

# UCD IMPROVE Technical Instruction #226F

## Controller Repair

*Interagency Monitoring of Protected Visual Environments  
Air Quality Research Center  
University of California, Davis*

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## **1. PURPOSE AND APPLICABILITY**

The purpose of this technical instruction (TI) is to describe an overview of the procedures used to diagnose, repair, and ship controllers that are used at every site in the IMPROVE network. Detailed guides of repair procedures are now held within in-house documents. Controllers are diagnosed and repaired at the Air Quality Research Center shop, which is located off-campus of University of CA, Davis at the Drew Avenue location.

## **2. SUMMARY OF THE METHOD**

When an IMPROVE controller fails in the field, it is shipped to the Air Quality Research Center (AQRC) shop. At the shop, it is inventoried and a note is logged regarding the symptoms the controller had in the field. Field technicians or student shop assistants test the controller components in order to recreate and diagnose the problem(s). Once the problem has been determined, the controller is repaired and then tested again to confirm that it is fully functional. It is then ready to be shipped out to the next site in need of a controller.

## **3. DEFINITIONS**

- AQRC: Air Quality Research Center of UC Davis
- IMPROVE: Interagency Monitoring Program of Visual Environments
- JIRA: an online database used to track issues and manage programs
- TI: technical instruction document, a subset of a SOP (standard operating procedure)

## **4. HEALTH AND SAFETY WARNINGS**

The controller circuitry must be unplugged before any work is performed; the electrical contacts behind the protective panels operate at Line voltages.

When first testing a repaired controller, IT should be done using a GFI rated outlet and the technician should not touch any part the of the metal body of the controller. It is possible to mistake the wiring on reassembly and cause the shell of the controller to become energized. This will cause a ground fault that should be cleared by the GFI receptacle.

## **5. CAUTIONS**

Both of the controller power supplies need to be grounded to earth ground before the controller is worked on. If they are not, do not touch any part of the power supplies while the controller is uncovered and powered up in order to avoid an electrical shock.

## **6. INTERFERENCES**

Not applicable.

## **7. PERSONNEL QUALIFICATIONS**

Student shop assistants and field technicians work in the AQRC shop under the supervision of the field manager and shop manager. Each new student shop assistant and field technician receives one-on-one training on how to completely assemble/disassemble controllers. Each new employee also observes an experienced employee diagnose and repair controllers before he or she attempts one on their own. An experienced employee oversees the new employee for the first few controllers he or she repairs in order to correct any mistakes and to answer any questions.

## **8. EQUIPMENT AND SUPPLIES**

The equipment and supplies for each controller repair vary significantly depending on what issues the controller has. Thus, the necessary equipment and supplies will be described in each section.

## **9. PROCEDURAL STEPS**

### **9.1 Diagnosis of Controller Problems**

An IMPROVE controller can be thought of as a sprinkler timer with a digital microcontroller and an SD card for data logging.

A timer module opens and closes solenoids and relays and records the data from the pressure sensors to the memory card. While this seems like a simple system, a myriad of problems can and do occur with these units. In the best-case scenario, the problem can be recreated on the spot and isolated to one component, which is then replaced or reworked so that the controller can go back into service. Unfortunately, however, the process is typically not so straightforward.

#### **9.1.1 Receiving, Inventorying, and Documenting a Controller**

Controllers must be checked in when they are received from the field. Locate the UPS shipping label on the box that the controller came in and note the sender's site code (five characters) and JIRA issue tracking number. Use this data to locate the issue reported through JIRA, the online issue-tracking database used by AQRC.

Open up the box and remove the controller. Note any damage to the controller that may have occurred during shipping. Discard the box by breaking it down and dispose of it in the cardboard recycling bin, which is located outside the Drew Avenue building. If the foam inserts in the box are intact, place them with the other shipping supplies. If they cannot be reused, throw them away.

Each controller has an assigned inventory number in order to keep track of where it has been and what problems it has had in the past. Inventory numbers are five characters long. Each inventory number begins with the letter "C" and is followed by four digits. The first digit signifies the version of the equipment and the next three digits are a sequential count of controllers. Inventory numbers can be found on the inside of the controller door or on the inside of the case of the left side. Locate the inventory number for the controller and open the

Microsoft Access controller inventory sheet located in U:\IMPROVE\_Field\Shop and Operator Resources\Equipment Inventory. Find the entry for the controller. Follow the workflow dictated by the inventory application. If there is a discrepancy, notify a supervisor. The simplest way to determine why the controller was removed from the field is to check the JIRA issue number in the online issue-tracking database, JIRA. Either type the four-letter site code or unique JIRA issue number, the four-letter site code followed by a number, (SITE-99 for example) that was pulled from the controller box shipping label. A new page should load, which should display all of the recorded problems for the site.

Close to the top (where the most recent entries are located), there should be both an equipment request issue type entry indicating when a replacement controller was sent to the site, as well as a parent entry the subtask belongs to, detailing the problem that prompted the equipment replacement. Summarize the problems associated with the controller in the comment field of the inventory application. The Microsoft Access inventory database auto-saves all data entered, and allows simultaneous use by multiple users.

Next, advance the JIRA equipment request through its workflow. This means advancing the issue from “Pending Equipment Return” to “Completed” by clicking **Equipment Checked In**. This will prompt the user to enter “Checked In By”, “Check In Date”, “Return Inventory”, and “Comments” if applicable. JIRA workflow is shown in section 9.4.7.

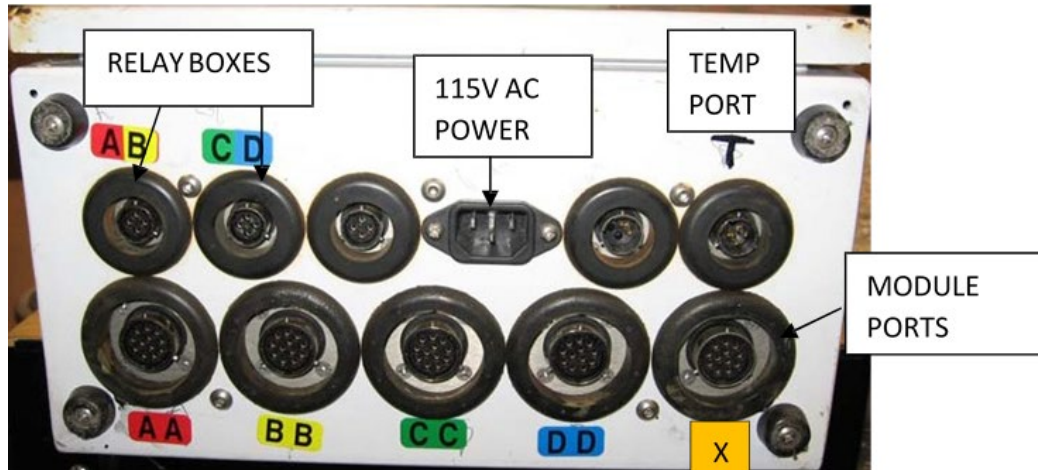
Now that the controller has been checked in, the next step is to test the controller in order to diagnose the exact cause of the problem and to check for any additional problems not detailed in the JIRA issue. Often the diagnosis is time sensitive. For example, if the checked in controller works fine, typically that means a different component will need to be sent to fix the problem in the field. If this is the case, the controller should be tested upon receiving.

To proceed with diagnosis, continue on to the next section. If the controller is only being checked in, place it on the “To Be Repaired” shelves in the AQRC shop.

### 9.1.2 Controller Set-Up

Set up the controller, five modules, three relay boxes, five pumps, and a temperature probe along with all of the corresponding cables. Make sure that all components are properly installed in order to accurately model a working sampling unit. The controller should have five module cables, which should be plugged into the 1A (Red), 2B (Yellow), 3C (Green), 4D (Blue), and 5X (Orange) ports, respectively. Relay box cables should be plugged into the 1A/2B port (Red/Yellow), the 3C/4D port (Green/Blue), and the 5X port (Orange) (see Figure 1). A temperature probe should be plugged into the temperature probe port. Do not plug in the controller’s power cord yet. Note that when testing the 5X port, the controller must first be configured for a 5X module.

Figure 1. Port layout.



Each module should be operational and attached to a vacuum pump via a pump hose. The five pumps should be plugged into the AC outlets of the relay boxes. Make sure that each pump is plugged into the correct relay box, as the pump and relay box should both correspond to the same module. The relay box power cords should be plugged into 115 Volt AC outlets.

Warning: before touching any of the boards, make sure to dissipate any static electricity by touching the steel controller case.

## 9.2 Controller Configuration

The following steps describe the specific information required to configure a controller for the site it is being shipped to.

In the V4 controller, the site configuration information is stored in a repository within the controller. To access and configure this repository, press the **Menu** button from the Home Screen, then **Advanced Menu**, and enter code **1123**. Press **Site Config**, then press the **pencil icon** next to row labeled “Site”. Use the < and > arrows to move the cursor position. Use the ^ and v to change the character. Enter the four-letter site name with number. Press **Save**, then use the **Back arrow** to navigate back to the Advanced Menu. Press the **Update Cfg File** button, and then press the **Replace config.ini** button.

The controller must now restart for settings to take effect. Press the **Back arrow**, then press **More**, press **More** again, then press **Shutdown, Restart**, and then **Yes**. When controller reboots, all the site configuration parameters should be correct.

## 9.3 Controller Shipping

### 9.3.1 Controller Preparation

- 1) Obtain a repaired controller with a completed “Controller Information” sheet. Fill out the shipping portion on the sheet (see Figure 2).
- 2) Fill out the “Controller Checklist” form for final inspection before shipping.



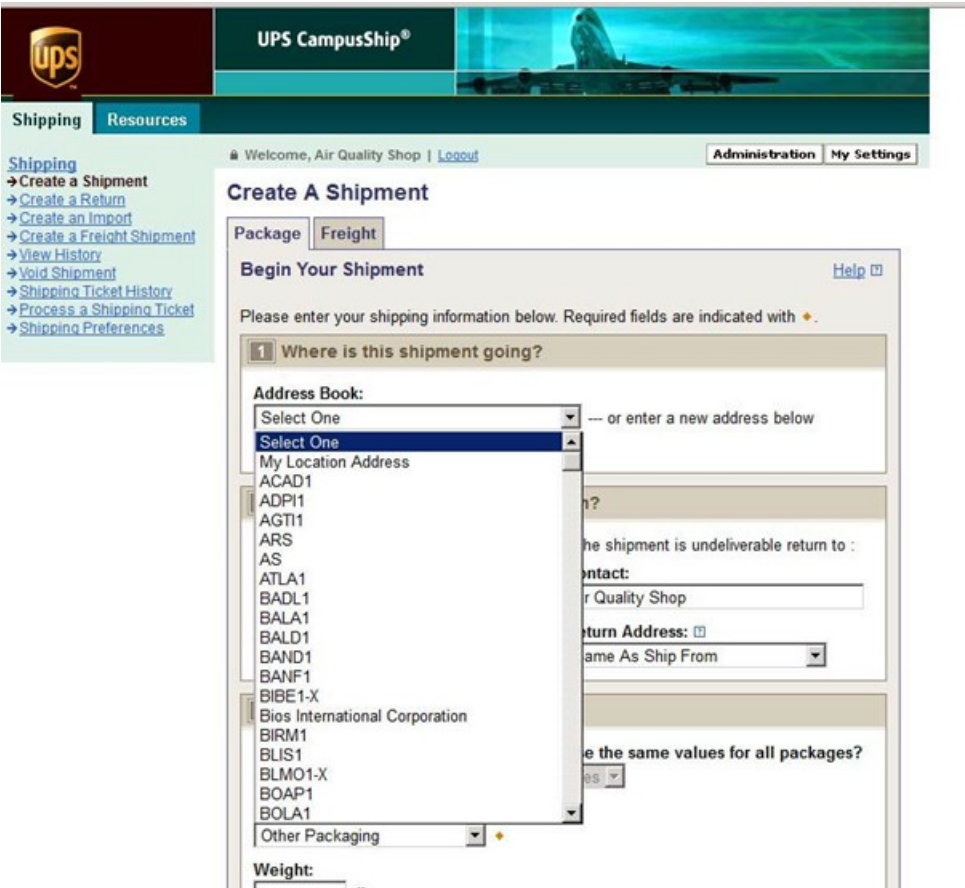
Figure 2. “Shipping” portion of “Controller Information” sheet.

<u>Shipping</u>		<u>Final Configuration</u>	
Date Ready For Shipping:		MB:	
	Shipped By:	BB:	
Completed By:		CFLASH:	
	Destination Site:	CPU:	
<u>Run Through Checklist:</u>		EPROM:	
	Shipping Date	Batt Volt:	Ground H?
		Volt Reg:	

9.3.2 Creating the Shipping Label

- 1) Go to the UPS website and log in using the AQRc shop account.
- 2) Click on the **Create a Shipment** option on the left-hand side and select the shipping site under the address book drop-down menu.

Figure 3. “Create a Shipment” on the UPS website.



Select **Other Packaging** under the “Packaging Type” drop-down menu and enter the appropriate weight and dimensions of the controller box (see Figure 3).

Figure 4. Shipment details.

The screenshot shows a form titled "3 What are you shipping?". It includes the following fields and options:

- Number of Packages:** A dropdown menu set to "1".
- Use the same value:** A dropdown menu set to "Yes".
- Packaging Type:** A dropdown menu set to "Other Packaging".
- Weight:** A text input field containing "30" followed by "lb".
- Package Dimensions:** Three text input fields for Length, Width, and Height, containing "23", "19", and "13" respectively, followed by "in.".
- Large or Unusually Shaped Packages:** A checkbox labeled "Large Package" which is currently unchecked.

Select the appropriate shipping service and fill out “Reference” lines 1 and 2 in the following format:

Reference #1: JIRA issue number (No dash between site name and issue number)

Reference #2: Packaged and Shipped by XX (<= user initials)

Figure 5. “Select Service” and “References” on the UPS website.

The screenshot shows a form titled "4 How would you like to ship?". It includes the following fields and options:

- Service:** A dropdown menu set to "UPS 2nd Day Air". A "Compare Time and Cost" link is visible.
- Service Selection List:** A list of shipping services with a "Fee?" column:

Service	Fee?
Select Service	
UPS Next Day Air Early A.M.	Free
UPS Next Day Air	Free
UPS Next Day Air Saver	Yes
UPS 2nd Day Air A.M.	
UPS 2nd Day Air	
UPS 3 Day Select	
UPS Ground Service	
- Reference numbers to this shipment?:** A section with the text "UPS gives you the option to track your shipments using references that you define." and three text input fields:
  - Reference # 1:** "130808SITE101"
  - Reference # 2:** "Packaged and Shipped by INI"
  - Reference # 3:** (empty)

Once complete, review the shipment on the next page and select **Ship Now**.

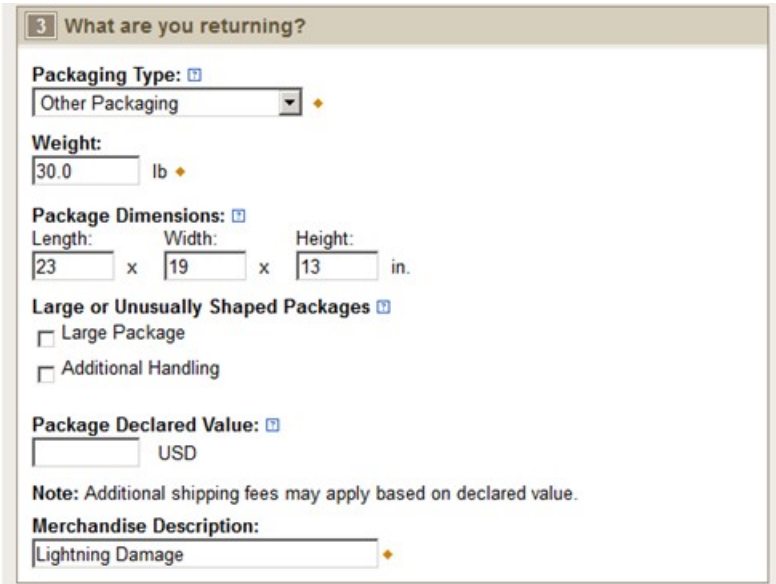
9.3.3 Creating the Return Label Select “Create a Return Shipment”

Figure 6. “Create a Return Shipment” on the UPS website.



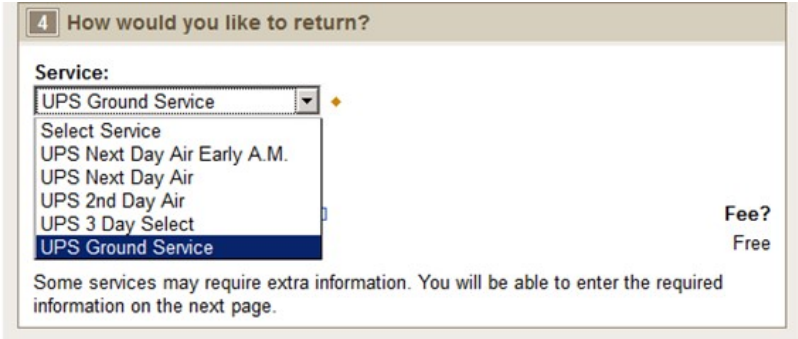
Under “Merchandise Description,” enter a short description of the problem that the controller at the site has.

Figure 7. Return shipment details.



Select **Ground Service** for the return shipment and print the return shipping label.

Figure 8. Return shipment service.



### 9.3.4 Packaging the Controller

Place the controller in a shipping box (same size as for shipping modules) with special module protection foam inserts. Also, place the return label with the field letter instructions on how to replace and install a new controller in the box. Tape up controller box and leave the box in the shipping bay for UPS pickup.

Note: UPS pickup times are daily at around 4 pm.

### 9.3.5 Update the Inventory Data Base and JIRA

Go to the equipment inventory database located in “U:\IMPROVE\_Field\Shop and Operator Resources\Equipment Inventory” and open the inventory application titled, “Field\_Inventory\_App.exe”. Update the controller information for the controller being shipped using the **Ship Equipment** button, making sure to account for any equipment changes during repairs.

Edit the Equipment Request issue on the online issue-tracking JIRA software. The issue should be advanced through the workflow from either, “Open” or “In Progress” to “Pending Equipment Install” by selecting the **Equipment Shipped** button. The information necessary to fill out the form that comes up is date shipped, shipper’s initials, inventory number, relevant UPS tracking numbers, and any applicable comments.

## 9.4 Temperature Probe Construction/Repair

### 9.4.1 Equipment/Supplies

The following pieces of equipment are necessary for building and/or repairing temperature probes:

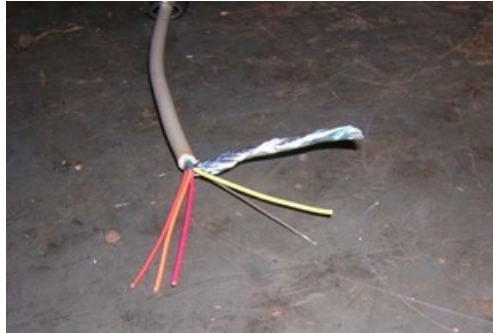
- Solder
- Soldering iron
- Small Allen wrench
- Wire cutters/strippers
- Crimpers
- Pin removal tool

### 9.4.2 Stripping Wires

First, check to see if the new wire is damaged. Next, choose any side to start with and strip the gray casing off about an inch from the end. Be careful not to cut through the encased wires.

If foil is still on the wires, remove it before continuing. There will be five wires remaining: one orange, one brown, one red, one yellow, and one bare. Cut off the yellow wire and the bare wire. Next, strip the orange, brown, and red wires about halfway. Twist the ends of the wires so that each of them is intact. Before continuing, ensure that the Tee plug and bottom plastic cap are on the wire because it will be difficult to fit them on later.

Figure 9. Exposed wiring.



#### 9.4.3 Soldering the Thermistor

The next step will be to solder the temperature chip to the three wires that have been exposed (red, brown, and orange). The order in which they are soldered is very important as mixing wires can damage electrical components in the controller. With the flat face of the temperature chip facing 6 o'clock, solder the red wire to the left prong (1), the brown wire to the middle prong (2), and the orange wire to the right prong (3). All exposed wires must now be coated with liquid electrical tape, which can be found in the cabinet. None of the wires can touch each other. After one or two coats (depending on coverage), press all the wires together and put on a final coat of electrical tape to keep the wires compact. There should not be so much tape that the end is bulbous, but there should be enough to separate and protect all of the wires. All of the exposed wires, including yellow and bare wires cut earlier, should be covered.

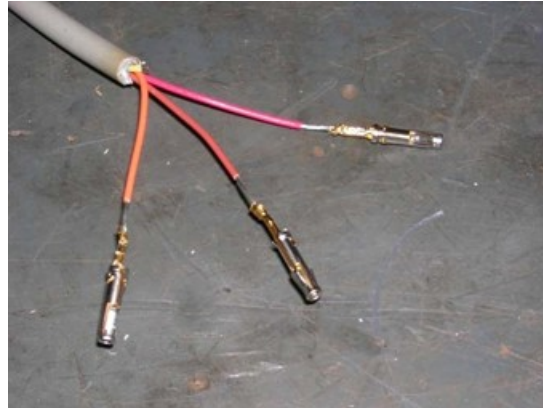
Figure 10. Wires in order from left to right: red, brown, orange.



#### 9.4.4 Crimping on Pins

To start the connector side of the temperature probe, strip off about one inch of the gray wire casing. Again, cut off the yellow and bare wires and strip the red, brown, and orange wires. For the next step, use the wire crimpers. Hold the largest part of the pin's tail in place using the 2.3 mm crimpers and carefully insert the exposed part of the red wire into the pin. Crimp them together. Finish off by crimping the protrusions from the pin with the 1.6 mm crimper. Repeat with the other two wires.

Figure 11. Wires with pin attached.



#### 9.4.5 Assembling Plug

For the next part, insert the pins attached to the wire into the connector that attaches to the controller. Before doing this, all extra parts that go with the same connector should already be attached (the bottom attachment, two washers, and a spacer as shown in Figure 11).

Figure 12. Order of connector pieces.



Look carefully at the bottom of the connector and note that there are four letters present: A, B, C, and D. Only A, B, and D are used. The red pin should be inserted into the 1A slot, brown into the 2B slot, and orange into the 4D slot. Once again, it is important that the order is correct to not cross wires. All three pins are inserted at once, so try to align the pins into a triangle (in the right order) and then slide them into their correct slots. Use an Allen wrench or other thin object to push the pins all of the way through. A little force may be required to get the pins to the proper depth. The end of the pin should be nearly flush to the end of the connector (see Figure 13). Finish off by pushing all of the parts of the connector together and screwing it together. Finally, screw the clamp onto the base of the connector.

Figure 13. End of the female plug.



#### 9.4.6 Repairing Temperature Probes

The procedure for repairing a temperature probe follows the same procedure as creating one from scratch, with the exception that the previously used parts of the wire have to be removed. If there is a noticeably broken or corroded part, remove and replace only that part. The temperature chip is just cut off and thrown away, followed by the procedures listed in section 9.4.2. To remove the pins from the connector, unscrew the bottom and use the pin removal tool to disconnect the pins from the connector. Simply cut off the pins and continue with the gray wire as described in section 9.4.4.

Figure 14. Removing the connector pins.

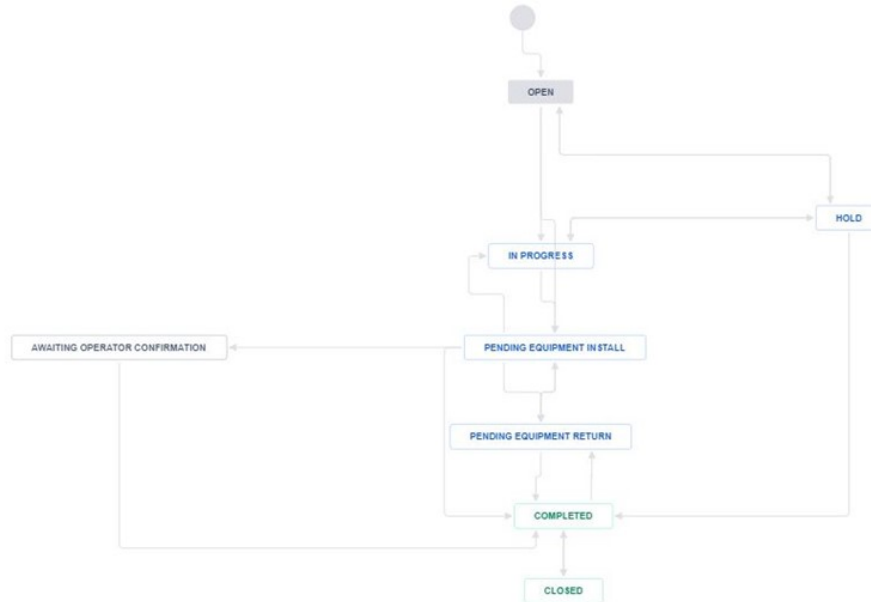


#### 9.4.7 JIRA Workflow

JIRA is the online issue-tracking software used by the Air Quality Research Center at UC Davis. This software has the capability to track different issues from all sites in the sampling network in a user-friendly, highly organized, and searchable way. Each issue has a parent issue based on data received from the field – whether it is an email, phone call, or logsheet comment from the operator – or a review of the memory card data received. Each issue can have many different requests for equipment to fix the issue. These equipment requests are sub-tasks

associated with the parent issue. Shown below in Figure 14 is the workflow that an equipment request sub-task can go through as the equipment request is processed.

Figure 15. Equipment request workflow.



## 10. DATA AND RECORDS MANAGEMENT

Equipment Ticket tracking is accomplished using the commercial cloud software package “JIRA” by Atlassian. This ticketing system will store all relevant information about the nature of the problem at the site.

Equipment inventory is stored on a Microsoft SQL server instance running on a local network server. Some custom-made .NET software tools facilitate the updating of records. The status of the equipment is also kept in the SQL server. It is up to the technician to verify all equipment changes are properly reflected in the database.

## 11. QUALITY ASSURANCE AND QUALITY CONTROL

The controller is a complicated system of hardware and software; diagnosing intermittent problems can prove difficult. Any problems exhibited by a controller in the field must be recreated in the shop conditions before it is sent out again. If the issue is not replicable under these conditions, the equipment must be long-term tested for proper operation for at least a week before being marked as ready to go into the field again.

## 12. REFERENCES

Not applicable.