CLEAResult®

CoolSaver

A/C Tune-up Program

AEP TEXAS
An AEP Company

TECHNICIAN TRAINING MANUAL

We change the way people use energy™

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Introduction

CLEAResult works with local HVAC distributors and service networks to offer improvements to HVAC equipment efficiencies and capacities. HVAC efficiency services (A/C tune-ups) are offered to residential and commercial customers within applicable service regions.

Program Contractor Requirements and Qualifications:

- Contractor must be State Licensed by the Texas Department of Licensing and Regulations
- Contractor must hold liability insurance and meet the limits set forth on the agreement
- Technician performing tune-ups must have EPA and TDLR technician registration

Program equipment requirements and qualifications include the following:

AEP is the service provider regardless of the retailer the bill is being paid to.

- Participant must be a customer of the utility providing the incentive
- Participating equipment is eligible for a tune-up if it has never had a tune-up by the program or 5 years from the date of the last tune-up administered by the program **(After the 5th year is complete, on the 6th year)**
- Equipment must be in operable condition as defined by having an EER > 1 during the "Test-In" **(Must operate)**
- Equipment size is limited to 25 tons and under
- Only the following equipment types are eligible:
  - Air Cooled Direct Expansion Packaged Systems
  - Air Cooled Direct Expansion Split Systems
  - Air Cooled Direct Expansion Packaged Heat Pumps
  - Air Cooled Direct Expansion Split Heat Pumps

To identify appropriate energy saving measures, pre A/C tune-up equipment measurements will be collected to determine current system baseline efficiency and capacity. The procedure to determine the baseline efficiency and capacity is called the "Test In" or "TI." After Test In, key energy saving measures are to be implemented, including the following:

- Clean Condenser – **required**
- Clean Evaporator -- **required**
- Clean Blower -- **required**
- Verify clean filter: change or clean as needed – **required**
- Verify Airflow within range (+/- 15% of 400 CFM/ton) , and adjust as needed, – **required**
- Check refrigerant charge; adjust to Manufacturer's spec's as needed - **required**

All of the energy saving measures listed above are intended to increase A/C equipment efficiency and capacity. Increases in efficiency and capacity will reduce overall yearly energy consumption and energy demand during peak hours. After implementing energy saving measures, post A/C tune-up equipment measurements will be collected to determine the new system operating efficiency and capacity. The procedure to determine the new system operating efficiency and capacity after implementation of corrective measures is called the "Test Out" or "TO."

The measurement and verification of A/C tune-up demand and energy savings requires a special approach due to the complexity of the equipment involved and the necessary measurements to determine the savings. The significant issue is to determine the performance of the system both before and after the tune-up. The metric of choice is the energy efficiency ratio or EER. The EER of cooling equipment is defined as follows:

$$EER = \frac{Useful\ Cooling}{Net\ Energy\ Consumed} = \left(\frac{Capacity\ in\ Btu/hr}{Input\ in\ watts}\right)$$

Thus, cooling capacity and power measurements are needed before and after the A/C tune-up is performed. The following measurements are required to calculate the EER:

- Electrical input to the HVAC Equipment
- Supply and return air dry bulb temperatures taken across the cooling coil
- Supply and return air humidity or wet bulb temperatures taken across the cooling coil
- Outdoor ambient air temperature
- Airflow through the system

All of these measurements are required to be able to calculate real-time BTU & EER

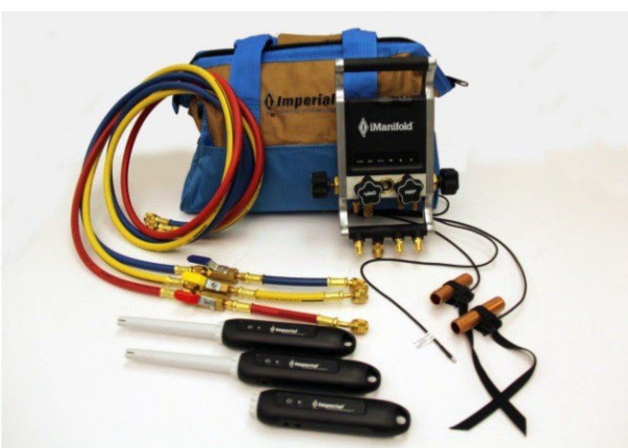
The Modeled Tune-up differs from an M&V tune-up and consists of:

- Confirming the Air Conditioner is operational
- Verifying the system is clean and performing professional cleanings, as needed
- Measuring and adjusting airflow, if needed to tonnage specification
- Verifying proper refrigerant level and adjust, if necessary
- Performing the Test on the system

In order to perform either M&V or Modeled Tune-ups, the technician must have a good understanding of the **Refrigeration Cycle, Air distribution measurements** and **temperatures, Electrical consumption** and **Air Conditioning Performance** and gather data as indicated in this Protocol. The technician must input information into the program-approved application and submit any additional information requested into the program's database.

Approved Tools

- **900-M Imperial iManifold™** is designed for adding and removing refrigerant, performing physical measurements, measurement conditioning, measurement verification, data acquisition, data management, data sharing, and data reporting. (**Not included** is the smart device - Smartphone/Tablet to operate the user interface iManifold App)
- **912-M Repeater Probe.** Extends the range of the Humidity & Temp probes
- **911-M (x3): Humidity & Temperature.** Transmit up to (4) points of wireless data including air temperature, air relative humidity
- **901-M (x2): Thermistor Pipe Strap Surface Probe.** Perfect tool to measure pipe surface temperatures. Temperature range: -25° to 212°F (-32° to 100°C).
- **955 MRS**: Charging Hose, PolarShield®, Set of 3, 5' w\Low Loss Ball Valves
- **TB-52 15-Pocket Professional Tool Bag**
- **913-M / 914M: Low/High Pressure & Temperature/Repeater** (Optional)



Additional equipment required to perform CoolSaver A/C Tune-ups:

- Program-approved method for measuring airflow. The following are recommended options:
  - AAB SPM-100 Dual Port Manometer (Not included in toolkit)
  - Testo 417 Vane Anemometer (Not included in toolkit)
  - Testo 510 Manometer (Not included in toolkit)
  - Testo 510i Manometer (Not included in toolkit)

Testo 417
Large Vane Anamometer

Testo 510 / 510i
Manometer

SPM-100
Manometer

One of these additional air measuring devices are required to accurately measure airflow across the air handler.

TOOLS NEEDED FOR TRAINING

Our goal is to get through vast amounts of material, containing new technical concepts, and all-important compliance requirements. There is only one way for everybody to absorb the training and take the written test in the allotted time. That is for there to be little or no distractions and for everybody to be focused and well prepared.

This checklist below is provided to make preparing easier and to eliminate disruptions during the training.

1. **Have reviewed all training manuals/help videos for the iManifold toolkit and smart device pairing/set-up**
   - iManifold reference book and video list
2. **Wear Proper Attire: dress code (per your company)**
   - **NO**: wife-beaters; shorts; flip-flops; undergarments showing; inappropriate-for-work printing
   - **Required**: Proper PPE (personal protective equipment) for each task (e.g. safety glasses, gloves, etc.)
   - **Recommended**: button shirt, Polo, Cargo, socks, shoes w/non-slip soles, back-up clothes for rain, etc.
3. **Have Proper Documentation:**
   - State Identification, (e.g. Driver's License)
   - EPA 608 ID card
   - State Technician License
   - Pre-test (completed prior to training)

   Techs must have all 3
4. **Bring proper tools and materials to testing location**
   a. **Approved CoolSaver Instruments:**
      i. Either:
         - Imperial iManifold with refrigerant hoses with low-loss connections OR
         - Imperial iConnect with wireless pressure probes

      ii. Approved, working, connected, configured Apple or Android Smart Device/Tablet.
      iii. 3 wireless humidity probes
         - 1 repeater

      iv. Pipe clamp or wrap temperature probes
      v. Additional wireless temperature probe or wired air temp probe
      vi. Digital amp/volt meter
      vii. Tape Measure
      viii. Inspection Scope (optional)
      ix. CoolSaver-approved Vane Anemometer
      x. CoolSaver-approved Manometer and accessories

   b. **Needed Hand Tools:**
      i. 1/4" and 5/16" magnetic nut drivers
      ii. Phillips and Flat head screw drivers
      iii. Medium 7~10" crescent wrench
      iv. Portable Drill/Impact Driver 18V

   c. **Portable Office Supplies:**
      i. Mobile phone
      ii. Camera with flash (phone/tablet is OK)
      iii. Clipboard, pens
      iv. CoolSaver data collection and invoice sheets
      v. CoolSaver stickers
      vi. Black paint pen/Permanent Marker
      vii. Spare batteries and charger for tablet, instruments and tool

Helpful Tips:

- For improved tool life, do not scrub suction line or liquid line with thermistor pipe or wrap clamp.
- Improve accuracy by not storing probes in direct sunlight.

Tune-up Procedures

CLEARESULT IMANIFOLD M&V TUNE-UP PROCEDURE

1. Verify HVAC System is operable turn it on and do a quick check
    a. Air handler & condenser on (indoor fan should be on & condenser should be blowing heat)
    b. Access voltage and amperage for measurements for air handler
    c. Turn on temperature probes and put one in supply and return. (holes may need to made)
2. Power up Tablet / tap on iManifold Application / turn on the iManifold App. and connect to iManifold
    a. Hook up iManifold and accessories to the condenser
    b. Access voltage and amperage for measurements for condenser
3. Tap on Menu selection Key / Reporting / New Project / CLEAResult – fill out information
    a. Tap Project Name / Utility / M&V / Res. Or Comm. / Enrollment ID (CNP-only) & continue
    b. Tap Site information / Geotag Address or fill out the Customer information-Service address (if geotagging, confirm address matches customer's correct address; correct manually, if necessary)
    c. Customer Address Different – fill out if different
4. Equipment Information
    a. Geotag the Condenser - you may need to adjust the pin marker. Tap Save Location / Continue (Data connection needed)
    b. System Configuration – select Split / Package – line set length
    c. Condenser – take photo (Data tag) / tap on Compressor Type – select (scroll or recip.) / Number of Circuits 1-4 – (this should always be 1 or 2 unless you are in EAI territory)
    d. Nominal charge slide the bar or tap on the "0" to the left and enter the Lbs. & Oz
    e. Service Port at the Compressor (this is if the service port is on the hot gas line)
    f. Unit Location – Condenser Location(Ground or Roof) / fill out Condenser information
    g. Unit ID = CoolSaver sticker name (e.g. main, bonus, upstairs)
5. Air Handler Location – fill out
6. Utility Information – ESI ID, Meter #, or Account # (AEP = ESI ID & Meter Photo)
7. Building Information – Building Type (Res. Or Comm.) (photo opportunity)
8. Tap Submit on all selections individually – All site information should have a green arrow.
9. Tap Back
10. Tap Pre Inspection – Fill out selections (photo opportunity)
11. Years in remaining life – slide bar – Tap Submit
12. Profile a System
    a. Select refrigerant type
    b. Fill out the rest of the information (system, metering, system targets - condenser, evaporator type, superheat and subcooling & nominal tonnage) – Tap Submit
13. Go back to iManifold / Menu / User Inputs – verify all tabs & enter electrical measurements for the condenser and the air handler
14. SUBMIT
15. Tap on Menu / Reporting / take Test In snapshot
16. Review Test In information – if anything is red it must be fixed and corrective measurements need to be done except charge adjustment. Ensure condenser is completely dry before this step!
17. Perform Corrective measures: clean indoor blower and coil, wash condenser, and replace filter(s), adjust airflow, if needed
18. Turn on HVAC system and allow time for stabilization (>10 minutes)
19. Now take a Precharge Snapshot / continue

20. Complete Refrigerant Charge Adjustment (if needed)
21. Take Test Out Snapshot / this can be reviewed by tapping on the Review Test Out tab
22. SUBMISSION
    a. Tap Corrective Measurements and enter all applicable fields
23. Tap Invoice and obtain customers signature / Confirm / Submit
24. Additional photos, if needed
25. Technicians notes
26. Send Data / Confirm

ELECTRIC PROVIDER VERIFICATION

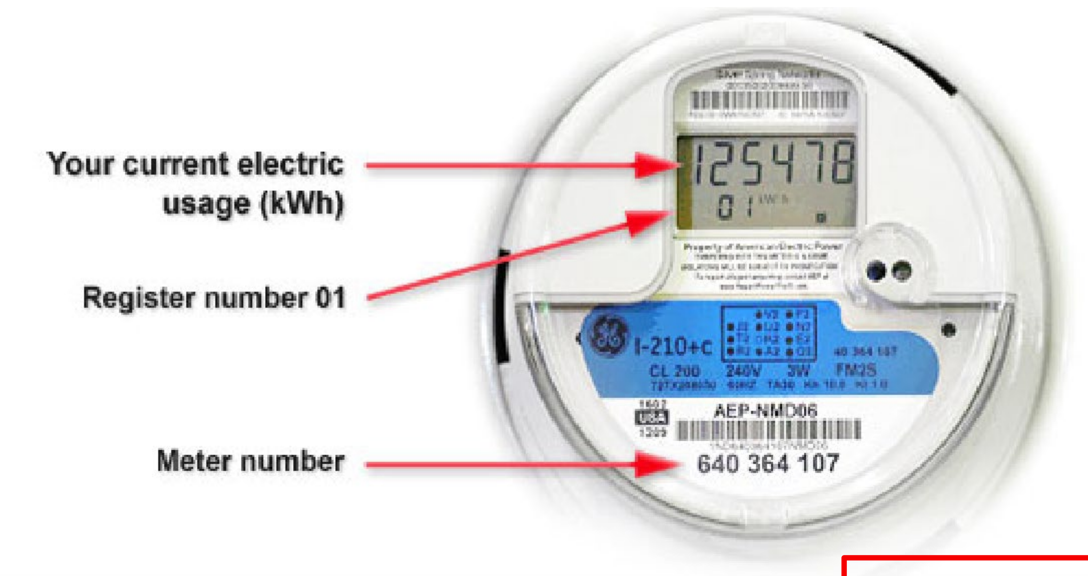


Figure 1: Typical utility meters and identification number

If you cannot find the ESI ID number on the customers light bill, submit the meter number on the meter. Meter number sequence is 9 numbers in sets of 3 > "000 000 000"

ESI ID VERIFICATION

- Locate ESI ID number on customers light bill. AEP's ESI Id number always starts with the same prefix numbers that will be the same for every AEP customer "100327894-00000000".
- Record ESI ID number and service address. Make sure to record numbers correctly to prevent delay in payment.
- If you cannot find the service address or ESI ID, you can look them up on the ESI ID Look-up website. Login to website and set-up account. http://www.esiids.com/login.php Information on this website may not be 100% accurate. (Not affiliated with AEP or CLEAResult)

BUILDING TYPES

- Determine if the customer falls into the Residential Program or Commercial Program.
- Determine the customer's building type according to the following table. Choose the building type that most accurately represents the operating hours and cooling requirements for the location.

Table 1: Building Type Description

Building Type	Description
College	Buildings used for academic or technical classroom instruction with summer and winter sessions.
Convenience	Buildings used for retail sale of food, gasoline, and other convenience goods
Fast Food	Buildings used for preparation and sale of food and beverages with no inside seating (Example: Sonic)
Grocery	Buildings used for retail or wholesale of food. Also includes general retail outlets that offer refrigerated, frozen, or canned foods.
Hospital	Buildings used for emergency care with either short or long term patient occupancy. NOTE: small clinics,outpatient care, urgent care, small MRI facilities, and admin offices should be classified as "Large Office."
Hotel	Multi-story buildings used to offer multiple accommodations for short-term residents.
Large Office	Buildings with multiple air conditioning units used for general office space, professional office, or administrative office space. (Example: City Government, Banks, Apartment Admin. offices, School and Church Administration offices) Be sure when doing Schools, Colleges, and Churches to screen these out separately.
Motel	Single story buildings used to offer multiple accommodations for short-term residents.
Multi-Family	Buildings used to offer multiple accommodations for long-term residents.(ask the Trainer for clarification on a per-program basis)
Nursing Home	Buildings used for providing skilled nursing, assisted living and care for short-term or long-term residents.
Public Assembly	Buildings in which people gather for social or recreational activities, whether in private or non-private meeting halls. (Ex: Gymnasiums, Conference Rooms, Auditoriums, etc. Be sure when doing Schools, Colleges and Churches to screen these out separately. Most gov't buildings will be either "Small Office" or "Large Office").
Religious Worship	Buildings in which people gather for religious activities, (such as chapels, churches, mosques, synagogues, and temples). (Ex: this applies to the general assembly and classroom areas only; administrative areas should be categorized as "Large Office" or "Small Office" due to occupancy. Gymnasiums and Auditoriums should be classified as "Public Assembly.")
Restaurant	Buildings used for preparation and sale of food and beverages with inside seating (Ex: McDonalds, Taco Bell, KFC, Chili's, Olive Garden, upper-end restaurants, etc.)
Retail	Buildings or malls used for the retail sale of dry goods (Ex: Sears, Academy, Best Buy, Hobby Lobby, etc.)
School	Classroom buildings used for academic instruction with minimal summer sessions (administrative areas should be categorized as "Large Office" while gymnasiums and auditoriums are categorized as "Public Assembly").

Building Type	Description
Service	Small buildings with one air conditioning system (five tons or less) that offers some type of service (such as insurance, jewelry, repairs of auto or electronics, etc.).
Single Family	Detached homes occupied by permanent residents year round.
Small Office	Small buildings with one air conditioning system (five tons or less) used for general office space, professional office, or administrative offices (Ex: law offices, medical offices, etc.)
Warehouse	Buildings used to store goods, manufactured products, merchandise, or raw materials (administrative areas associated with these facilities should be categorized as "Large Office" or "Small Office").
Manufacturing	Buildings containing machinery used for the mass production of a product.

Cooling System Types and Descriptions

Unit Type	Description	Power
Split A/C	Compression cycle system used only to cool a conditioned space where the condenser and evaporator are located separately.	Condensing unit and air handler on separate circuits.
Split Heat Pump	Compression cycle system used to supply or remove heat from a conditioned space where the condenser and the evaporator are located separately.	Condensing unit and air handler on separate circuits.
Packaged A/C	Compression cycle system used only to cool a conditioned space where the condenser and evaporator are packaged together in a single unit.	Unit typically supplied power on 1 circuit
Packaged Heat Pump	Compression cycle system used to supply or remove heat from a conditioned space where the condenser and the evaporator are packaged together in a single unit.	Unit typically supplied power on 1 circuit
Compressor	Record Make, Model and Serial Number	N/A
Line-set	Provide length in feet. Determine height difference between Condenser and Evaporator coil.	N/A

PROJECT SETUP

Project Setup: You will need to setup the project to allow you to proceed to the tune-up Test-in procedures:

- Unit ID (Name the project accordingly)
- Utility (Electric provider)
- Type of Project (Tune-up)
- Classification (Residential or Commercial)

TEST-IN PROCEDURES: *(Reference page. 26)*

Startup system bring thermostat setting at least 5* below set temperature to allow enough time to test-in. Deploy toolkit and start the CoolSaver app test-in procedure.

Proper Probe Placement: Make sure probes are placed in the correct location, in some cases you will need to relocate the probes to make sure you are reading temperatures correctly and accurately.

- **Supply** probe needs to be at least 10’ from the evaporator coil.
  - If the probe is too close to the evaporator coil it will sense too much moisture from the evaporator and will affect wet bulb readings causing inaccurate system capacity and EER.
- **Return** probe needs to be at return air grill or the return plenum depending on return duct design.
  - Probes in return plenums will often read inaccurate temps due to plenum not being properly sealed or sensing too much moisture from the coil
- **Outdoor probe (ODA)** needs to be away from the condenser to avoid sensing the warm air from the condenser. ODA probe needs to be in a shaded well ventilated area to avoid sensing direct sunlight.
  - ODA probe that senses building radiant temperature, condenser air temperature or direct sunlight will result in “liquid line temp less than outdoor temp”.
  - If ODA probe is reading inaccurate temperature the target superheat and sub- cooling will be incorrectly calculated and refrigerant charge will be off.

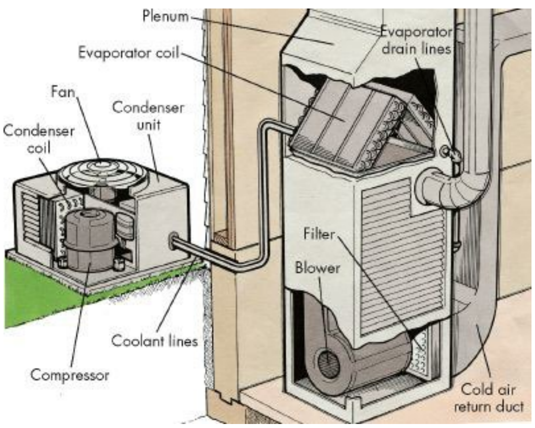


Figure 2: Split system

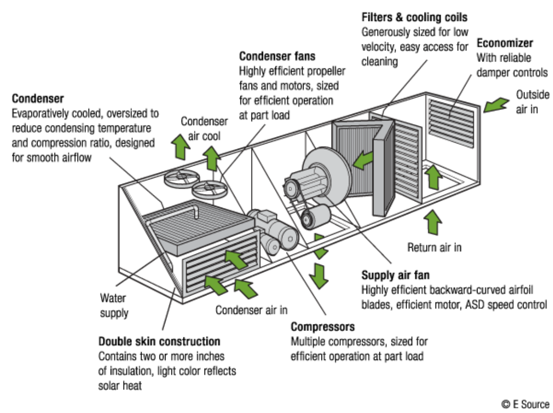


Figure 3: Packaged system

Airflow Measurement Methods

1. **Handheld Vane Anemometer:** Using a tape measure or ruler, measure and record the return grille dimensions. Next, with the cooling system on, traverse the return grille with the handheld rotary vane anemometer and determine the average air speed of the air entering the return grille in feet per minute [FPM]. Record the air speed for each return grille. Proceed to the next return grille; you can record dimensions and air speed for up to four return grilles. If you have more than 4 return grilles, select a different airflow method. Instructions on how to use the Testo 417, 4" Vane Anemometer are shown below:

Testo 417
4"Vane Anemometer

Initial Set-Up:

a. Turn instrument on.
b. Push and hold "hold "button until display changes.
c. Set F FACT to off by pressing "Vol" button.
d. Press "hold" Set area to 0.
e. Press "hold" set K.FACT to 0
f. Press "hold" set AutoOff to on.
g. Press "hold" set UNIT to fpm.
h. Press "hold" leave reset to no.

Operation:

a. Turn unit on. 0 fpm and xx.x F should display.
b. Make sure hold, max, min do not appear on display. Use "Hold" button to toggle off.
c. Press "Mean" button twice until 00:00 is displayed on top and 0 fpm on bottom. Use "Vol button to toggle between FPM, CFM and xx.xF. Set to FPM.
d. Place the rotary vane in one corner of the return grille open area. The instrument should be one inch from the face of the grille. Observe the fpm display and when it reaches max speed start the timer by pressing the "Hold" button. The timer display will start.
e. Move the vane at a steady rate across the grille no faster than 4 seconds per foot. Cover the entire open area of the grille with minimal overlapping. When the entire grille is traversed, immediately stop the timer by pushing the "Hold" button.
f. Press the "Mean" button to display the Mean average FPM.
g. Press the "Mean" button twice to erase and take another measurement.

Manufacturer Data: If the equipment manual is available, with the cooling system on in full load cooling, measure the return and supply air static pressures using the digital manometer at locations specified in the equipment manual. Look up the airflow in the manufacturer's manual.

2. **Handheld Digital Manometer:** Instructions for using the Testo 510 Digital Manometer are included below:

Testo 510 Digital Manometer

Set Up

a. Turn the unit on.
b. Press the left top up "arrow button" to change between units of measure. Set to "inH2O" by pressing the "mode button".
c. Press and hold the up "arrow button" for two seconds to zero or null the display.

Measuring Component Pressure Drop (coil, filter, etc.)

a. Press the on /off button. The display should show "0.00 inH2O"
b. Place the instrument in the location it will be used. Moving the instrument during measurement is not recommended. Press the up arrow button to zero the unit. Zeroing the unit must be done without hoses attached.
c. Install a static pressure probe on each side of the component to be measured.
d. Attach the suction or lower pressure probe to the minus barb on the instrument.
e. Attach the higher pressure probe to the plus barb on the instrument.
f. Read the pressure drop in inH2O.

Refer to static pressure hand-outs

Measuring TESP, Total External Static Pressure Measurement

- Press the on /off button. The display should show “00.0 inH2O.”
- Place the instrument in the location it will be used. Moving the instrument is not recommended. Press the up arrow button to zero the unit. This must be done with no hoses attached.
- Install a static pressure measurement probe in the supply air stream at the location directed by the manufacturer. This is normally at each end of the equipment module as it was shipped. For an up flow gas furnace, between the heat exchanger and the cooling coil. (Remove high limit or drill hole for access) For an AHU, locate the probe between the blower and supply plenum. (Drill hole for access)
- Install a static pressure probe in the blower suction compartment. (drill hole for access)
- Attach the suction or low pressure tube to the barb marked with a - minus. Read and record the negative pressure. Remove the suction hose and attach the discharge or high pressure hose to the barb marked with a + plus. Read and record high pressure. Attach hoses, read and record total external static pressure

3. **AAB SPM-100 Dual Port Manometer:** The AAB SPM-100 is a wireless manometer using Bluetooth communication protocol to communicate with the SMP-100 application (app) that will be installed on your iOS or Android mobile device.

Preparing the Manometer for use

- If the SPM-100 tool has not been used, remove the tool from the box and inspect for shipping damage (possible but unexpected).
- Install the battery (CR2450 button battery provided) by removing the battery cover using a quarter or screw driver. Install the battery positive side up and replace the battery cover.

CAUTION: Do not overtighten the cover which can damage the cover or the O-ring gasket.

Download the SPM-100 App

- Open the App Store on a compatible iOS or Android device.
- In the App store search field type “aab tools” and locate the SPM-100 app. Follow the on-screen prompts to download the app onto your device. The app is free and can be downloaded onto multiple devices such as your iPad and your iPhone. Verify the app has loaded onto your device by pressing the “OPEN” button.
- Ensure Bluetooth communication is activated on your device. If it is not active, go to the device “SETTINGS” menu, locate the Bluetooth and activate it.

Using the SPM-100 Manometer

- Open the SPM-100 app on your device. The first time the SPM-100 tool is used it will need to be paired to the device. When the pairing is successful, the display will indicate “SPM-100 CONNECTED”. When the app is closed or communication is lost, the blue LED indicator light on the SPM-100 will flash for 30 seconds or until communication is re-established.
- Prior to taking any readings, remove the caps from the hose connections and press the blue “CALIBRATE METER” button on the SPM-100. Repeat the calibration each time the tool is used.
- To take measurements, press the green “TAKE A READING” button and select the desired test from the available menu. When a test is selected, a diagram will appear showing the proper location for the Pitot tube probes for that test. Refer to the program trainer for required and alternate test locations for the Pitot tube probes.
- Holes will need to be drilled into the plenum, duct, etc. to provide access for the Pitot tube probes.
- CAUTION: When drilling holes use caution to ensure the area behind the intended location is clear of obstructions.
- Drill holes using a 3/8” or step drill bit designed for drilling through metal. Drill through the metal and any duct liner and/or secondary liners (if used).
- Insert the Pitot tube probes into the proper location(s) for the desired test. The Pitot tube probe must have a clear unobstructed path into the system airflow for accurate test results. Orient the probe so the Pitot tube faces directly into the path of the airflow. An indicator on the probe base will indicate the orientation of the probe in relation to the base. The probe base is magnetic and will stick to metallic ducts. If the ducts are not metallic, holding the probe in place for the duration of the test(s) will be required.
- When ready to take a reading, press the green “TAKE A READING” button on your device. Allow time for the test measurements to stabilize, usually 15-30 seconds depending on the test in process. When the reading has

stabilized, press the red “STOP” button to end the test. DO NOT MOVE, ROTATE, OR REMOVE THE PITOT TUBE PROBES DURING THE TEST. If the readings are satisfactory, press the green “SAVE” button to save the reading. If they are not satisfactory, press the red “DELETE” button to delete the file and retake the test.

- After all required tests have been performed all holes must be plugged or properly sealed to prevent air leakage.
- If the static pressure readings are not within the required parameters, the cause should be determined and corrected if possible. Refer to the Duct System Troubleshooting Guide for more information.

Additional information and instructional videos can be found at www.aabsmart.com.

BLOWER MOTOR TYPES

Determine the blower motor type as either “**PSC**” or “**ECM**.”

- **PSC: Permanent Split Capacitor** blower motors are popular in older air conditioning systems. A capacitor is connected between the running winding and the starting winding. PSC motor efficiencies are lower than ECM motor efficiencies. Figure 4 shows an example of a PSC motor and typical wiring diagrams for a PSC motor.

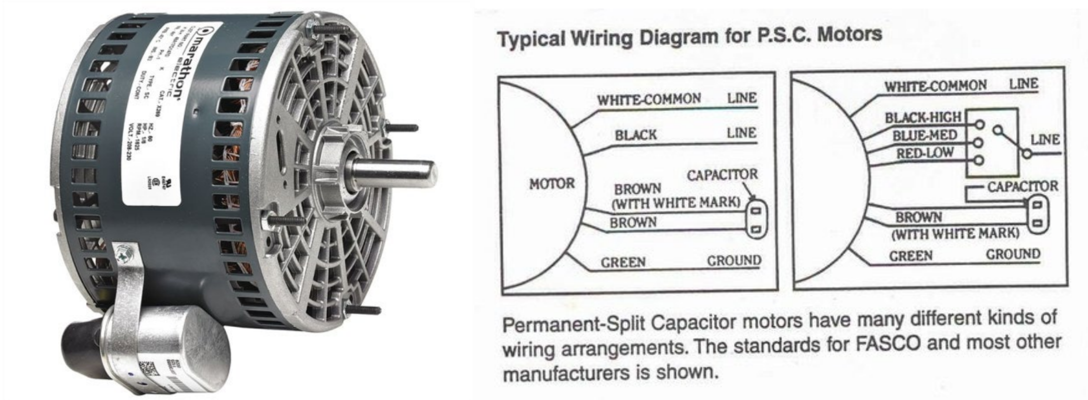


Figure 4: Permanent Split Capacitor (PSC) Motor and Typical Wiring Diagrams

- **ECM: Electrically Commutated Motor.** A high efficiency brushless DC motor utilizing a permanent magnet rotor and a built-in inverter also referred to as an electronic variable speed motor. Typically, speed is adjusted using a potentiometer. The photo at left and below are examples of an ECM. Newer, advanced HVAC equipment may constantly control ECM speed depending on system operating characteristics. Some HVAC manufacturers have a feature that allows ECM motors to operate at full speed for system diagnostics; therefore, if you encounter an ECM, make sure it is operating in full load cooling mode during the tune-up before taking any measurements as noted in section 1.1 at the beginning of the protocol. Figure 5 shows an example of an ECM and typical wiring diagrams for ECMs.
- With the cooling system on, measure and record the blower voltage and current. If you have a three phase blower motor, record the average voltage and the average current.

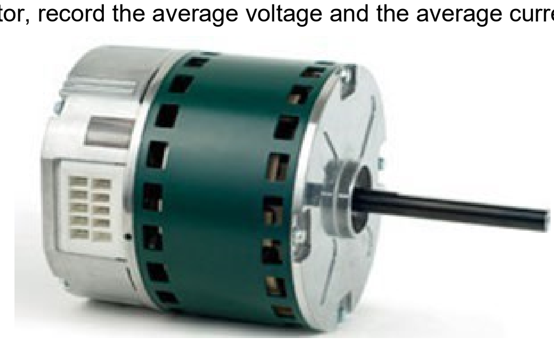
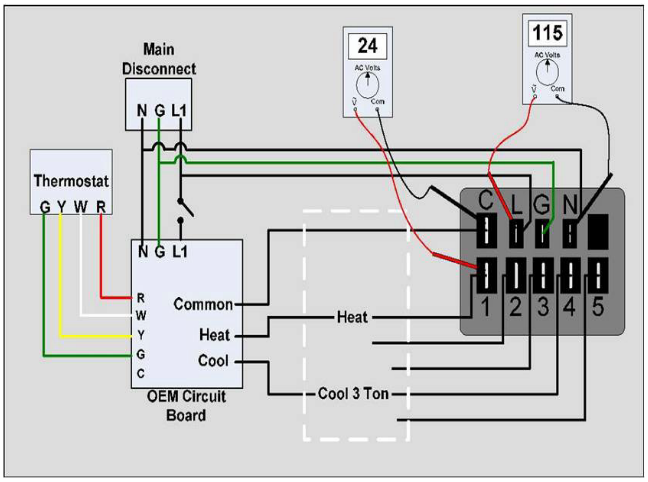
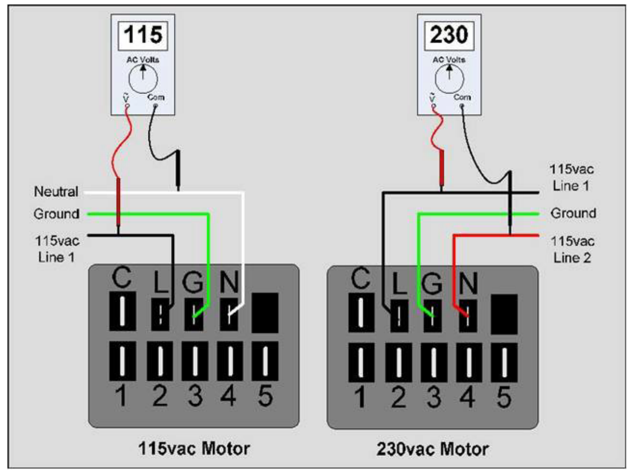



Figure 5: Electrically Commutated Motor (ECM) and Typical Wiring Diagrams





CONDENSER AND COMPRESSOR MEASUREMENTS

Proceed to the location of the condenser and compressor. Record the following information:

1. **Compressor Type** (Scroll or Reciprocating)
2. **Refrigerant Type** (R22, R410A, or other)
3. **Metering Device** (Fixed Orifice, TXV or Capillary Tube)
4. **Condenser Model Number**
5. **Condenser Serial Number**
6. **Compressor Phase** (Single or Three)
7. **Compressor Make Model Serial Number**
8. **Line-set length and height difference**

Multiple Compressors: 2 through 4 circuits, additional paired transducers will be needed for each circuit. (Ask your CLEAResult trainer for specific needs for your company)

913-M & 914-M Wireless High- & Low Pressure & Temperature Probes

Set Up

a. Press the on-off button.
b. Yellow light should be a steady blink if connected.
c. If not connected and needs to be paired. Refer to help videos in iManifold application.
d. Press and hold the button until yellow light stops flashing, to turn the unit off

9. **Condenser Volts:** With the system in cooling mode, measure the complete incoming voltage at L1 and L2 for Single Phase using a digital multi-meter. Three Phase needs to be measured L1-L2, L2-L3, L1-L3 if you have any questions contact a CoolSaver Trainer.
10. **Condenser Current:** With the system in cooling mode, measure the current of the circuit supplying the compressor and condenser fan using a digital multi-meter. Single Phase measure the amps on L1 and record on form. Three Phase measure amps on L1 and record on form, measure amps on L2 and record on form, measure amps on L3 and record on form.

912-M Repeater Probe

Set Up

a. Press the on-off button.
b. Yellow light should be a steady blink if connected.
c. If not connected and needs to be paired. Refer to help videos in iManifold application.
d. To turn the unit off, press and hold the button until yellow light stops flashing

Practice Good Mechanical Integrity:

- While checking condenser volts and current use this time to visually inspect the contactor for any debris or dirty contacts. Check all wiring in condenser control box and compressor terminal box for any loose connections and repair if needed.
- If repairs are major or needs parts that may incur a charge make sure and let the customer know before going any further with the tune-up. Explain to the customer that major repairs and or parts are not covered under the tune-up program.

Always remember that it is best to use good practice than to have a customer call you back a couple of days after the tune-up was completed because his/her unit is not working due to a loose wire or faulty contactor.

11. **Ambient Air Dry Bulb Temperature:** Measure the dry bulb temperature of the ambient air using the iManifold 903-M Thermistor Air Probe with 12’ cord or iManifold 911-M Relative Humidity Probe. The measurement should be taken in a dry, shaded location near the condensing unit at least a foot above the ground. If the ambient air dry bulb temperature is between 70°F and 74.9°F, the ambient air wet bulb temperature must be at least 56°F to perform the tune-up; ambient air dry bulb temperatures 75°F and above do not require a wet bulb temperature check to perform a tune-up.
12. **Ambient Air Wet Bulb Temperature:** Only required if ambient air dry bulb temperature is between 70-75°F. Measure using iManifold 911-M Relative Humidity Probe.

Information from Refrigerant Analyzer: With the cooling system stabilized and running, use a digital refrigerant analyzer to measure and record the following information. If you have a multiple compressor system operating in series, enter only the high and low side conditions for the system. If you have a multiple compressor system operating in parallel, enter the conditions for only one of the compressors.

13. **Suction Pressure [PSI]:** Measured at the low-pressure side of the system extending from the outlet of the refrigerant control device, through the evaporator, and to the inlet valve of the compressor.
14. **Discharge Pressure [PSI]:** Measured at the high-pressure side of the system extending from the outlet of the compressor, through the condenser, and to the inlet of the refrigerant control device.

15. **Evaporator Temperature [°F]:** The temperature corresponding to the suction pressure that results in the phase change of the refrigerant from liquid to vapor. The evaporator temperature is calculated by the digital refrigerant analyzer using the suction pressure measurement.
16. **Condenser Temperature [°F]:** The temperature corresponding to the discharge pressure that results in the phase change of the refrigerant from a vapor to a liquid. The condenser temperature is calculated by the digital refrigerant analyzer using the discharge pressure measurement.
17. **Vapor Line Temperature (VLT) [°F]:** Measured by clamping the digital refrigerant analyzer temperature probe to the vapor line. The vapor line is also commonly referred to as the suction line.
18. **Liquid Line Temperature (LLT) [°F]:** Measured by clamping the digital refrigerant analyzer temperature probe to the liquid line.

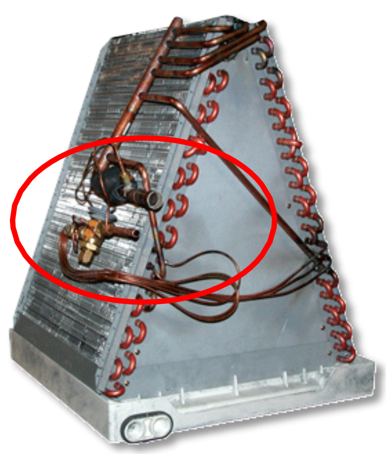
Helpful Tips:
- Always use a wire brush to clean the surface of the copper line where the temperature probe is going to be clamped. A clean surface will always give a more accurate reading.
- ODA measurements should be taken in the shade and not in direct sunlight.

Superheat [°F]: The temperature corresponding to the number of degrees the refrigerant vapor is above its boiling temperature as a liquid at that pressure. The digital refrigerant analyzer calculates the superheat based on other measurements input. Typically used to evaluate the refrigerant charge on cooling equipment using fixed orifice or capillary tube refrigerant control devices. For units with fixed orifice or capillary tube refrigerant metering devices, the iManifold will calculate and display a target superheat value in the main gauge page of the iManifold app.

Subcooling [°F]: The temperature corresponding to the number of degrees the liquid refrigerant has been cooled below its condensing temperature for that pressure. Typically used to evaluate the refrigerant charge on cooling equipment using TXV refrigerant control devices. For units with TXV refrigerant metering devices, the iManifold will calculate and display a target subcooling value in the main gauge page of the iManifold app.

Helpful Tips:
- When checking coils to determine if it is a Capillary tube, Fixed Orifice or Expansion Valve always make sure you remove the cover completely. There are some coils that have the expansion valves mounted on the side right over the coil and hard to see. These coils can be mistaken for a Capillary type metering device.
- When checking to see the type of metering device, if it's an Expansion Valve-type, proceed to check the Expansion Valve Sensing Bulb mounted on the suction. Make sure it is secured on properly and free of any corrosion. If loose or dirty clean by sanding down the bulb and the suction line and re-secure to suction line. Doing this beforehand will save you a lot time rather than having to come back and do it if pressures won't stabilize.

Supply and Return Air Conditions: Following the refrigerant charge check, the cooling system should still be stable. Drill one 9/16" diameter hole on the supply air side and one on the return air side of the cooling coil. The location of the holes should be such to allow the iManifold Hygrometer to be in contact with well-mixed air for both the supply and return measurements.



Helpful Tips:
- Do not take the supply and return air measurements at a return or supply grille.
- Do not allow the iManifold Hygrometers to come into direct contact with condensate or water droplets

Instructions on how to use the iManifold Hygrometers is below:

911-M Thermal Hygrometer

The thermal-hygrometer measures humidity, dry-bulb and wet-bulb temperature. With two humidity sticks and accurate airflow measurements, we can calculate the capacity of an air conditioning system.

Set-up

a. Press the on-off button.
b. Yellow light should be a steady blink if connected.
c. If not connected and needs to be paired. Refer to help videos in iManifold application.
d. Press and hold the button until yellow light stops flashing, to turn the unit off.

With the system in the cooling mode, measure and record the following supply and return air conditions across the cooling coil:

Helpful Tips:

- Get a piece of 3/4" copper 3" long, file one ends until you get it nice and sharp. On duct systems made of fiberglass duct board it is very easy to get your hygrometers dirty really quick and start getting false reading. Use the piece of copper to make the holes using a twisting motion while inserting it into the fiberglass, making a nice clean round hole in the duct. Remove the fiberglass from inside the piece of copper and set aside. Reinsert the copper into the hole using it as a sleeve to insert your hygrometer. The hygrometer never comes in contact with the fiberglass, staying clean at all times and getting better readings and last longer.
- Use the round piece of fiberglass that was cut out and remove from inside the copper to re-plug the holes. Silicone, polyurethane foam will also work as good.

19. **Return Air Dry Bulb Temperature [°F]:** Insert the iManifold Hygrometer into the hole drilled on the return air side of the ductwork. Allow the reading to stabilize and record the dry bulb temperature.
20. **Return Air Wet Bulb Temperature [°F]:** Insert the iManifold Hygrometer into the hole drilled on the return air side of the ductwork. Allow the reading to stabilize and record the wet bulb temperature.
21. **Supply Air Dry Bulb Temperature [°F]:** Insert the iManifold Hygrometer into the hole drilled on the supply air side of the coiling coil. Minimum of 2 feet past the coil for adequate air mixture. Allow the reading to stabilize and record the dry bulb temperature.
22. **Supply Air Wet Bulb Temperature [°F]:** Insert the iManifold Hygrometer into the hole drilled on the supply air side of the coiling coil. Allow the reading to stabilize and record the wet bulb temperature.

Helpful Tip:

The wet bulb temperature should **always** be lower than the dry bulb temperature.

CORRECTIVE MEASURES

Note: *Always shut off the power to the A/C system when performing any corrective measure. Check the box corresponding to the corrective measure performed on the Corrective Measures Tab.*

1. **Clean Condenser Coil:** Professionally cleaning the condenser is required regardless of how it appears. Clean the condenser first to allow it dry while performing other tasks. Program rules require the condenser to be dry of any condenser cleaning agents applied before starting the test out procedure.

Helpful Tip:

When washing out a Micro-Channel type condenser coil it can take in access of 20-30 minutes to completely dry, due to the channel being flat and not allowing water to easily run off. Blowing off the access water with a leaf blower or the blower port of a Wet & Dry Vac will significantly save you time.

2. **Clean Blower Assembly**: Access the blower motor compartment and professionally clean if required.

   Note: *Cleaning is required when the blower assembly is rated at 2 – 5 on the CoolSaver Program's cleanliness scale, meaning that, during the pre-inspection, it was not "very clean." Any blower with dust build-up must be cleaned.*

Practice Good Mechanical Integrity:

- When the Blower assembly is pulled out for cleaning, the blower compartment is easily accessible. With a Wet & Dry Vac clean out all the dirt inside the blower compartment.
- Drain pan and drain line should also be easily accessible. Clean it with the Wet & Dry Vac, as well.

3. **Clean Evaporator Coil:** Access the evaporator coil and professionally clean if required.

   Note: *Cleaning is required when the blower assembly is rated at 2 – 5 on the CoolSaver Program's cleanliness scale, meaning that, during the pre-inspection, it was not "very clean." Any blower with dust build-up must be cleaned.*
4. **Clean Filter:** Check the condition of the air filter then clean or replace, as needed. A clean filter must be installed before the final test is performed.

Practice Good Customer Skills:

- Talk to Customer about how often they change the filters and how they go about changing the filters.
- Educate the customer on the importance of a filter changing routine to the life & efficiency of the equipment.

5. **Adjust Airflow:** Check the air flow after all cleaning is complete. Adjust the airflow according to manufacturer's specifications or to achieve 350-425 CFM/ton. Additional changes to blower motor speed or duct work may be required to achieve proper air flow.

Helpful Tips:

- When lowering the speed on the blower motor to adjust air-blower, may sometimes not be enough, especially when returns are over-sized. The easiest and most efficient way to adjust the CFMs on a system without creating any drain problems is to block-off the air intake at the blower housing.
- When Airflow needs to be increased with a correctly sized return and blower motor on high speed. Adding an extra supply grille outlet with a balancing damper to the main duct plenum will increase CFMs and the balancing damper will allow for proper adjustment of CFMs.
- Advise customer of the issue at hand and how the equipment is low on airflow. Educate customer on the fix and let them know there might be an incurred charge for the fix.
- Take this time to check all electrical connections at the air handler electrical and control box.

6. **Adjust Refrigerant:** Do not adjust refrigerant until all cleaning has been performed and any corrections to air flow have been completed. Utilize the provided target superheat for fixed metering devices (see Cool Saver on computer). You must allow the system to stabilize after each refrigerant charge adjustment (addition or removal) before rechecking the charge again to ensure it is correct. Follow the refrigerant charge adjustment procedure based on the type of refrigerant metering device as shown in Table 3.

Measure Line-set: Measure and record line-set height difference between the Condenser and Evaporator as well as the entire length of line-set.

Table 3: Refrigerant Charge Adjustment

Refrigerant Metering Device	
Fixed Orifice or Capillary Tube	TXV (Thermostatic Expansion Valve)
1. Check superheat	1. Check subcooling
2. Add/Remove refrigerant to bring superheat to manufacturer's recommended specification or within +/-5°F of the target value.	2. Add/Remove refrigerant to bring sub-cooling to manufacturer's recommended specification or within +/-5°F of the target value.
3. Record any changes to the refrigerant charge on the corrective measures tab	3. Record any changes to the refrigerant charge on the corrective measures tab

7. **Additional Measures:** Additional corrective measures recommended by the program but not required include the following:
   - Check thermostat operation
   - Check condensate removal
   - Check line set pressure drops
   - Seal leaky ducts
   - Repair kinked or crushed ducts
   - Install new split or packaged unit
   - Install larger or additional return/supply grilles
   - Remove excess flex duct length
   - Install new indoor coil
   - Replace transition to coil
   -

TEST OUT PROCEDURES

Test Out: The Test Out (TO) procedure requires measurements that are used to determine the performance characteristics of the cooling system after all corrective measures have been implemented. The procedure will determine the system's new cooling capacity and energy efficiency ratio (EER) resulting from the corrective measures. Make sure the cooling system has stabilized before beginning the test out procedure.

Air Flow: Program requirements are to use the same air flow method and instruments as used during test in.

Air Flow Power Consumption: With the cooling system on, measure and record the blower voltage and current. If you have a three phase system, record the voltage L1-L2, L1-L3, L2-L3 and the current of each leg.

Supply and Return Air Conditions: Take the test out supply and return air conditions at the same location used during the test in procedure. **Do not allow the iManifold Hygrometers to come into direct contact with condensate or water droplets.** With the system in the cooling mode, measure and record the following supply and return air conditions across the cooling coil:

1. **Return Air Dry Bulb & Wet Bulb Temperatures [°F]:** Insert the iManifold Hygrometer 911-M into the hole drilled on the return air side of the coiling coil. Allow the reading to stabilize and record the dry bulb & wet bulb temperatures.
2. **Supply Air Dry Bulb & Wet bulb Temperatures [°F]:** Insert the iManifold Hygrometer 911-M into the hole drilled on the supply air side of the coiling coil. Allow the reading to stabilize and record the dry bulb & wet bulb temperatures.

Condenser and Compressor Measurements: Proceed to the location of the condenser and compressor. Record the following information:

1. **Compressor Volts:** With the system in cooling mode, measure the voltage of the circuit supplying the compressor and condenser fan using a digital multi-meter.
2. **Compressor Current:** With the system in cooling mode, measure the current of the circuit supplying the compressor and condenser fan using a digital multi-meter.
3. **Ambient Air Dry Bulb Temperature:** Measure the dry bulb temperature using the same guidelines and procedures as test–in.

Information from Refrigerant Analyzer: With the cooling system stabilized and running, use a digital refrigerant analyzer to measure and record the following information:

1. **Suction Pressure [PSI]:** Measured at the low-pressure side of the system extending from the outlet of the refrigerant control device, through the evaporator, and to the inlet valve of the compressor.
2. **Discharge Pressure [PSI]:** Measured at the high-pressure side of the system extending from the outlet of the compressor, through the condenser, and to the inlet of the refrigerant control device.
3. **Evaporator Temperature [°F]:** The temperature corresponding to the suction pressure that results in the phase change of the refrigerant from liquid to vapor. The evaporator temperature is calculated by the digital refrigerant analyzer using the suction pressure measurement.
4. **Condenser Temperature [°F]:** The temperature corresponding to the discharge pressure that results in the phase change of the refrigerant from a vapor to a liquid. The condenser temperature is calculated by the digital refrigerant analyzer using the discharge pressure measurement.
5. **Vapor Line Temperature (VLT) [°F]:** Measured by clamping the digital refrigerant analyzer temperature probe to the vapor line. The vapor line is also commonly referred to as the suction line.
6. **Liquid Line Temperature (LLT) [°F]:** Measured by clamping the digital refrigerant analyzer temperature probe to the liquid line. The liquid line is also commonly referred to as the discharge line.
7. **Superheat [°F]:** The temperature corresponding to the number of degrees the refrigerant vapor is above its boiling temperature as a liquid at that pressure. The digital refrigerant analyzer calculates the superheat based on other measurements input. Typically used to evaluate the refrigerant charge on cooling equipment using fixed orifice or capillary tube refrigerant control devices.
8. **Subcooling [°F]:** The temperature corresponding to the number of degrees the liquid refrigerant has been cooled below its condensing temperature for that pressure. Typically used to evaluate the refrigerant charge on cooling equipment using TXV refrigerant control devices.
9. **Technician Notes:** If any measured performance value is determined abnormal, check instrument deployment and read value again. If verified that the abnormal value is actual, provide explanation for this abnormal value in the Technician Notes box.

Additional information to collect prior to submittal:

1. **Technician Notes**- Explanations for system operating out of normal range and additional system repairs

2. **Customer Signature**- A customer signature is required

CLEAResult iManifold Modeled Tune-up Procedure

A Modeled Tune-up verifies that the Blower is Clean, the Evaporator is Clean, the Condenser is clean, the Airflow is adjusted to the proper CFM/ton, and the Refrigerant is adjusted properly for optimal system performance.

1. **Turn System on to make sure everything operates**
2. **Check refrigerant level versus superheat or sub cooling per charging charts**
   - If refrigerant needed exceeds one pound, speak with customer concerning additional charges. If customer declines additional refrigerant perform M&V tune-up
3. **Perform Professional Cleanings/Condenser/Evaporator/Blower**
4. **Clean / Change Filter**
5. **Set up project on the iManifold CoolSaver app.**
6. **Profile system**
7. **Deploy Dry Bulb/Wet Bulb Probes in Return and Supply.** Do not record at this time.
8. **Measure and record # of Returns and size of each**
9. **Measure airflow with Vane Anemometer or Static Pressure**
10. **Adjust/Verify Airflow to proper CFM/Ton**
11. **Record Blower Volts & Amps**
12. **Hook up iManifold refrigerant analyzer to the condenser.**
13. **Deploy Outdoor Dry Bulb/Wet Bulb Probe in shaded area**
14. **Adjust/Verify Refrigerant. Weigh in and out. Record**
15. **Allow system to stabilize after charge adjustment.**
16. **Record Condenser Volts & Amps into the app.**
17. **Verify system operation in the system performance tab make any necessary final adjustments if needed before Test-out snapshot.**
18. **Proceed to take a Test-out snapshot.**
19. **Review Test-out snapshot and address any warning flags before moving forward.**
20. **Reset the thermostat back to the customers set temperature setting.**
21. **Continue to complete the field review and customer tabs in the app.**
22. **Complete invoice tab, review tune-up with customer and have them sign the invoice.**
23. **Send completed tune-up data.**
24. **Provide customer with leave behind form**
25. **Provide customer with any recommendations for HVAC unit**

Helpful Tip:

Remember that all components must be in **stellar condition**. The CoolSaver Program will inspect for a professionally clean blower, evaporator coil and proper refrigerant charge.

Each modeled tune-up indicates that this unit is operating at its best capacity.

Tune-up Technician Guide

Performance Data Normal Parameters and Troubleshooting

Test In or Test Out capacity is greater than the system tonnage

- Re-check indicated tonnage in unit mod# or compressor mod#
- Re-check number of return air grilles, size and face velocity (airflow method #1)
- Re-check blower volts, amps and static pressures (airflow method #2)
- Re-check deployment of wet bulb/dry bulb sensors

Test In or Test Out latent capacity is negative

- Re-check deployment of wet bulb/dry bulb sensors

Superheat is higher than normal

- System may be undercharged
- Liquid line may be excessively long, routed through hot attic or restricted at a filter/ dryer, metering device or line kink
- TXV failed to close due to loss of charge in sensing bulb

Superheat is lower than normal or zero

- Usually caused by low airflow across evaporator coil
- Check for blocked return air grilles, dirty air filter, dirty evaporator coil, undersized return air duct or grilles, closed supply air registers, worn blower drive belt, belt tension or incorrect blower motor speed selection
- System may be overcharged
- TXV failed to open or sensing bulb not attached to suction line securely

Subcooling is higher than normal

- Outdoor ambient temperature low, condenser coil wet or system overcharged

Subcooling is lower than normal

- High outdoor ambient temperature, condenser coil dirty or system undercharged

Lower EER or capacity result at Test Out

- Re-check deployment of wet bulb/dry bulb sensors
- Re-check number of return air grilles, size and face velocity (airflow method #1)
- Re-check blower volts, amps and static pressures (airflow method #2)
- Check that airflow increased as the result of cleaning the evaporator, air filter and any other airflow improvements
- Make sure that blower volts and amps were measured with consistent technique and location
- Make sure the system is operating at 100% capacity, all stages of cooling engaged

Performance Data Normal Parameters

If system performance is outside the parameters below, note the reason for the variance.

Superheat

- 5 to 10°F within target
- Cannot be negative

Subcooling

- 3 to 5°F within manufacture recommendations
- Cannot be negative

Capacity

- Sensible and latent capacities should not be negative
- Total capacity should increase as a result of system cleaning and improvements
- Test Out capacity should approximate the indicated system tonnage

Airflow

- Test Out airflow should increase as a result of system cleaning and improvements
- System airflow should approximate 340 to 460 cfm per ton of rated cooling capacity

EER

- Test Out EER should increase as a result of system cleaning and improvements
- Test In and Test Out EER should not be substantially greater than the manufacturer's design specifications
- Must be greater than 1.00

Refrigerant operating pressures

- R22 (Low 58psig to 85psig) (High 170psig to 350psig)
- R410A (Low 102psig to 155psig) (High 275psig to 500psig)
- Wet bulb temperatures can never be greater than dry bulb temperatures
- Superheat and subcooling can never be negative
- Liquid line temperature should never be less than the ambient temperature
- Always allow a minimum of 5 minutes of system operation for stabilization before recording performance data. Also, never allow excessive operation that will result in the abnormal reduction of heat load in the conditioned space
- If system has been off and conditioned space temperature is excessive, allow system to operate until space temperature is below 80 degrees before performing Test In or Test Out

Instrument Deployment Reminders

- Refer to sections below to eliminate deployment issues when instrument readings and TI or TO output fields violate the normal guidelines
- Check operation and calibration of instruments frequently as demonstrated in training

Digital Hygrometers (Wet bulb/Dry bulb)

- Dust cover is open and sensor mirrored surface is directed into the airflow
- Supply air preferred location is in plenum or supply duct as close to unit as possible but must maintain at least 10’ distance from evaporator (but not within 4” of the plenum wall). When this location is not possible locate the nearest supply register to the unit and install so sensor extends into the register. Do not lay across the surface of the supply register
- Return air preferred location is in heat exchange blower cabinet for gas furnaces and return duct or plenum far enough from evaporator coil to prevent sensing moisture.
- Seal duct opening around sensor so ambient air is not pulled in around sensor & does not foul the reading
- Be careful not to record the displayed %RH from this instrument as though it were a temperature

Digital Manometer (Blower static pressure)

- Calibrate to atmospheric pressure before each measurement, with tubes disconnected and ports open by bumping the button with the white triangle
- Position probes to point into the airflow at blower inlet and outlet
- Record all decimal places; do not round the displayed value

Ammeter

- Position wire at a right angle between lines on the ammeter jaws
- Use the lowest range and record all decimal places; do not round the displayed value
- Avoid proximity to transformers, relay/contactor coils and motors
- Blower amps must be measured with blower panels on so air does not bypass the return duct system

Voltmeter

- Take measurements line-to-line on 3 phase equipment and line to ground on single phase equipment.
- Blower voltage and condensing unit voltage must be measured with panels in place so air does not bypass its normal intended pathway
- Use the lowest range and record all decimal places, do not round the displayed value

Digital Vane Anemometer

- Traverse rate of about 4 seconds per foot
- Position 3/8 to 1/2 inch from return grille surface and traverse only the louvered area
- Allow prop to stabilize speed in position before starting traverse
- Do not remove away from grille until traverse and timer are stopped

Refrigerant Analyzer Temperature Probes

- Avoid suction line within 6” of compressor and position away from direct sunlight
- Purge refrigerant analyzer lines
- Double check refrigerant setting
- Make sure liquid line sensor is not installed on similarly sized discharge line
- Dedicate ports to clamps (Port 1 vapor line/suction line) (Port 2 liquid line)

Acronyms

EVAP- Evaporator

DP- Discharge Pressure

LLP- Liquid Line Pressure

SP- Suction Pressure

VLP- Vapor Line Pressure

Temp- Temperature

ET- Evaporator Temp

CT- Condenser Temp

T1/SLT/VLT- Suction/Vapor Line Temp

T2/LLT- Liquid Line Temp

SH- Superheat

SC- Subcooling

EEV- Electronic Expansion Valve

TXV-Thermostatic Expansion Valve

FFU- Field Follow Up

ODA- Outside Ambient Temperature

WB- Wet Bulb

DB- Dry Bulb

RCA- Refrigerant Charge Adjustment

GRD- Ground

RAWB- Return Air Wet Bulb

RADB- Return Air Dry Bulb

SAWB- Supply Air Wet Bulb

SADB- Supply Air Dry Bulb

SEER- Sessional Energy Efficiency Ratio

EER- Energy Efficiency Ratio

PSC- Permanent Split Capacitor

ECM- Electronic Commutated Motor

Δ**T**- Delta Temp (Change in Sensible Temp)

REP- Retail Electric Provider

CFM- Cubic Feet per Minute

L1- Line One **L2**- Line Two **L3**- Line Three

QB- QuickBase

PCG- Package Unit

RTU- Roof Top Unit

<- Less Than

>- More Than

CoolSaver Technical Support

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2024 CoolSaver A/C Tune-up

iManifold Toolkit & Application Manual

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CLEAResult®

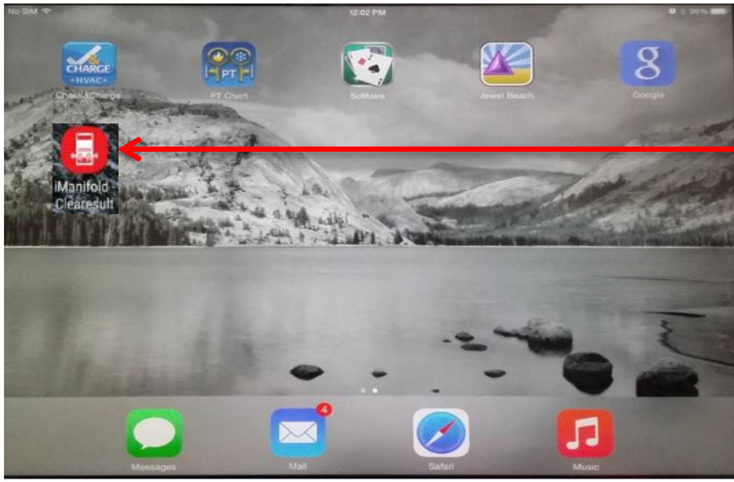
Introduction

- The purpose of this document is to outline the workflow that a technician will follow to gather data and submit a project using the CLEAResult Plugin Application.

- The CLEAResult Application is intended to be used exclusively with the iManifold and associated probes and sensors, collectively called the "CoolSaver Toolkit".

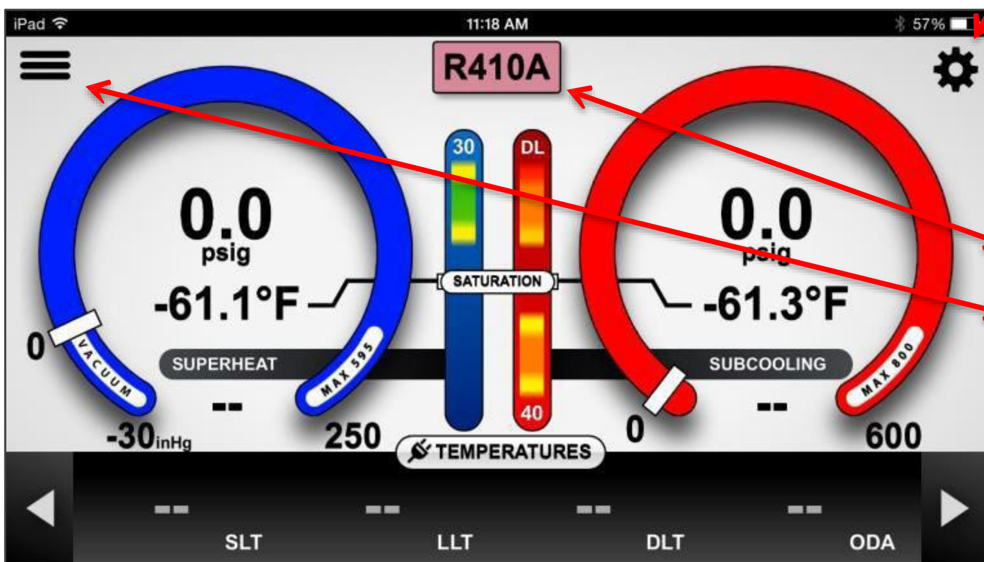
- This presentation does not include actions required to download the iManifold application or sync probes and sensors.

Getting Started



How to get started:

1. Download the iManifold app from the Apple App Store or Google Play Store
2. Tap the iManifold app icon ( )

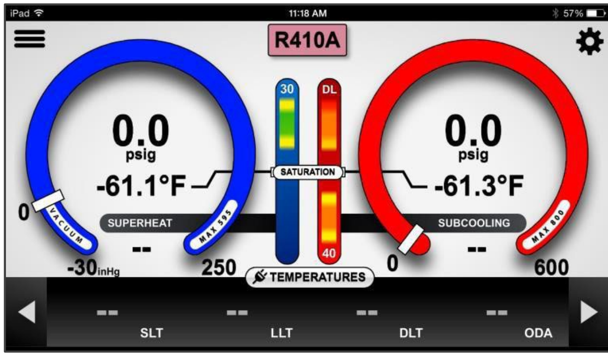


Navigating inside the app:

1. Settings ( ) gear icon
   - Connect to iManifold
   - Tech Connect
   - Tools (trouble shooting, multi-circuit)
   - Settings
2. Refrigerant identification
3. Menu ( ) icon
   1. Equipment Profiling
   2. User Inputs
   3. System Performance
   4. Reporting (new projects)

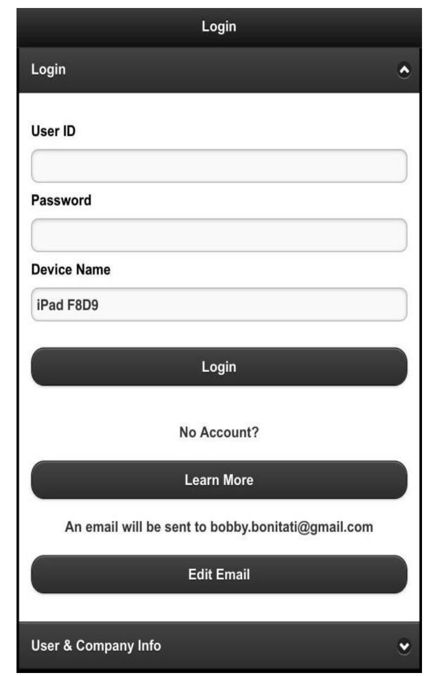
CLEAResult®

Account Login



Log into your iCloud account:

1. Click on gear icon ( )
2. Click on **Account**
3. Enter your **User ID** and **Password**
   - Provided by CLEAResult

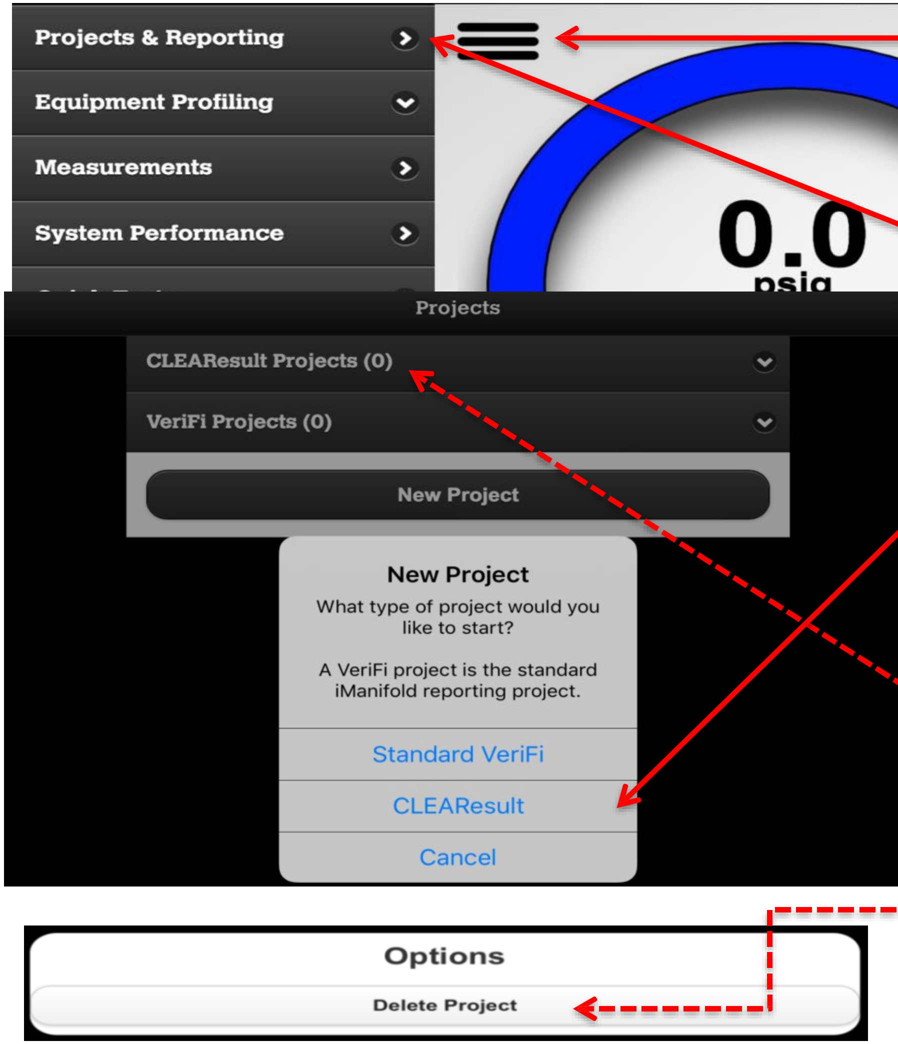


Notes:

- CLEAResult plug in access is managed by the CLEAResult Program.
- Uninstalling the iManifold app will erase all data stored on the device and will require a user to re-log into their account again.
- If a user is past their quota of number of active login attempts, a user can manage their devices from the **Account** screen under **Settings**.

CLEAResult®

Access CLEAResult Application



Getting started:

1. On the Main Screen, tap the **MENU** button (top left)
2. Select **Projects & Reporting**

Projects:

Start a new project by

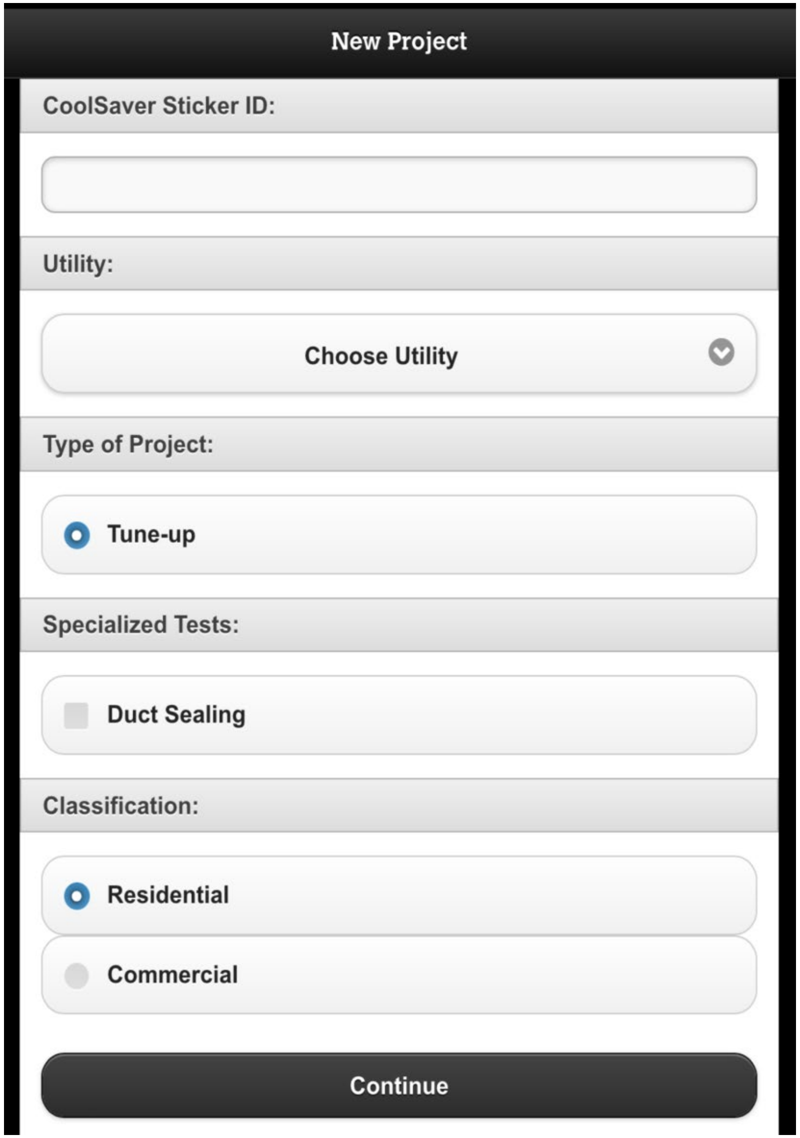
1. Selecting **New Project/CLEAResult** **for a Utility funded project.**

Notes:

1. If there are existing projects, you can reopen them by tapping on the CLEAResult(0).
2. The button allows further actions to be completed on that project.

CLEAResult®

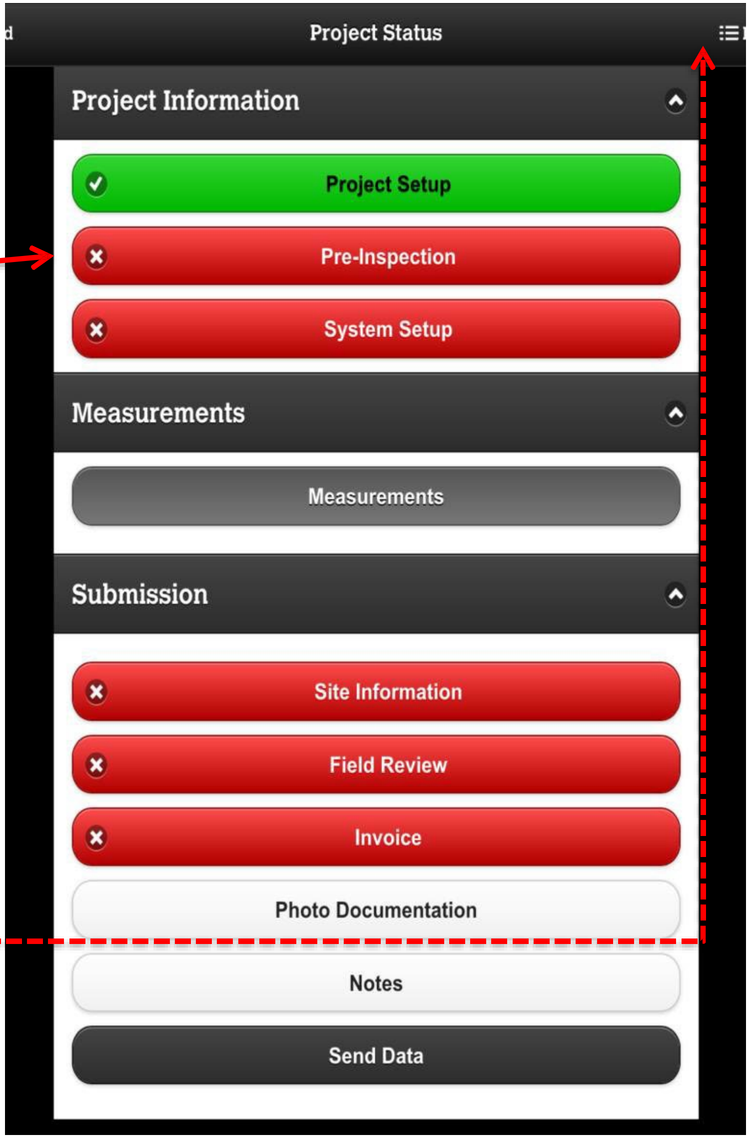
Project Setup



After selecting CLEAResult:

1. Enter a **CoolSaver Sticker ID**
    - This is the name that will show up in the Projects List for later reference and be on the Condenser Sticker.
2. Choose **Utility**
3. Choose **Type of Project**
    - Tune-Up/ER/ROB
4. Specialized Tests
    - Duct Sealing
5. Classification – Res/Com – refer to Resource Book
6. Enter an **Enrollment ID**
7. Tap **Continue**

Action: To begin the Project workflow:
<u>Tap Pre-Inspection</u>



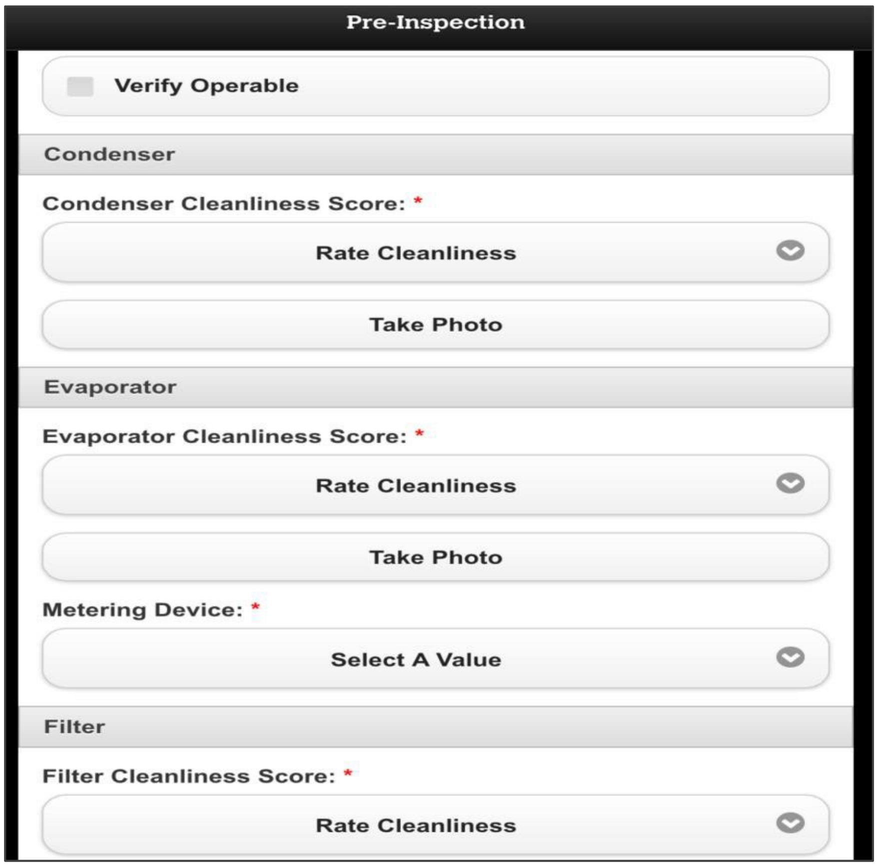
Notes about the Project Status screen:

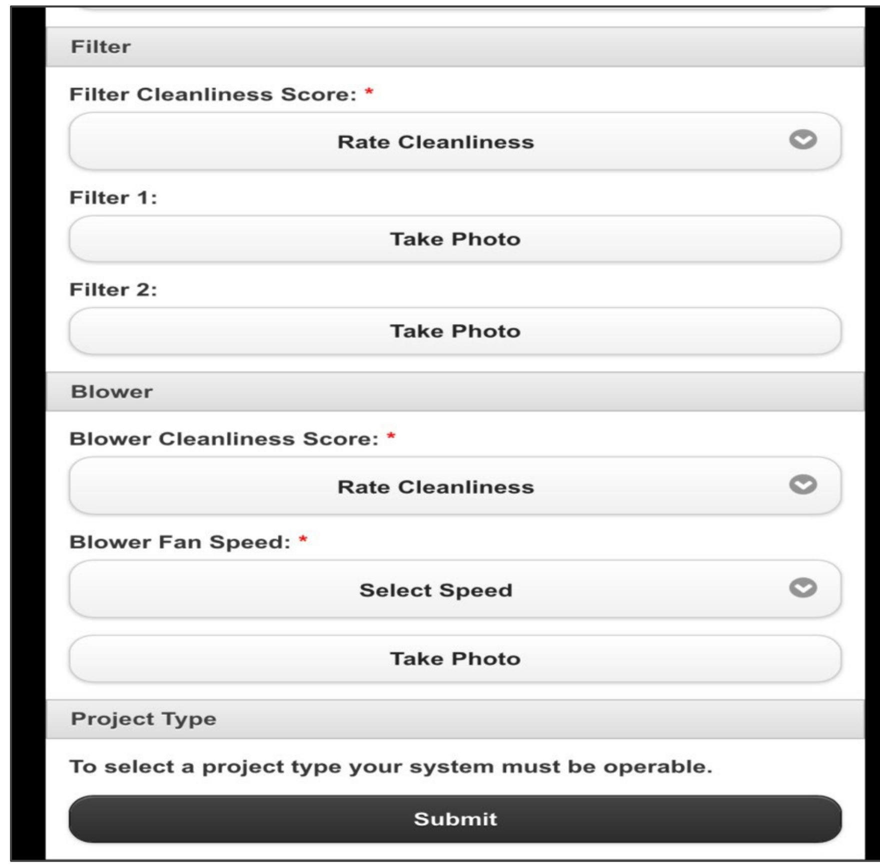
- This is the Active screen that opens when the **Reporting** tab is selected from the **Main Screen**.
- This **Project Status** screen is *meant to be done in order* (from top to bottom).
- To view a list of projects or start a new project, tap the Exit **Projects** button.

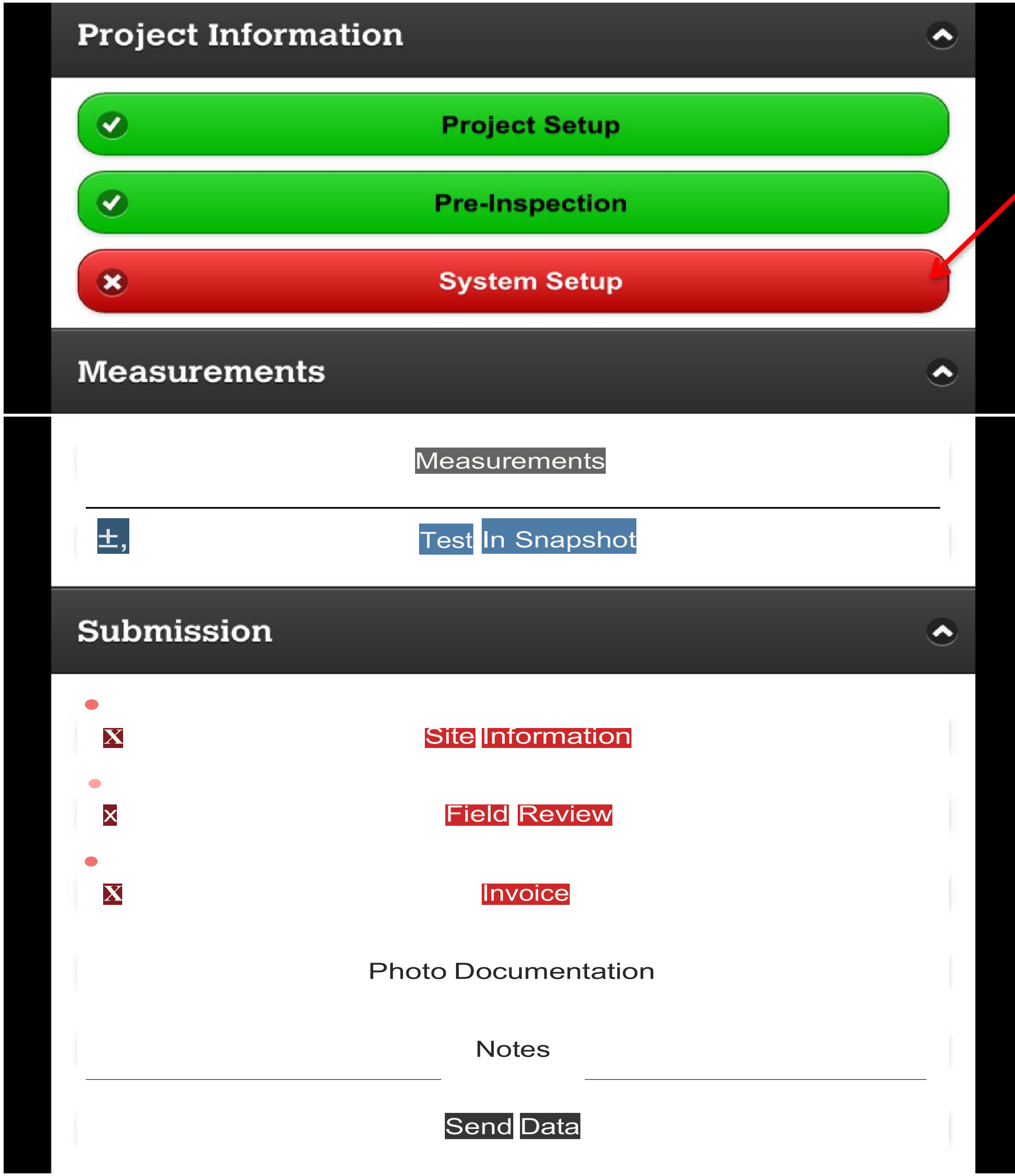
Action for Pre-Inspection:

*Verifiable Operable – unit must be in working order for a CLEAResult A/C tune-up

1. Rate Cleanliness 1-5 – 1 being clean 2 and above needs to be cleaned.
2. Photo's are required for all not being preformed due to Access or that cleaning may cause inoperable damage.
3. Upon completion of this section tap submit to proceed.

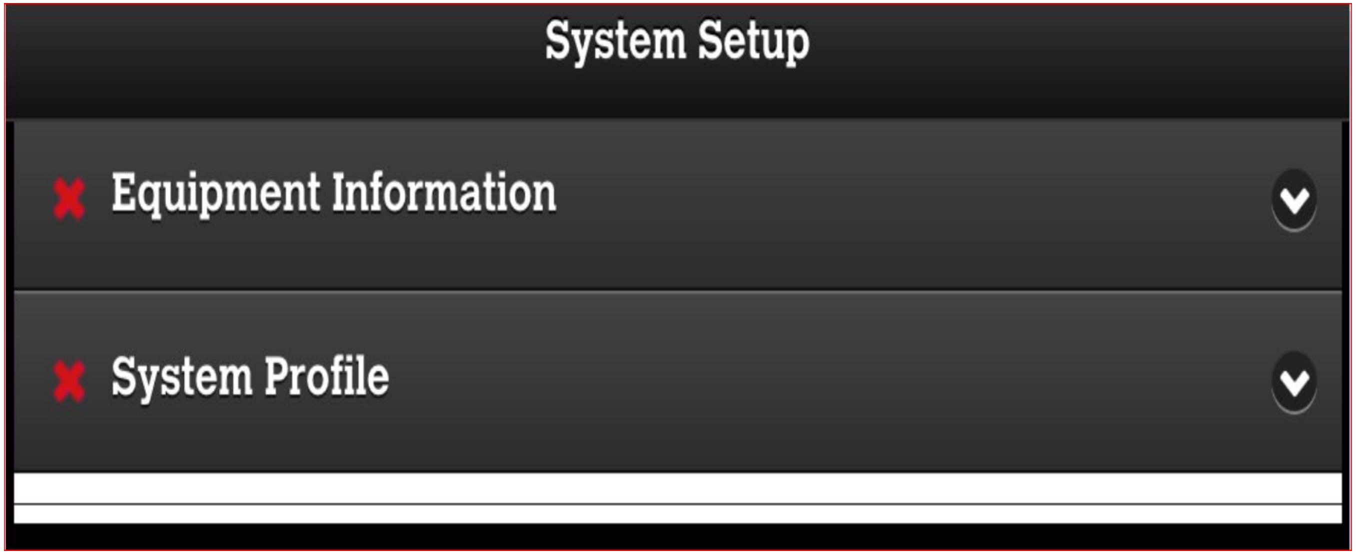






System Setup

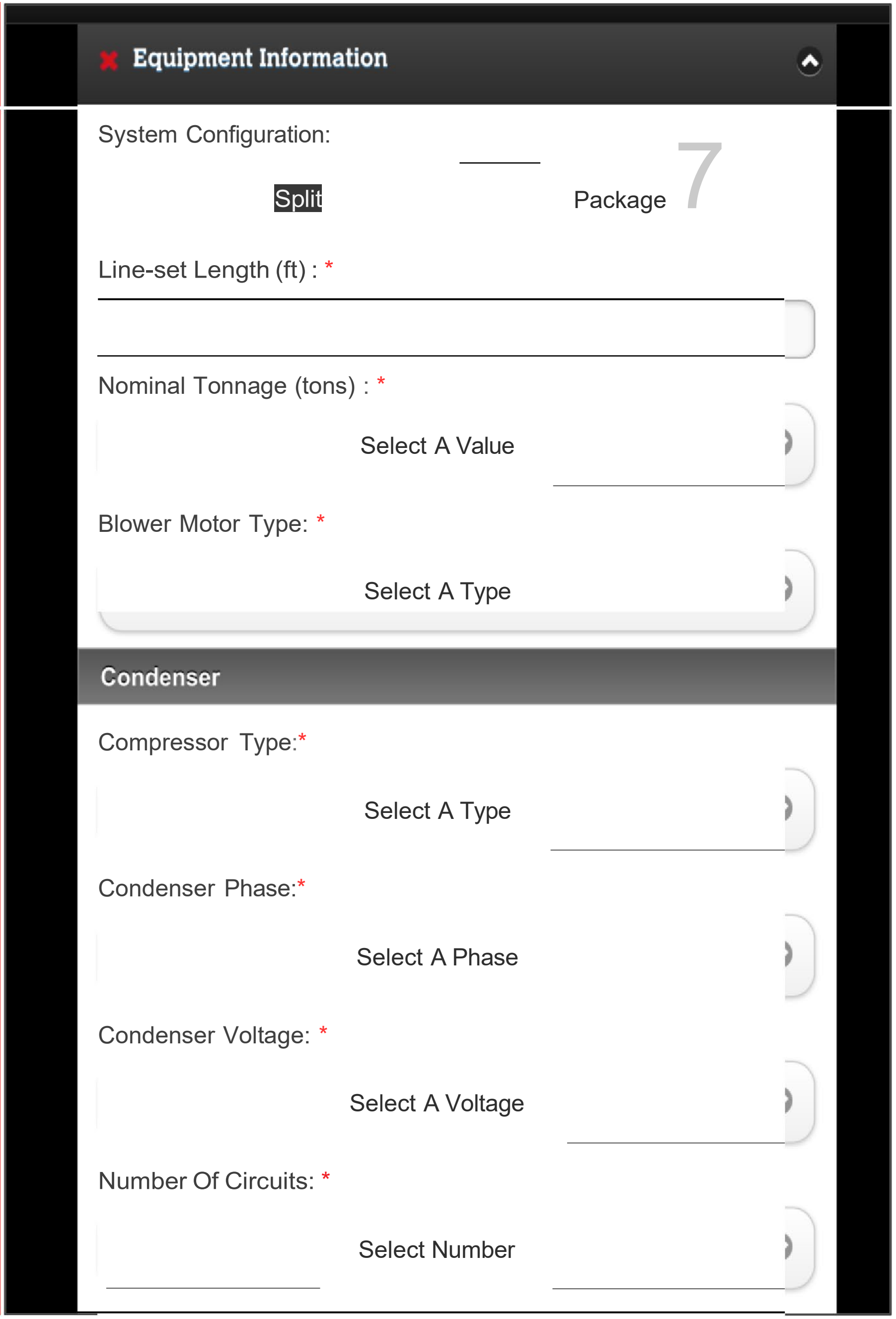
Tap on System Setup

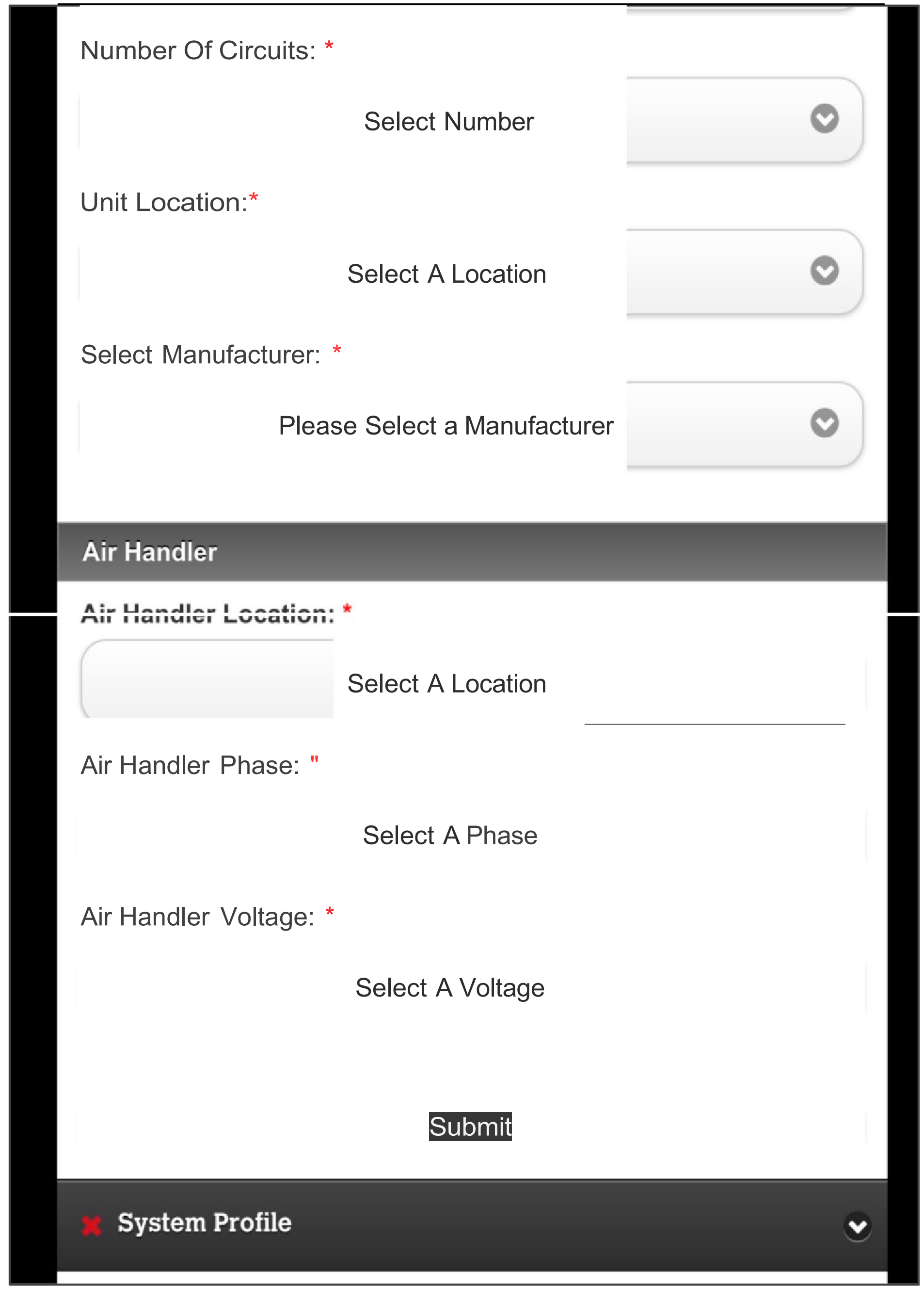


System Setup:

Tap on Equipment Information – fill out the information completely tap submit and this will bring you back to the System Setup page.

Then Tap System Profile - and fill out the information as well.


Equipment Information
System Configuration:
Split
Package
7
Line-set Length (ft) : *
Nominal Tonnage (tons) : *
Select A Value
Blower Motor Type: *
Select A Type
Condenser
Compressor Type:*
Select A Type
Condenser Phase:*
Select A Phase
Condenser Voltage: *
Select A Voltage
Number Of Circuits: *
Select Number


Number Of Circuits: *
Select Number
Unit Location:*
Select A Location
Select Manufacturer: *
Please Select a Manufacturer
Air Handler
Air Handler Location: *
Select A Location
Air Handler Phase: "
Select A Phase
Air Handler Voltage: *
Select A Voltage
Submit
System Profile

System Profile

Refrigerant: *

Select A Value

System Type: *

Select A Value

Metering Device:*

Standard TXV

Head Pressure Controls:

None

Condenser Type: *

Select A Value

Evaporator Type: *

Select A Value

Charge Method: *

Select A Type

System Profile

Refrigerant: *

R22

System Type: *

Air Conditioning

Metering Device: *

Fixed Orifice

Head Pressure Controls:

None

Condenser Type: *

High Efficiency (13-16 SEER)

Evaporator Type: *

Standard Efficiency DTD = 35°F

Charge Method:*

CLEAResult Target SH/SC

Metering Device:*

Standard TXV

Head Pressure Controls:

None

Condenser Type: *

Select A Value

Evaporator Type: *

Select A Value

Charge Method:*

Select A Type

Superheat Target: *

Subcooling Target: *

Submit

Metering Device: *

Fixed Orifice

Head Pressure Controls:

None

Condenser Type: *

High Efficiency (13-16 SEER)

Evaporator Type: *

Standard Efficiency DTD = 35°F

Charge Method: *

CLEAResult Target SH/SC

Superheat Target: *

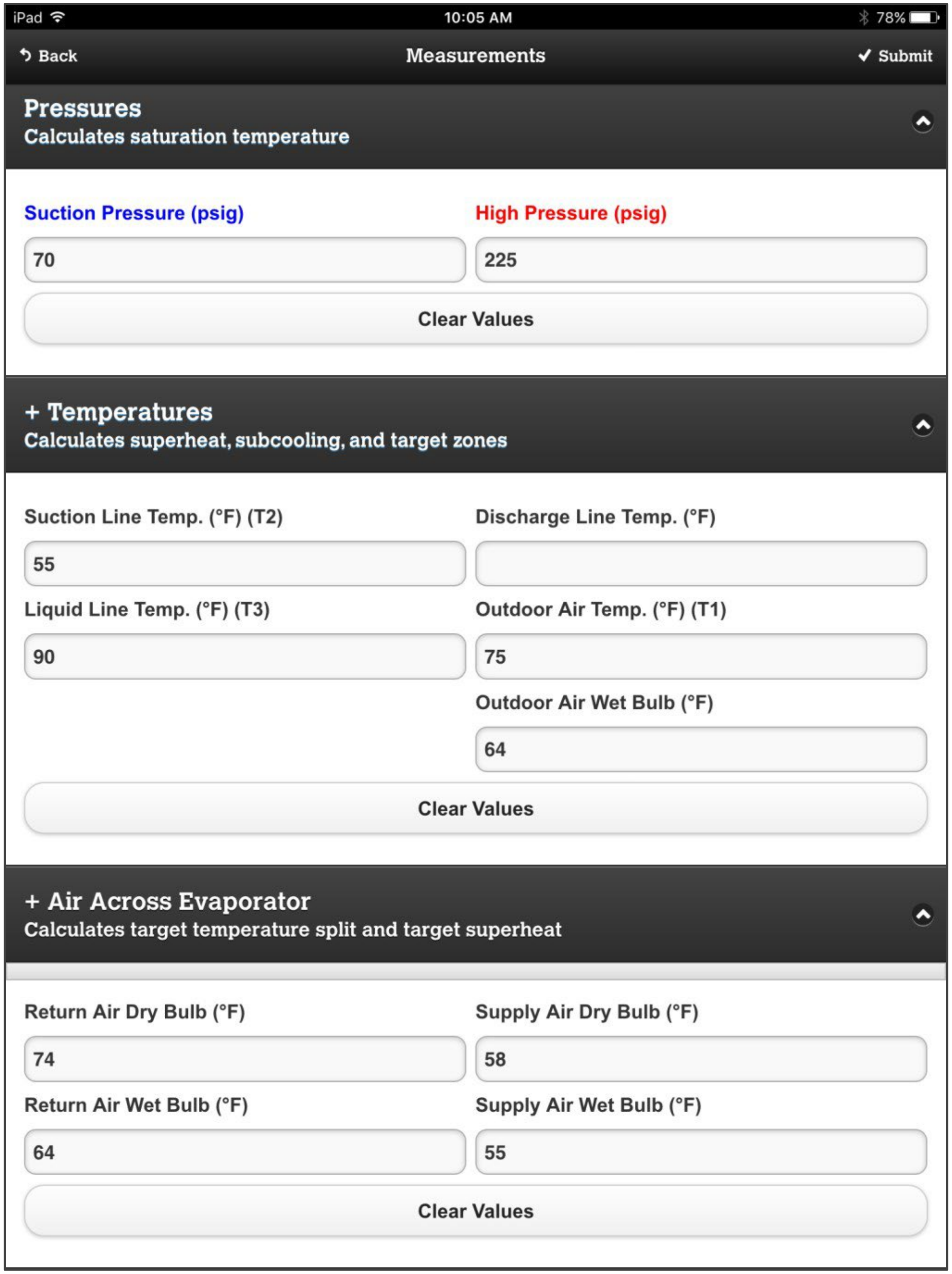
(Auto Calcula d

Subcooling Target: *

15

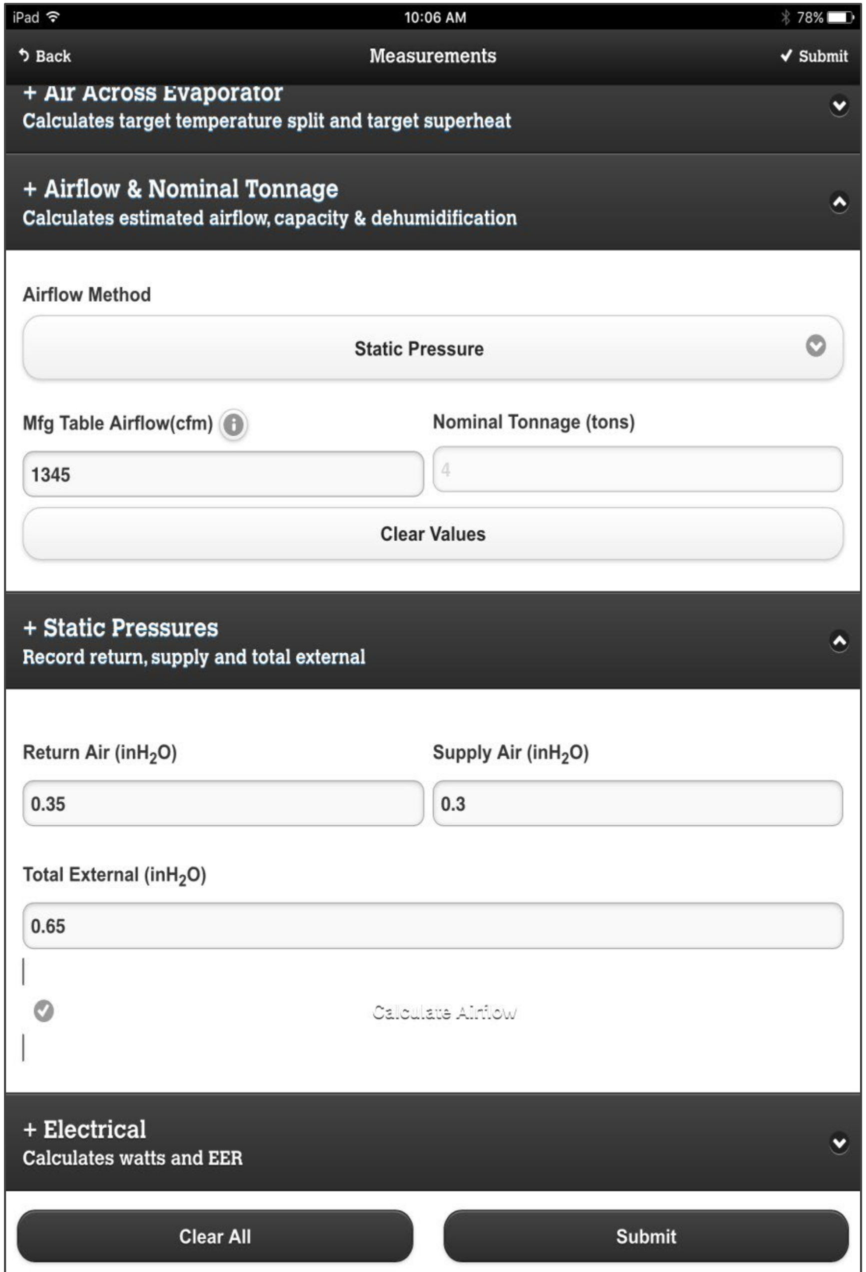
Submit

After both the System Setups have been completed and submitted, both of the tabs should have a green check mark beside them indicating they have been completed correctly. If there is missing information the application will prompt you to complete the information.



Measurements:

*With proper communication these measurements should be populated via the ZigBee mesh network.



Airflow Method's

1. Static Pressure
2. Vane Anemometer
3. Temperature Rise (Furnace)
4. Temperature Rise (Electric)
5. True Flow Meter

With the iMperial manometer measurements will come in live with your ZigBee network.

With all other approved manometers, photos and manual entries will need to be done, for test in and out.

Refer to training manual "Airflow Measurements Methods" section for operating instructions on manometers & vane anemometer.

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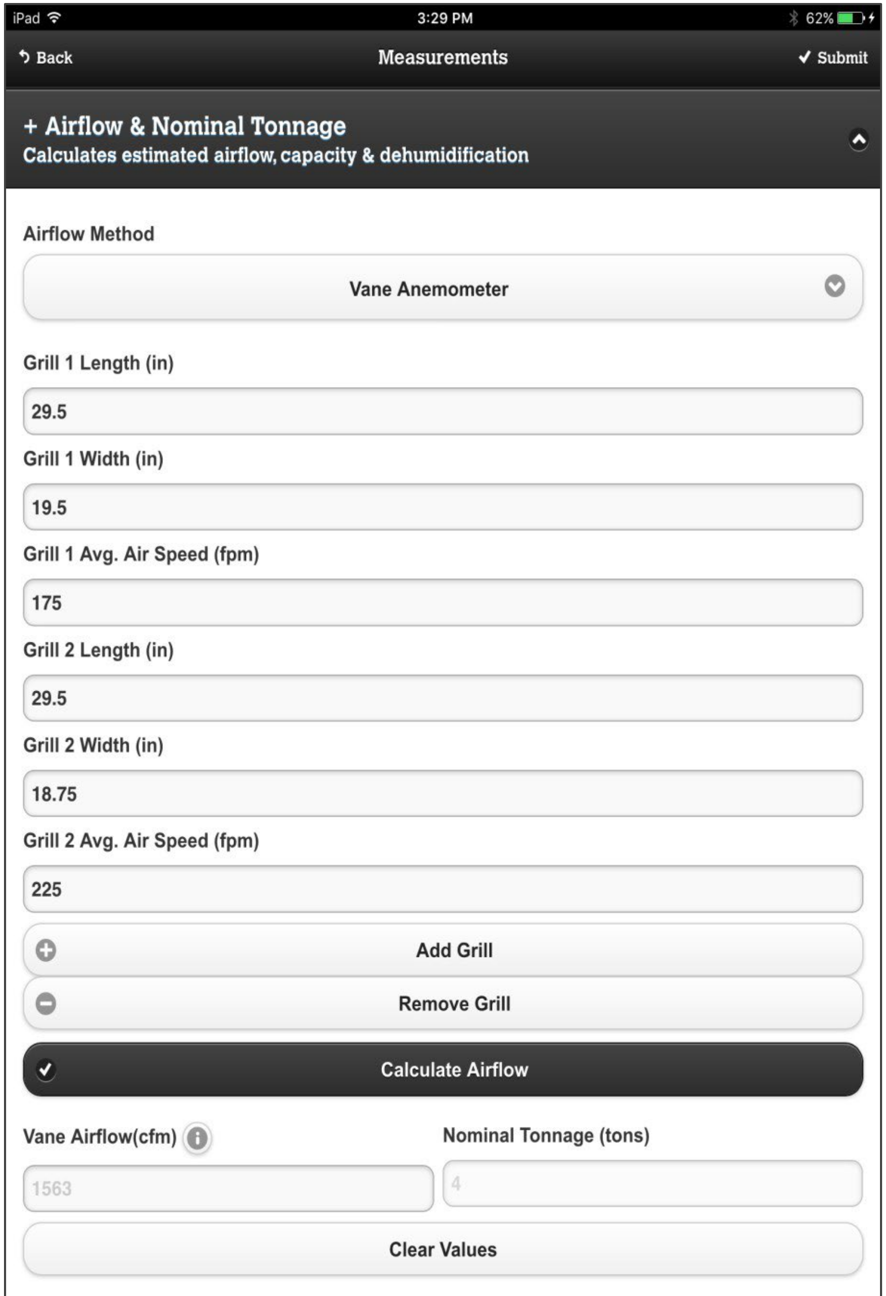

With an approved Vane Anemometer
*Select – Vane Anemometer
Enter measurements less the frame for length and width. Make sure to measure all return grills that are attached to the system being tested. Then enter the FPM (Feet Per Minute), tap the Calculate Airflow button to get the total CFM up to 4 return grills.

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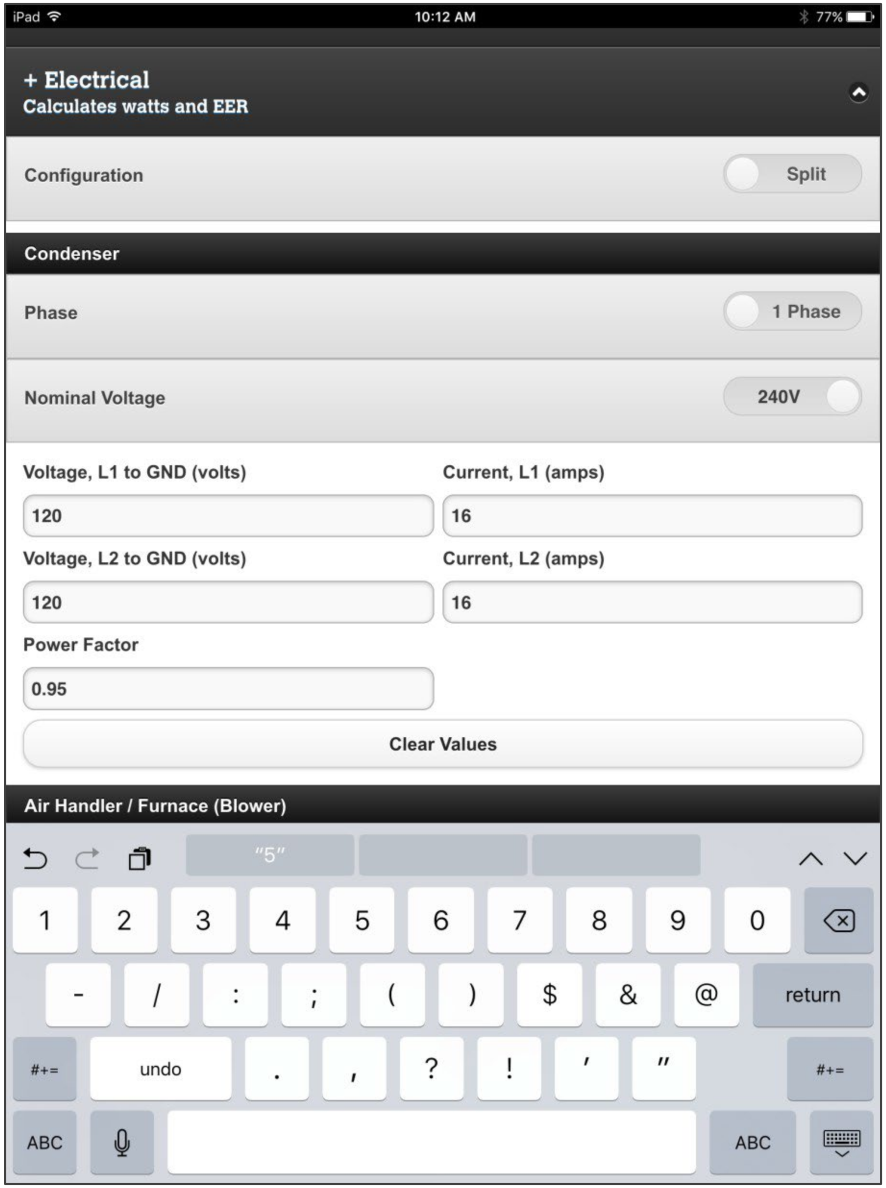
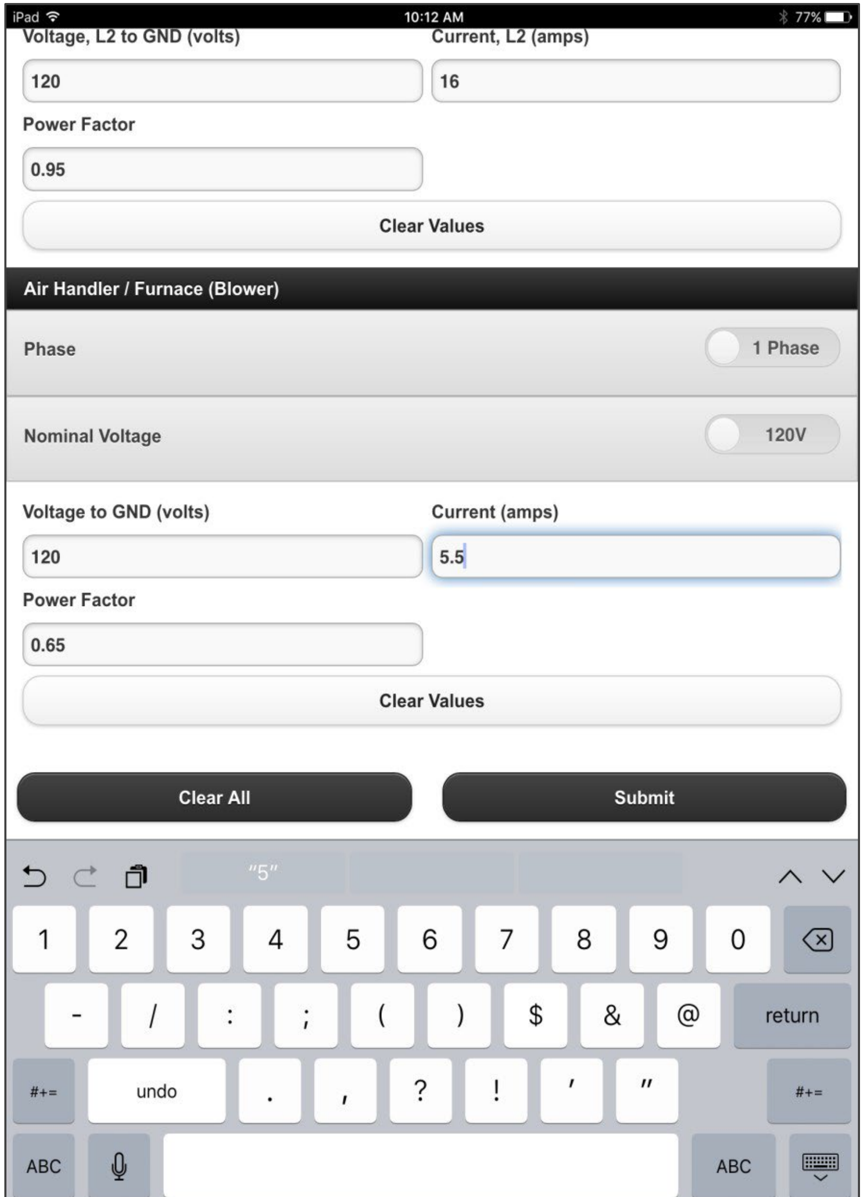
Electrical Measurements Condenser:



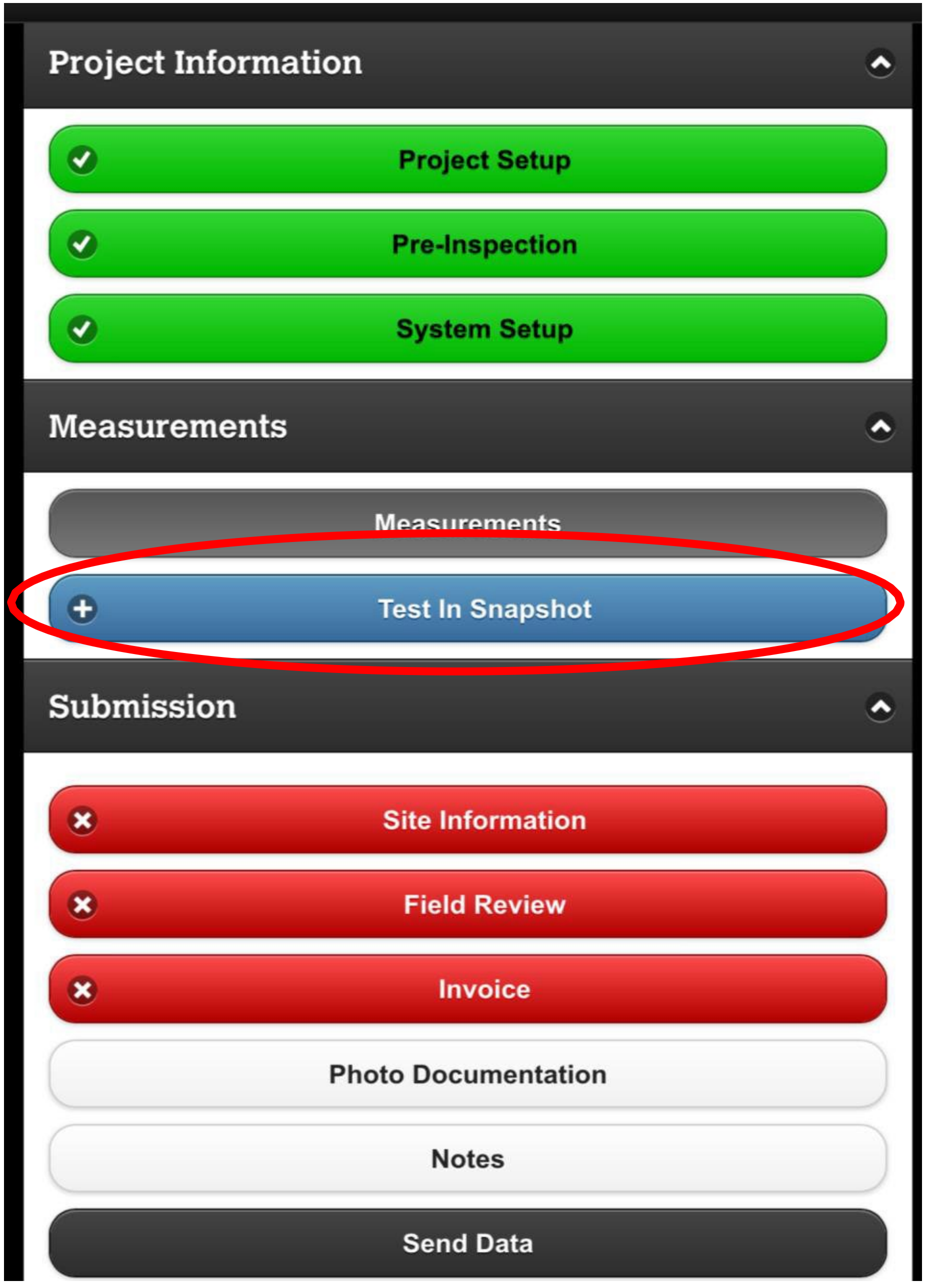
- Single & Single Split – are measured from line to ground and the amperage measurement is taken on each hot leg coming from the disconnect box.
- Three Phase measurements are from Line to Line with amperage measurements from each hot leg coming from the disconnect.

NOTE:
If you are at the indoor unit, you can skip to the Air Handler section to input electrical measurements.

Electrical Measurements Indoor Fan Motor (IFM)



- Single & Single Split – are measured from line to ground and the amperage measurement is taken on each hot leg coming from the load panel.
- Three Phase measurements are from Line to Line with amperage measurements from each hot leg coming from the load panel



Once all of the measurements have been transmitted in and others manually entered, you are ready to take your Test In (TI) Snapshot. If you take the snapshot before this time the snapshot tab will turn red indicating a hard stop and will not continue until measurements have been entered correctly and a new TI has been taken. When the snapshot turns green make sure to review the Review Test In Snapshot. Anything in yellow will need repaired or adjusted to specifications. If it is limited and further adjustments can not be made before Test Out (TO), take photos and make sure an explanation is provided within the tune ups note section.

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These must be done before making a Refrigerant Charge Adjustment.
Start by following the SOW and then tap the Cleaning & Modification and the Airflow buttons.

See the next slides for needed information

10:54 AM

Corrective Measures

Cleaning & Modifications

Condenser

Did you clean the condenser? *

Select An Answer

Did you repair any bent fins? *

Select An Answer

Condenser **After** Photo:

Take Photo

Evaporator

Did you clean the evaporator? *

Select **An Answer**

Evaporator After Photo:

Take Photo

Additional services needed to access system for cleaning declined

Select An Answer

Condenser After Photo:

Take Photo

Evaporator

Did you clean the evaporator? *

Select An Answer

Evaporator After Photo:

Take Photo

Additional services needed to access system for cleaning declined

Filter

Did you clean or replace the filter? *

Select An Answer

Filter After Photo:

Take Photo

Filter 2 After Photo:

Corrective Measures

Condenser

Did you clean the condenser? *

Yes

Did you repair any bent fins?*

No

Condenser After Photo:

Take Photo

Evaporator

Did you clean the evaporator? *

No

Reason evaporator wasn't cleaned:*

Training

Evaporator After Photo:

2/22/201610:SSam

Take Photo

Evaporator

Did you clean the evaporator?*

No

Reason evaporator wasn't cleaned: *

Training

Evaporator After Photo:

2/22/2016 10:55am

rJ Additional services needed to access system for cleaning declined

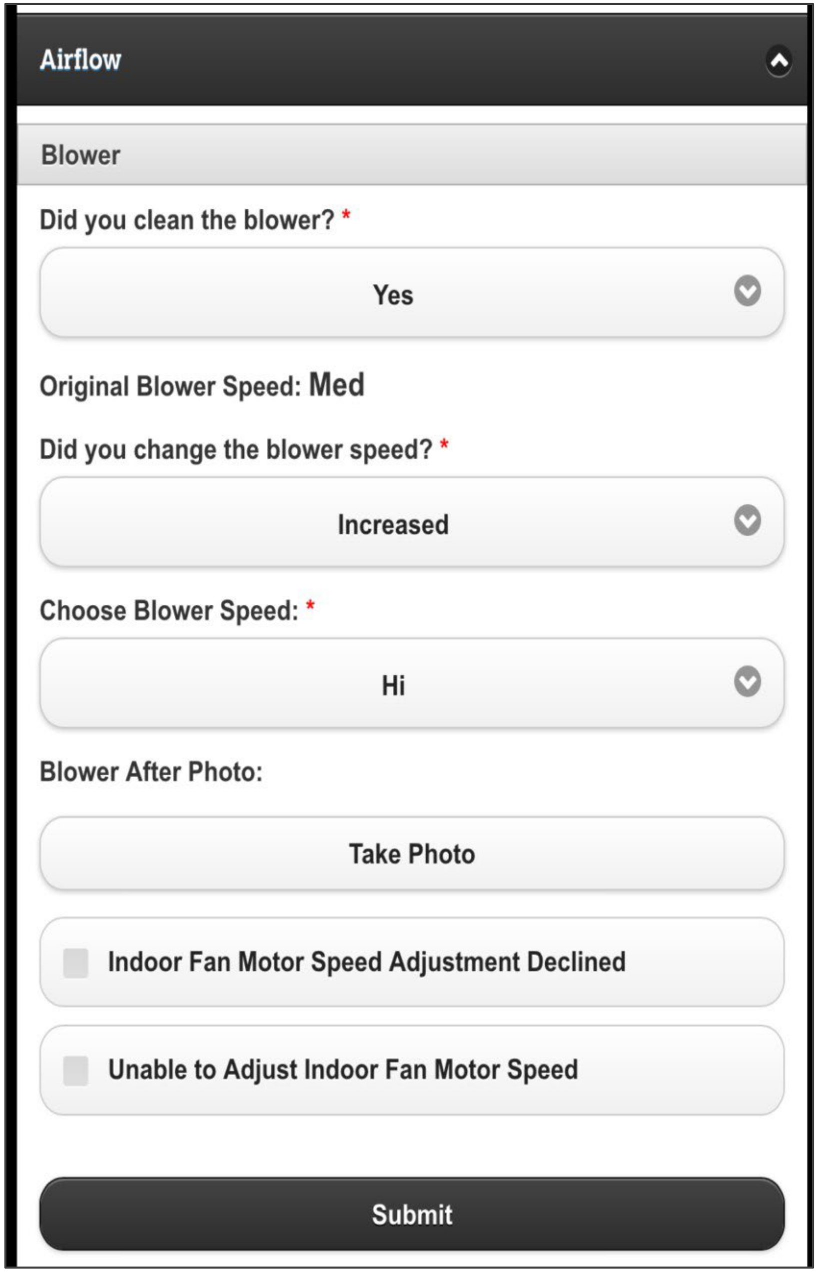
Filter

Did you clean or replace the filter?*

Cleaned

Filter After Photo:

Take Photo



Make sure after all cleanings and corrective measures (Adjustments) have made and recorded, to tap on the Submit button to continue on to the Refrigerant Charge Adjustment portion of the Application.

Refrigerant Charge Adjustments

RCA should be the last adjustment made!

1. Ensure the project follows the SOW.
2. Corrective Measures are complete and field explanations are entered.
3. The condenser is dry and the unit is stabilized.
4. Follow the Charging method selected & provide photo’s as needed.

Notes:

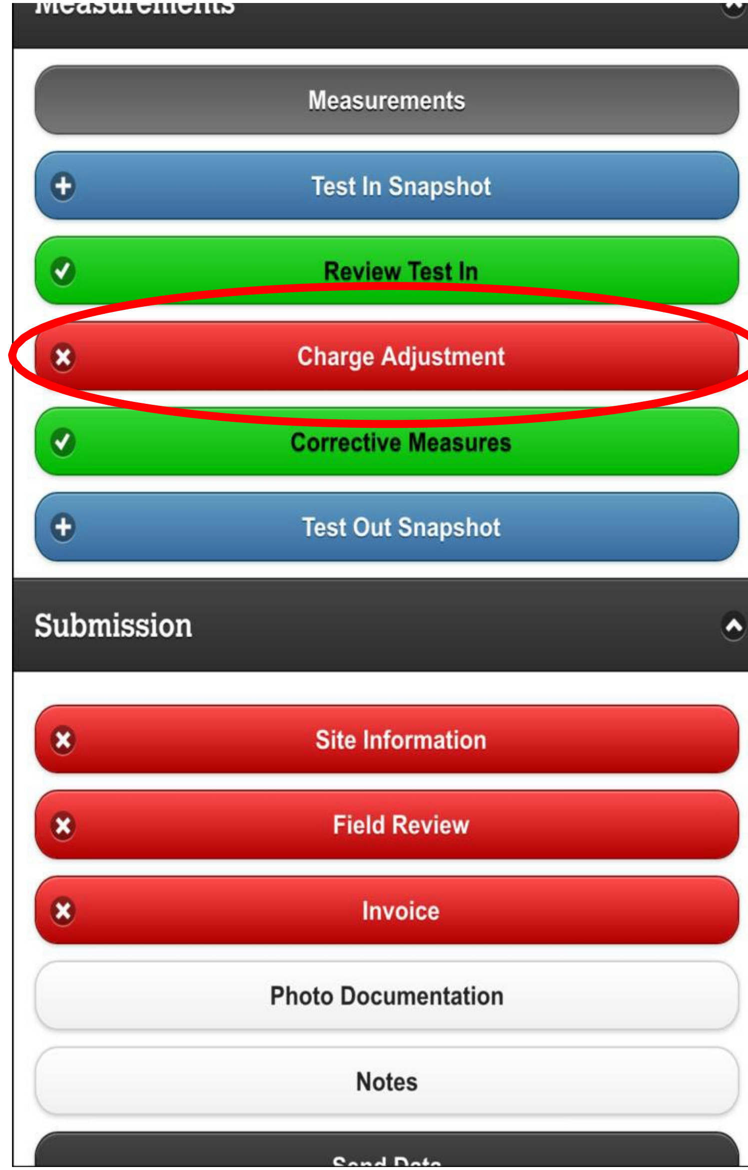
Superheat should be within +/-5*.

Subcooling should be within +/-3*

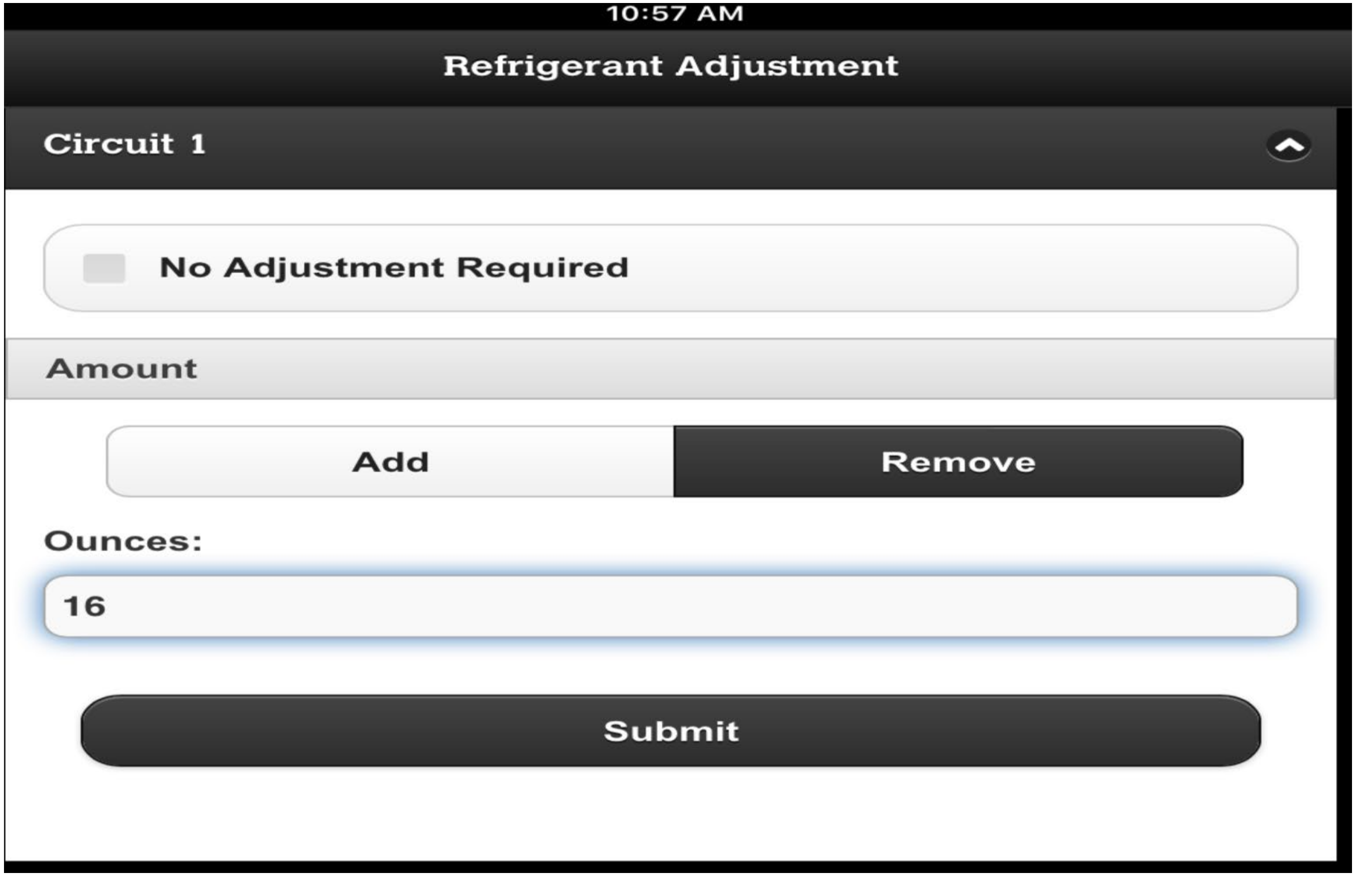
Indoor coil needs to be above 32* after RCA

After RCA complete tap the Charge Adjustment tab and enter the requested information. (See next slide)

<u>Do Not Add refrigerant if the indoor coil will be left below 32*</u>



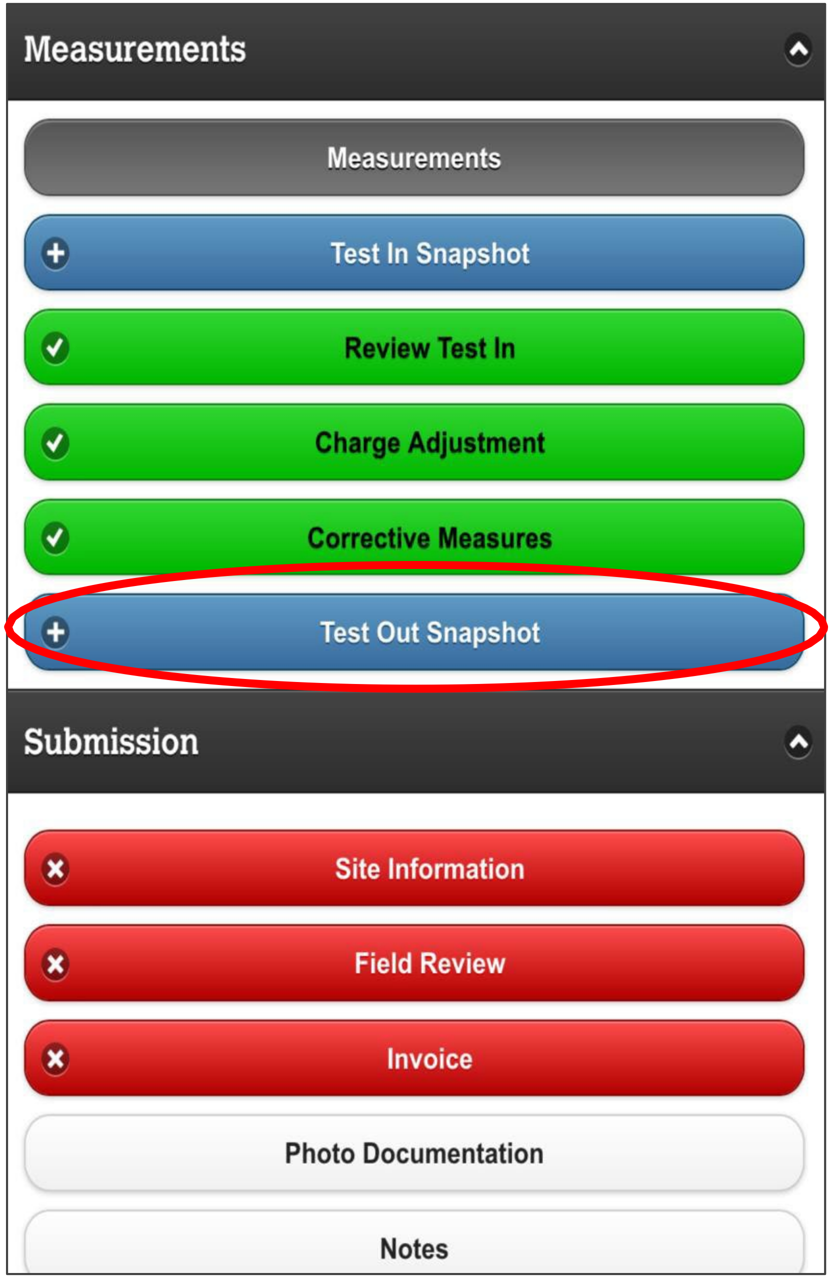
CLEAResult®



No Adjustment Required, Add or Remove then enter the total RCA in ounces and tap submit to move to the next step of the A/C tune up. This is an required field and is used in the calculation of savings in energy.

Test Out Snapshot

After the Corrective Measures, adjustments have been made and unit is stabilized.
TO Snapshot is next.
But first go into the measurements tab, put in AFM calculations (Static Pressure or Vane Anemometer measurements) and Electrical measurements for the Condenser and the Indoor Fan Motor (IFM) and tap the submit at the bottom of the measurement page.
This accepts the input measurements and should complete the measurement section to enable an accurate TO Snapshot.



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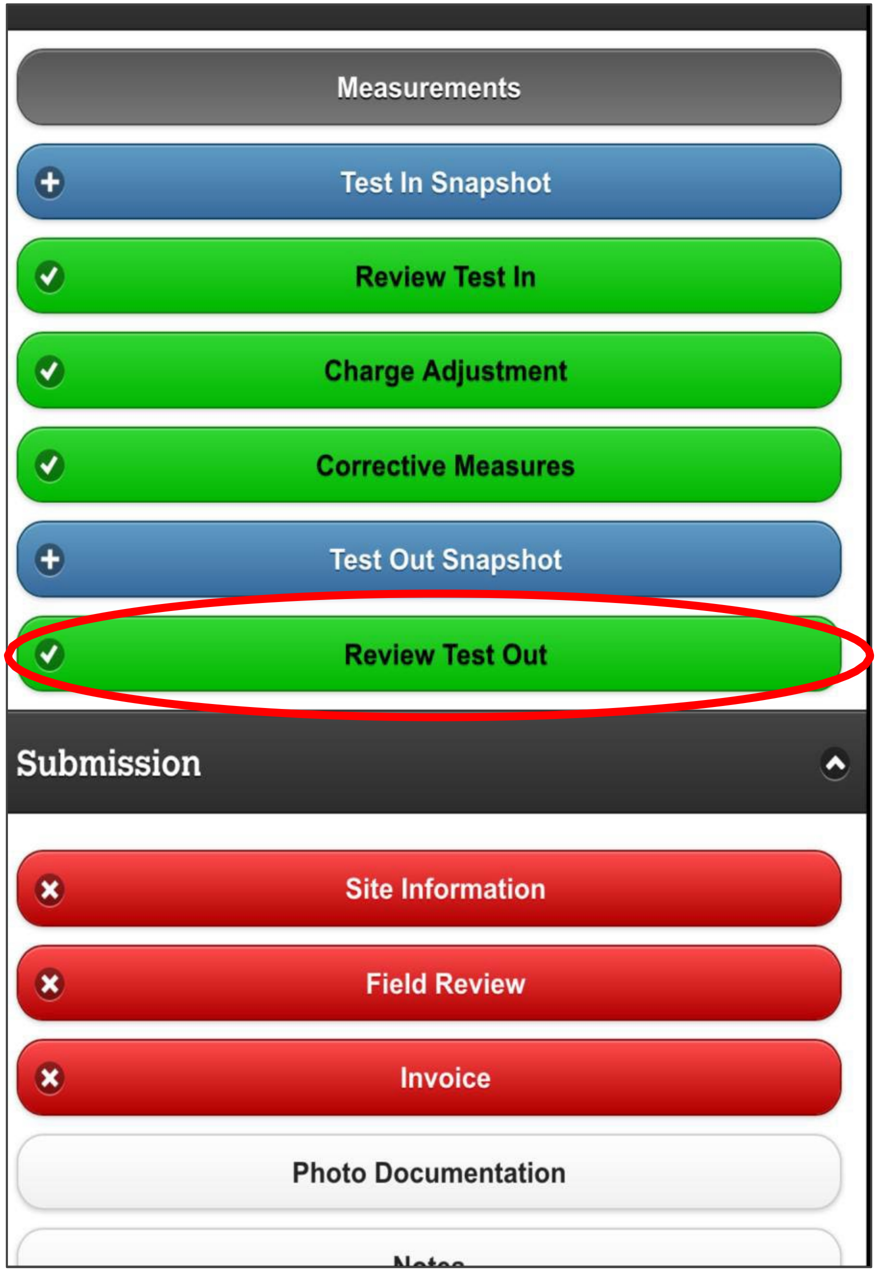
Review TO Snapshot

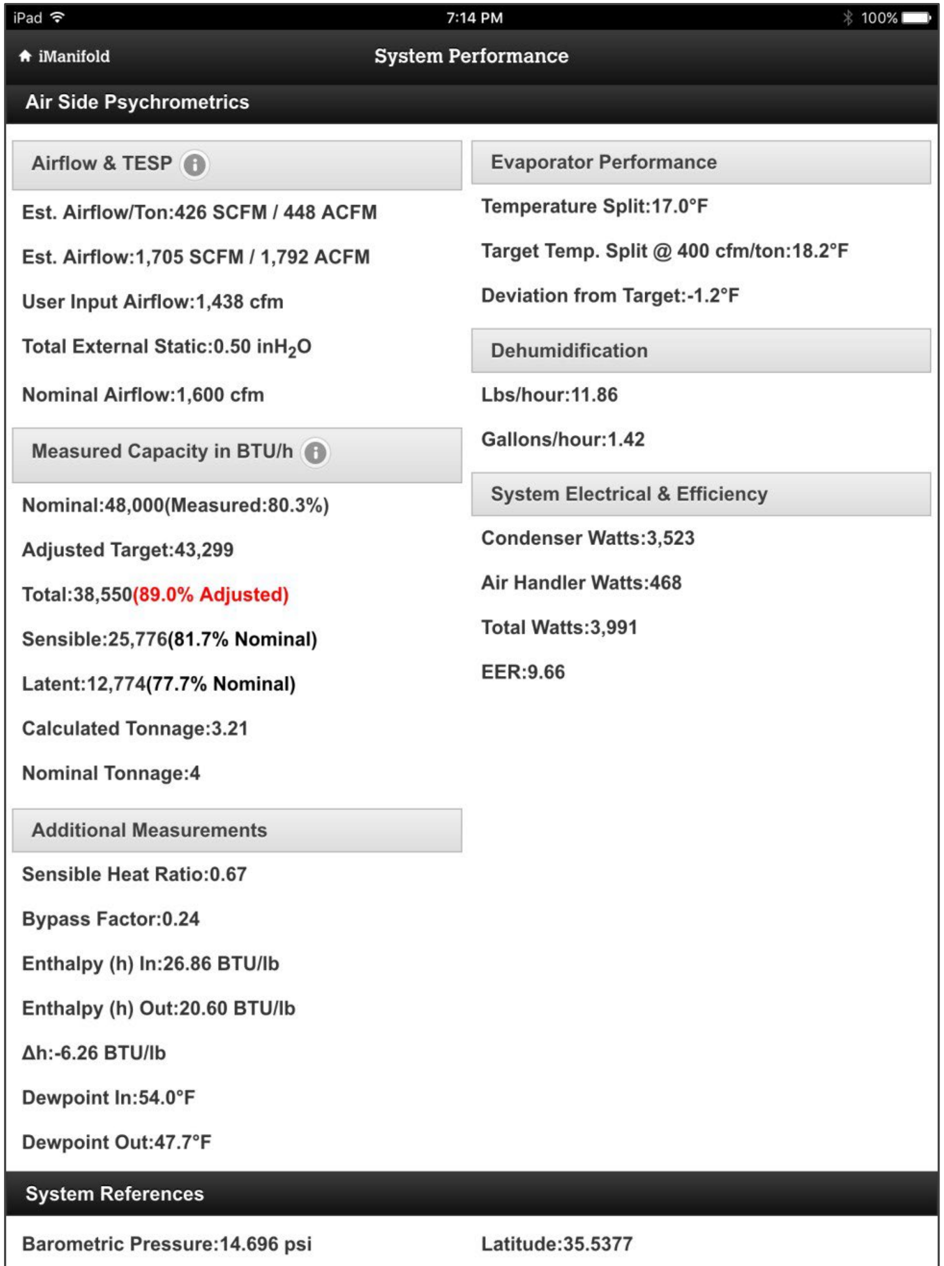
Tap on the Review TO Snapshot & review the measurements.
If there any in Red, this is a hard stop and will require entering the measurement again and retaking the TO Snapshot.
There may be some in Yellow, refer to above statement. If the measurement that is in yellow is accurate then an explanation will be required in the note section and possible a photo as well.



Review Test Out

Example

System Information
Nominal Tonnage: 4 tons
External Static Pressure
Return Air Static Pressure: 0.3 inH_2O Supply Air Static Pressure: 0.3 inH_2O
Airflow
Airflow (Input/Measured): 1438 cfm
Airflow Power Consumption
Blower Voltage: L1: 120 volts Blower Current: L1: 6 amps Blower Power 0.5 kW
Condenser and Compressor Measurements
Condenser Voltage: L1: 120 volts L2: 120 volts Condenser Current: L1: 15.5 amps L2: 15.4 amps Condenser Power **3.5 kW**

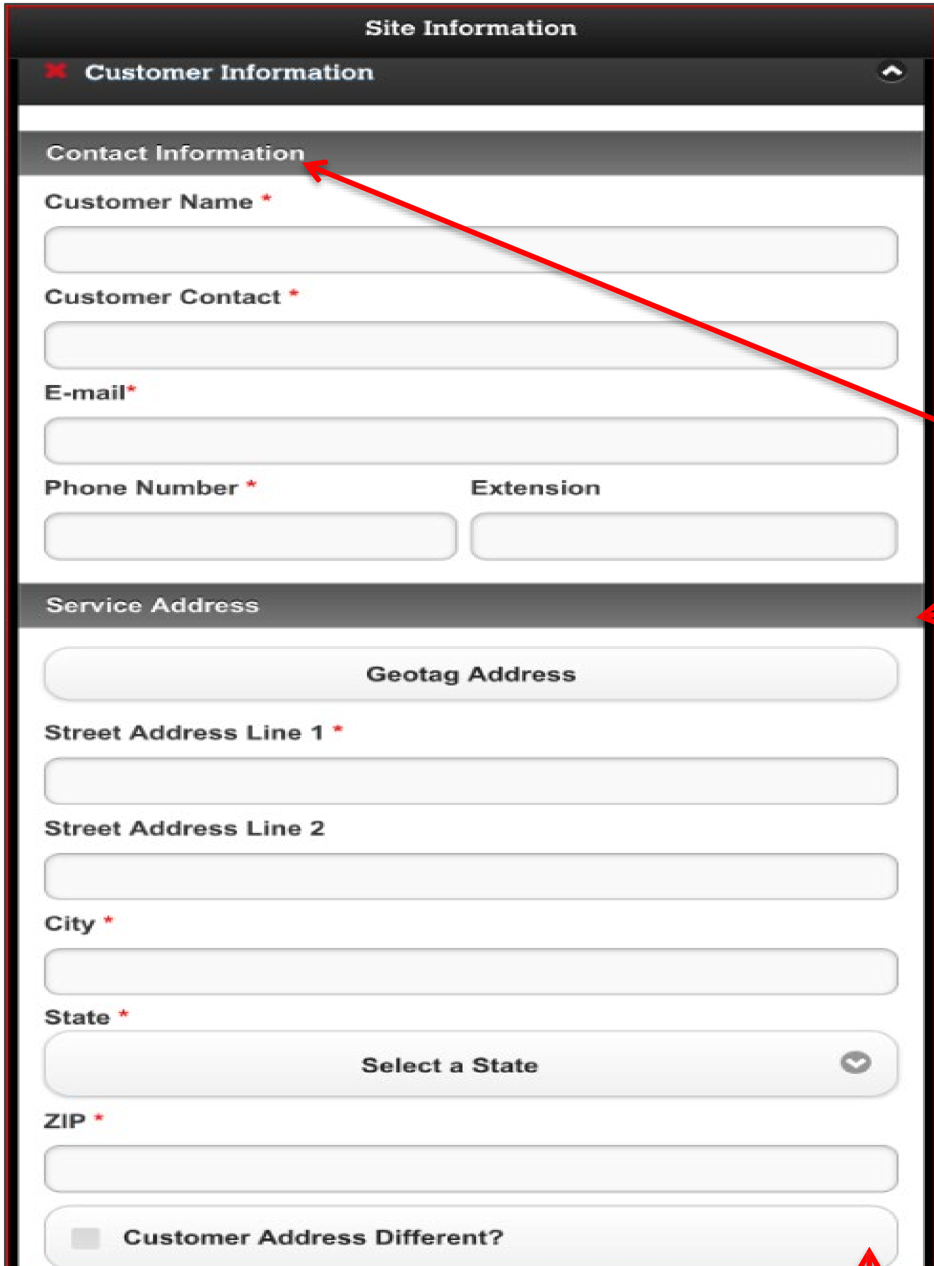


System Performance

Go back to:
Main screen/Menu/System Performance

This page is a summary of your work!

CLEAResult®



Site Information

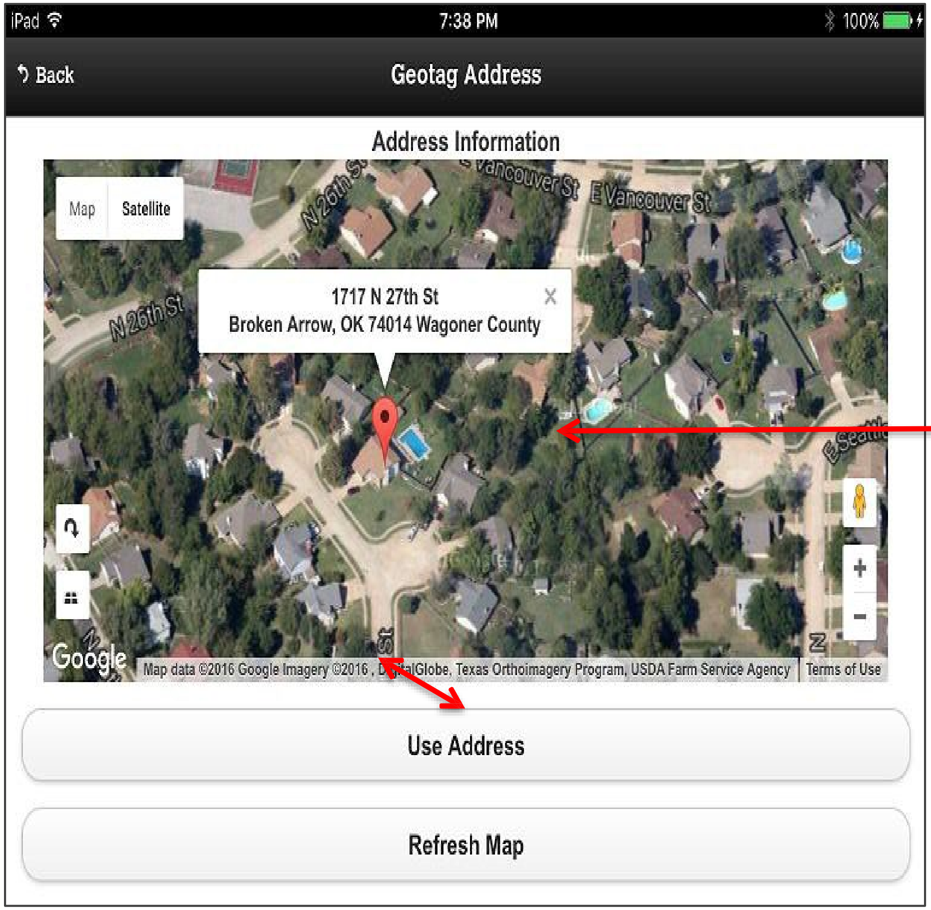
Action: For Customer Information:

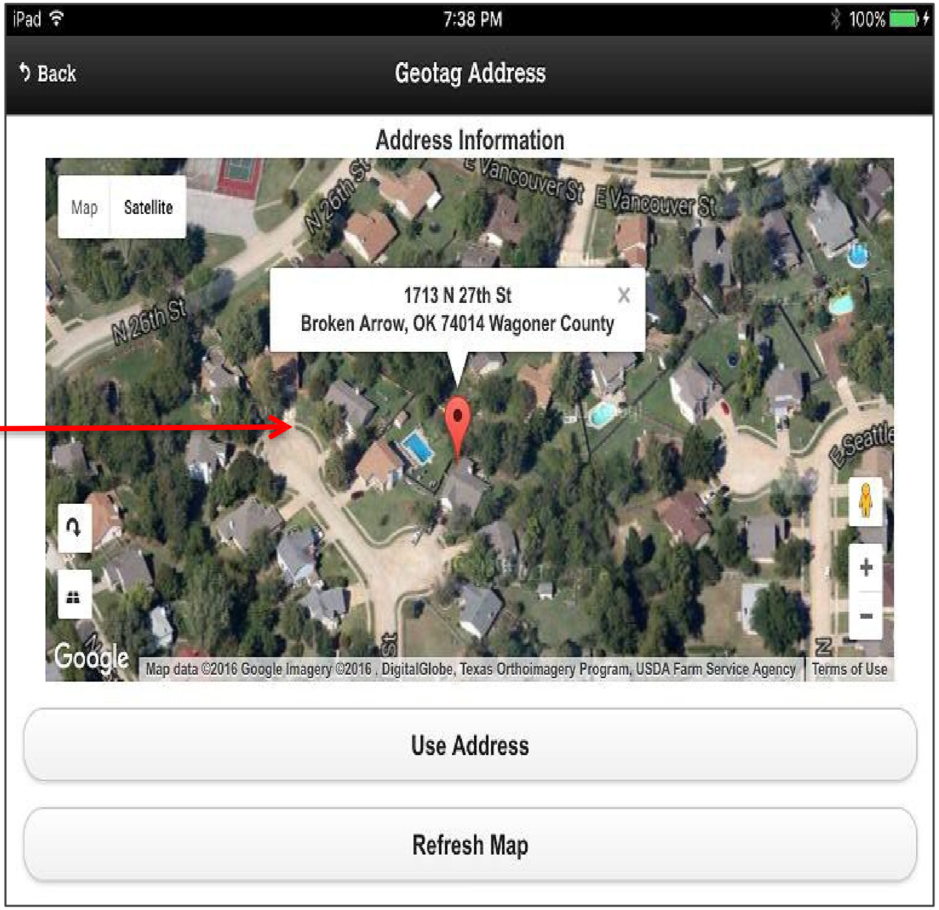
1. Enter all available customer information
2. Gather customer's email and phone #
3. For **Service Address**, either:
   - Geotag Address – requires Wi-Fi or data

     OR
   - Type in information
4. Select **Customer Address Different?**

   If the customer's address is different than the address where service is being performed, check the box and provide additional information.

CLEAResult®





By knowing the address and when using the Geotag function (only available with Wi-Fi or Data enabled tablets or phones). Verifi the address is correct if it is, tap use address and if not move the pin drop on the map to the correct address in the box and then tap the use address tab.

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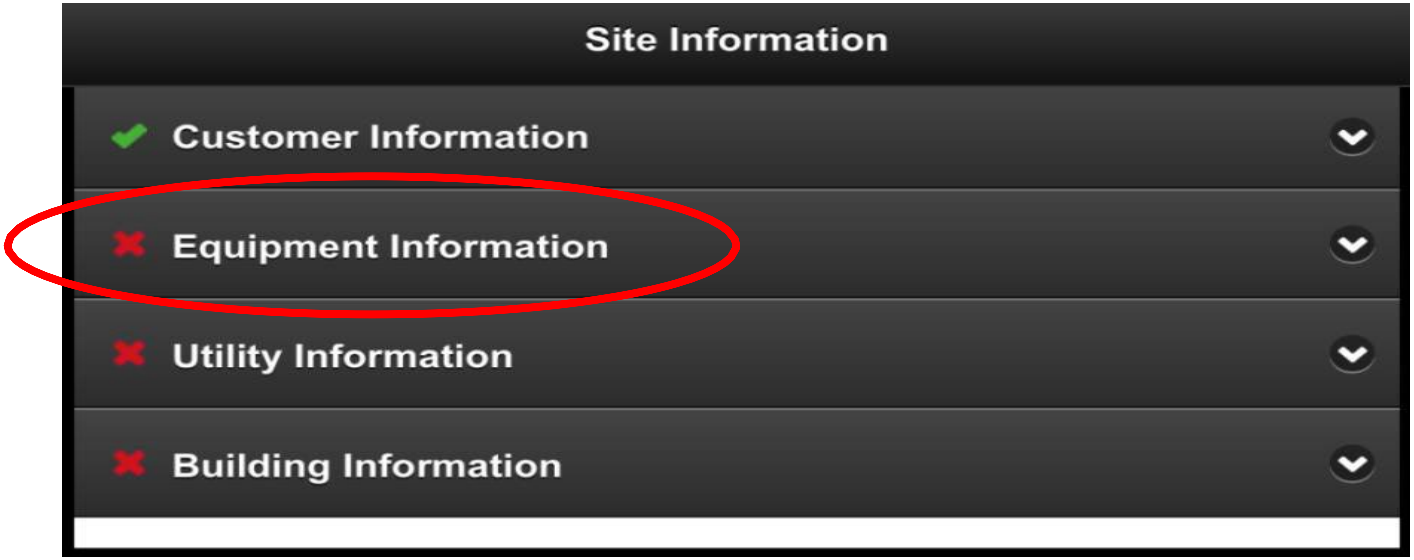
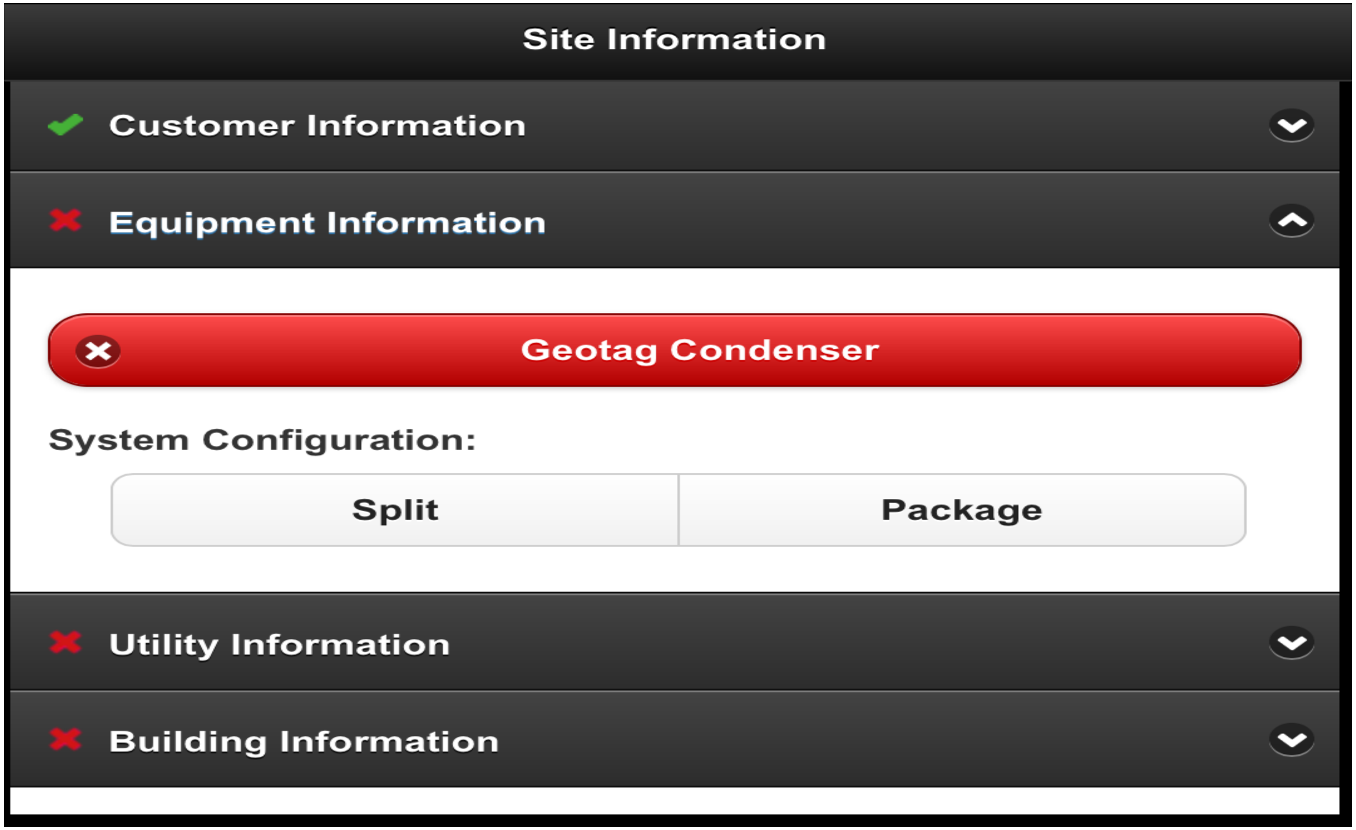


Note:

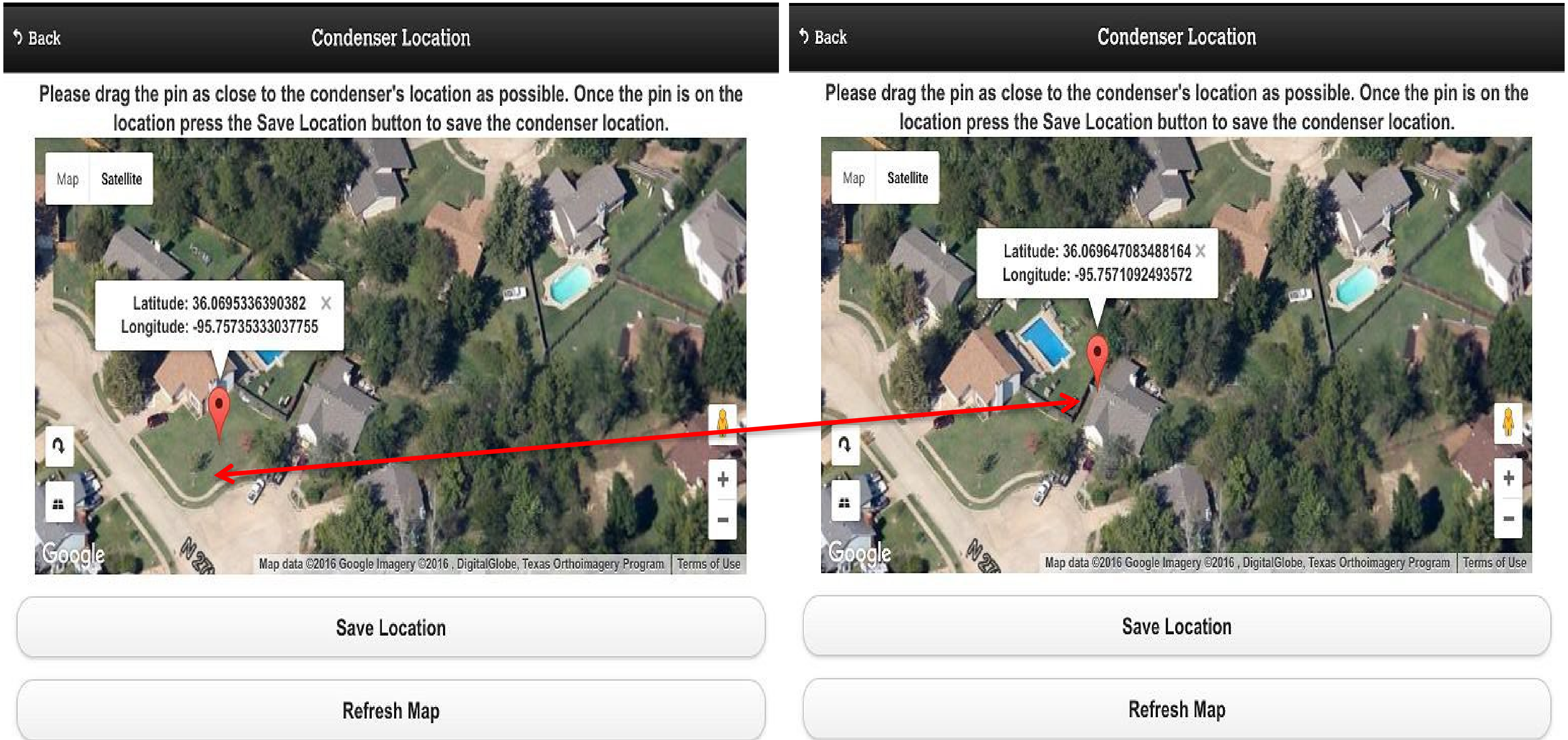
After successful completion of each section, a green check mark  will show up next to the completed item.

Continued action for Site Information: Tap Equipment Information

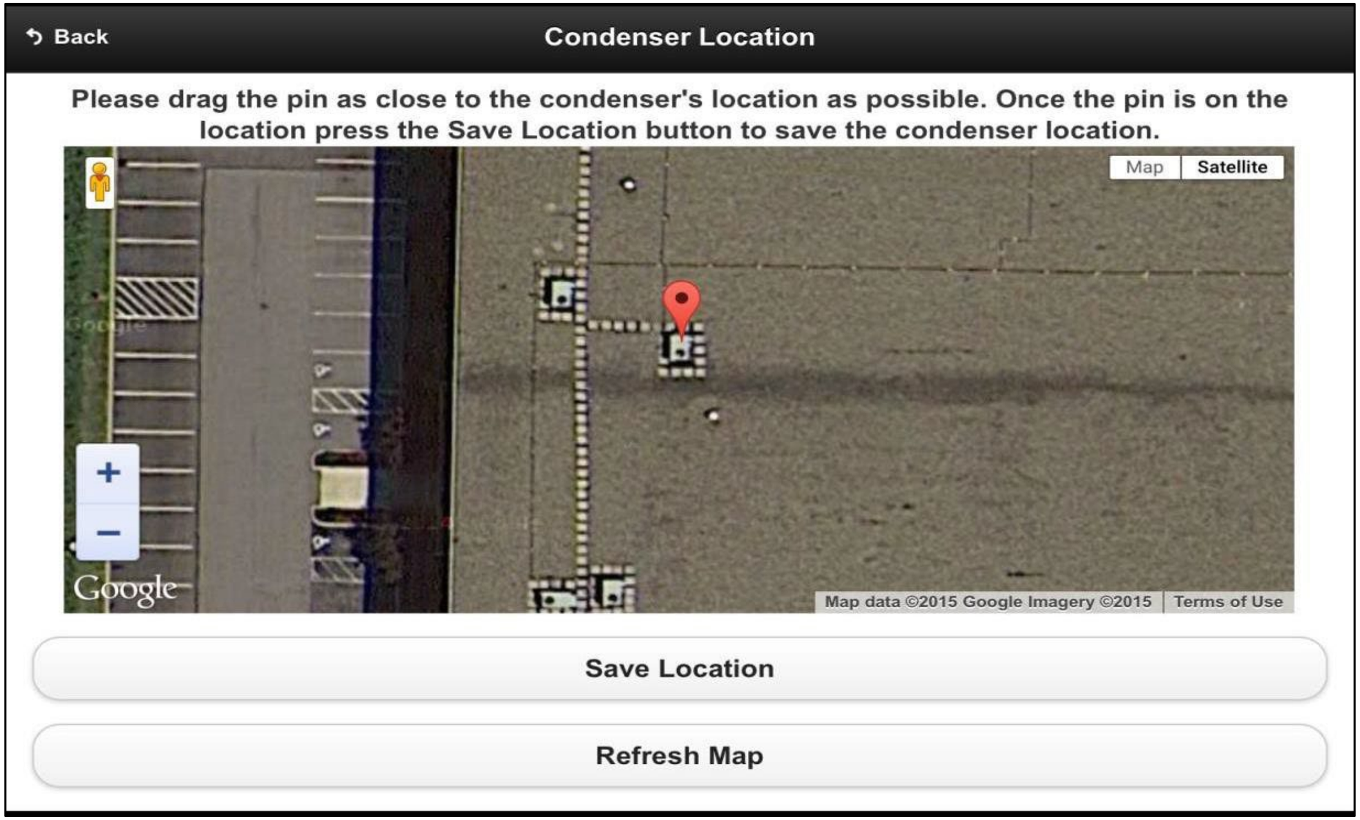


Action for Equipment Information: Tap Geotag Condenser

Note: The user may only Geotag the Condenser if using Wi-Fi or data. If no Wi-Fi or data, then service address will be used.



Drag the pin as close to the condenser as possible. Once the pin is on the correct location press the save location tab to save the Condenser location. Remember this function does not work unless you have Wi-Fi, or a Data plan with your tablet.



Action for Geotag Condenser Location:

1. Drag pin to precise location of condenser
2. Tap **Save Location**

Site Information

Customer Information

Equipment Information

System Configuration:

Split Package

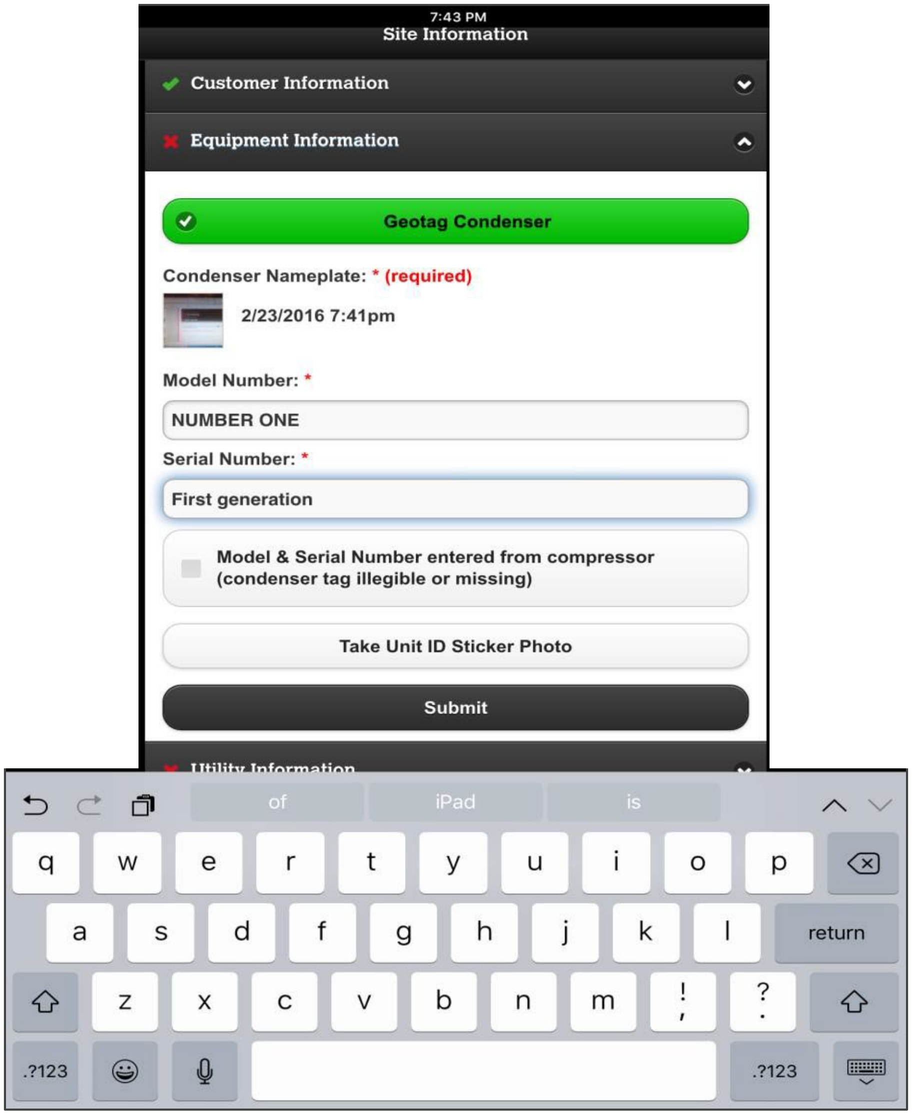
Utility Information

Building Information

Continued action for Equipment Information:

1. Select either **Split** or **Package**

Equipment Information Data Entry



Action for Equipment Information:

1. Complete:
   1. Model & Serial #'s

   * If the Data material is not legible, the Compressor Model & Serial #'s are to be used. Then indicate this by checking the box indicating this.
2. Tap **Submit**

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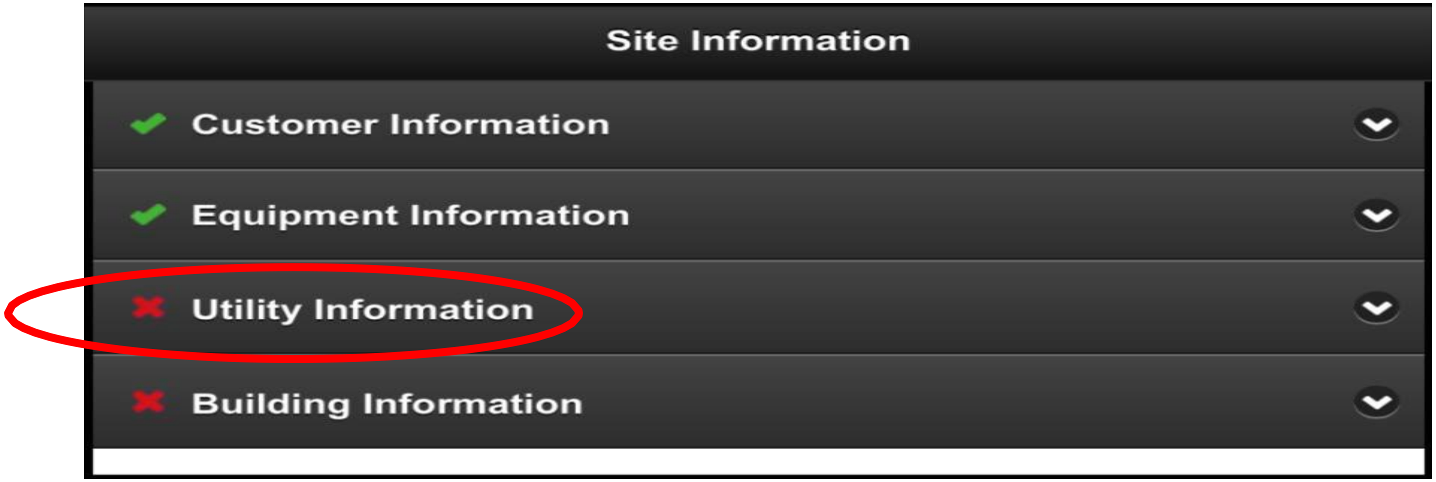
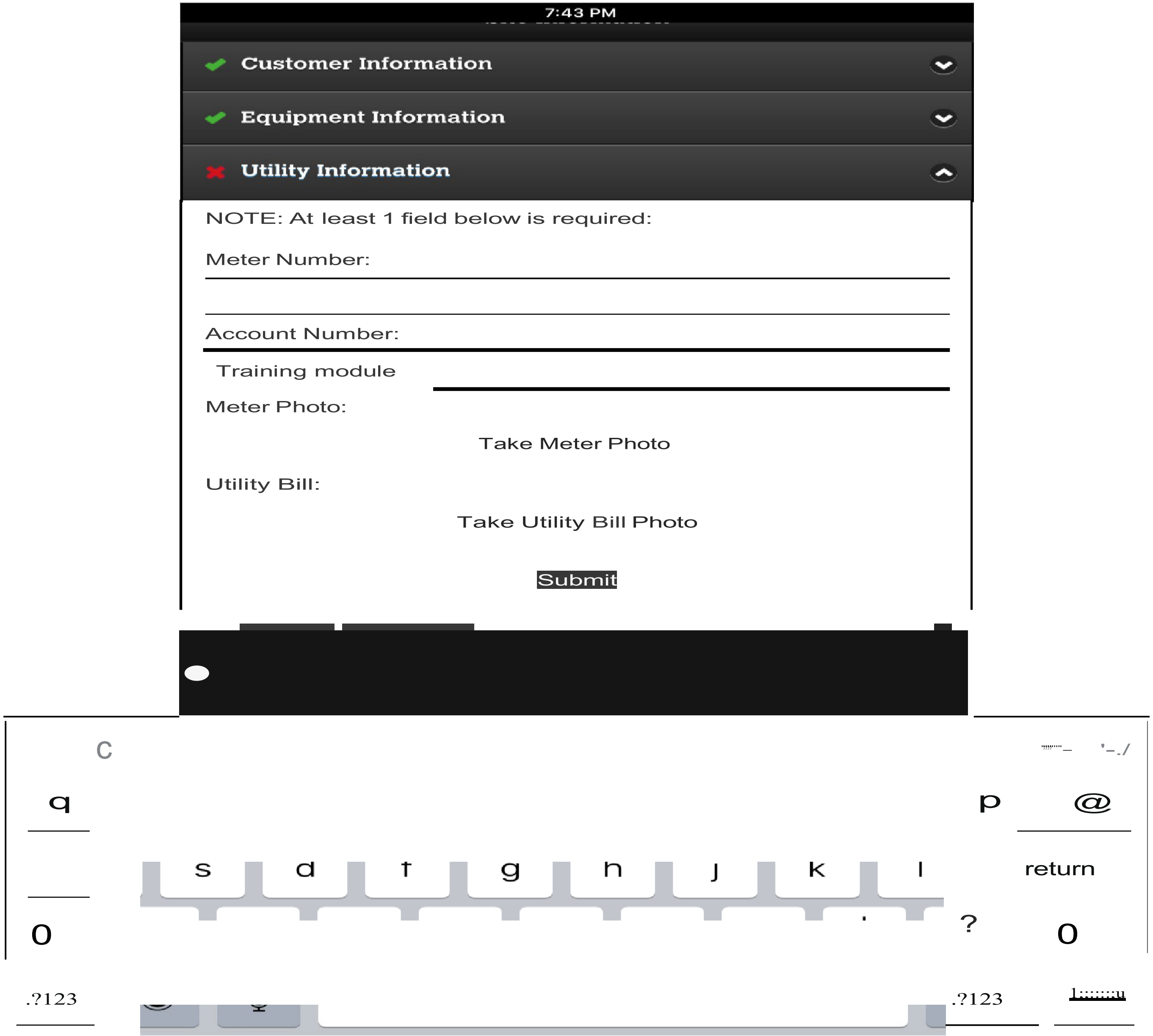
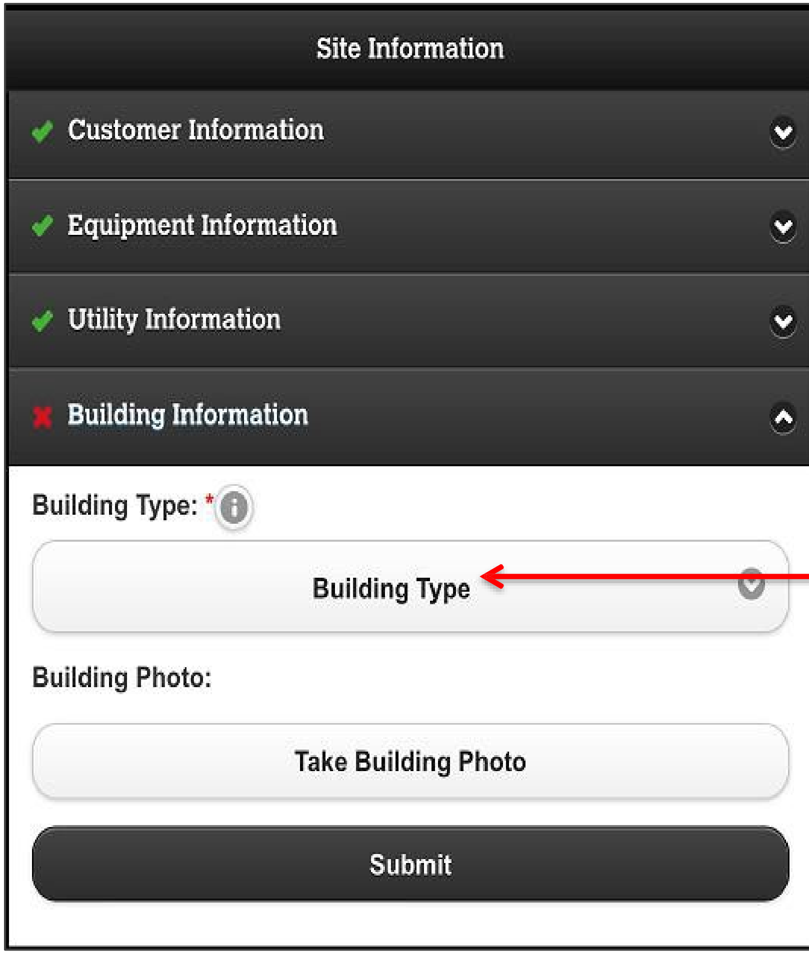
Utility Information



Continued action for Site Information:

1. Tap **Utility Information**


7:43 PM
Customer Information
Equipment Information
Utility Information
NOTE: At least 1 field below is required:
Meter Number:
Account Number:
Training module
Meter Photo:
Take Meter Photo
Utility Bill:
Take Utility Bill Photo
Submit
return



Building Type Description

College Buildings used for academic or technical classroom instruction with summer and winter sessions

Convenience Buildings used for retail sale of food, gasoline, and other convenience goods

Fast Food Buildings used for preparation and sale of food and beverages with no inside seating (Example: Sonic)

Grocery Buildings used for retail or wholesale sales of food

Hospital Buildings used for emergency care with either short or long term patient occupancy

Hotel Multi-story buildings used to offer multiple accommodations for short-term residents

Large Office Buildings with multiple air conditioning units used for general, professional, or administrative office space (Ex: City Government, Banks, School and Church Administration)

Manufacturing Buildings containing machinery used for the mass production of a product

CLEAResult®

Site Information

Customer Information

Equipment Information

Utility In

Building

Single-Family

Multi-Family

Building Ty1-

Building Type

Building Photo:

Take Building Photo

Submit

Site Information

Customer Information

Equipment !Information

Utility Information

Building Information

Building Type: *8

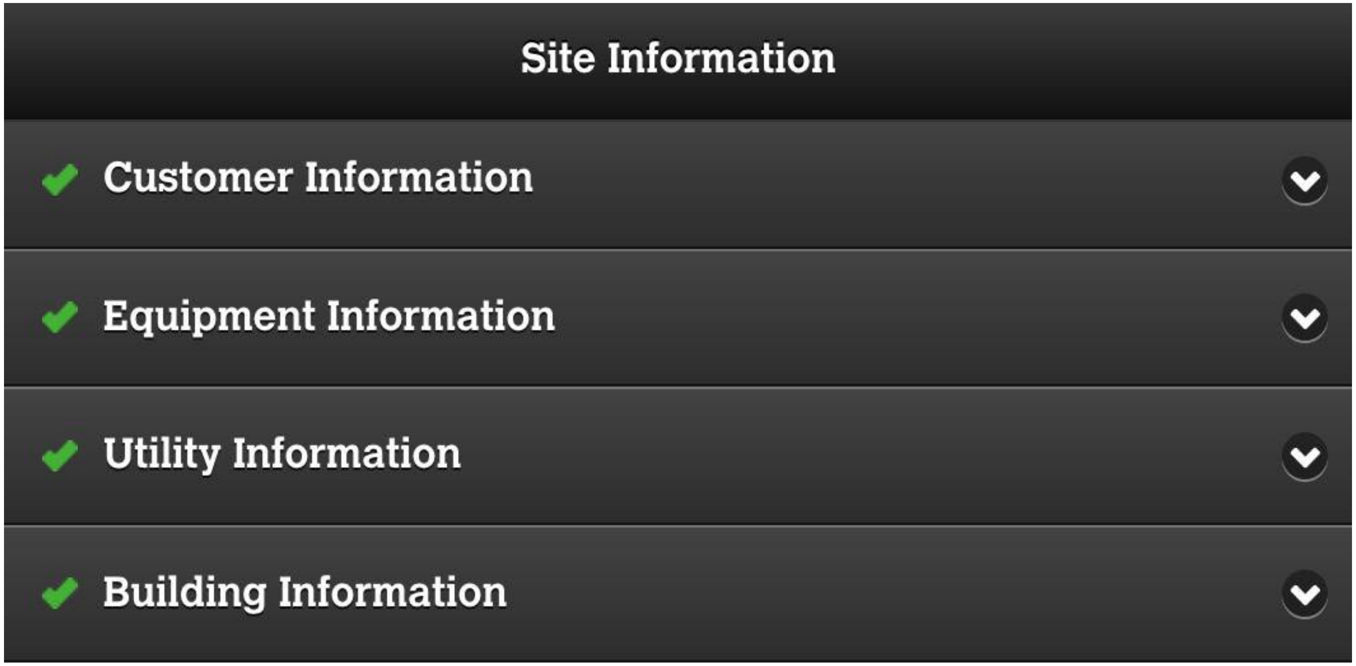
Single-Family

Building Type Detail (Optional):

Building Photo:

Take Building Photo

Submit

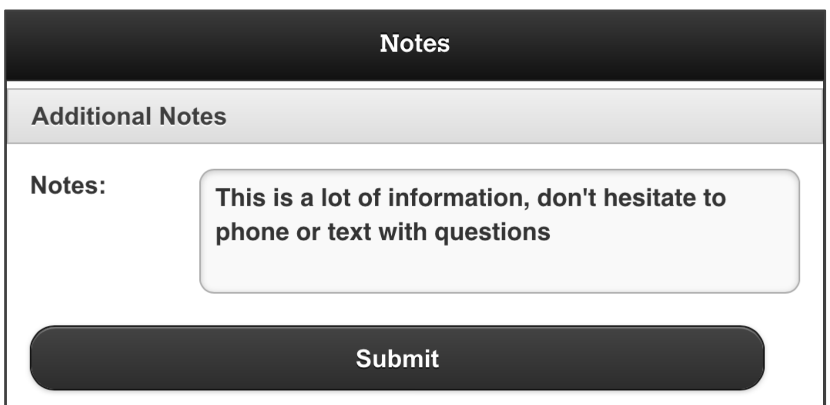


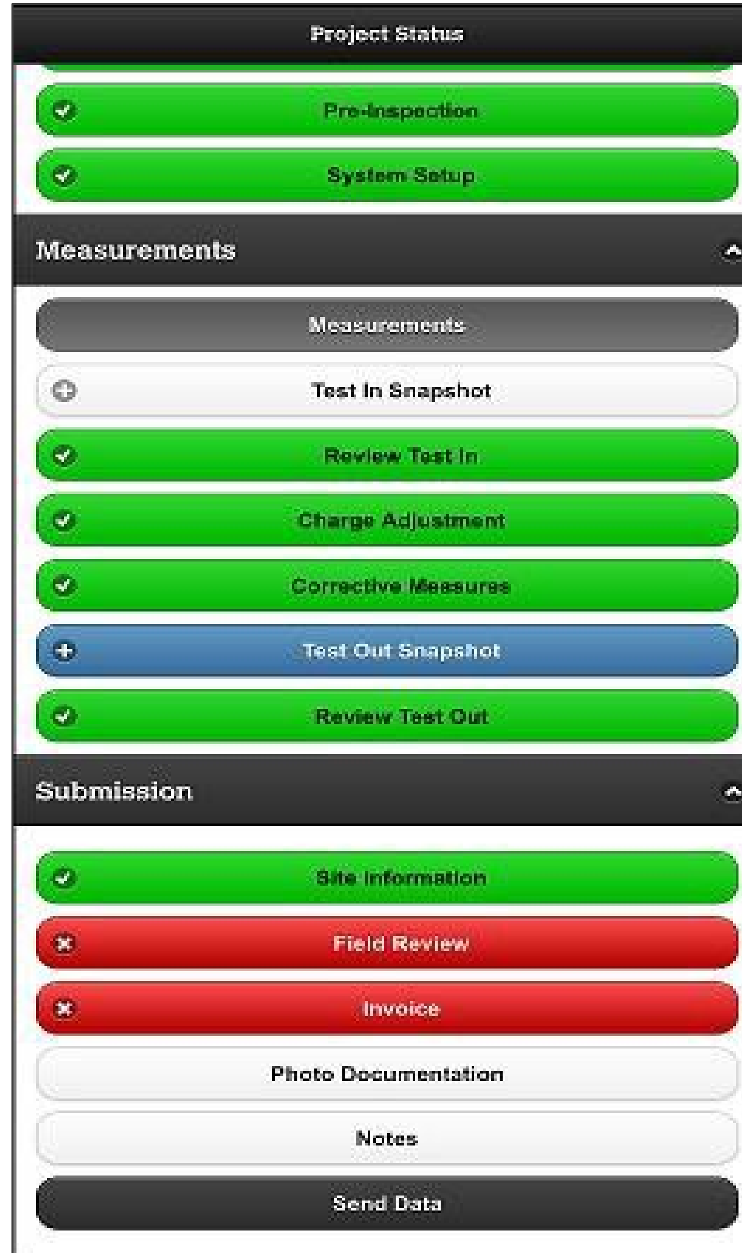
This completes the site information, and can be done while the Condenser is drying and stabilizing.

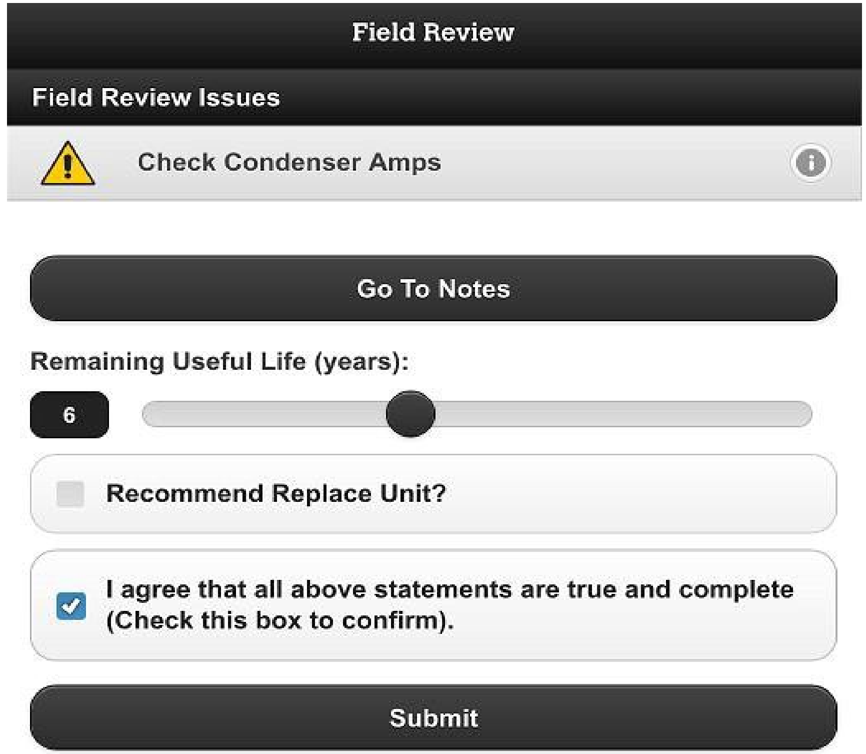
Field Review

Access this tab, by tapping on the FR tab.

This allows you to view the items that are not normal, and gives you the opportunity to go back and correct them and retake a TO Snapshot. If these are the actual measurements and they are outside of CLEAResults SOW, then the technician will have the responsibility to provide an explanation of why this A/C tune-up was left in this condition.



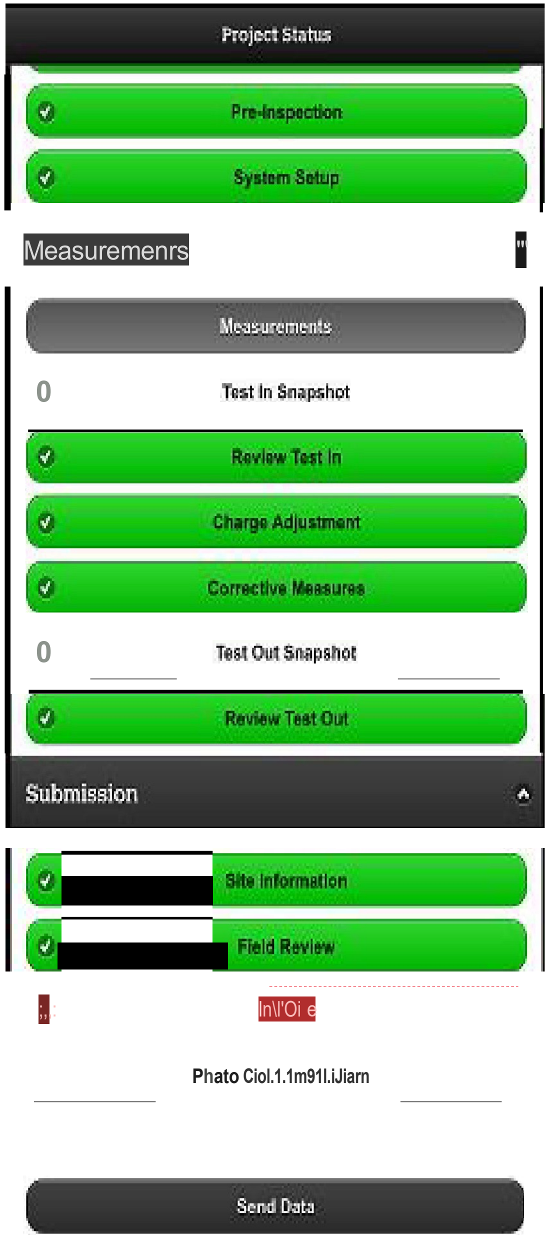




Put in other notes not already entered into the application, that are pertinent to the SOW and the Consumer.

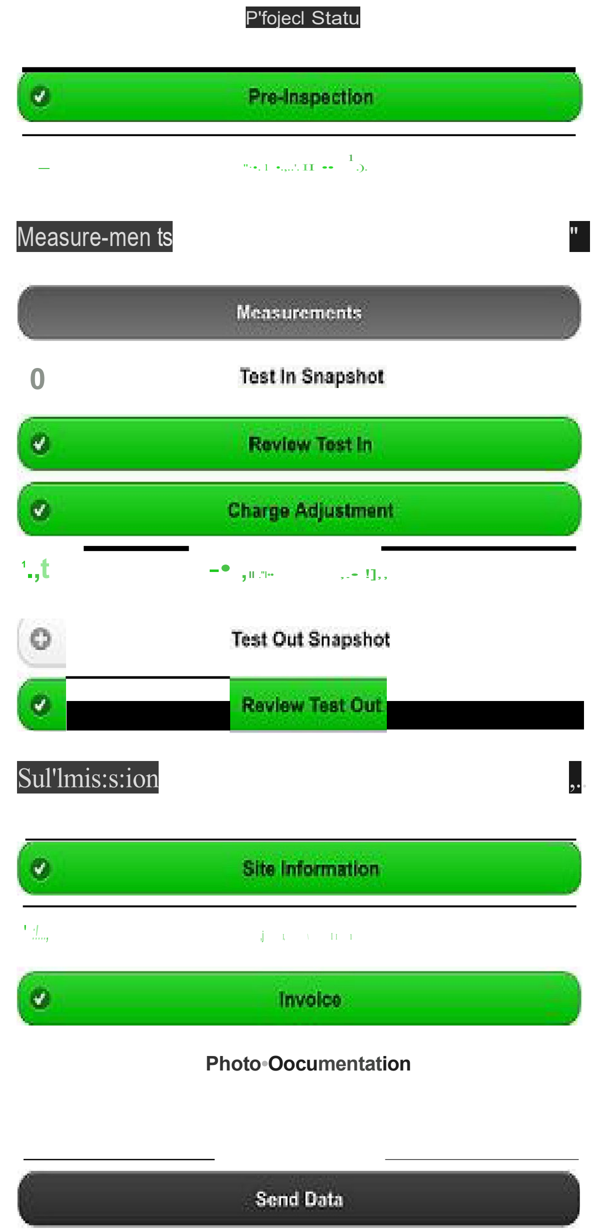
The (I agree) box means that the A/C tune up is complete, accurate, with notes as needed that are complete and true.

Inaccurate, incomplete or false information will result in warnings, lost privileges up to and including termination from the program.



Project Status
Pre-Inspection
System Setup
Measurements
Measurements
Test In Snapshot
Review Test In
Charge Adjustment
Corrective Measures
Test Out Snapshot
Review Test Out
Submission
Site Information
Field Review
Send Data

Cleaned Condenser
Removed Refrigerant from System
Receipt Section
250
Total Incentive Amount: $ *
17S
Net Customer Cost: $75.00
Total Cost
On File
Capture
Keep Signature on File?
Submit



Pre-Inspection
Measurements
Test In Snapshot
Review Test In
Charge Adjustment
Test Out Snapshot
Review Test Out
Site Information
Invoice
Send Data

Make sure to Send your tunes to get PAID

Time to put this to use

Thanks for your attention

I-Manifold Training

Phone, Tablet & Wireless Probe Set-Up

- Turn on apple I pad
  - Update apple product
    - Settings
      - General
        - Software update (if update needed), and then reboot.
  - New I-Pad Set up without Apple ID, and I-tunes account
    - <u>This option by-passes credit card needed information</u>
    - Main e-mail for the Apple ID Ex:(youreID@gmail.com) & (password)
    - Secondary e-mail for an ITunes account different than above Ex:(youreID@Yahoo.com), (and password)
      - Password can be the same for both
  - Go to the app. Store *(icon with "A" inside a circle)*
    - Search for "I-manifold" (CoolSaver)
      - Download *(cloud icon with down arrow – may take a moment)*
      - Open application *(touch "iManifold" icon)*
      - Register your Apple device *(I Pad, I Phone, etc.)*
        - Follow the prompts
        - Email recipients should be added at this time
- Learn how to utilize the "iManifold" application
  - Touch the "gear" symbol in upper right corner
    - Select "settings"
    - Select "help" *(videos for the iManifold)*
    - Select "view all videos"
      - General Information Videos *(2 videos totaling 27 minutes)*
      - Equipment profiling *(1 video totaling 3.5 minutes)*
        - Also click and read "show profiling help"
      - Wireless probes *(2 videos totaling 28 minutes)*
      - Estimated airflow *(1 video totaling 16 minutes)*
      - Trending *(1 video totaling 15 minutes)*
      - Bluetooth (2 videos totaling 3 minutes)
      - Trouble shooting (1 video totaling 4 minutes)
      - Differential pressures (1 video totaling 1 minute)
      - Refrigeration management *(1 video totaling 2 minutes)*
      - Miscellaneous Information *(2 videos totaling 13 minutes)*

        14 short films …. Estimated viewing time 2 hours

- ## Utilizing the I-manifold with the Application on your Tablet
    - Power up the I-manifold by pressing the "power button"
    - Select "Settings" on the Tablet:
        - Enable "Blue Tooth" on the Tablet
    - Connecting Tablet to Manifold
        - Push "Blue Tooth" button on I-manifold (Blue lights flash fast)
        - On tablet (in blue tooth settings) scan for Bluetooth devices – click button and it pairs the device *(the device serial number on your screen should match the serial number on the back of the I-Manifold)*
- ## Open I-Manifold App.
    - Click the gear symbol in the right hand upper corner
        - Select "Connect to the I-manifold" *(if multiple I-Manifolds have paired with your Tablet in the past, you must select the I-Manifold serial number that you are presently working with)*
            - While "pairing", the I-Manifold application will search for any updates that may be available since the last time the application was utilized …. If prompted, select continue"
- ## Pairing wireless probes *(Temperature, Repeater, Transducer)*
    - Select gear symbol upper right area of home screen / settings / connect button
    - I-Manifold should connect
    - After connection, wireless probes will appear under settings
    - Select wireless probes
    - Probe depictions should appear *(follow the prompts)*
    - On wireless probe beneath power button – Press and release the wireless symbol as prompted
    - When the probe is added successfully, *a "yes/no" prompt to add another device* will appear
    - If other probes should be added, select *yes* and repeat the steps above until all wireless probes are added *(keeping the probes in order as they are added …. This will be important later)*
    - When all the probes have been added, select *no* to the *yes/no* prompt
    - A list of all probes *(that have been added)* will appear on the screen with a number by each one
    - Place a small white sticker on each wireless probe and put the number indicated in the app on the sticker
    - Notes regarding wireless "Transducers" for pressure readings
        - When wireless transducer probes are used, the main screen showing LLT, SLT, DLT, and ODA will have dashes …. These values will be unavailable to the I-Manifold unless wired probes are plugged into the back of the manifold ….
        - To connect the gauges to the corresponding transducer
            - Touch the "low pressure gauge" and pair it with the transducer that has the blue low pressure band
            - Touch the "high pressure gauge" and pair it with the transducer that has the red low pressure band

- To verify the circuit, tap the screen and wireless probe number is indicated

- Mapping the Dry bulb / Wet bulb probes *(designating the return and supply)*
  - Select Gear symbol / connect to manifold / under settings / wireless probes
  - Select one of the wireless probes (from the list displayed on the screen)
  - An additional screen *(with temp and humidity values)* will be displayed ….
  - Tap gear symbol to display the "options" screen for that probe
  - Select "Map DB/RH" …
  - Select "Return Air" for this first probe
  - Repeat the previous 3 steps to map the second probe for "Supply Air"
  - Select "I-Manifold" *(upper left corner)* to return to home screen
- At the I-Manifold "Home Screen", select the menu prompt in the upper left
  - Select "User Inputs"
  - Select "Air Across Evaporator"
  - Move the switch marked "Wet Bulb or %RH" to WB …. Note that as you touch and release the switch, it will change from wet bulb (WB) to relative humidity (%RH) … leaves this setting on WB ….
  - Select I-manifold *(upper left screen)* and make certain that wireless probes are communicating temperature values to the lower part of the home screen ….
- Mapping the Repeating probe
  - Push gear symbol
    - Wireless probes
      - Select Repeating & Temperature probe
      - Plug the thermal couple into the side of the repeater probe
        - Click on the displayed temperature
        - Select ODA
- Once you are connected to both wireless temperature probes and the repeating probe, you are ready to set the "Sampling Rate"
  - Select the gear symbol *(upper right corner of home screen)*
  - Select "Sampling Rate"
    - Set to medium as default
- Zeroing I-Manifold pressures –
  - Push gear symbol
  - Zeroing pressures at this point will consider any pressures trapped in the hoses or the manifold …. *therefore:*
    - Open hoses or remove hoses from manifold, and open valves on I-manifold
    - Select zero pressures *(a pop up box appears)*
    - Select confirm – *(this zeros I-manifold for PSIG)*

- Setting up your "Tech Connect" information
  - Touch the gear symbol *(upper right corner of home screen)*
  - Select "Tech Connect" – Need valid e-mail on the sign in sheet to set up tech connect for CoolSaver technicians. When the tool is being used for your business if you want techni cal through Imperial you will need to have your own account.
- Wireless Transducers
  - Select gear symbol
    - Select wireless probes
      - Select add
        - Turn transducer on / bump wireless button on wireless transducer repeatedly until it connects

- Each Circuit
  - When wireless probes are used – the main screen showing LLT, SLT, DLT, and ODA will have dashes and they are not available unless plugged in directly into the back of the I-Manifold
  - Main screen press the low pressure gauge and select the wireless circuit number from the white symbol of the probe. Repeat for the high side pressure side.
  - To verify the circuit tap the screen and wireless probe number is indicated.

- **Tools**
  - Select gear symbol
    - Tools
      - Trouble shooting *(Turn on as "Default")*
        - *With "Trouble Shooting" turned on, a yellow triangle will appear on the home screen during the tune-up to indicate a problem …. This triangle can be "tapped" to view a screen describing the problem*
      - Temperature differential … applies to the wired probes
        - *When turned on will indicate a temperature difference between T1/T2 and T3/T4*
      - Flashlight – turns on the "flashlight feature" of your device
      - Settings
  - Select gear symbol
    - Settings
      - Account and User ID …. *(User selected)*
      - General Settings
        - Auto Restore should be set to "on"
      - Manage refrigerants
        - Choosing "quick select" displays the refrigerant for quick selection on the home screen
      - Units of measure settings
        - PSIG/PSIA – PSIG in default
        - Temperature F/C – F in default
        - Vacuum – in HG default
        - Air flow – CFM in default
      - Help … videos for the I-Manifold *(details on page 1)*
      - Accessories … describes various available accessories
      - About this app
        - Policies and procedures regarding the I-Manifold
- **Menu line button Icon** *(top left corner of home screen)*
  - Equipment profiling
  - User inputs
  - System performance
  - Reporting
  - Quick tests
  - Trending

TONS=	1.5	TOTAL EXTERNAL STATIC PRESSURE									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
SPEED	Low	613	551	489	427	365	304	242	180	118	56
	Med-Low	726	664	603	541	479	417	355	293	232	170
	Med	840	778	716	654	592	531	469	407	345	283
	Med-High	953	891	830	768	706	644	582	520	459	397
	High / ECM	1067	1005	943	881	819	758	696	634	572	510

TONS=	2	TOTAL EXTERNAL STATIC PRESSURE									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
SPEED	Low	782	720	658	596	535	473	411	349	287	225
	Med-Low	895	834	772	710	648	586	524	463	401	339
	Med	1009	947	885	823	762	700	638	576	514	452
	Med-High	1122	1061	999	937	875	813	751	690	628	566
	High / ECM	1236	1174	1112	1050	989	927	865	803	741	679

TONS=	2.5	TOTAL EXTERNAL STATIC PRESSURE									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
SPEED	Low	951	889	827	766	704	642	580	518	456	395
	Med-Low	1065	1003	941	879	817	755	694	632	570	508
	Med	1178	1116	1054	993	931	869	807	745	683	622
	Med-High	1292	1230	1168	1106	1044	982	921	859	797	735
	High / ECM	1405	1343	1281	1220	1158	1096	1034	972	910	848

TONS=	3	TOTAL EXTERNAL STATIC PRESSURE												
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3
SPEED	Low	1120	1058	996	935	873	811	749	687	625	564	502	440	378
	Med-Low	1234	1172	1110	1048	986	924	863	801	739	677	615	553	492
	Med	1347	1285	1223	1162	1100	1038	976	914	852	791	729	667	605
	Med-High	1461	1399	1337	1275	1213	1151	1090	1028	966	904	842	780	719
	High / ECM	1574	1512	1450	1389	1327	1265	1203	1141	1079	1018	956	894	832

TONS=	3.5	TOTAL EXTERNAL STATIC PRESSURE												
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3
SPEED	Low	1289	1227	1166	1104	1042	980	918	856	795	733	671	609	547
	Med-Low	1403	1341	1279	1217	1155	1094	1032	970	908	846	784	723	661
	Med	1516	1454	1393	1331	1269	1207	1145	1083	1022	960	898	836	774
	Med-High	1630	1568	1506	1444	1382	1321	1259	1197	1135	1073	1011	950	888
	High / ECM	1743	1681	1620	1558	1496	1434	1372	1310	1249	1187	1125	1063	1001

TONS=	4	TOTAL EXTERNAL STATIC PRESSURE												
		0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5
SPEED	Low	1335	1273	1211	1149	1087	1026	964	902	840	778	716	655	593
	Med-Low	1448	1386	1325	1263	1201	1139	1077	1015	954	892	830	768	706
	Med	1562	1500	1438	1376	1314	1253	1191	1129	1067	1005	943	882	820
	Med-High	1675	1613	1552	1490	1428	1366	1304	1242	1181	1119	1057	995	933
	High / ECM	1789	1727	1665	1603	1541	1480	1418	1356	1294	1232	1170	1109	1047

TONS=	5	TOTAL EXTERNAL STATIC PRESSURE												
		0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5
SPEED	Low	1673	1611	1549	1487	1426	1364	1302	1240	1178	1116	1055	993	931
	Med-Low	1786	1725	1663	1601	1539	1477	1415	1354	1292	1230	1168	1106	1044
	Med	1900	1838	1776	1714	1653	1591	1529	1467	1405	1343	1282	1220	1158
	Med-High	2013	1952	1890	1828	1766	1704	1642	1581	1519	1457	1395	1333	1271
	High / ECM	2127	2065	2003	1941	1880	1818	1756	1694	1632	1570	1509	1447	1385

TONS=	6	TOTAL EXTERNAL STATIC PRESSURE												
		0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5
SPEED	Low	2011	1949	1888	1826	1764	1702	1640	1578	1516	1455	1393	1331	1269
	Med-Low	2125	2063	2001	1939	1877	1815	1754	1692	1630	1568	1506	1444	1383
	Med	2238	2176	2114	2053	1991	1929	1867	1805	1743	1682	1620	1558	1496
	Med-High	2352	2290	2228	2166	2104	2042	1981	1919	1857	1795	1733	1671	1610
	High / ECM	2465	2403	2341	2280	2218	2156	2094	2032	1970	1909	1847	1785	1723

TONS=	7.5	TOTAL EXTERNAL STATIC PRESSURE												
		0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6
SPEED	Low	2457	2395	2333	2271	2209	2148	2086	2024	1962	1900	1838	1776	1715
	Med-Low	2570	2508	2447	2385	2323	2261	2199	2137	2075	2014	1952	1890	1828
	Med	2684	2622	2560	2498	2436	2374	2313	2251	2189	2127	2065	2003	1942
	Med-High	2797	2735	2673	2612	2550	2488	2426	2364	2302	2241	2179	2117	2055
	High / ECM	2911	2849	2787	2725	2663	2601	2540	2478	2416	2354	2292	2230	2169

TONS=	10	TOTAL EXTERNAL STATIC PRESSURE												
		0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7
SPEED	Low	3240	3179	3117	3055	2993	2931	2869	2808	2746	2684	2622	2560	2498
	Med-Low	3354	3292	3230	3168	3107	3045	2983	2921	2859	2797	2736	2674	2612
	Med	3467	3406	3344	3282	3220	3158	3096	3035	2973	2911	2849	2787	2725
	Med-High	3581	3519	3457	3395	3334	3272	3210	3148	3086	3024	2963	2901	2839
	High / ECM	3694	3633	3571	3509	3447	3385	3323	3262	3200	3138	3076	3014	2952

TONS=	**12.5**	**TOTAL EXTERNAL STATIC PRESSURE**												
		0.5	**0.6**	**0.7**	**0.8**	**0.9**	**1**	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**
SPEED	**Low**	4086	4024	3962	3900	3839	3777	3715	3653	3591	3529	3468	3406	3344
	Med-Low	4199	4138	4076	4014	3952	3890	3828	3767	3705	3643	3581	3519	3457
	Med	4313	4251	4189	4127	4066	4004	3942	3880	3818	3756	3695	3633	3571
	Med-High	4426	4365	4303	4241	4179	4117	4055	3994	3932	3870	3808	3746	3684
	High / ECM	4540	4478	4416	4354	4293	4231	4169	4107	4045	3983	3922	3860	3798

TONS=	**15**	**TOTAL EXTERNAL STATIC PRESSURE**												
		0.5	**0.6**	**0.7**	**0.8**	**0.9**	**1**	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**
SPEED	**Low**	4932	4870	4808	4746	4684	4622	4561	4499	4437	4375	4313	4251	4190
	Med-Low	5045	4983	4921	4860	4798	4736	4674	4612	4550	4489	4427	4365	4303
	Med	5159	5097	5035	4973	4911	4849	4788	4726	4664	4602	4540	4478	4417
	Med-High	5272	5210	5148	5087	5025	4963	4901	4839	4777	4716	4654	4592	4530
	High / ECM	5386	5324	5262	5200	5138	5076	5015	4953	4891	4829	4767	4705	4644

TONS=	**20**	**TOTAL EXTERNAL STATIC PRESSURE**												
		0.6	**0.7**	**0.8**	**0.9**	**1**	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**
SPEED	**Low**	6561	6499	6437	6375	6314	6252	6190	6128	6066	6004	5943	5881	5819
	Med-Low	6674	6613	6551	6489	6427	6365	6303	6242	6180	6118	6056	5994	5932
	Med	6788	6726	6664	6602	6541	6479	6417	6355	6293	6231	6170	6108	6046
	Med-High	6901	6840	6778	6716	6654	6592	6530	6469	6407	6345	6283	6221	6159
	High / ECM	7015	6953	6891	6829	6768	6706	6644	6582	6520	6458	6397	6335	6273

TONS=	**25**	**TOTAL EXTERNAL STATIC PRESSURE**												
		0.6	**0.7**	**0.8**	**0.9**	**1**	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**
SPEED	**Low**	8252	8190	8128	8067	8005	7943	7881	7819	7757	7696	7634	7572	7510
	Med-Low	8366	8304	8242	8180	8118	8056	7995	7933	7871	7809	7747	7685	7623
	Med	8479	8417	8355	8294	8232	8170	8108	8046	7984	7922	7861	7799	7737
	Med-High	8593	8531	8469	8407	8345	8283	8221	8160	8098	8036	7974	7912	7850
	High / ECM	8706	8644	8582	8520	8459	8397	8335	8273	8211	8149	8088	8026	7964

Belt Drive / Three Phase Blower

TONS=	3	TOTAL EXTERNAL STATIC PRESSURE												
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3
BLOWER POWER	0.5	1977	1901	1825	1748	1672	1596	1519	1443	1366	1290	1214	1137	1061
	0.6	2015	1938	1862	1786	1709	1633	1557	1480	1404	1327	1251	1175	1098
	0.7	2052	1976	1899	1823	1747	1670	1594	1518	1441	1365	1288	1212	1136
	0.8	2089	2013	1937	1860	1784	1708	1631	1555	1479	1402	1326	1250	1173
	0.9	2127	2050	1974	1898	1821	1745	1669	1592	1516	1440	1363	1287	1211
	1	2164	2088	2011	1935	1859	1782	1706	1630	1553	1477	1401	1324	1248
	1.1	2201	2125	2049	1972	1896	1820	1743	1667	1591	1514	1438	1362	1285
	1.2	2239	2162	2086	2010	1933	1857	1781	1704	1628	1552	1475	1399	1323
	1.3	2276	2200	2123	2047	1971	1894	1818	1742	1665	1589	1513	1436	1360
	1.4	2314	2237	2161	2084	2008	1932	1855	1779	1703	1626	1550	1474	1397
	1.5	2351	2275	2198	2122	2046	1969	1893	1816	1740	1664	1587	1511	1435
	1.6	2388	2312	2236	2159	2083	2007	1930	1854	1777	1701	1625	1548	1472
	1.7	2426	2349	2273	2197	2120	2044	1968	1891	1815	1738	1662	1586	1509
	1.8	2463	2387	2310	2234	2158	2081	2005	1929	1852	1776	1699	1623	1547
	1.9	2500	2424	2348	2271	2195	2119	2042	1966	1890	1813	1737	1661	1584
	2	2538	2461	2385	2309	2232	2156	2080	2003	1927	1851	1774	1698	1622

TONS=	4	TOTAL EXTERNAL STATIC PRESSURE												
		0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7
BLOWER POWER	0.5	1884	1808	1731	1655	1579	1502	1426	1350	1273	1197	1120	1044	968
	0.6	1921	1845	1769	1692	1616	1540	1463	1387	1311	1234	1158	1081	1005
	0.7	1959	1882	1806	1730	1653	1577	1501	1424	1348	1272	1195	1119	1042
	0.8	1996	1920	1843	1767	1691	1614	1538	1462	1385	1309	1233	1156	1080
	0.9	2033	1957	1881	1804	1728	1652	1575	1499	1423	1346	1270	1194	1117
	1	2071	1994	1918	1842	1765	1689	1613	1536	1460	1384	1307	1231	1155
	1.1	2108	2032	1955	1879	1803	1726	1650	1574	1497	1421	1345	1268	1192
	1.2	2146	2069	1993	1916	1840	1764	1687	1611	1535	1458	1382	1306	1229
	1.3	2183	2107	2030	1954	1877	1801	1725	1648	1572	1496	1419	1343	1267
	1.4	2220	2144	2068	1991	1915	1838	1762	1686	1609	1533	1457	1380	1304
	1.5	2258	2181	2105	2029	1952	1876	1800	1723	1647	1570	1494	1418	1341
	1.6	2295	2219	2142	2066	1990	1913	1837	1761	1684	1608	1531	1455	1379
	1.7	2332	2256	2180	2103	2027	1951	1874	1798	1722	1645	1569	1492	1416
	1.8	2370	2293	2217	2141	2064	1988	1912	1835	1759	1683	1606	1530	1453
	1.9	2407	2331	2254	2178	2102	2025	1949	1873	1796	1720	1644	1567	1491
	2	2444	2368	2292	2215	2139	2063	1986	1910	1834	1757	1681	1605	1528

TONS=	5	TOTAL EXTERNAL STATIC PRESSURE												
		0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7
BLOWER POWER	0.5	2096	2020	1943	1867	1791	1714	1638	1562	1485	1409	1333	1256	1180
	0.6	2133	2057	1981	1904	1828	1752	1675	1599	1523	1446	1370	1294	1217
	0.7	2171	2094	2024	1942	1865	1789	1713	1636	1560	1484	1407	1331	1255
	0.8	2208	2132	2055	1979	1903	1826	1750	1674	1597	1521	1445	1368	1292
	0.9	2246	2169	2093	2016	1940	1864	1787	1711	1635	1558	1482	1406	1329
	1	2283	2207	2130	2054	1977	1901	1825	1748	1672	1596	1519	1443	1367
	1.1	2320	2244	2168	2091	2015	1938	1862	1786	1709	1633	1557	1480	1404
	1.2	2358	2281	2205	2129	2052	1976	1900	1823	1747	1670	1594	1518	1441
	1.3	2395	2319	2242	2166	2090	2013	1937	1861	1784	1708	1631	1555	1479
	1.4	2432	2356	2280	2203	2127	2051	1974	1898	1822	1745	1669	1592	1516
	1.5	2470	2393	2317	2241	2164	2088	2012	1935	1859	1783	1706	1630	1553
	1.6	2507	2431	2354	2278	2202	2125	2049	1973	1896	1820	1744	1667	1591
	1.7	2544	2468	2392	2315	2239	2163	2086	2010	1934	1857	1781	1705	1628
	1.8	2582	2505	2429	2353	2276	2200	2124	2047	1971	1895	1818	1742	1666
	1.9	2619	2543	2466	2390	2314	2237	2161	2085	2008	1932	1856	1779	1703
	2	2657	2580	2504	2427	2351	2275	2198	2122	2046	1969	1893	1817	1740

TONS=	6	TOTAL EXTERNAL STATIC PRESSURE												
		0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7
BLOWER POWER	0.7	2383	2307	2230	2154	2077	2001	1925	1848	1772	1696	1619	1543	1467
	0.8	2420	2344	2268	2191	2115	2039	1962	1886	1809	1733	1657	1580	1504
	0.9	2458	2381	2305	2229	2152	2076	2000	1923	1847	1770	1694	1618	1541
	1	2495	2419	2342	2266	2190	2113	2037	1961	1884	1808	1731	1655	1579
	1.1	2532	2456	2380	2303	2227	2151	2074	1998	1922	1845	1769	1692	1616
	1.2	2570	2493	2417	2341	2264	2188	2112	2035	1959	1883	1806	1730	1654
	1.3	2607	2531	2454	2378	2302	2225	2149	2073	1996	1920	1844	1767	1691
	1.4	2644	2568	2492	2415	2339	2263	2186	2110	2034	1957	1881	1805	1728
	1.5	2682	2605	2529	2453	2376	2300	2224	2147	2071	1995	1918	1842	1766
	1.6	2719	2643	2566	2490	2414	2337	2261	2185	2108	2032	1956	1879	1803
	1.7	2757	2680	2604	2527	2451	2375	2298	2222	2146	2069	1993	1917	1840
	1.8	2794	2718	2641	2565	2488	2412	2336	2259	2183	2107	2030	1954	1878
	1.9	2831	2755	2679	2602	2526	2449	2373	2297	2220	2144	2068	1991	1915
	2	2869	2792	2716	2640	2563	2487	2411	2334	2258	2181	2105	2029	1952
	2.1	2906	2830	2753	2677	2601	2524	2448	2372	2295	2219	2142	2066	1990
	2.2	2943	2867	2791	2714	2638	2562	2485	2409	2333	2256	2180	2103	2027

TONS=	7.5	TOTAL EXTERNAL STATIC PRESSURE												
		0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7
BLOWER POWER	1	2813	2737	2660	2584	2508	2431	2355	2279	2202	2126	2050	1973	1897
	1.1	2850	2774	2698	2621	2545	2469	2392	2316	2240	2163	2087	2011	1934
	1.2	2888	2812	2735	2659	2582	2506	2430	2353	2277	2201	2124	2048	1972
	1.3	2925	2849	2773	2696	2620	2543	2467	2391	2314	2238	2162	2085	2009
	1.4	2963	2886	2810	2734	2657	2581	2504	2428	2352	2275	2199	2123	2046
	1.5	3000	2924	2847	2771	2695	2618	2542	2465	2389	2313	2236	2160	2084
	1.6	3037	2961	2885	2808	2732	2656	2579	2503	2427	2350	2274	2197	2121
	1.7	3075	2998	2922	2846	2769	2693	2617	2540	2464	2388	2311	2235	2158
	1.8	3112	3036	2959	2883	2807	2730	2654	2578	2501	2425	2349	2272	2196
	1.9	3149	3073	2997	2920	2844	2768	2691	2615	2539	2462	2386	2310	2233
	2	3187	3110	3034	2958	2881	2805	2729	2652	2576	2500	2423	2347	2271
	2.1	3224	3148	3071	2995	2919	2842	2766	2690	2613	2537	2461	2384	2308
	2.2	3261	3185	3109	3032	2956	2880	2803	2727	2651	2574	2498	2422	2345
	2.3	3299	3222	3146	3070	2993	2917	2841	2764	2688	2612	2535	2459	2383
	2.4	3336	3260	3184	3107	3031	2954	2878	2802	2725	2649	2573	2496	2420
	2.5	3374	3297	3221	3145	3068	2992	2915	2839	2763	2686	2610	2534	2457
	2.6	3411	3335	3258	3182	3106	3029	2953	2876	2800	2724	2647	2571	2495
	2.7	3448	3372	3296	3219	3143	3067	2990	2914	2837	2761	2685	2608	2532
	2.8	3486	3409	3333	3257	3180	3104	3028	2951	2875	2799	2722	2646	2569
	2.9	3523	3447	3370	3294	3218	3141	3065	2989	2912	2836	2760	2683	2607
	3	3560	3484	3408	3331	3255	3179	3102	3026	2950	2873	2797	2721	2644

TONS=	10	TOTAL EXTERNAL STATIC PRESSURE												
		0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7
BLOWER POWER	1	3343	3267	3191	3114	3038	2962	2885	2809	2733	2656	2580	2504	2427
	1.2	3418	3342	3265	3189	3113	3036	2960	2884	2807	2731	2655	2578	2502
	1.4	3493	3416	3340	3264	3187	3111	3035	2958	2882	2806	2729	2653	2577
	1.6	3568	3491	3415	3338	3262	3186	3109	3033	2957	2880	2804	2728	2651
	1.8	3642	3566	3490	3413	3337	3261	3184	3108	3031	2955	2879	2802	2726
	2	3717	3641	3564	3488	3412	3335	3259	3183	3106	3030	2953	2877	2801
	2.2	3792	3715	3639	3563	3486	3410	3334	3257	3181	3105	3028	2952	2876
	2.4	3866	3790	3714	3637	3561	3485	3408	3332	3256	3179	3103	3027	2950
	2.6	3941	3865	3788	3712	3636	3559	3483	3407	3330	3254	3178	3101	3025
	2.8	4016	3940	3863	3787	3711	3634	3558	3481	3405	3329	3252	3176	3100
	3	4091	4014	3938	3862	3785	3709	3633	3556	3480	3403	3327	3251	3174
	3.2	4165	4089	4013	3936	3860	3784	3707	3631	3555	3478	3402	3326	3249
	3.4	4240	4164	4087	4011	3935	3858	3782	3706	3629	3553	3477	3400	3324
	3.6	4315	4238	4162	4086	4009	3933	3857	3780	3704	3628	3551	3475	3399
	3.8	4390	4313	4237	4160	4084	4008	3931	3855	3779	3702	3626	3550	3473
	4	4464	4388	4312	4235	4159	4083	4006	3930	3853	3777	3701	3624	3548
	4.2	4539	4463	4386	4310	4234	4157	4081	4005	3928	3852	3775	3699	3623
	4.4	4614	4537	4461	4385	4308	4232	4156	4079	4003	3927	3850	3774	3698
	4.6	4688	4612	4536	4459	4383	4307	4230	4154	4078	4001	3925	3849	3772
	4.8	4763	4687	4610	4534	4458	4381	4305	4229	4152	4076	4000	3923	3847
	5	4838	4762	4685	4609	4532	4456	4380	4303	4227	4151	4074	3998	3922

TONS=	12.5	TOTAL EXTERNAL STATIC PRESSURE												
		0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7
BLOWER POWER	2	4247	4171	4095	4018	3942	3865	3789	3713	3636	3560	3484	3407	3331
	2.2	4322	4246	4169	4093	4017	3940	3864	3788	3711	3635	3558	3482	3406
	2.4	4397	4320	4244	4168	4091	4015	3939	3862	3786	3710	3633	3557	3480
	2.6	4471	4395	4319	4242	4166	4090	4013	3937	3861	3784	3708	3632	3555
	2.8	4546	4470	4393	4317	4241	4164	4088	4012	3935	3859	3783	3706	3630
	3	4621	4545	4468	4392	4315	4239	4163	4086	4010	3934	3857	3781	3705
	3.2	4696	4619	4543	4467	4390	4314	4238	4161	4085	4008	3932	3856	3779
	3.4	4770	4694	4618	4541	4465	4389	4312	4236	4160	4083	4007	3930	3854
	3.6	4845	4769	4692	4616	4540	4463	4387	4311	4234	4158	4082	4005	3929
	3.8	4920	4843	4767	4691	4614	4538	4462	4385	4309	4233	4156	4080	4004
	4	4995	4918	4842	4765	4689	4613	4536	4460	4384	4307	4231	4155	4078
	4.2	5069	4993	4917	4840	4764	4687	4611	4535	4458	4382	4306	4229	4153
	4.4	5144	5068	4991	4915	4839	4762	4686	4610	4533	4457	4380	4304	4228
	4.6	5219	5142	5066	4990	4913	4837	4761	4684	4608	4532	4455	4379	4302
	4.8	5293	5217	5141	5064	4988	4912	4835	4759	4683	4606	4530	4454	4377
	5	5368	5292	5215	5139	5063	4986	4910	4834	4757	4681	4605	4528	4452
	5.2	5443	5367	5290	5214	5137	5061	4985	4908	4832	4756	4679	4603	4527
	5.4	5518	5441	5365	5289	5212	5136	5059	4983	4907	4830	4754	4678	4601
	5.6	5592	5516	5440	5363	5287	5211	5134	5058	4982	4905	4829	4752	4676
	5.8	5667	5591	5514	5438	5362	5285	5209	5133	5056	4980	4904	4827	4751
	6	5742	5665	5589	5513	5436	5360	5284	5207	5131	5055	4978	4902	4826

TONS=	15	TOTAL EXTERNAL STATIC PRESSURE												
		0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7
BLOWER POWER	2	4777	4701	4625	4548	4472	4396	4319	4243	4167	4090	4014	3938	3861
	2.2	4852	4776	4700	4623	4547	4470	4394	4318	4241	4165	4089	4012	3936
	2.4	4927	4851	4774	4698	4622	4545	4469	4392	4316	4240	4163	4087	4011
	2.6	5002	4925	4849	4773	4696	4620	4544	4467	4391	4315	4238	4162	4085
	2.8	5076	5000	4924	4847	4771	4695	4618	4542	4466	4389	4313	4237	4160
	3	5151	5075	4998	4922	4846	4769	4693	4617	4540	4464	4388	4311	4235
	3.2	5226	5149	5073	4997	4920	4844	4768	4691	4615	4539	4462	4386	4310
	3.4	5301	5224	5148	5072	4995	4919	4842	4766	4690	4613	4537	4461	4384
	3.6	5375	5299	5223	5146	5070	4994	4917	4841	4764	4688	4612	4535	4459
	3.8	5450	5374	5297	5221	5145	5068	4992	4916	4839	4763	4687	4610	4534
	4	5525	5448	5372	5296	5219	5143	5067	4990	4914	4838	4761	4685	4609
	4.2	5599	5523	5447	5370	5294	5218	5141	5065	4989	4912	4836	4760	4683
	4.4	5674	5598	5522	5445	5369	5292	5216	5140	5063	4987	4911	4834	4758
	4.6	5749	5673	5596	5520	5444	5367	5291	5214	5138	5062	4985	4909	4833
	4.8	5824	5747	5671	5595	5518	5442	5366	5289	5213	5137	5060	4984	4907
	5	5898	5822	5746	5669	5593	5517	5440	5364	5288	5211	5135	5059	4982
	5.2	5973	5897	5820	5744	5668	5591	5515	5439	5362	5286	5210	5133	5057
	5.4	6048	5971	5895	5819	5742	5666	5590	5513	5437	5361	5284	5208	5132
	5.6	6123	6046	5970	5894	5817	5741	5664	5588	5512	5435	5359	5283	5206
	5.8	6197	6121	6045	5968	5892	5816	5739	5663	5586	5510	5434	5357	5281
	6	6272	6196	6119	6043	5967	5890	5814	5738	5661	5585	5509	5432	5356

TONS=	20	TOTAL EXTERNAL STATIC PRESSURE												
		0.6	**0.7**	**0.8**	**0.9**	**1**	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**
BLOWER POWER	**3**	6135	6059	5983	5906	5830	5754	5677	5601	5524	5448	5372	5295	5219
	3.2	6210	6134	6057	5981	5905	5828	5752	5676	5599	5523	5446	5370	5294
	3.4	6285	6208	6132	6056	5979	5903	5827	5750	5674	5598	5521	5445	5369
	3.6	6359	6283	6207	6130	6054	5978	5901	5825	5749	5672	5596	5520	5443
	3.8	6434	6358	6281	6205	6129	6052	5976	5900	5823	5747	5671	5594	5518
	4	6509	6433	6356	6280	6203	6127	6051	5974	5898	5822	5745	5669	5593
	4.2	6584	6507	6431	6355	6278	6202	6126	6049	5973	5896	5820	5744	5667
	4.4	6658	6582	6506	6429	6353	6277	6200	6124	6048	5971	5895	5818	5742
	4.6	6733	6657	6580	6504	6428	6351	6275	6199	6122	6046	5970	5893	5817
	4.8	6808	6731	6655	6579	6502	6426	6350	6273	6197	6121	6044	5968	5892
	5	6883	6806	6730	6653	6577	6501	6424	6348	6272	6195	6119	6043	5966
	5.2	6957	6881	6805	6728	6652	6575	6499	6423	6346	6270	6194	6117	6041
	5.4	7032	6956	6879	6803	6727	6650	6574	6498	6421	6345	6268	6192	6116
	5.6	7107	7030	6954	6878	6801	6725	6649	6572	6496	6420	6343	6267	6190
	5.8	7181	7105	7029	6952	6876	6800	6723	6647	6571	6494	6418	6342	6265
	6	7256	7180	7103	7027	6951	6874	6798	6722	6645	6569	6493	6416	6340
	6.2	7331	7255	7178	7102	7025	6949	6873	6796	6720	6644	6567	6491	6415
	6.4	7406	7329	7253	7177	7100	7024	6948	6871	6795	6718	6642	6566	6489
	6.6	7480	7404	7328	7251	7175	7099	7022	6946	6870	6793	6717	6640	6564
	6.8	7555	7479	7402	7326	7250	7173	7097	7021	6944	6868	6792	6715	6639
	7	7630	7553	7477	7401	7324	7248	7172	7095	7019	6943	6866	6790	6714

TONS=	25	TOTAL EXTERNAL STATIC PRESSURE												
		0.6	**0.7**	**0.8**	**0.9**	**1**	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**
BLOWER POWER	**2**	6822	6746	6669	6593	6517	6440	6364	6288	6211	6135	6059	5982	5906
	2.4	6972	6895	6819	6743	6666	6590	6513	6437	6361	6284	6208	6132	6055
	2.8	7121	7045	6968	6892	6816	6739	6663	6587	6510	6434	6358	6281	6205
	3.2	7270	7194	7118	7041	6965	6889	6812	6736	6660	6583	6507	6431	6354
	3.6	7420	7344	7267	7191	7115	7038	6962	6885	6809	6733	6656	6580	6504
	4	7569	7493	7417	7340	7264	7188	7111	7035	6959	6882	6806	6730	6653
	4.4	7719	7642	7566	7490	7413	7337	7261	7184	7108	7032	6955	6879	6803
	4.8	7868	7792	7716	7639	7563	7487	7410	7334	7257	7181	7105	7028	6952
	5.2	8018	7941	7865	7789	7712	7636	7560	7483	7407	7331	7254	7178	7102
	5.6	8167	8091	8014	7938	7862	7785	7709	7633	7556	7480	7404	7327	7251
	6	8317	8240	8164	8088	8011	7935	7859	7782	7706	7629	7553	7477	7400
	6.4	8466	8390	8313	8237	8161	8084	8008	7932	7855	7779	7703	7626	7550
	6.8	8616	8539	8463	8386	8310	8234	8157	8081	8005	7928	7852	7776	7699
	7.2	8765	8689	8612	8536	8460	8383	8307	8231	8154	8078	8001	7925	7849
	7.6	8914	8838	8762	8685	8609	8533	8456	8380	8304	8227	8151	8075	7998
	8	9064	8988	8911	8835	8759	8682	8606	8529	8453	8377	8300	8224	8148
	8.4	9213	9137	9061	8984	8908	8832	8755	8679	8603	8526	8450	8374	8297
	8.8	9363	9286	9210	9134	9057	8981	8905	8828	8752	8676	8599	8523	8447
	9.2	9512	9436	9360	9283	9207	9131	9054	8978	8901	8825	8749	8672	8596
	9.6	9662	9585	9509	9433	9356	9280	9204	9127	9051	8975	8898	8822	8746
	10	9811	9735	9658	9582	9506	9429	9353	9277	9200	9124	9048	8971	8895

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F.Y.I.

TEMPERATURE CONTROLLERS... PORTABLE CHILLERS... CENTRAL CHILLERS... PUMP TANK STATIONS... TOWER SYSTEMS...

SUBJECT: TEMPERATURE - PRESSURE CHART FOR R-22, R-410A, R-407C, R-134A & R-404A REFRIGERANTS **FYI #289 9/17/2009**

Temperature		Refrigerant				
ºF	ºC	R-22	R-410a	R-407c	R-134a	R-404a
-60	-51.1	*11.9*	*0.9*	*16.0*	*21.6*	-
-55	-48.3	*9.2*	1.8	*13.7*	*20.2*	-
-50	-45.6	*6.1*	4.3	*11.1*	*18.6*	-
-45	-42.8	*2.7*	7.0	*8.1*	*16.7*	-
-40	-40.0	0.6	10.1	*4.8*	*14.7*	4.9
-35	-37.2	2.6	13.5	*1.1*	*12.3*	7.5
-30	-34.4	4.9	17.2	1.5	*9.7*	10.3
-25	-31.7	7.5	21.4	3.7	*6.8*	13.5
-20	-28.9	10.2	25.9	6.2	*3.6*	16.8
-18	-27.8	11.4	27.8	7.2	*2.2*	18.3
-16	-26.7	12.6	29.7	8.4	*0.7*	19.8
-14	-25.6	13.9	31.8	9.5	0.4	21.3
-12	-24.4	15.2	33.9	10.7	1.2	22.9
-10	-23.3	16.5	36.1	11.9	2.0	24.6
-8	-22.2	17.9	38.4	13.2	2.8	26.3
-6	-21.1	19.4	40.7	14.6	3.7	28.0
-4	-20.0	20.9	43.1	15.9	4.6	29.8
-2	-18.9	22.4	45.6	17.4	5.5	31.7
0	-17.8	24.0	48.2	18.9	6.5	33.7
1	-17.2	24.8	49.5	19.6	7.0	34.7
2	-16.7	25.7	50.9	20.4	7.5	35.7
3	-16.1	26.5	52.2	21.2	8.0	36.7
4	-15.6	27.4	53.6	22.0	8.6	37.7
5	-15.0	28.3	55.0	22.8	9.1	38.8
6	-14.4	29.1	56.4	23.7	9.7	39.8
7	-13.9	30.0	57.9	24.5	10.2	40.9
8	-13.3	31.0	59.3	25.4	10.8	42.0
9	-12.8	31.9	60.8	26.2	11.4	43.1
10	-12.2	32.8	62.3	27.1	12.0	44.3
11	-11.7	33.8	63.9	28.0	12.6	45.4
12	-11.1	34.8	65.4	29.0	13.2	46.6
13	-10.6	35.8	67.0	29.9	13.8	47.8
14	-10.0	36.8	68.6	30.9	14.4	49.0
15	-9.4	37.8	70.2	31.8	15.1	50.2
16	-8.9	38.8	71.9	32.8	15.7	51.5
17	-8.3	39.9	73.5	33.8	16.4	52.7
18	-7.8	40.9	75.2	34.8	17.1	54.0
19	-7.2	42.0	77.0	35.9	17.7	55.3
20	-6.7	43.1	78.7	36.9	18.4	56.6
21	-6.1	44.2	80.5	38.0	19.2	57.9
22	-5.6	45.3	82.3	39.1	19.9	59.3
23	-5.0	46.5	84.1	40.2	20.6	60.6
24	-4.4	47.6	85.9	41.3	21.4	62.0
25	-3.9	48.8	87.8	42.4	22.1	63.4
26	-3.3	50.0	89.7	43.6	22.9	64.8

Temperature		Refrigerant				
ºF	ºC	R-22	R-410a	R-407c	R-134a	R-404a
27	-2.8	51.2	91.6	44.7	23.7	66.2
28	-2.2	52.4	93.5	45.9	24.5	67.7
29	-1.7	53.7	95.5	47.1	25.3	69.2
30	-1.1	54.9	97.5	48.4	26.1	70.7
31	-0.6	56.2	99.5	49.6	26.9	72.1
32	0.0	57.5	101.6	50.9	27.8	73.8
33	0.6	58.8	103.6	52.1	28.6	75.3
34	1.1	60.2	105.7	53.4	29.5	76.9
35	1.7	61.5	107.9	54.8	30.4	78.5
36	2.2	62.9	110.0	56.1	31.3	80.2
37	2.8	64.3	112.2	57.5	32.2	81.7
38	3.3	65.7	114.4	58.9	33.1	83.5
39	3.9	67.1	116.7	60.3	34.1	85.2
40	4.4	68.6	118.9	31.7	35.0	86.9
41	5.0	70.0	121.2	63.1	36.0	88.6
42	5.6	71.5	123.6	64.6	37.0	90.4
43	6.1	73.0	125.9	66.1	38.0	92.2
44	6.7	74.5	128.3	67.6	39.0	94.0
45	7.2	76.1	130.7	69.1	40.0	95.8
46	7.8	77.6	133.2	70.6	14.1	97.6
47	8.3	79.2	135.6	72.2	42.2	99.5
48	8.9	80.8	138.2	73.8	43.2	101.4
49	9.4	82.4	140.7	75.4	44.3	103.3
50	10.0	84.1	143.3	77.1	45.4	105.3
55	12.8	92.6	156.6	106.0	51.2	115.3
60	15.6	101.6	170.7	116.2	57.4	126.0
65	18.3	111.3	185.7	127.0	64.0	137.4
70	21.1	121.5	201.5	138.5	71.1	149.3
75	23.9	132.2	218.2	150.6	78.6	161.9
80	26.7	143.7	235.9	163.5	86.7	175.4
85	29.4	155.7	254.6	177.0	95.2	189.6
90	32.2	168.4	274.3	191.3	104.3	204.5
95	35.0	181.9	295.0	206.4	113.9	220.2
100	37.8	196.0	316.9	222.3	124.1	236.8
105	40.6	210.8	339.9	239.0	134.9	254.2
110	43.3	226.4	364.1	256.5	146.3	272.5
115	46.1	242.8	389.6	274.9	158.4	291.9
120	48.9	260.0	416.4	294.2	171.1	312.1
125	51.7	278.1	444.5	314.5	184.5	333.4
130	54.4	297.0	474.0	335.7	198.7	355.6
135	57.2	316.7	505.0	357.8	213.5	379.1
140	60.0	337.4	537.6	380.9	229.2	403.7
145	62.8	359.1	571.7	405.1	245.6	429.6
150	65.6	381.7	607.6	430.3	262.8	456.8
155	68.3	405.4	645.2	456.6	281.0	484.8

Italics indicates vacuum (inches of mercury) Standard font indicates pressure (pounds per inch gauge)

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Target Superheat Chart

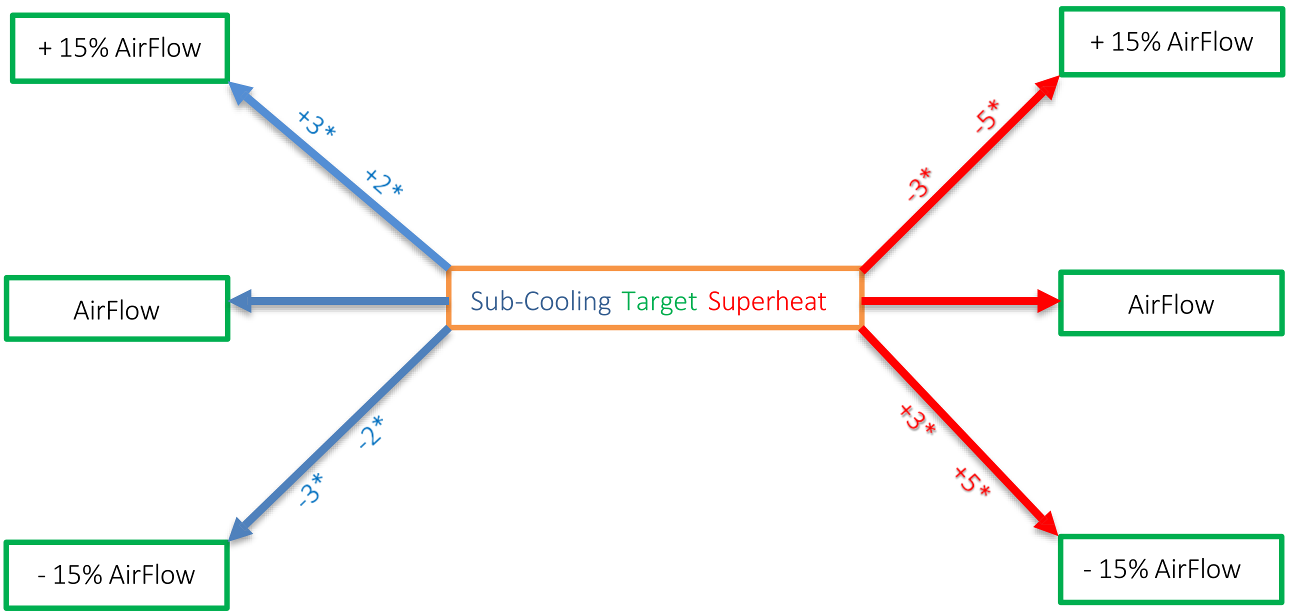
Return Air Wet-Bulb Temperature (F) across the top; Condenser Air Dry-Bulb Temperature (F) down the side.

Condenser Air Dry-Bulb Temperature (F)	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
70	5.3	5.4	5.5	5.5	6.4	8.1	9.7	11.2	12.7	14.2	15.7	17.0	18.4	19.7	20.9	22.3	23.9	25.4	27.0	28.5	30.0	31.5	33.0	34.4	35.9	37.3	38.7
71	5.3	5.4	5.5	5.5	5.6	7.3	8.9	10.5	12.1	13.6	15.0	16.4	17.8	19.1	20.3	21.7	23.3	24.9	26.4	28.0	29.5	31.0	32.5	34.0	35.4	36.9	38.3
72	5.3	5.4	5.5	5.5	5.6	6.4	8.1	9.8	11.4	12.9	14.4	15.8	17.2	18.5	19.7	21.2	22.8	24.3	25.9	27.4	29.0	30.5	32.0	33.5	35.0	36.5	37.9
73	5.3	5.4	5.5	5.5	5.6	5.6	7.3	9.0	10.7	12.2	13.7	15.2	16.6	17.9	19.2	20.6	22.2	23.8	25.4	26.9	28.5	30.0	31.5	33.1	34.6	36.0	37.5
74	5.3	5.4	5.5	5.5	5.6	5.6	6.5	8.2	9.9	11.5	13.1	14.5	15.9	17.3	18.6	20.0	21.6	23.2	24.8	26.4	28.0	29.5	31.1	32.6	34.1	35.6	37.1
75	5.3	5.4	5.5	5.5	5.6	5.6	5.6	7.4	9.2	10.8	12.4	13.9	15.3	16.7	18.0	19.4	21.1	22.7	24.3	25.9	27.5	29.1	30.6	32.2	33.7	35.2	36.7
76	5.3	5.4	5.5	5.5	5.6	5.6	5.6	6.6	8.4	10.1	11.7	13.2	14.7	16.1	17.4	18.9	20.5	22.1	23.8	25.4	27.0	28.6	30.1	31.7	33.3	34.8	36.3
77	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	7.5	9.3	11.0	12.5	14.0	15.4	16.8	18.3	20.0	21.6	23.2	24.9	26.5	28.1	29.7	31.3	32.8	34.4	36.0
78	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	6.7	8.5	10.2	11.8	13.4	14.8	16.2	17.7	19.4	21.1	22.7	24.4	26.0	27.6	29.2	30.8	32.4	34.0	35.6
79	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	7.7	9.5	11.1	12.7	14.2	15.6	17.1	18.8	20.5	22.2	23.8	25.5	27.1	28.8	30.4	32.0	33.6	35.2
80	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	6.9	8.7	10.4	12.0	13.5	15.0	16.6	18.3	20.0	21.7	23.3	25.0	26.7	28.3	29.9	31.6	33.2	34.8
81	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	6.0	7.9	9.7	11.3	12.9	14.3	16.0	17.7	19.4	21.1	22.8	24.5	26.2	27.9	29.5	31.2	32.8	34.4
82	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	7.1	8.9	10.6	12.2	13.7	15.4	17.2	18.9	20.6	22.3	24.0	25.7	27.4	29.1	30.7	32.4	34.0
83	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	6.3	8.2	9.9	11.6	13.1	14.9	16.6	18.4	20.1	21.8	23.5	25.2	26.9	28.6	30.3	32.0	33.7
84	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	7.4	9.2	10.9	12.5	14.3	16.1	17.8	19.6	21.3	23.0	24.8	26.5	28.2	29.9	31.6	33.3
85	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	6.6	8.5	10.3	11.9	13.7	15.5	17.3	19.0	20.8	22.6	24.3	26.0	27.8	29.5	31.2	32.9
86	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.8	7.8	9.6	11.3	13.2	15.0	16.7	18.5	20.3	22.1	23.8	25.6	27.3	29.1	30.8	32.6
87	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	7.0	8.9	10.6	12.6	14.4	16.2	18.0	19.8	21.6	23.4	25.1	26.9	28.7	30.4	32.2
88	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	6.3	8.2	10.0	12.0	13.9	15.7	17.5	19.3	21.1	22.9	24.7	26.5	28.3	30.1	31.8
89	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	7.5	9.4	11.5	13.3	15.1	17.0	18.8	20.6	22.4	24.3	26.1	27.9	29.7	31.5
90	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	6.8	8.8	10.9	12.8	14.6	16.5	18.3	20.1	22.0	23.8	25.6	27.5	29.3	31.1
91	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	6.1	8.1	10.3	12.2	14.1	15.9	17.8	19.7	21.5	23.4	25.2	27.1	28.9	30.8
92	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	7.5	9.8	11.7	13.5	15.4	17.3	19.2	21.1	22.9	24.8	26.7	28.5	30.4
93	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	6.8	9.2	11.1	13.0	14.9	16.8	18.7	20.6	22.5	24.4	26.3	28.2	30.1
94	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	6.2	8.7	10.6	12.5	14.4	16.3	18.2	20.2	22.1	24.0	25.9	27.8	29.7
95	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	8.1	10.0	12.0	13.9	15.8	17.8	19.7	21.6	23.6	25.5	27.4	29.4
96	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	7.5	9.5	11.4	13.4	15.3	17.3	19.2	21.2	23.2	25.1	27.1	29.0
97	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	7.0	8.9	10.9	12.9	14.9	16.8	18.8	20.8	22.7	24.7	26.7	28.7
98	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	6.4	8.4	10.4	12.4	14.4	16.4	18.3	20.3	22.3	24.3	26.3	28.3
99	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.8	7.9	9.9	11.9	13.9	15.9	17.9	19.9	21.9	24.0	26.0	28.0
100	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	7.3	9.3	11.4	13.4	15.4	17.5	19.5	21.5	23.6	25.6	27.7
101	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	6.8	8.8	10.9	12.9	15.0	17.0	19.1	21.1	23.2	25.3	27.3
102	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	6.2	8.3	10.4	12.4	14.5	16.6	18.6	20.7	22.8	24.9	27.0
103	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.7	7.8	9.9	11.9	14.0	16.1	18.2	20.3	22.4	24.5	26.7
104	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.2	7.2	9.3	11.5	13.6	15.7	17.8	19.9	22.1	24.2	26.3
105	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.2	6.7	8.8	11.0	13.1	15.2	17.4	19.5	21.7	23.8	26.0
106	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.2	6.2	8.3	10.5	12.6	14.8	17.0	19.1	21.3	23.5	25.7
107	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.2	5.7	7.9	10.0	12.2	14.4	16.6	18.7	21.0	23.2	25.4
108	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.2	5.2	7.4	9.5	11.7	13.9	16.1	18.4	20.6	22.8	25.1
109	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.2	5.2	6.9	9.1	11.3	13.5	15.7	18.0	20.2	22.5	24.7
110	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.2	5.2	6.4	8.6	10.8	13.1	15.3	17.6	19.9	22.1	24.4
111	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.2	5.2	5.9	8.1	10.4	12.6	14.9	17.2	19.5	21.8	24.1
112	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.2	5.2	5.4	7.6	9.9	12.2	14.5	16.8	19.1	21.5	23.8
113	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.2	5.2	5.4	7.2	9.5	11.8	14.1	16.4	18.8	21.1	23.5
114	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.2	5.2	5.4	6.7	9.0	11.4	13.7	16.1	18.4	20.8	23.2
115	5.3	5.4	5.5	5.5	5.6	5.6	5.6	5.7	5.9	5.2	5.5	5.0	5.5	5.4	5.6	5.3	5.2	5.2	5.4	6.2	8.6	10.9	13.3	15.7	18.1	20.5	22.9

Wet Bulb Temperature to Enthalpy Conversion Table

Wet Bulb Temperature ºF	Tenths of a Degree Fahrenheit									
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
35	13.01	13.05	13.1	13.14	13.18	13.23	13.27	13.31	13.35	13.4
36	13.44	13.48	13.53	13.57	13.61	13.66	13.7	13.75	13.79	13.83
37	13.87	13.91	13.96	14	14.05	14.09	14.14	14.18	14.23	14.27
38	14.32	14.37	14.41	14.46	14.5	14.55	14.59	14.64	14.68	14.73
39	14.77	14.82	14.86	14.91	14.95	15	15.05	15.09	15.14	15.18
40	15.23	15.28	15.32	15.37	15.42	15.46	15.51	15.56	15.6	15.65
41	15.7	15.75	15.8	15.84	15.89	15.94	15.99	16.03	16.08	16.13
42	16.17	16.22	16.27	16.32	16.36	16.41	16.46	16.51	16.56	16.61
43	16.66	16.71	16.76	16.81	16.86	16.91	16.96	17	17.05	17.1
44	17.15	17.2	17.25	17.3	17.35	17.4	17.45	17.5	17.55	17.6
45	17.65	17.7	17.75	17.8	17.85	17.91	17.96	18.01	18.06	18.11
46	18.16	18.21	18.26	18.32	18.37	18.42	18.47	18.52	18.58	18.63
47	18.68	18.73	18.79	18.84	18.89	18.95	19	19.05	19.1	19.16
48	19.21	19.26	19.32	19.37	19.43	19.48	19.53	16.59	19.64	19.7
49	19.75	19.81	19.86	19.92	19.97	20.03	20.08	20.14	20.19	20.25
50	20.3	20.36	20.41	20.47	20.52	20.58	20.64	20.69	20.75	20.8
51	20.86	20.92	20.97	21.03	21.09	21.15	21.2	21.26	21.32	21.38
52	21.44	21.5	21.56	21.62	21.67	21.73	21.79	21.85	21.91	21.97
53	22.02	22.08	22.14	22.2	22.26	22.32	22.38	22.44	22.5	22.56
54	22.62	22.68	22.74	22.8	22.86	22.92	22.98	23.04	23.1	23.16
55	23.22	23.28	23.34	23.41	23.47	23.53	23.59	23.65	23.72	23.78
56	23.84	23.9	23.97	24.03	24.1	24.16	24.22	24.29	24.35	24.42
57	24.48	24.54	24.61	24.67	24.74	24.8	24.86	24.93	24.99	25.06
58	25.12	25.19	25.25	25.32	25.38	25.45	25.52	25.58	25.65	25.71
59	25.78	25.85	25.92	25.98	26.05	26.12	26.19	26.26	26.32	26.39
60	26.46	26.53	26.6	26.67	26.74	26.81	26.87	26.94	27.01	27.08
61	27.15	27.22	27.29	27.36	27.43	27.5	27.57	27.64	27.71	27.78
62	27.85	27.92	27.99	28.07	28.14	28.21	28.28	28.35	28.43	28.5
63	28.57	28.64	28.72	28.79	28.87	28.94	29.01	29.09	29.16	29.24
64	29.31	29.39	29.46	29.54	29.61	29.69	29.76	29.84	29.91	29.99
65	30.06	30.14	30.21	30.29	30.37	30.45	30.52	30.6	30.68	30.75
66	30.83	30.91	30.99	31.07	31.15	31.23	31.3	31.38	31.46	31.54
67	31.62	31.7	31.78	31.86	31.94	32.02	32.1	32.18	32.26	32.34
68	32.42	32.5	32.59	32.67	32.75	32.84	32.92	33	33.08	33.17
69	33.25	33.33	33.42	33.5	33.59	33.67	33.75	33.84	33.92	34.01
70	34.09	34.18	34.26	34.35	34.43	34.52	34.61	34.69	34.78	34.86
71	34.95	35.04	35.13	35.21	35.3	35.39	35.48	35.57	35.65	35.74
72	35.83	35.92	36.01	36.1	36.19	36.29	36.38	36.47	36.56	36.65
73	36.74	36.83	36.92	37.02	37.11	37.2	37.29	37.38	37.48	37.57
74	37.66	37.76	37.85	37.95	38.04	38.14	38.23	38.33	38.42	38.52
75	38.61	38.71	38.8	38.9	38.99	39.09	39.19	39.28	39.38	39.47
76	39.57	39.67	39.77	39.87	39.97	40.07	40.17	40.27	40.37	40.47
77	40.57	40.67	40.77	40.87	40.97	41.08	41.18	41.28	41.38	41.48
78	41.58	41.68	41.79	41.89	42	42.1	42.2	42.31	42.41	42.52
79	42.62	42.73	42.83	42.94	43.05	43.16	43.26	43.37	43.48	43.58
80	43.69	43.8	43.91	44.02	44.13	44.24	44.34	44.45	44.56	44.67
81	44.78	44.89	45	45.12	45.23	45.34	45.45	45.56	45.68	45.79
82	45.9	46.01	46.13	46.24	46.36	46.47	46.58	46.7	46.81	46.93
83	47.04	47.16	47.28	47.39	47.51	47.63	47.75	47.87	47.98	48.1
84	48.22	48.34	48.46	48.58	48.7	48.83	48.95	49.07	49.19	49.31
85	49.43	49.55	49.68	49.8	49.92	50.05	50.17	50.29	50.41	50.54
	Enthalpy in BTU per Pound of Dry Air									

Superheat / Sub-Cooling / Air-Flow Correlation Chart



Airflow/Sub-Cooling Correlation

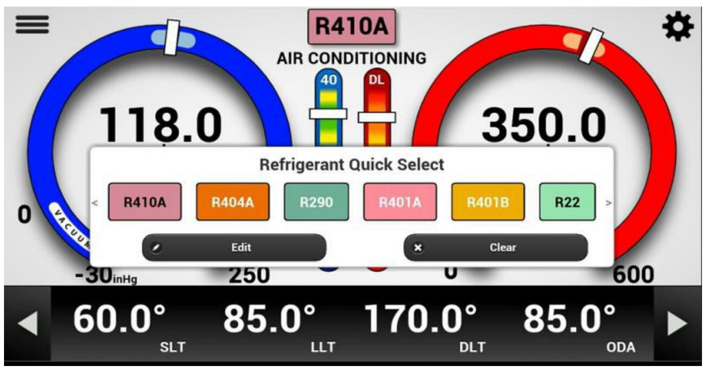
1. Airflow Right on target, sub-cooling should be right on target or fluctuating +/- right at target
   i. When the system is moving the correct amount of airflow there is no need to flood or starve the evaporator coil. The TXV if working properly will meter the correct amount of refrigerant into the coil.
2. Airflow -15% from target, sub-cooling should be left at -3* or fluctuating between target and -3*
   i. When the system is at the -15% airflow this clearly means there is not enough air flowing through the evaporator coil allowing it to get colder than designed.
   ii. The TXV will modulate to meter the correct amount of refrigerant into the evaporator coil maintaining a constant coil temp that correlates to the amount of air flowing through the coil. If left at +3* above target this means the TXV has to close more than designed to maintain the correct amount of refrigerant flowing into the coil causing inaccurate pressure readings.
   iii. If the system is lacking airflow with too much refrigerant, chances are it will cause compressor slugging and pressures are going to be off.
3. Airflow +15% from target, sub-cooling should be left at +3* or fluctuating between target and +3*
   i. When the system is at the +15% airflow this clearly means there is too much air flowing though the evaporator coil not allowing it to get cold enough.
   ii. The TXV will modulate to meter the correct amount of refrigerant into the evaporator coil maintaining a constant coil temp that correlates to the amount of air flowing through the coil. If left at -3* below target this means the TXV has to open more than designed to compensate for the lack of refrigerant and maintain the correct amount of refrigerant flowing into the coil causing inaccurate pressure readings.
   iii. If the system is moving too much airflow with not enough refrigerant, chances are the evaporator coil is starving and pressures are going to be off.

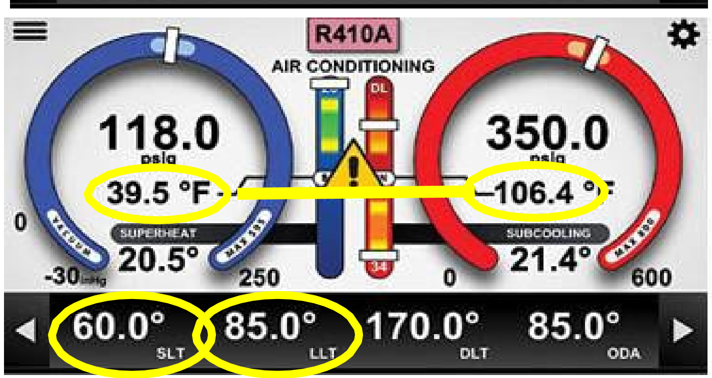
Airflow/Superheat Correlation

1. Airflow Right on target, superheat should be right on target or fluctuating +/- right at target
    i. When the system is moving the correct amount of airflow there is no need to flood or starve the evaporator coil. The fixed orifice will meter the correct amount of refrigerant into the coil.
    ii. Keep in mind that a fixed orifice does not modulate open or closed
2. Airflow -15% from target, superheat should be left at +5* or fluctuating between target and +5*
    i. When the system is at -15% airflow this clearly means there is not enough air flowing through the evaporator coil allowing it to get colder than designed if superheat is not adjusted accordingly.
    ii. A Fixed orifice is a simple fixed device with no moving parts. It cannot vary the amount of refrigerant flowing into the evaporator the way an expansion valve can. The correct charge in the system is going to depend on the indoor WB and ODA to calculate a target superheat.
    iii. If the system is lacking airflow with too much refrigerant, chances are you are over flooding the evaporator and probably causing liquid to get back to the compressor
3. Airflow +15% from target, superheat should be left at -5* or fluctuating between target and -5*
    i. When the system is at +15% airflow this clearly means there is too much air flowing through the evaporator coil not allowing the evaporator coil to get cold enough if superheat is not adjusted accordingly.
    ii. A Fixed orifice is a simple fixed device with no moving parts. It cannot vary the amount of refrigerant flowing into the evaporator the way an expansion valve can. The correct charge in the system is going to depend on the indoor WB and ODA to calculate a target superheat.
    iii. If the system is moving too much airflow and not enough refrigerant you are starving the evaporator not allowing it to get cold enough.

Note: When superheat and/or sub-cooling do not correlate to the amount of airflow moving through the evaporator coil this will have an effect on Delta-T and Delta-H also having an effect on Capacity

Temperature °F	Temperature °C	R22	R407C Liquid Press.	R407C Vapor Press.	R417A Liquid Press.	R417A Vapor Press.	R410A
-40	-40.0	0.5	3.0	4.4	0.5	4.2	11.6
-35	-37.2	2.6	5.4	0.6	2.4	0.8	14.9
-30	-34.4	4.9	8.0	1.8	4.5	1.5	18.5
-25	-31.7	7.4	10.9	4.1	6.9	3.6	22.5
-20	-28.9	10.1	14.1	6.6	9.4	5.9	26.9
-15	-26.1	13.2	17.6	9.4	12.2	8.4	31.7
-10	-23.3	16.5	21.3	12.5	15.2	11.2	36.8
-5	-20.6	20.1	25.4	15.9	18.5	14.3	42.5
0	-17.8	24.0	29.9	19.6	22.0	17.6	48.6
5	-15.0	28.2	34.7	23.6	25.9	21.2	55.2
10	-12.2	32.8	39.9	28.0	30.0	25.1	62.3
15	-9.4	37.7	45.6	32.8	34.5	29.3	70.0
20	-6.7	43.0	51.6	38.0	39.3	33.9	78.3
25	-3.9	48.8	58.2	43.6	44.5	38.9	87.3
30	-1.1	54.9	65.2	49.6	50.8	44.2	96.8
35	1.7	61.5	72.6	56.1	56.0	49.9	107
40	4.4	68.5	80.7	63.1	62.4	56.1	118
45	7.2	76.0	89.2	70.6	69.2	62.7	130
50	10.0	84.0	98.3	78.7	76.4	69.8	142
55	12.8	92.6	108	87.3	87.2	77.3	155
60	15.6	102	118	96.8	95.7	85.4	170
65	18.3	111	129	106	105	93.9	185
70	21.1	121	141	117	114	103	201
75	23.9	132	153	128	124	113	217
80	26.7	144	166	140	134	123	235
85	29.4	156	180	153	146	134	254
90	32.2	168	195	166	157	145	274
95	35.0	182	210	181	170	158	295
100	37.8	196	226	196	183	170	317
105	40.6	211	243	211	197	184	340
110	43.3	226	261	229	211	198	365
115	46.1	243	280	247	225	212	391
120	48.9	260	300	266	241	227	418
125	51.7	278	321	286	258	244	446
130	54.4	297	342	307	275	261	476
135	57.2	317	365	329	293	279	507
140	60.0	337	389	353	312	297	539
145	62.8	359	-	-	-	-	573
150	65.6	382	-	-	-	-	608





iManifold Pressure Testing for Accuracy

Testing your iManifold device for accuracy periodically is very important.

Turn on your iManifold device and make sure your tablet is connected. Make sure to purge all refrigerant from the hoses, close off the low side and high side service valves at the end of the hoses. Connect the yellow charging hose to the refrigerant tank being used for pressure testing. (Be sure to correctly choose the refrigerant type on the tab at the top of the saturation bars of the app). Take T1(SLT) and T2(LLT) wired probes and tape them to the side of the refrigerant tank, and make sure they are on the liquid portion of the refrigerant. Open the Lo, Hi & Ref valves on the iManifold. Fully open the valve on the refrigerant tank to allow refrigerant vapor to flow through all the hoses. Allow 2-3 minutes for all thermistors to adjust. Determine the temperature of the refrigerant tank and refer to the PT chart to determine its corresponding pressure. Once you find the corresponding pressure on the PT chart for the type of refrigerant you are using, compare that pressure to the pressures on the iManifold. Low side and High side pressures should be at the same pressure and correspond to the PT Chart. Evap Temp, Cond Temp, T1 (SLT) & T2 (LLT) should all be at the same temperature as the refrigerant and correspond to the temperature and pressures on the PT Chart. In a large zip lock bag Add salt and water in a small container to create a consistent RH in the bag. Insert your hygrometers and wait several hours or overnight All instruments should display the same temperature and RH in the 73% to 75% range depending on temperature. Checking your iManifolds for accuracy should be a part of every technicians routine.

Formulas

Unit Capacity BTU = 4.5 x _________CFM x ________Δh =________BTU (Real Time)

As the owner an AC System, not only do you want to know that your AC system is producing the 10 tons of cooling you paid for, but you want to know that it produces that cooling at the efficiency you paid for.

EER = BTU/watts (10 ton, 120,000 BTU unit using 12,000 watts = 10 EER)

- Volts x amps x pf =watts
- 240V x 52.5A x.95pf = 12,000 watts or 12 kW

kW vs kWh = 10 ton unit running for 1 hour

Work Problem 1 (Test In)

Calculating real Time BTU

RADB__________ RAWB_______ R/A Enthalpy_________

SADB_________ SAWB_______ S/A Enthalpy_________

Subtract the Supply air enthalpy from return enthalpy = Enthalpy Difference___________

Enthalpy Diff________ X 4.5 X CFM__________= BTU__________(Real Time)

Calculating real time EER

Volts________X Amps________X Power Factor .95 = Watts or Kw___________

Actual BTU_______________Divide by Actual Kw_______________= Actual EER _____________

Work Problem 1 (Test Out)

Calculating real Time BTU

RADB__________ RAWB_______ R/A Enthalpy_________

SADB_________ SAWB_______ S/A Enthalpy_________

Subtract the Supply air enthalpy from return enthalpy = Enthalpy Difference___________

Enthalpy Diff________ X 4.5 X CFM__________= BTU__________(Real Time)

Calculating real time EER

Volts________X Amps________X Power Factor .95 = Watts or Kw___________

Actual BTU_______________Divide by Actual Kw_______________= Actual EER _____________

Work Problem 2 (Test In)

Calculating real Time BTU

RADB__________ RAWB_______ R/A Enthalpy__________

SADB_________ SAWB_______ S/A Enthalpy__________

Subtract the Supply air enthalpy from return enthalpy = Enthalpy Difference___________

Enthalpy Diff_________ X 4.5 X CFM__________= BTU__________(Real Time)

Calculating real time EER

Volts________X Amps________X Power Factor .95 = Watts or Kw____________

Actual BTU_______________Divide by Actual Kw_______________= Actual EER _____________

Work Problem 2 (Test Out)

Calculating real Time BTU

RADB__________ RAWB_______ R/A Enthalpy__________

SADB_________ SAWB_______ S/A Enthalpy__________

Subtract the Supply air enthalpy from return enthalpy = Enthalpy Difference___________

Enthalpy Diff_________ X 4.5 X CFM__________= BTU__________(Real Time)

Calculating real time EER

Volts________X Amps________X Power Factor .95 = Watts or Kw____________

Actual BTU_______________Divide by Actual Kw_______________= Actual EER _____________

Notes:

Work Problem 3 (Test In)

Calculating real Time BTU

RADB__________ RAWB________ R/A Enthalpy__________

SADB_________ SAWB________ S/A Enthalpy__________

Subtract the Supply air enthalpy from return enthalpy = Enthalpy Difference____________

Enthalpy Diff_________ X 4.5 X CFM__________= BTU__________(Real Time)

Calculating real time EER

Volts________X Amps_________X Power Factor .95 = Watts or Kw____________

Actual BTU_______________Divide by Actual Kw_______________= Actual EER _____________

Work Problem 3 (Test Out)

Calculating real Time BTU

RADB__________ RAWB________ R/A Enthalpy__________

SADB_________ SAWB________ S/A Enthalpy__________

Subtract the Supply air enthalpy from return enthalpy = Enthalpy Difference____________

Enthalpy Diff_________ X 4.5 X CFM__________= BTU__________(Real Time)

Calculating real time EER

Volts________X Amps_________X Power Factor .95 = Watts or Kw____________

Actual BTU_______________Divide by Actual Kw_______________= Actual EER _____________

Notes:

Work Problem 4 (Test In)

Calculating real Time BTU (3 phase)

RADB__________ RAWB_______ R/A Enthalpy__________

SADB_________ SAWB_______ S/A Enthalpy__________

Subtract the Supply air enthalpy from return enthalpy = Enthalpy Difference____________

Enthalpy Diff_________ X 4.5 X CFM__________= BTU__________(Real Time)

Calculating real time EER

Volts________X Amps_________X Power Factor .95 = Watts or Kw____________

Actual BTU_______________Divide by Actual Kw_______________= EER__________/ X 3= Actual EER______

Work Problem 4 (Test Out)

Calculating real Time BTU (3 phase)

RADB__________ RAWB_______ R/A Enthalpy__________

SADB_________ SAWB_______ S/A Enthalpy__________

Subtract the Supply air enthalpy from return enthalpy = Enthalpy Difference____________

Enthalpy Diff_________ X 4.5 X CFM__________= BTU__________(Real Time)

Calculating real time EER

Volts________X Amps_________X Power Factor .95 = Watts or Kw____________

Actual BTU_______________Divide by Actual Kw_______________= EER__________/ X 3= Actual EER______

Notes:

ESP - External Static Pressure

Perhaps one of the most frequently ignored factors in setting up a duct system is the external static duct pressure (ESP). Blowers move air throughout the system and are designed to overcome restrictions in the system external to the equipment such as system components and ductwork. They are rated for a given CFM at maximum External Static Pressure on high speed. PSC Motors are generally rated for 0.5" WC. ECM Motors are generally 0.8" WC to 1.0" WC (But typically 0.5" WC).

External Static Pressure is the measurement of all the resistance in the duct system that the fan has to work against. Examples are filters, grills, A/C coils and the ductwork. It is the sum of the suction pressure (negative) and discharge pressure (positive) created by the equipment blower.

External Static pressure is measured using a manometer and is expressed in inches of water column (i.e., #" WC). Readings are taken on a forced air furnace at the inlet of the furnace blower after the filter and exiting the discharge of the furnace blower before the evaporator coil. For an RTU and air handlers, measurements are taken at the inlet of the blower after the filter and the discharge or outlet of the RTU or air handler.

> *"If you know the ESP you can determine the CFM."*

The CFM of a motor is directly related to the external static pressure. The higher the ESP, the lower the CFM. The lower the ESP, the higher the CFM. High ESP readings indicate that there is excessive resistance in the system. This may be caused by dirty filters, a dirty evaporator coil, closed dampers, restricted supply or return grills or undersized duct. If you know the ESP you can determine the CFM.

The fan performance chart shows the relationship between ESP and CFM and is a vital tool in troubleshooting air side problems and calculating CFM.

How much ESP does the fan have to overcome?
Refer to diagram 1 for this example. The system fan has to create a negative pressure of -0.19" WC to pull air into the blower. 0.03" WC is lost across the return grill, 0.08" WC is lost through the return duct system and 0.08" WC is lost across the filter for a total of 0.19" WC.
The system fan has to create a positive pressure of +0.39° WC to push air into the conditioned space. 0.25" WC is lost across the A/C coil (when wet), 0.1" WC is lost through the supply duct system and 0.03" WC is lost across the supply register for a total of 0.39" WC. The total pressure drop of the system equals 0.58" WC. This means that the fan has to be able to overcome at least 0.58" WC of ESP at design CFM for the system to operate properly.
If the fan cannot overcome this ESP at the given CFM from the blower performance curve, then the fan needs to be increased or the resistance of the system lowered.

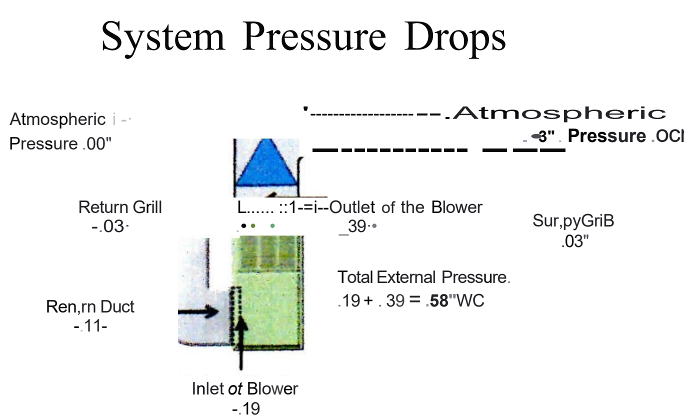


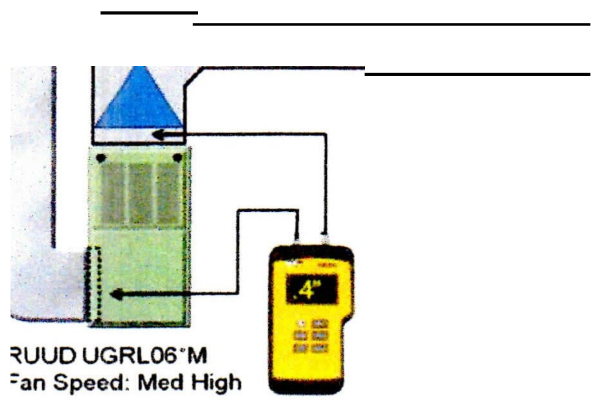
Diagram 1

Example:

What is the actual CFM of the RUUD URGL 06*M furnace with the fan set on Medium High and an ESP of 0.4" WC?

Answer:

The blower performance curve shows that the blower is moving 960 CMF.

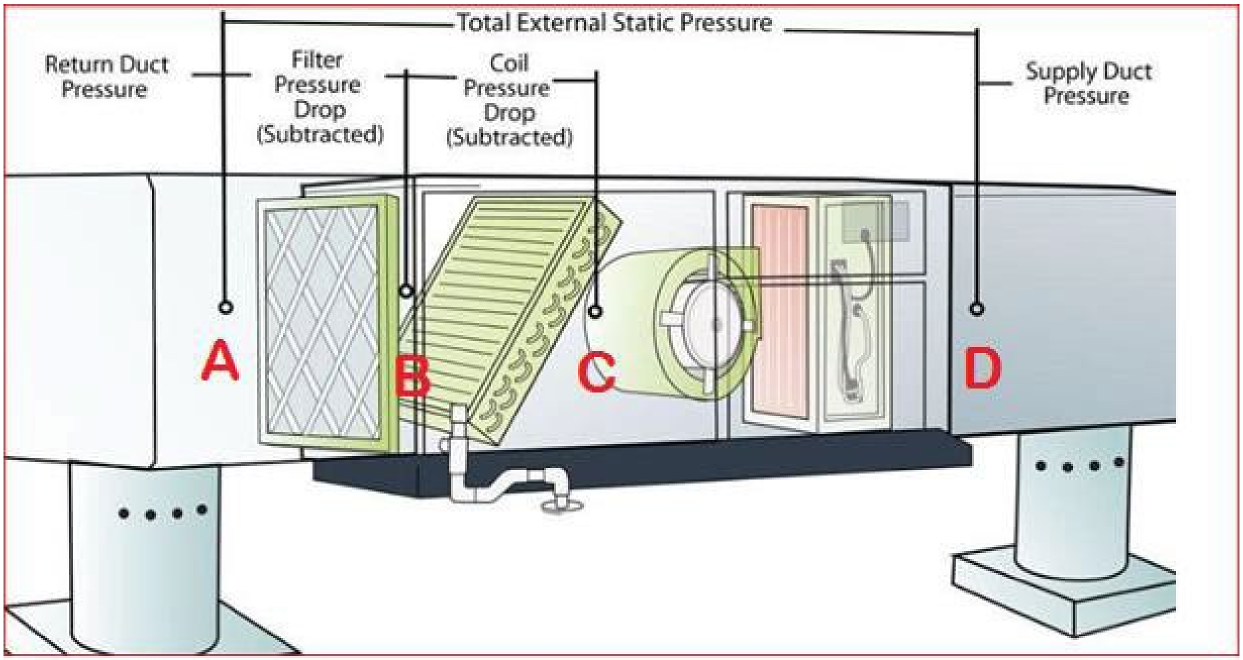


BLOWER PERFORMANCEDATA-RGRL MODELS

MODEL AGAL-	BLOWER SIZE lmml	MOTOR H.P. IWJ	BLOWER SPEED	CFM [Us] AIR DELIVERY EXTERNAL STATIC PRESSURE INCHES WATER COLUMN lkPal						
				0.1 [.02)	0.2 (.051	0.3 1.07)	0.4 (.10)	0.51.121	0.6 (.151	0.7 (.171
0-H.1	11x7 1219, ;eJ	Vi [3i3J	OW MED- 0 MED-HI HIGH	805IJSQI 92) 454 ; 1Ju1s3e 60 Jf42J				!!5 3 I i6J '|	t45 1 3 4 1 I3 0 3 4 4 95•) 1 --181 1 0 I538)	60512851 690 325 soo1m1 1-0eow1 I
%·M	11, 7 1279 781	12 13,3)	W-.'I ,IEO-LD MEO- HIGH	i7013€-3] eso1J1s1				30-Ij 359] 361 5 9	6051285] ,15 53,j £8,) Ji:I tuo .191	57 1269] 67 3 6J 335 39JI 985 165]
O,·Y	12.i !31JS x 7£1	3- 1ss91	OW MED-LO !ED-HI HIGH	11()515221 290 609 .:so i69BI ,OS18C5I				4661 56.I 64 1	miit ' 3/JO 61	gop! 671 40 53S 25<515921 JC,() 66f
OM,1	110 1279x,E-J	1(2 [373)	LO'N MW-LO MED-HI HIGH	iS01368-) 880 J15) 9D[514I 3 0[613)						s:s 1201J 65S[309J 925 i389] %5[Jn
OQ·Z	12,. i [305,<2 91	3:4 J559j	01,,1 MED-LO MED-H' 413H	21515821 :ifLi 11c1I 1720 211 21 li19G11		0 €. 620 iE4 (Ji)() 944	4[b 6;},J 955 j			02<[J9&1 2551592/ 46,0 745(823
! ..Z	2x 1 1305 (279)	3.-I (55)	OW MED-LO MEO- H!5H	m [6eo1 1jQ(I [7GlI 1,10 ,OlI 2010 1949		161)[i 05[f,63 6W liG-1 9C•) [e97	155 ! 3,5 5;i) 655			U. [..195j 24 [585) 410 [665 610f 6Q

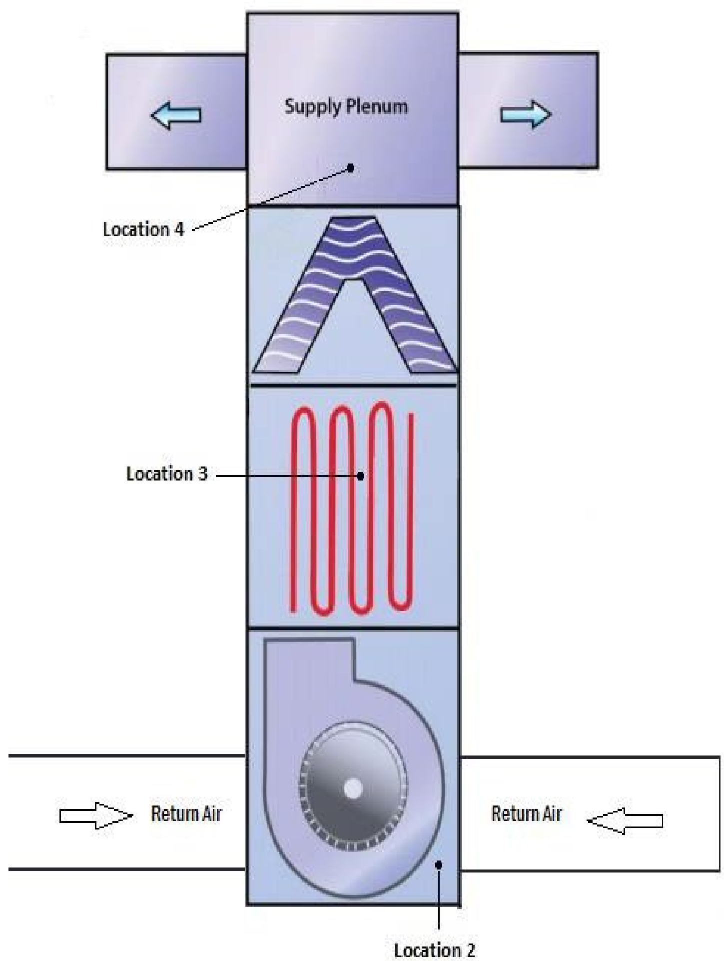
In conclusion, by understanding and using ESP and the proper blower performance, chart technicians can verify unit CFM and the system operation. If the measured ESP is greater than 0.5" WC, or if the measured ESP is beyond the maximum allowable of the blower performance curve this MAY indicate a restrictive system due to undersized duct, dirty components and/or closed branch ducts. If measured ESP is within the allowable range as listed in the blower performance curve then the CFM can be determined.

Measuring Static in Horizontal Systems



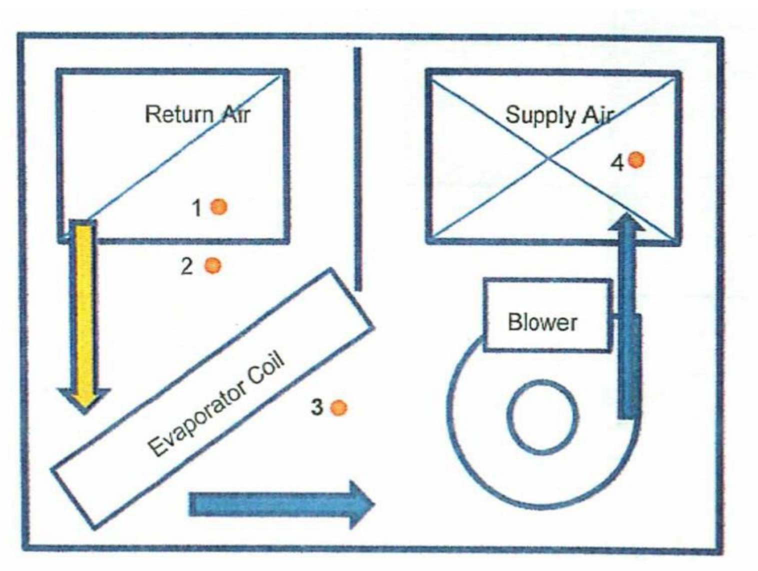
1) **When taking Total external static pressure (A-D) you must subtract the pressure drop from filter (A-B) and pressure drop across the evap coil (B-C).**
2) **When taking static pressure across the blower, it should be taken at the blower section (C-D).**

Measuring Static in Up Flow Systems



Notes:

Measuring static in package unit

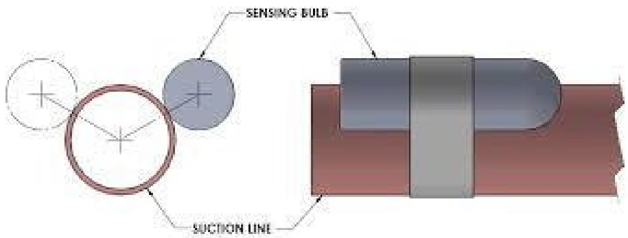


Notes:

Proper TXV Sensing bulb Mounting

Sensing Bulb Location — *What is the correct position for the TXV sensing bulb?*

The placement of the remote sensing bulb of the TXV onto the suction line is critical to proper TXV performance. A lot of "hunting", "flooding", "starving" and other problems can be corrected by making sure the TXV is properly located on the suction line of the evaporator coil. Too often, the TXV is mis-diagnosed as being bad simply because it was not responding correctly. Contractors figure that because the coil comes with a TXV *factory installed* that they have nothing to do. In most cases, manufacturers will install the TXV on the coil but leave the sensing bulb installation to the installer based on how they run their line set, etc. Same holds true when the sensing bulb is mounted on the suction line inside the cabinet and is not insulated. When the sensing bulb is in the airstream and not insulated it is exposed to supply temperature. Lets look at sensing bulb mounted surface vs exposed surface. In the illustration below shows the amount of bulb surface that is actually making contact to the suction line and the amount of surface exposed to supply temperature.

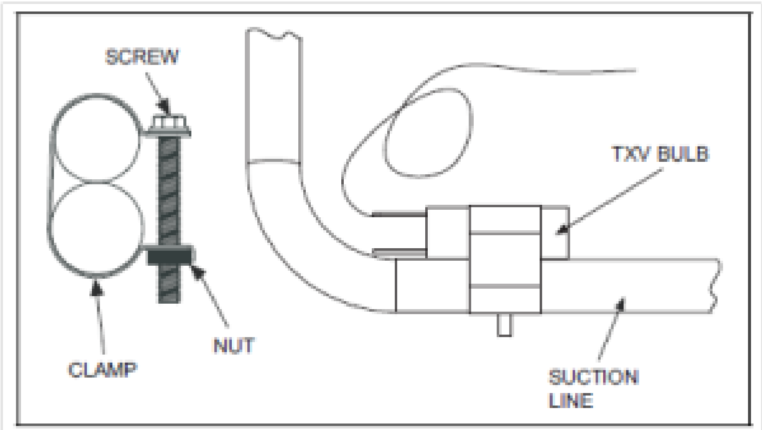


5% of bulb surface is in contact with the suction line the other 95% of bulb surface is exposed to supply plenum temperature.

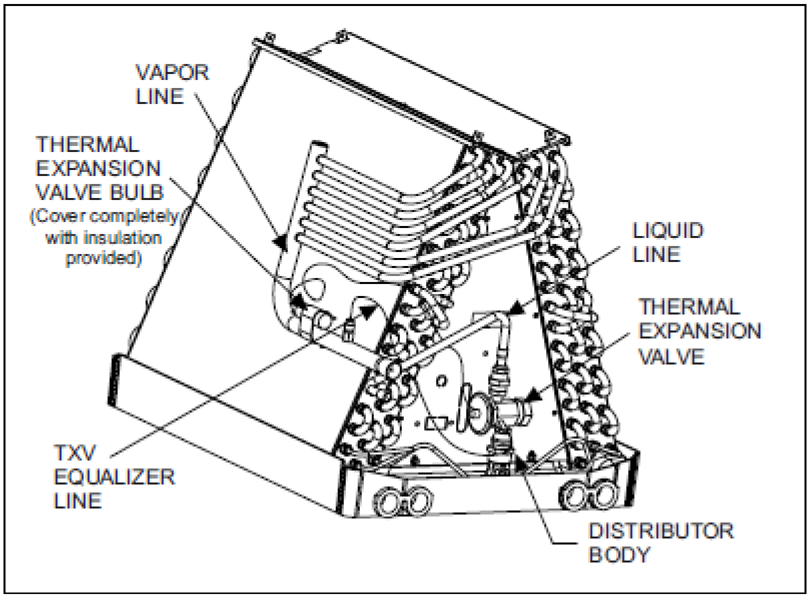
If the bulb is fighting against 2 temperatures it is causing the TXV to hunt for a position causing sub-cooling and superheat to fluctuate. If the sub-cooling and superheat is fluctuating it is very hard to get a correct charge. Regardless of where the sensing bulb is located it should always be properly insulated.

The important points to follow in regards to the TXV Sensing bulb are:

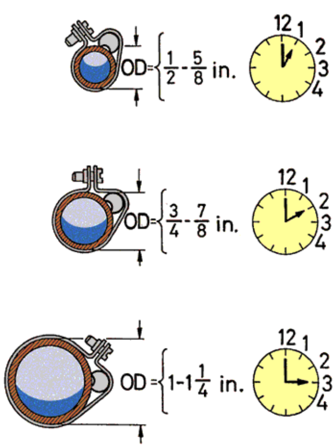
- Clean the suction line near the outlet of the evaporator. Even on new installs, this is very important.
- The **entire length** of the sensing bulb must be in contact with the cleaned portion of the suction line. It must be *clamped* to the suction line to maintain good contact.
- Use the proper bulb clamps to mount the sensing bulb (Do not use tape or plastic tie straps)
- The sensing bulb should always be **properly insulated** regardless of its location.

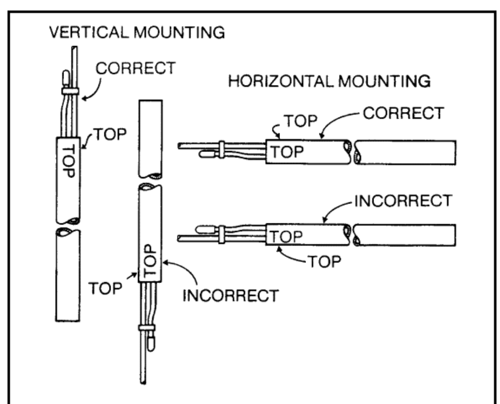


Proper TXV Sensing bulb Mounting



- The sensing bulb should be placed several inches **upstream** of the external equalizer connection.
- The sensing bulb should be attached at **12 o'clock** on any suction line of **7/8-inch diameter or smaller**. On lines **larger than 7/8-inch** diameter, the bulb should be **placed at either 4 or 8 o'clock**. The bulb should **never be placed at 6 o'clock.**
- Always insulate the **entire** sensing bulb after installation.
- A sensing bulb can be installed on a vertical suction line if necessary, but never with the tail end down.
- When putting the bulb on a vertical line — always — **TAIL END UP!** And — when clamped to a horizontal suction line — always **TAIL END DOWN**. The reason for keeping the tail end up on vertical lines and down on horizontal lines is to assure that the liquid refrigerant charge in the bulb *stays in the bulb* and allows it to react better and quicker to changes in the suction line temperature. Even when clamping the bulb at the 3 or 9 o'clock positions on larger horizontal lines, rotate bulb so the tail is always down to prevent liquid from migrating to txv diaphragm.





Cross Ambient Bulb Mounting

A lot of TXV's are misdiagnosed and replaced because of refrigerant flow control issues and all that really is wrong with the TXV is the "installation". Keep these little steps in mind when diagnosing TXV's problems.

Identifying Common TXV Issues When Having Problems Adjusting Refrigerant Charge

In this presentation I will be covering what I think is one of the most over looked part and service procedures when it comes to adjusting refrigerant charge.

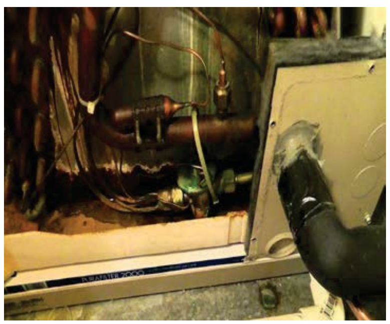
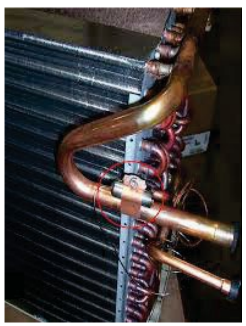
“TXV remote sensing bulb”

The placement, cleanliness, location and insulation of the remote sensing bulb of the TXV onto the suction line is critical to proper TXV performance. A lot of “hunting”, “overfeeding”, “flooding” and other problems such as having a hard time adjusting refrigerant charge can be corrected by making sure the TXV remote sensing bulb is properly clean, located, fastened and insulated onto the suction line of the evaporator coil.

At least 40% of the times a TXV is diagnosed to be bad turns out to be that the sensing bulb was not properly mounted on to the suction line.

Here are 4 key points to look at on a TXV system

1. **Where is the TXV remote sensing bulb located?**
2. **Is the remote sensing bulb properly fastened?**
3. **Is the remote sensing bulb clean?**
4. **Is the remote sensing bulb properly insulated?**

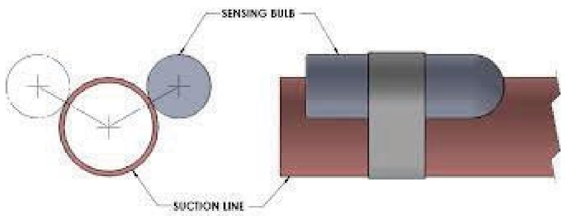





TXV Bulb Location

Countless times I have come across sensing bulbs inside the air-handler cabinet uninsulated mounted onto the suction line. Bulbs were clean and fastened properly, but the TXV would not stop hunting. Most manufactures will tell you the bulb does not need to be insulated if located inside the cabinet. I have experienced too much TXV hunting due to no insulation on the bulb.

Example



5% of bulb surface is in contact with the suction line the other 95% of bulb surface is exposed to supply plenum temperature.

Elaboration

If the bulb is fighting against 2 temperatures it is causing the TXV to hunt for a position causing sub-cooling to fluctuate giving the tech a hard time to adjust sub-cooling properly. If the sub-cooling is fluctuating it is very hard to get a correct charge.

TXV Sensing Bulb Proper Fastening

A lot of the times when a techs has problems adjusting charge it is not due to a faulty TXV, it is because the TXV sensing bulb was not fastened properly even though it was properly insulated the bulb was loose causing overfeeding of the evaporator and flooding of the compressor.

Example

The photos to the right show a perfect example of blubs that were properly insulated but were not properly fastened. One of the photos the bulb is attached with silver duct tape on the other the bulb is attached with plastic tie straps.

Elaboration

Performance of TXV depends on the correct location and installation of its remote sensing bulb. A TXV sensing bulb that is not properly located or fastened will not read accurate line temperature and will not adjust the TXV correctly. Overfeeding and flooding will not allow you to adjust superheat and sub-cooling correctly and can cause major damage to the compressor.

Dirty TXV BULB

Numerus times I have come across sensing bulbs that are dirty and not fastened properly. A dirty TXV bulb will give you problems major problems.

Example

The photo an the right is of a sensing bulb that was properly insulated and located in the right place but very dirty and not reading line temperature correctly

Elaboration

A dirty TXV sensing bulb will not sense suction line temperature correctly regardless of where its located and will cause the TXV to drive fully open overfeeding the evaporator and flooding the compressor. Overfeeding the evaporator will cause low superheat and low sub-cooling and can also cause damage to the compressor.

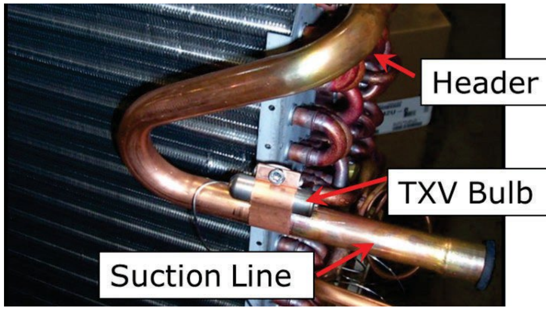
Insulating the TXV Sensing Bulb

Many times I have come across TXV sensing bulbs that are not properly insulated or the electrical tape used to hold the insulation in place is coming off because not enough tape was used.

Using the correct insulation, enough of it and proper insulating procedure is crucial to maintaining proper insulated TXV sensing bulb.

When you look at the sensing bulb and how it is affixed to the suction line, the first thing you will probably notice is that there is a lot of bulb not actually touching the pipe. In fact probably about 95+ %. Since the heat absorbed by the bulb from the suction line comes from conduction, only having a small percentage of the bulb in contact limits how much heat can actually flow. Air, on the other hand surrounds the rest of the bulb and will have a greater influence on it, regardless if its inside or outside of the cabinet.

A sensing bulb that is properly insulated removes the influence of the air so that the great majority of heat flow into the bulb comes from the suction line. However, remember the point about how little of the bulb is actually in contact with the copper line? For conduction alone to achieve sufficient heat transfer from the suction line to the bulb will require a properly insulated bulb.



Elaboration

Most technicians have a habit of overlooking the condition of the TXV sensing bulb knowing that the sensing bulb is crucial to the performance of the TXV. Every technician that I have worked with that has trouble adjusting sub-cooling realizes that they could have saved 20-30 minutes if they would have taken the time to service the TXV sensing bulb.

Technicians will frustrate themselves for 20-30 minutes trying to adjust sub-cooling with out even looking at the conditions of the sensing bulb. After 20-30 minutes of adding and removing refrigerant they call in for technical support, my first response is to guide them to the TXV sensing bulb.

A sensing bulb that is properly insulated does not mean that the bulb is properly fastened or that it is very clean and making good contact with the suction line. Never assume that the previous contractor fastened or cleaned the bulb correctly.

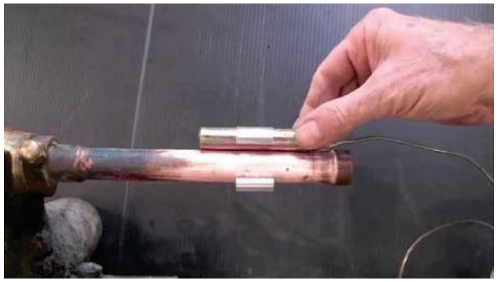
In the past year I have worked with contractors and techs on implementing some TXV sensing bulb best practice procedures as part of their corrective measures and have seen a big improvement on their charge adjustment time on TXV systems

Getting into the habit of servicing the TXV sensing bulb while doing corrective measures will defiantly improve TXV performance and cut back on headaches and charge adjustment time!

TXV Sensing Bulb Best Practices

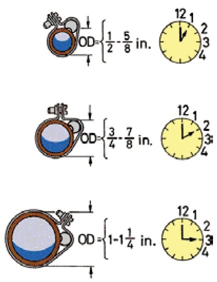
1. Remove the sensing bulb regardless if it looks properly insulated or fastened. (A properly insulated bulb does not mean that it is clean and making good contact)

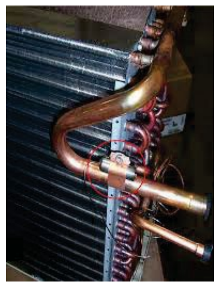
2. Clean the sensing bulb and the suction line with abrasive emery cloth and wipe clean with a cloth. (It is important that both the copper and the bulb are clean to get good contact between both)



TXV Sensing Bulb Best Practices

3. Remount the sensing bulb onto the suction line at one of the recommended points using the correct mounting clamps. (If no clamps are available, some stainless steel hose clamps will work just as well) “Do not use tape or plastic tie straps”





4. Properly insulate the TXV sensing bulb using foam or cork insulation tape. Wrap the entire sensing bulb past the ends so that the ends are covered as well then wrap the entire insulation with black duct tape.

Closing

This process takes only about 5-8 minutes and will save you a lot of time in the process of adjusting refrigerant charge. I have been implementing these TXV Sensing Bulb Best Practices in the field while doing tech shadowing and it has really improved the techs time when it comes to adjusting refrigerant charge.

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Modeled Step by Step

The Molded approach is verifying the: the blower, evaporator, and condenser are clean, and airflow has been adjusted to proper CFM/ton prior to the refrigerant charge being targeted, verified and/or adjusted.

Verification:

1. Record customer's thermostat setting (off/on and temp) in notes. Drop setting 5* below customers set-point to allow enough time to perform Test-in
2. Turn System on to make sure everything operates.
3. Perform preliminary inspection of equipment, if visible damage or repairs are foreseen notify the customer of any potential charges not covered by the program.

Corrective Measures:

4. Turn system off and start to perform all the corrective measures
    - **Clean Condenser Coil:** Professionally cleaning the condenser is required regardless of how it appears. Clean the condenser first to allow it dry while performing other tasks. Program rules require the condenser to be dry of any condenser cleaning agents applied before starting the test out procedure.
    - **Clean Blower Assembly**: Access the blower motor compartment and professionally clean if required.

Note: *Cleaning is required when the blower assembly is rated at 2 – 5 on the CoolSaver Program's cleanliness scale, meaning that, during the pre-inspection, it was not "very clean." Any blower with dust build-up must be cleaned.*

- **Clean Evaporator Coil:** Access the evaporator coil and professionally clean if required.

Note: *Cleaning is required when the blower assembly is rated at 2 – 5 on the CoolSaver Program's cleanliness scale, meaning that, during the pre-inspection, it was not "very clean." Any blower with dust build-up must be cleaned*

- **Clean Filter:** Check the condition of the air filter then clean or replace, as needed. A clean filter must be installed before the final test is performed.
- **Adjust Airflow:** Check the air flow after all cleaning is complete. Adjust the airflow according to manufacturer's specifications or to achieve +/- 15% from target CFM/ton. Additional changes to blower motor speed may be required to achieve proper air flow. Collect the electrical measurements from the blower motor and Input new airflow measurements into the "Airflow & Nominal tonnage section
- **Adjust Refrigerant:** Turn system on and allow to stabilize, adjust refrigerant charge according to superheat and sub-cooling targets. *(Do not adjust refrigerant charge unless airflow has been properly corrected and is within acceptable range)*
- **Charge Adjustment tab**: Record charge adjustment in the **"Charge adjustment tab"** make sure to input refrigerant amount in ounces.
- After all corrective measures and refrigerant charge adjustments have been achieved allow for the system to stabilize.
- Record electrical measurements from the condenser. Input the condenser and air handler electrical data recorded into the electrical section in the **Test-out measurements** tab.

CoolSaver

Modeled Step by Step

Test-out:

5. Once the system has stabilized go to the **System Performance Tab** and review all the data and how the system is performing.
6. Take a Test-out Snapshot and review the review the test-out page by going to the **Review Test-out Tab.**
7. Address any yellow or red flags in the review test-out page before moving forward.
   - Yellow Flag – means some of the targets are out of range.
   - Red flag – means a hard stop, missing information or data
8. If all issues in the review test-out page have been addressed and taken care of the system can now be turned off and thermostat setpoint can be reverted to its original customer setpoint.

Submission:

9. Site Information Tab; go to sight information tab and complete the customer information, equipment information, utility information and the building information and submit.
10. Field Review; go to the field review tab and address any issues or this is where you may input notes for issues that were not able to be corrected **(Do not put notes for issues that can be corrected but chosen not to correct).** If no issues were found check off the "**I Agree that all above statements are true and complete"** box and all sections have been completed go ahead and submit field review page.

Note: *If this is a retest for a previously submitted tune-up, check-off the **"Is this a re-test"** box in the field review page.*

Invoice:

11. Review invoice page with customer, fill in the amounts and have the customer sign the invoice on the device, accept the signature then submit.

Photo Documentation:

12. Any additional photos that need to be taken and submitted will need to be submitted through the **"Photo Documentation"** section using the appropriate field**.**

Notes:

13. The **"Notes"** section is where you will be attaching additional notes that need to be relayed to the engineers that review projects.

Send Data:

14. Tap "**Send Data"** to submit the project for processing.

Note: *When project is submitted* a submission confirmation box will pop-up on the screen with the following information.

- Measure number
- Equipment number
- Customer number
  - Recommendation is to take a screenshot of the pop-up box showing the project information.

CoolSaver

Modeled Step by Step

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Measure and Verification (M&V) Step by Step

M&V method is the complete test-in, test-out method of verifying the initial capacity and efficiency; the blower, evaporator and condenser are clean; the airflow is correct; the refrigerant level has been targeted and/or adjusted and is within range; then the actual savings can be calculated.

Test-in:

1. Record customer's thermostat setting (off/on and temp) in notes. Drop setting 5* below customers set-point to allow enough time to perform Test-in
2. Turn System on to make sure everything operates.
3. Perform preliminary inspection of equipment, if visible damage or repairs are foreseen notify the customer of any potential charges not covered by the program.
4. Go to menu on the top left and select Projects and Reporting.
5. Select new project "**Clearesult"** project (Select "**Clearesult Projects"** if it's an existing project that has not been submitted)
6. Start new project setup on your tablet (Apple or Android device). Be sure to name project and enter project data accordingly.
7. Hook-up iManifold or iConnect to the condenser and connect via Bluetooth to tablet.
8. Place all temperature probes at the recommended locations in the supply air duct or grill and return plenum or grill. **(Refer to Proper Probe Placement on page 1. In the training manual)**
    - Supply probe needs to be at least 10' from the evaporator coil.
      If the probe is too close to the evaporator coil it will sense too much moisture from the evaporator and will affect wet bulb readings causing inaccurate system capacity and EER.
    - Return probe needs to be at return air grill or the return plenum depending on return duct design. Probes in return plenum will often read inaccurate temps due to plenum not being properly sealed or sensing too much moisture from the coil
    - Outdoor probe (ODA) needs to be away from the condenser to avoid sensing the warm air from the condenser. ODA probe needs to be in a shaded well-ventilated area to avoid sensing direct sunlight or radiant heat radiating from the wall of the building.
9. Select Pre-inspection; verify equipment is operable and rate cleanliness for every component and submit.
10. Select System Setup; Enter equipment information and Profile the system
11. Proceed to the air handler and perform the Test-in Airflow measurements using methods 1 or 2 and the electrical measurements for the blower motor. (Remember these are the Test-in measurements, do not make any corrections yet)
12. Select Test-In measurements to input Airflow measurements in the Airflow & nominal Tonnage section.
13. Allow the system to run for at least 5-10 minutes to have plenty of time to stabilize.
14. Once system is stabilized according to the stabilizer indicator record condenser electrical measurements.
15. Go into the Test-in measurements tab and Input condenser and air handler electrical measurements into the electrical section.
16. Perform a run capacitor capacitance test on the capacitor for the compressor and input into the run capacitor capacitance test section of the Test-in Measurements tab and submit. (The airflow & nominal tonnage and the electrical sections are the only 2 sections that are manual input)

17. Take a test-in Snapshot; Review the Test-in Snapshot and make sure all the data is good Test-in data.

What is good Test-in Data?

Good test-in data is actual data coming off the system itself. Making sure all strap on sensors are properly fastened to the copper lines and are not loose or dangling off the side of the lines. Make sure the lines are clean and that there's no debris between sensor and copper line. As a best practice use some a wire brush or abrasive emery cloth to clean the lines before strapping on the sensors. The ODA sensor is not sensing warm air coming off the condenser, radiant heat from the building or sensing direct sunlight. Indoor temperature probes are properly placed to where they are sensing good air temperature in the supply and return sections of the system. For example; if the unit is up in the attic and the return grill is close to the attic access, make sure the attic access is closed when ready to Test-in or Test-out to make sure its not picking up heat from the attic.

Technicians have no control on how the system is operating before the tune-up but that does not mean that accurate data can not be recorded. For example; if the system is showing a very high superheat at test-in, indications of low refrigerant charge but pressures look to be normal and suction line temp is showing to be very high. Check the suction sensor, it might be too loose or dirty not sensing the correct temperature.

Another example; pressures look to be normal, but the liquid line temp is showing to be lower than the ODA temperature, check the ODA probe placement it might be sensing direct sunlight, radiant heat or condenser air temperature.

Collecting good accurate test-in Data is essential to the overall performance of the systems tune-up.

Corrective Measures:

18. Turn system off and start to perform all the corrective measures

- **Clean Condenser Coil:** Professionally cleaning the condenser is required regardless of how it appears. Clean the condenser first to allow it dry while performing other tasks. Program rules require the condenser to be dry of any condenser cleaning agents applied before starting the test out procedure.

- **Clean Blower Assembly**: Access the blower motor compartment and professionally clean if required.

Note: *Cleaning is required when the blower assembly is rated at 2 – 5 on the CoolSaver Program's cleanliness scale, meaning that, during the pre-inspection, it was not "very clean." Any blower with dust build-up must be cleaned.*

- **Clean Evaporator Coil:** Access the evaporator coil and professionally clean if required.

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- **Clean Filter:** Check the condition of the air filter then clean or replace, as needed. A clean filter must be installed before the final test is performed.

Measure and Verification (M&V) Step by Step

- **Adjust Airflow:** Check the air flow after all cleaning is complete. Adjust the airflow according to manufacturer's specifications or to achieve +/- 15% from target CFM/ton. Additional changes to blower motor speed may be required to achieve proper air flow. Collect the electrical measurements from the blower motor and Input new airflow measurements into the "Airflow & Nominal tonnage section
- **Adjust Refrigerant:** Turn system on and allow to stabilize, adjust refrigerant charge according to superheat and sub-cooling targets. *(Do not adjust refrigerant charge unless airflow has been properly corrected and is within acceptable range)*
- **Charge Adjustment tab**: Record charge adjustment in the **"Charge adjustment tab"** make sure to input refrigerant amount in ounces.
- After all corrective measures and refrigerant charge adjustments have been achieved allow for the system to stabilize.
- Record electrical measurements from the condenser. Input the condenser and air handler electrical data recorded into the electrical section in the **Test-out measurements** tab.

Test-out:

19. Once the system has stabilized go to the **System Performance Tab** and review all the data and how the system is performing.
20. Take a Test-out Snapshot and review the review the test-out page by going to the **Review Test-out Tab.**
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Measure and Verification (M&V) Step by Step

Photo Documentation:

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Notes:

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Send Data:

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Note: *When project is submitted* a submission confirmation box will pop-up on the screen with the following information.

- Measure number
- Equipment number
- Customer number
    - Recommendation is to take a screenshot of the pop-up box showing the project information.

*****Project is complete and submitted*****

ECM Blower Motor Quick Test

ECM blower motors are used on some furnace models. These motors are variable speed. They will adjust their RPM in an attempt to deliver the CFM that is programmed by the installing technician. The motors operate on 115 volts if installed on furnaces and 230 volts if installed on air handlers.

The motor has two plugs (fig. 1). One plug is a five pin plug that connects the line voltage to motor. The line voltage must be present for the motor to operate.

The second plug is a 16 pin plug that connects to the furnace IFC board (fig. 2). This plug carries control signals between the IFC and the ECM Motor.

Fig. 1

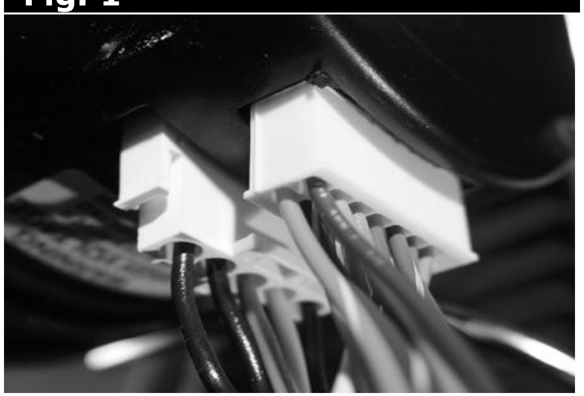
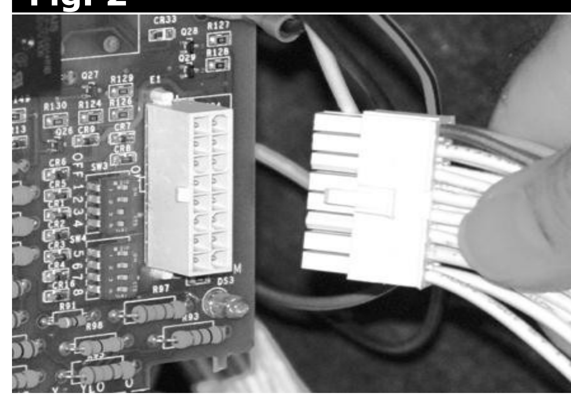


Fig. 2



ECM Blower Motor Quick Test

Check Procedure

If the motor does not run, make sure you have power to the IFC board and then check the voltage between pins 4 and 5 of the 5 pin plug on the motor. You should read 115 volts.
If voltage is not present, the motor will not run. Check for a break in the wiring between the IFC board and the motor. If the motor is equipped with a choke coil, the choke coil may be open.

If line voltage is present to the motor and the motor does not run, jumper R to G on the thermostat terminal strip (fig. 3). If the motor runs the problem is in the low voltage thermostat wire.

If the motor does not run, remove the 16 pin plug from the IFC board. Locate pins 12 and 15. Connect 24 volts from R to pin 12 and pin 15. Connect pins 1 and 3 to the common side of the 24 volt transformer (fig. 4). The motor should run.

Fig. 3

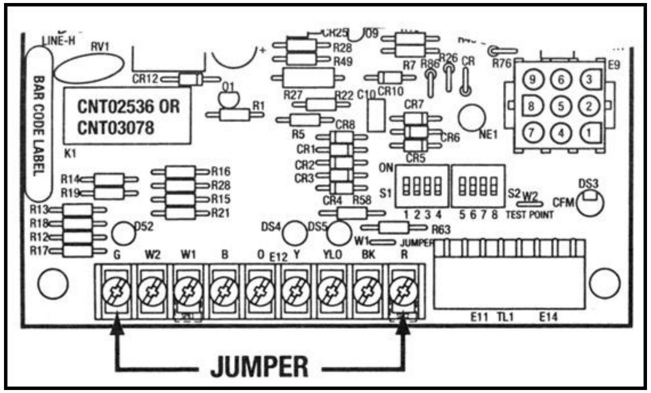
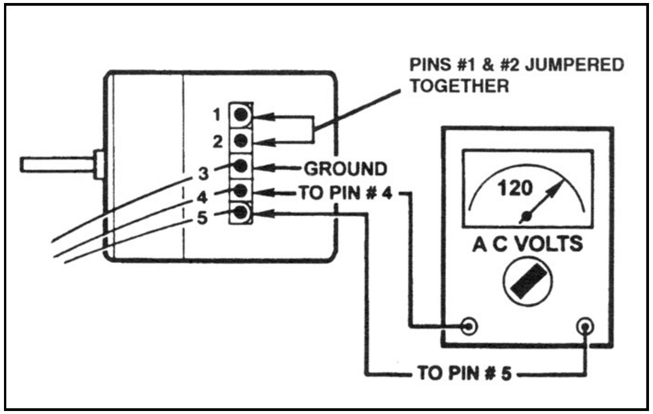


Fig. 4



Continued on Next Slide…

ECM Blower Motor Quick Test

Continued…

If the motor does not run, unplug the 16 pin wiring harness from the motor (fig. 5). Put 24 volts to pins 12 and 15 and 24 volt common to pins 1 and 3 at the motor (fig. 6). If the motor starts, the fault is in the harness. If the motor does not run, replace the motor module.

Fig. 5

Fig. 6