat**
  - Proper Harness Attachment
    - Refer to **https://www.lomir.com/slings/sling-suit-rodent-sling/** for harness attachment to the rat and propper usage.
  - Clip the harness into the **BLUE** chord using the carabiner. Ensure the chord is threaded properly



- **Stopping the System**
    - Routine Stops
        1. Slow the treadmill to a stop using the rotary encoder
        2. Disconnect the Rat from the harness chord and remove the Rat
        3. Power off the machine
    - Emergency Stops
        1. Press the large **RED E-Stop** button on the front of the machine in case of emergency.

        2. Gently remove the rat to ensure no harm is caused.
        3. Power off machine then restart using the “Powering On” procedure

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6. Maintenance and Cleaning

Maintenance:

Lubricating the Bearings

- **Frequency**: Check bearings monthly or as dictated by the treadmill's usage level.
- **Procedure**:
    1. **Access Bearings**: Remove covers or guards if necessary (follow instructions in "Maintenance" or "Troubleshooting" sections).
    2. **Apply Light Oil**: Use a small amount of light machine oil on the bearings.
    3. **Wipe Excess**: After a brief rotation to distribute lubricant, wipe away any surplus oil to prevent drip or contamination.

Treadmill Belt and Pulley Checks

- **Inspection**:
    1. Ensure the treadmill belt is tracking correctly (running true) and has proper tension. Tightening a knob will make the belt veer away from that knob.
    2. Use the **blue** knobs to tension the belt. It is desired to have it track as closely to the center. It should be able to move by hand, driving the motors backwards easily.
    3. Inspect pulleys for visible wear or misalignment.
- **Adjustment**:
    1. If the belt shows signs of drifting or slipping, refer to the "Belt Alignment and Tensioning" instructions in the "Troubleshooting" section.
    2. Replace belts or pulleys if damage or significant wear is evident.

Harness System Inspection

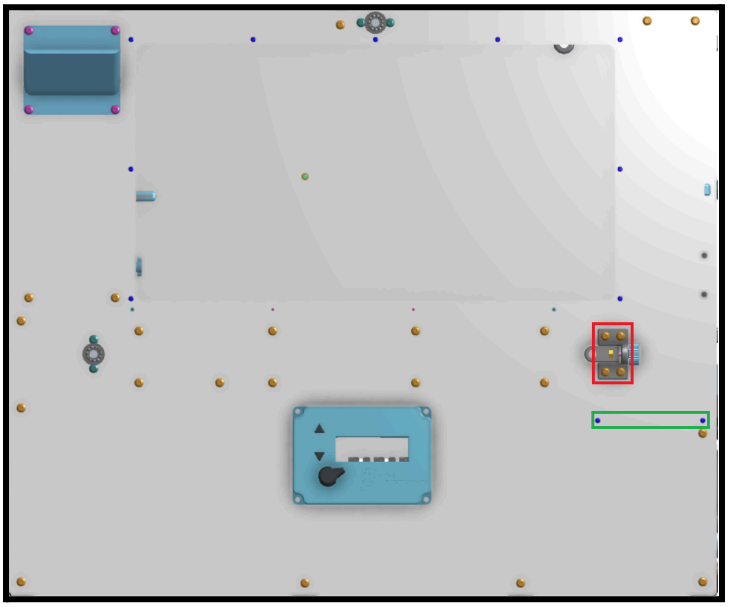
- **Purpose**: A properly functioning harness system is essential for animal safety and data integrity.
- **Procedure**:
    1. **Visual Inspection**: Look for fraying straps, worn clips, or loose stitching.
    2. **Attachment Points**: Confirm that all clips and fasteners are secure and functioning.
    3. **Testing**: Manually pull the harness lightly to ensure it holds steady without slipping or detaching.

Aggregate Circulation System Cleaning

- **Fine Dust Buildup**: Dust can accumulate in the hoppers, rollers, and the electronics compartment, potentially causing clogs, uneven flow, jamming, or electrical failure.
- **Procedure**:
    1. **Power Down and Unplug**: Ensure the treadmill is off and disconnected before cleaning.
    2. **Open Accessible Panels**:

        Rollers/Beneath Belt

        - Untension the Treadmill belt
        - Remove the 23 M5x10mm Button head Screws (Yellow), the 4 M5x15mm Button Head Screws (Magenta), and the 2 M3x10mm Button Head Screws (Blue Inside green Box). Do not remove the 4 M5x10 Screws holding the tensioner on.

        - Remove the entire front panel, being cautious with the electronics. Disconnect the power to the ESP32 and the motor driver cables.
        - Clean out the build up using a vacuum, brush, etc.
        - Replace the panel ensuring to plug in the cables and that all of the rods (both rollers and the harness) are all lined up.
        - Replace and tighten all of the screws.

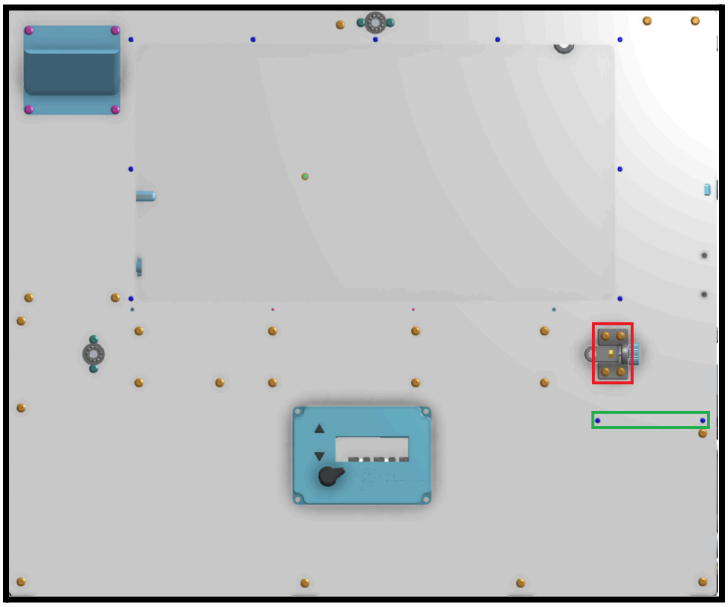
        Electronics

- Remove the 8 M5x15mm Button Head Screws
- Remove the bottom panel
- Clean out the build up using a vacuum, brush, etc.

Belt Replacement

If the treadmill belt becomes worn, frayed, or damaged, replace it promptly to maintain safe and accurate operation.

1. Untension the Treadmill belt
2. Remove the 23 M5x10mm Button head Screws (Yellow), the 4 M5x15mm Button Head Screws (Magenta), and the 2 M3x10mm Button Head Screws (Blue Inside green Box). Do not remove the 4 M5x10 Screws holding the tensioner on.



3. Remove the entire front panel, being cautious with the electronics. Disconnect the power to the ESP32 and the motor driver cables.
4. Remove the remaining screws for the upper hopper
5. Remove the Belt and replace the belt
6. Reverse the steps to assemble the system

Replacement and Tensioning Instructions for the GT2 Belts

1. **Power Down and Unplug**
    - For safety, **disconnect the treadmill from its power source** before performing any maintenance on the drive system.
2. **Access the Belt Area**

    - Remove the **clear cover** that protects the GT2 belt.
    - Consult the exploded diagrams or parts list to identify the belt tensioning bolts or motor adjustment slots.
3. **Loosen the Tensioner or Motor Mount**
    - Locate the 4 screws that allow the motor to slide and **loosen them carefully**. This will reduce tension on the belt, making it easier to adjust.
4. **Adjust the Belt Tension/Replace Belt**
    - **Pull the motor** gently in the appropriate direction to increase or decrease the belt tension.
    - Replace Belt if needed.
    - Take care not to **over-tighten** the belt; excessive tension can lead to accelerated wear on bearings or belt teeth.
    - Conversely, **under-tension** may cause slipping or skipping, especially during operation at higher loads.
5. **Verify Alignment**
    - Ensure the GT2 belt is **aligned properly** with the pulley teeth. The belt should track straight across the pulleys without drifting toward the edges. Realign the motor or idler pulley if necessary.
6. **Tighten the Screws**
    - Once you have the desired tension, **securely retighten** the screws.
    - Double-check that the belt remains aligned and maintains the appropriate tension as you tighten.
7. **Test Run**
    - Reinstall the clear cover(s).
    - **Restore power** and perform a brief test run at a low speed to confirm smooth, reliable operation.
    - Listen for unusual noise or clicking, which can indicate **excessive tension** or belt misalignment.
8. **Re-check After Initial Use**
    - After several test runs or one full session, **re-check belt tension** and alignment. Minor readjustments might be necessary as the belt wears in or settles into position.

Cleaning Instructions

Disinfecting the Belt and Harness

- **Frequency**: After each experimental run or whenever contamination is suspected.
- **Procedure**:

1. **Mild Disinfectant**: Use a lab-approved disinfectant that does not compromise materials (e.g., soap-water solution for the belt material).
2. **Soak and Wipe**: Apply disinfectant with a cloth, not by spraying. Thoroughly wipe belt and harness surfaces.
3. **Allow to Dry**: Ensure everything is fully dry before reassembling or using again.

Wiping Down Plastic Sides and Components

- **Important: Do not use alcohol-based wipes on the clear acrylic window**, as this can cause clouding and/or cracking over time.
- **Approved Surfaces**: White HDPE surfaces and black/blue PETG parts tolerate cleaners and alcohol-based wipes well.
- **Procedure**:
    1. **Use a Non-Abrasive Cloth**: Microfiber or soft lint-free cloths are recommended.
    2. **Use Appropriate Cleaning Agent**: Water with mild soap or an approved cleaner for acrylic/PETG/HDPE.
    3. **Gentle Pressure**: Avoid scrubbing aggressively to prevent scratches or surface damage.

Empty Waste Collection Tray

- Open Door
- Remove tray and dispose of waste

Troubleshooting

Common Issues and Resolutions

- **Belt Motor Skipping**
    - **Possible Cause**: Motor belt tension is too loose, or the GT2 drive belt is worn.
    - **Solution**: Check motor belt tension, replace GT2 belt if damaged.
- **Belt Tension Too High**
    - **Possible Symptoms**: Excessive strain on the motor, unusual noise (motor skipping), or belt damage.
    - **Solution**: Refer to tensioning instructions to loosen the belt slightly.
- **Jam in Treadmill Belt Area**
    - **Possible Cause**: Aggregate or foreign objects stuck under belt or in rollers.
    - **Solution**: Power down, remove obstruction, inspect belt for damage.
- **GT2 Drive Belt Issues**

    - **Possible Cause**: Misaligned pulleys, worn or torn belt.
    - **Solution**: Realign pulleys and/or replace belt following the steps in "GT2 Belt Replacement."
- **System Immediately Raising Harness When Powered On**
    - **Cause**: The emergency stop (E-stop) or fail-safe trigger may be **disengaged** upon startup.
    - **Solution**: Fully **engage the E-stop** (release or reset), then power on as per the "Powering On" procedure.

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7. Technical Specifications

Dimensions and Weight

- **Overall Dimensions XYZ**: 844.94mm × 219.16mm × 586.75mm (33.26in × 8.63in × 23.10in)
- **Weight**: 15.4 Kg (33.95lb)

Power Requirements

- **Voltage**: (110–120 V AC)
- **Frequency**: 60 Hz
- **Power Consumption**: (350 W)

Supported Weight Ranges for Simulated Gravity

- This treadmill is designed to accommodate rats weighing up to **800 grams**.
- Refer to **https://www.lomir.com/slings/sling-suit-rodent-sling/** for detailed guidance on selecting and installing the correct harness size for your specific animal weight range.

User Interface Features

1. **Rotary Encoder**
    - Turn the encoder to navigate through menus on the main screen.
2. **Up/Down Buttons**
    - Press these to adjust the rat's position or harness height in small increments.
3. **Set Position Button**
    - Once the desired harness height or position is reached, press this button to lock it in place.
4. **Screen**
    - Displays current speed, harness position, error messages, and other operational data.
5. **E-Stop Button**
    - Initiates a gradual deceleration of the treadmill rather than an immediate stop, preventing sudden jolts to the animal. Also triggers the harness to raise the rat off the belt.

Aggregate Type and Volume Guidelines

- **Aggregate Type**: Use regolith or aggregate that is safe with animals and that is electrically non-conductive. The maximum particle size should not exceed the sieve size being used.
- **Recommended Volume**: ~5kg or 5L (Assuming Clumping Litter Usage).

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8. Revision History

- Rev A - Created Owners Manual
- Rev B - Updated Procedures, added Figures.
- Rev C - Updated to reflect design changes.
