EEBA

Heat Pumps, Mini-Splits & Air Conditioners - Commissioning with Smart Tools to Get It Right the First Time

Joe Medosch
measureQuick

Shawn LeMons
MITSUBISHI ELECTRIC
HEATING & AIR CONDITIONING

February 9

Overview:

- Commissioning
- Smart probes and intelligent Apps
- Installation issues

For the purposes of this session a heat pump is:

- Ducted system
- Cooling and Heating
- Could be multi-stage, variable refrigerant

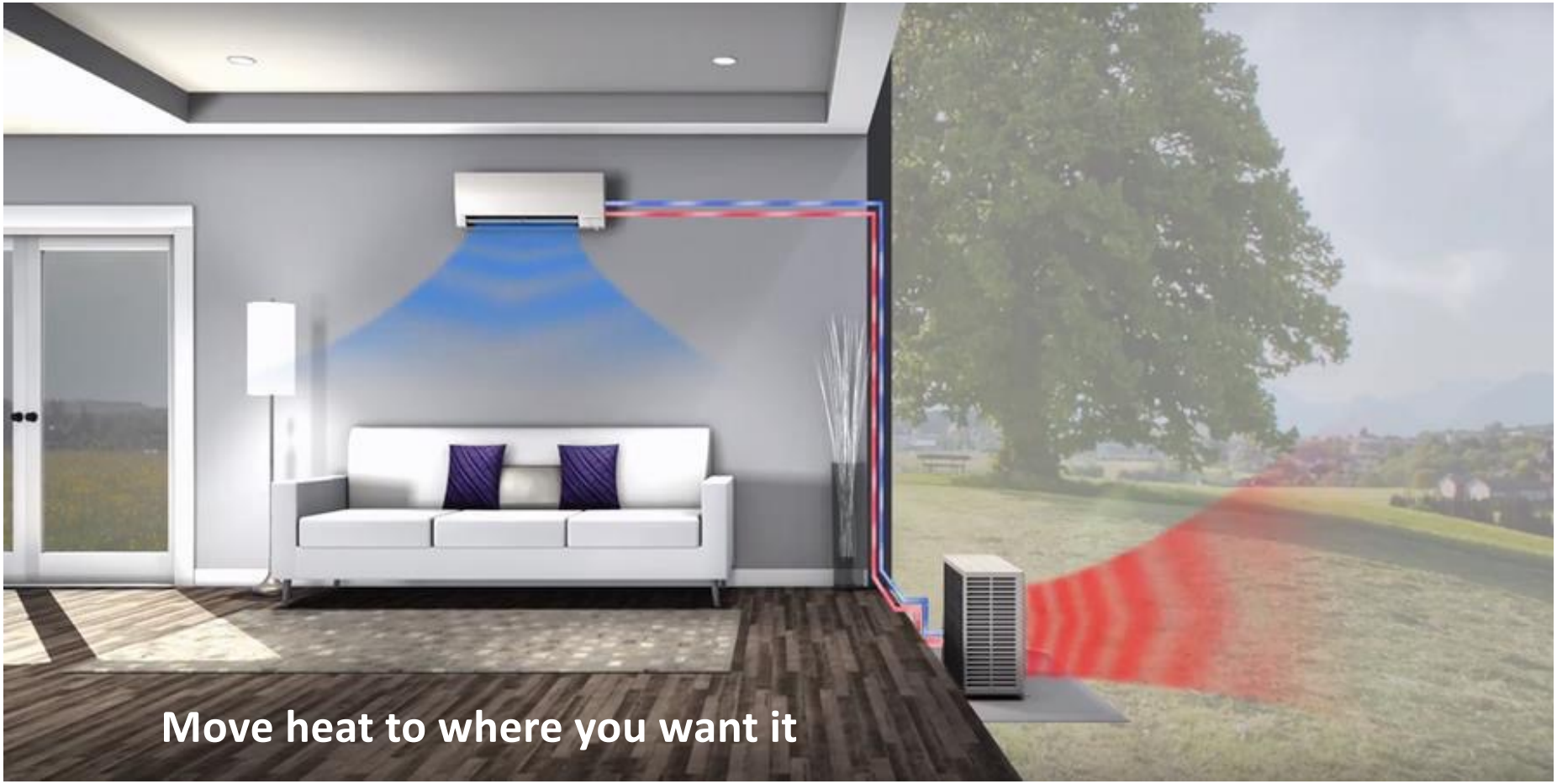
Quick Question:

- How many are installing or have heat pumps?

Conclusion

- Failure, It's rarely the unit
- System must be fully:
  - Designed
  - Commissioned
- The refrigerant charge is crucial
- Airflow and static pressure must me measured
- Use a good calibrated flair tool and practices

Heat Pumps…

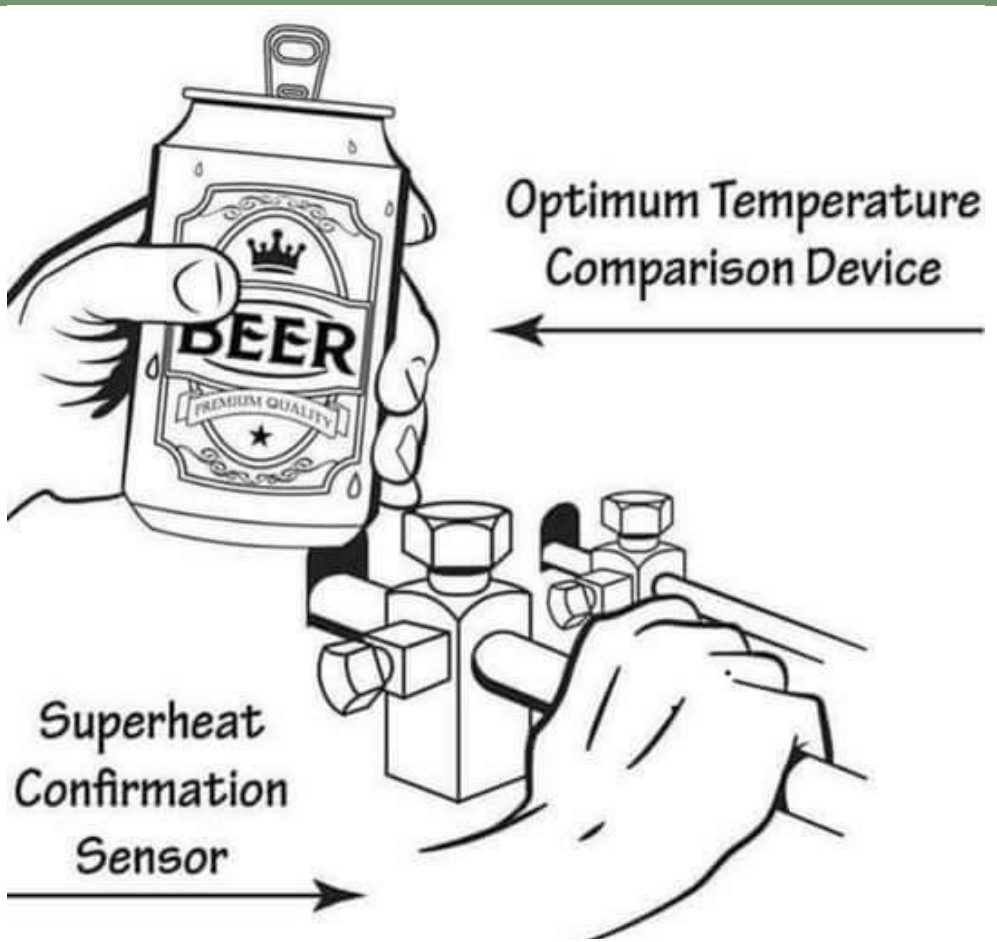


Heat Pumps…

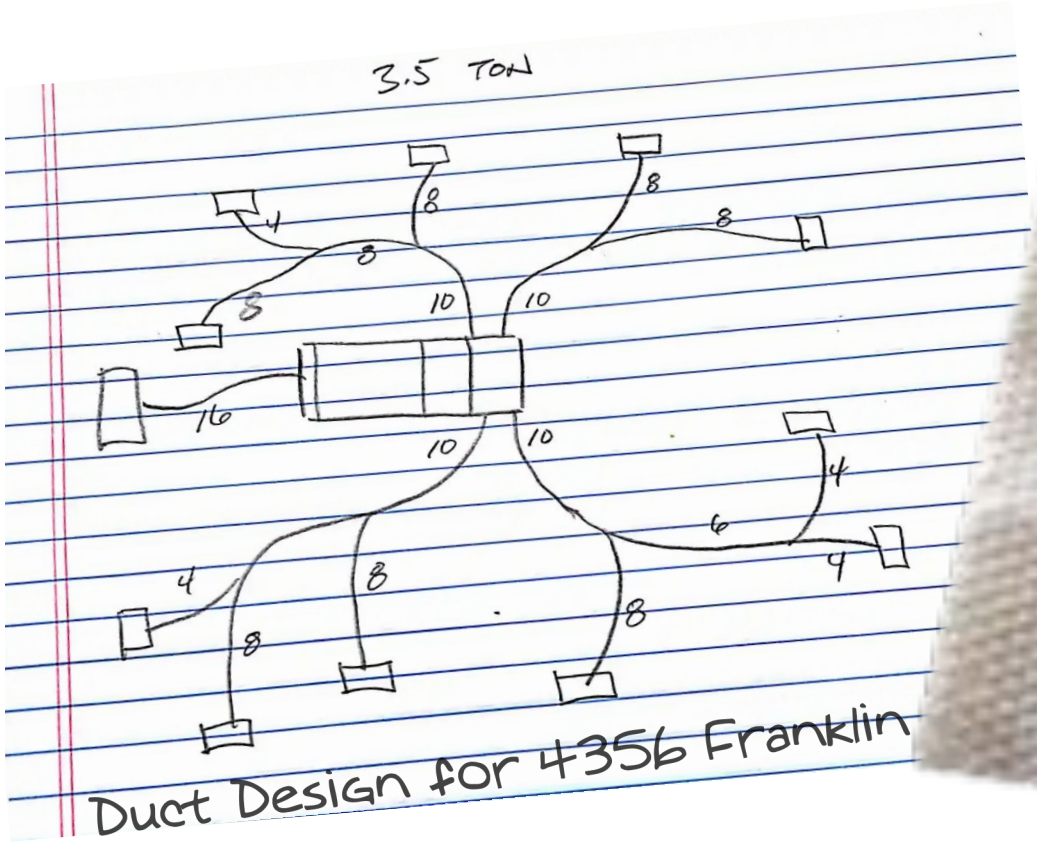
Rule of Thumbs

Cheers

Keep your hand calibrated every night!



Napkin Math



Commissioning Report
refrigerant = Yes
air flow = good
air was cold.

Jim Bergmann

Electrifying homes across America is becoming a train wreck, but we can fix it with #betterhvac.

- *Condensate traps need annual cleaning.*
- *Airflow needs to be checked or adjusted annually.*
- *Manufacturers are selling leaky coils.*
- *Condensers need annual cleaning.*
- *Commissioning processes do not provide enough value.*
- *Commissioning processes do not provide enough value.*
- *Static Pressure should only be tested in problem cases.*
- *A technician must average 6-8 calls a day.*
- *HVAC companies need to hire the "best" talent.*

The Problem and the Opportunity!

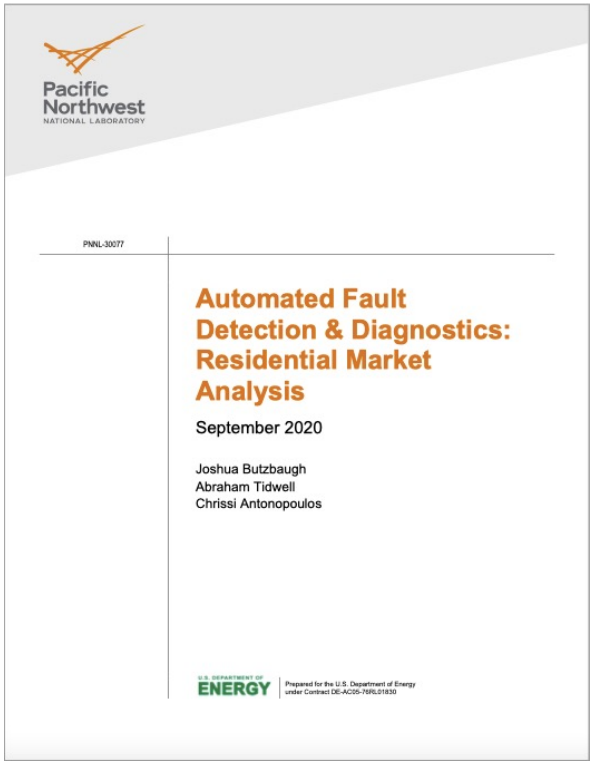
Collectively, central air conditioners (CACs) and air-source heat pumps (ASHPs) are installed in more than 70 million homes in the United States (EIA 2018). Multiple studies have shown that AFDD enables the repair and resolution of performance issues caused by inadequately installed or maintained HVAC equipment (Mowris, Blankenship, and Jones 2004; Downey and Proctor 2002; Turner, Staino, and Basu 2017). Improper HVAC installation is common in the residential sector. Many faults, and the resulting poor HVAC performance, are attributed to inadequate installation. A recent meta-analysis by the U.S. Department of Energy (DOE) found that poor HVAC installation results in at least one fault in 70–90% of homes, and when duct leakage is considered, this number increases to 90–100% (DOE 2018). Improper installation leads to increased energy use and higher HVAC repair costs over the lifetime of the equipment. For CACs and ASHPs, poor installation may increase energy use by 9% over an ideal installation with no faults, costing homeowners an extra $2.5 billion annually in utility bills (Winkler et al. 2020).

Field studies have demonstrated that common faults, namely inadequate refrigerant charge and insufficient evaporator airflow, were present in 50–72% of CACs and ASHPs inspected at varying stages in their lifecycle (Mowris, Blankenship, and Jones 2004; Roth, Westphalen, and Broderick 2006). Fixing these two faults alone has the potential to decrease residential cooling energy loads by 5–10% when considering the total CAC and ASHP stock. Technology solutions, such as embedded AFDD in CAC and ASHPs or smart diagnostic tools used during installation, can detect and diagnose HVAC system faults and facilitate quality equipment installation, preventing energy waste.

https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-30077.pdf

… at least one fault in 70 – 90% of homes,

(add) duct leakage increases to 90–100%

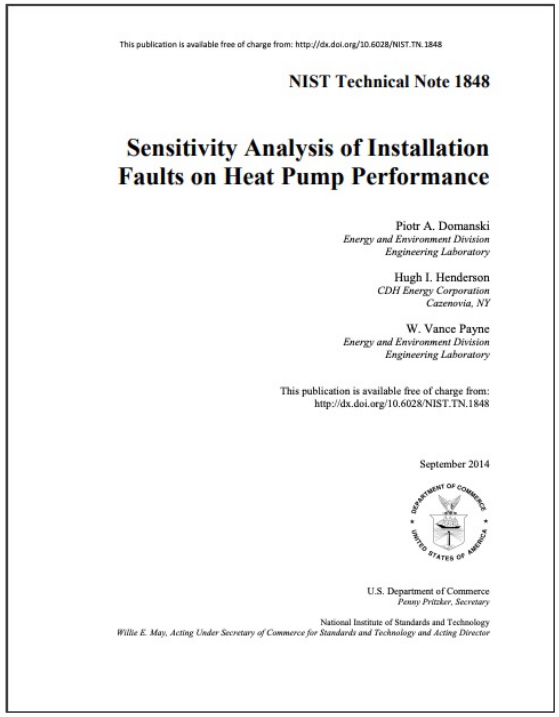


Level-Set: A state of mutual understanding among parties

As an industry we need to better understand the problem and the solutions.

1. Duct leakage
2. Refrigerant charge
3. Equipment Sizing
4. Low airflow (often due to undersized ducts or filter grills)
5. The resulting thermostat setting

For Houston, TX, lowering the thermostat setting by 2°F (1.1°C) increased the annual cooling energy use by 20%, and the energy use increase rate is even higher due to further lowering the setting (the effect is not linear).



This publication is available free of charge from: http://dx.doi.org/10.6028/NIST.TN.1848

NIST Technical Note 1848

Sensitivity Analysis of Installation Faults on Heat Pump Performance

Piotr A. Domanski
Energy and Environment Division
Engineering Laboratory

Hugh I. Henderson
CDH Energy Corporation
Cazenovia, NY

W. Vance Payne
Energy and Environment Division
Engineering Laboratory

This publication is available free of charge from:
http://dx.doi.org/10.6028/NIST.TN.1848

September 2014

U.S. Department of Commerce
Penny Pritzker, Secretary

National Institute of Standards and Technology
Willie E. May, Acting Under Secretary of Commerce for Standards and Technology and Acting Director

https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.1848.pdf

Level-Set: Well documented topic

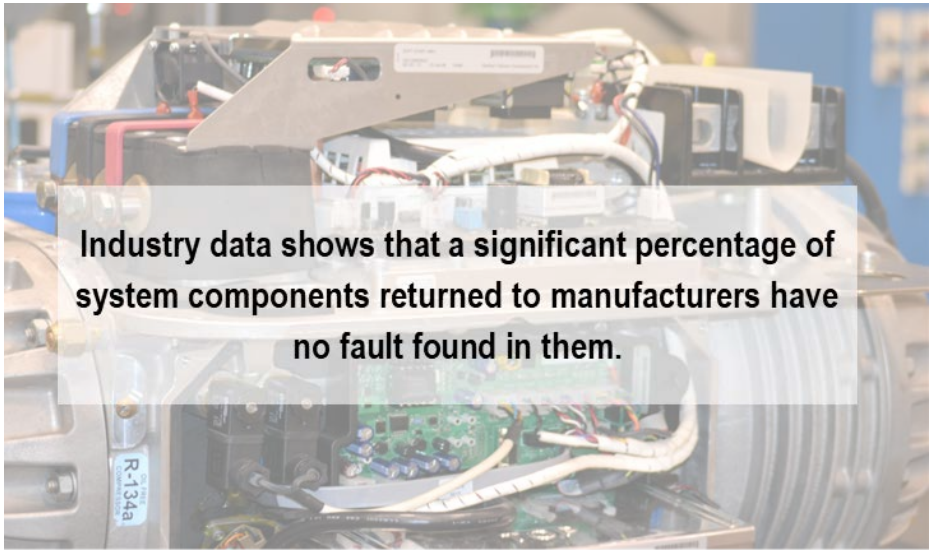
Improper airflow:

- Average airflow ~20% below target. Blasnik et al. (1995)
- Average airflow 14% below design. Proctor (1997)
- Measured airflow ranging from 130 - 510 CFM /ton.Parker (1997)
- 70% of units had airflow < 350 CFM / ton. Neme et al. (1999)
- Improper airflow in 44% of systems. Mowris et al. (2004)

Improper Refrigerant Charge:

- In 57% of systems. Downey/Proctor (2002)
- In 62% of systems. Proctor (2004)
- In 72% of systems. Mowris et al. (2004)
- In 82% of systems. Proctor (1997)

Failure- NOT! Returned Components = No Failures



82.1% of returned residential components...no fault found!

67.9% of returned light commercial components...no fault found!

28.6% of returned industrial components...no fault found!

10.7% of returned chiller components...no fault found!

HVAC Excellence.org

Why do we need Connected Tools – Smart Tools

Pacific Northwest National Laboratory

- Ensure high-performance heat pumps operate efficiently
- Maintain optimal performance over time
- Reducing contractor callbacks and delivering comfort
- Energy savings, and low carbon heating to homeowners

Initiative

Smart Tools for Efficient HVAC Performance Campaign

Working in partnership to help ensure high-performance heat pumps operate efficiently and maintain optimal performance over time, reducing contractor callbacks and delivering comfort, energy savings, and low carbon heating to homeowners.

**This campaign was previously referred to as the Residential HVAC Smart Diagnostic Tools Campaign*

https://www.pnnl.gov/projects/step-campaign

Residential Energy Consumption Survey, 2015

- Improper installation and maintenance of HVAC systems leads to increased energy use, unnecessary repairs, and occupant comfort issues.

- Researchers at NREL estimate that central air conditioners and air-source heat pumps in the US waste **20.7 terawatt hours (TWh) of energy per year due to equipment faults.**

source https://www.osti.gov/servlets/purl/1660191

Residential Energy Consumption Survey, 2015

- So annually, the amount of energy that we waste due to equipment faults is equal to about **5.7 times the volume of Lake Meade at its highest level**. Which is 8,510,000,000,000 gallons

Yes that's 8.5 trillion

- **9% of our total annual cooling costs are wasted, or about $2.5 billion**

https://www.pnnl.gov/sites/default/files/media/file/EED_1361_FLYER_EERE-SmartDiagnostic_FINAL5.pdf

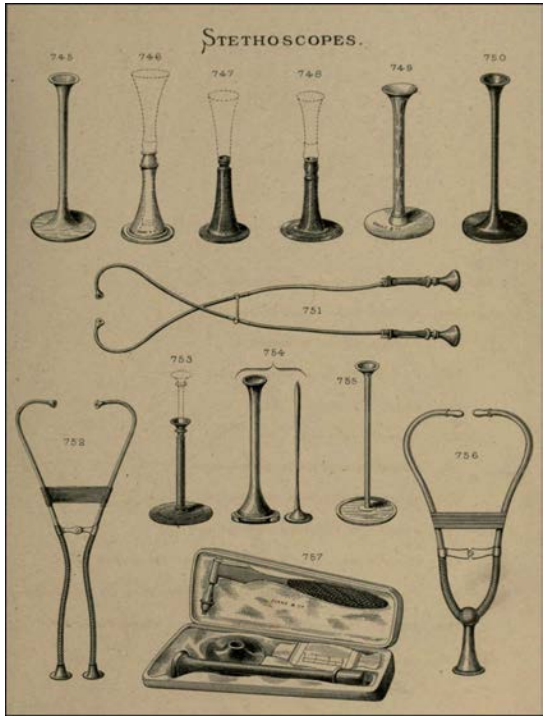
Smart Tools and Intelligent Apps

What Tools are You using?

If you were in a hospital l and they were using these devices...

... Concerned your contractor is not using the most current devices?

1900s



1930s

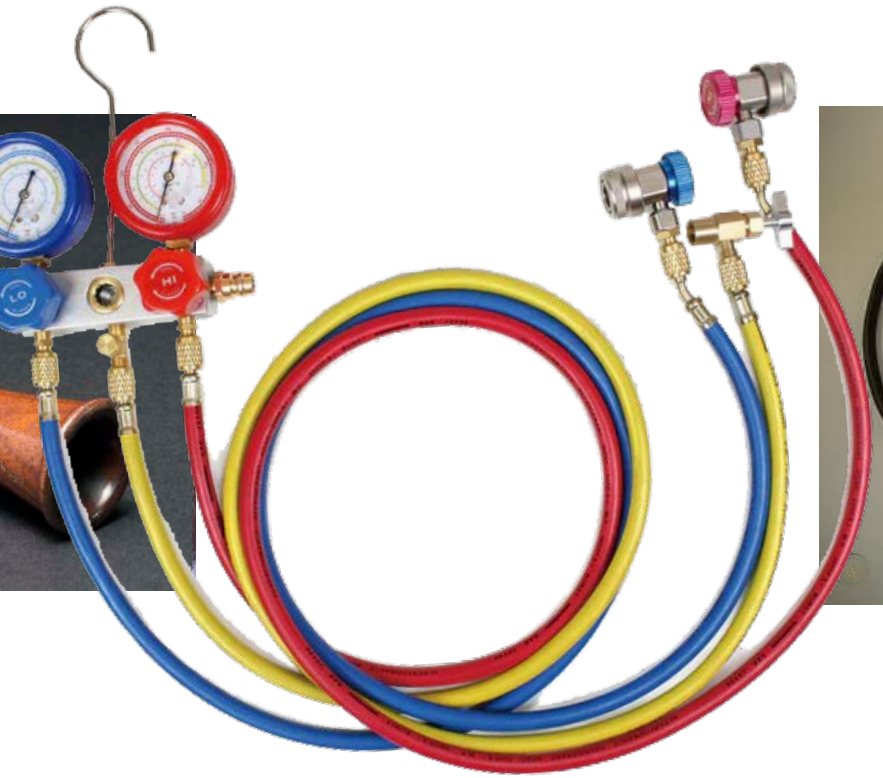
https://www.gettyimages.com/detail/video/1930s-animated-doctor-using-stethoscope-to-listen-stock-video-footage/583-231

What Tools are you using?

If you were in a hospital l and they were using these devices...

... Concerned your contractor is not using the most current devices?

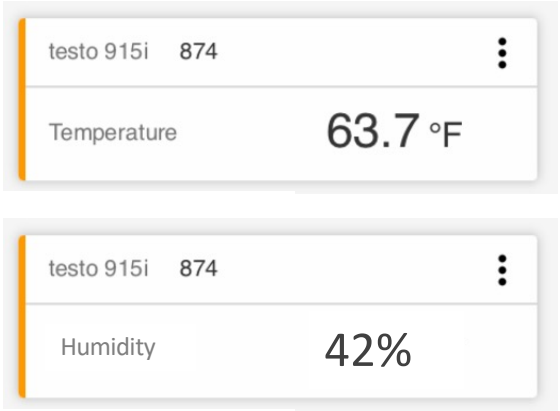
1900s



1930s

https://www.gettyimages.com/detail/video/1930s-animated-doctor-using-stethoscope-to-listen-stock-video-footage/583-231

How Smart are the Probes?



Temperature Split

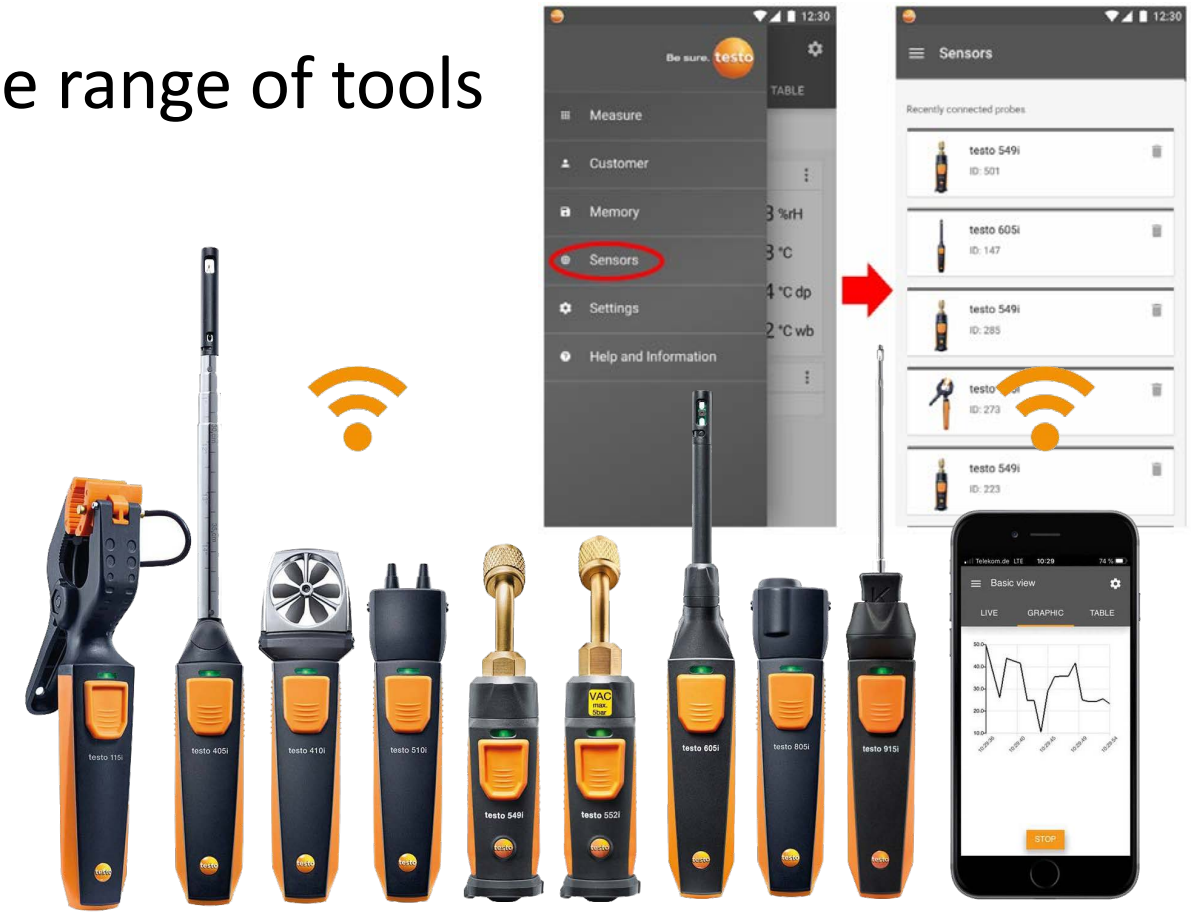
Current Value:	**24.2 °F**
Design Target:	**19.6 °F**
Ideal Range:	**15.9°F to 23.3 °F**

Measurement is ABOVE Ideal Range

Concert of Instruments

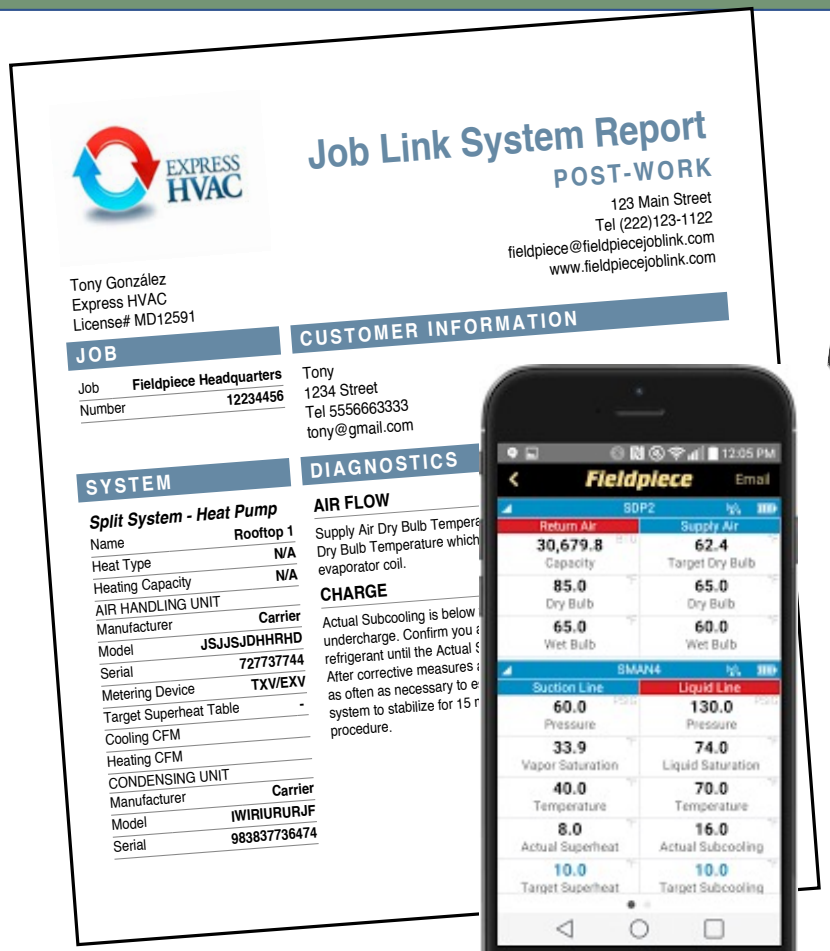
Testo Smart Probes & App

Wide range of tools



testo 915i	874	
Temperature		63.7 °F
testo 410i	668	
Temperature		64.3 °F
Flow Velocity		294 fpm
testo 405i	259	
Temperature		63.5 °F
Flow Velocity		129 fpm

Intelligent Apps



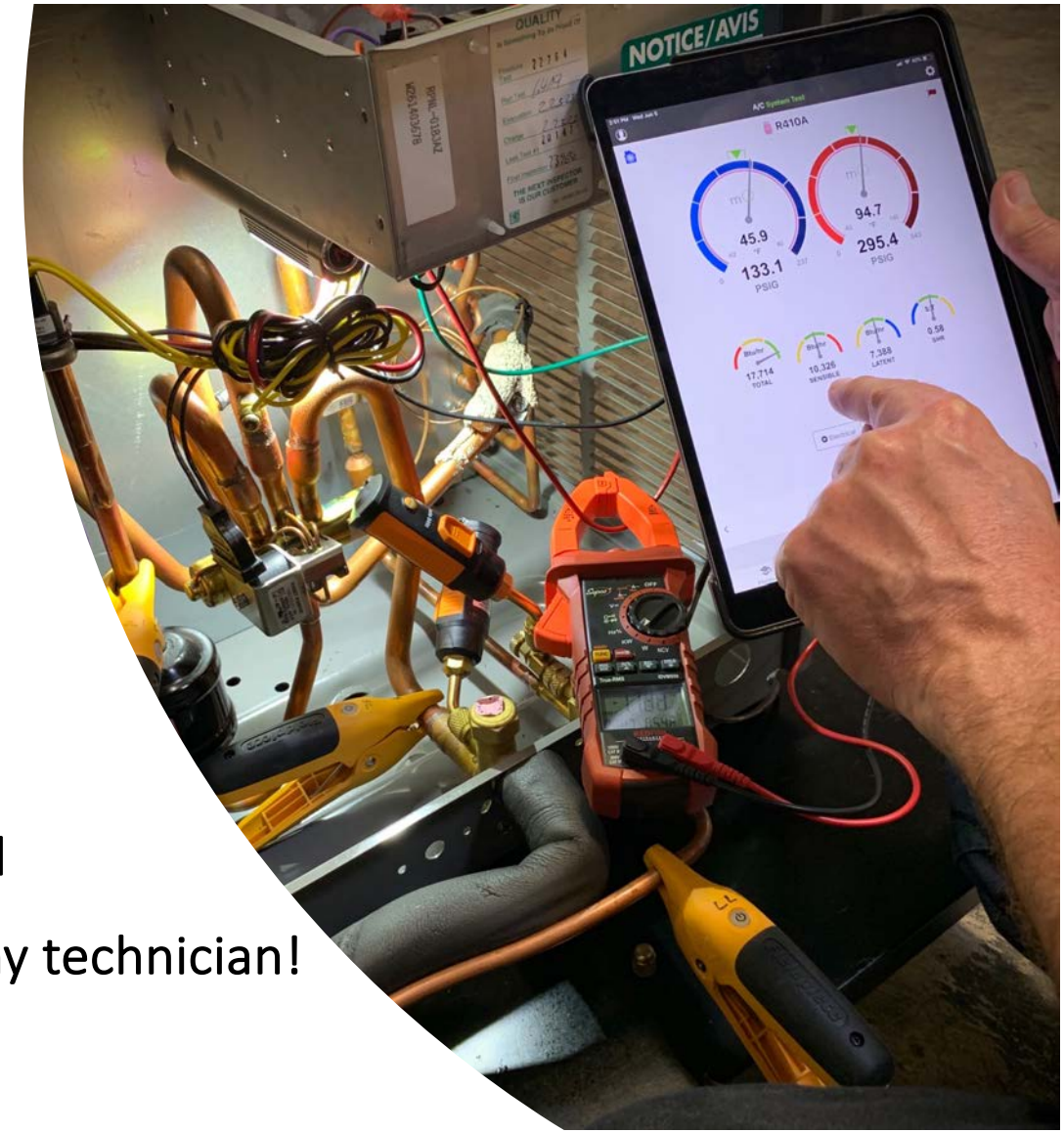
EEBA

Fieldpiece

MITSUBISHI ELECTRIC
HEATING & AIR CONDITIONING

measureQuick

- Walks the user through a process
- Assists with completion,
- Assists with problems,
- Documents the results,
- Looks at the entire system,
- Allows for easy sharing,
- Data is stored locally or in the cloud
- Can be accessed in the future by any technician!



EEBA

measureQuick

mQ

T·E·C

Fieldpiece

testo

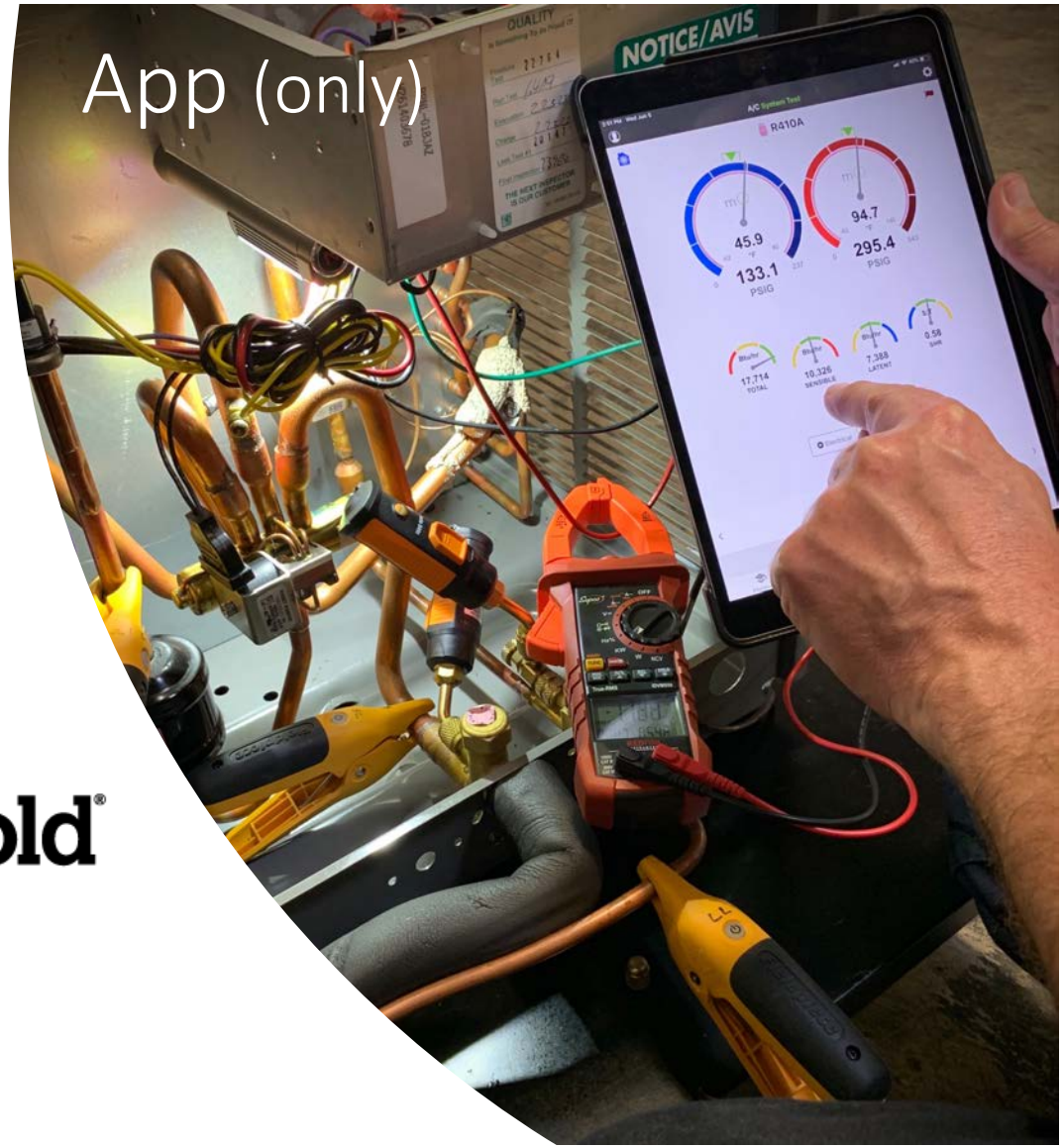
Supco

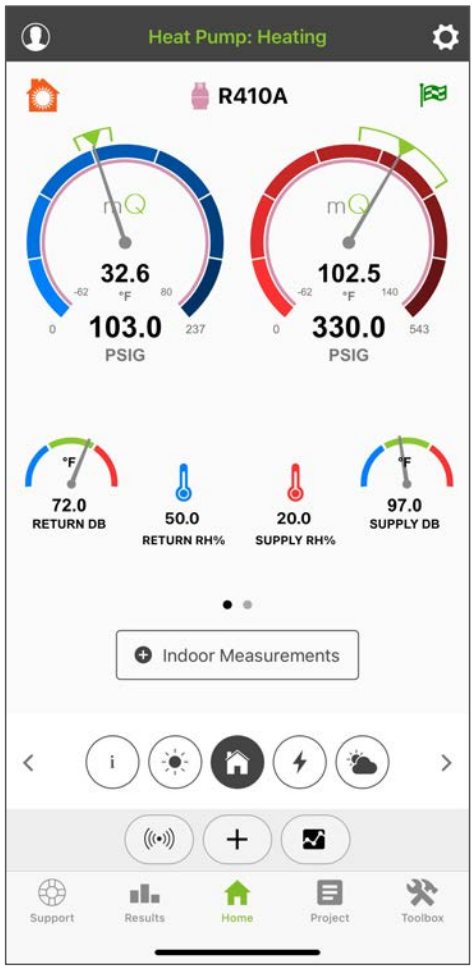
iManifold

ACCUTOOLS

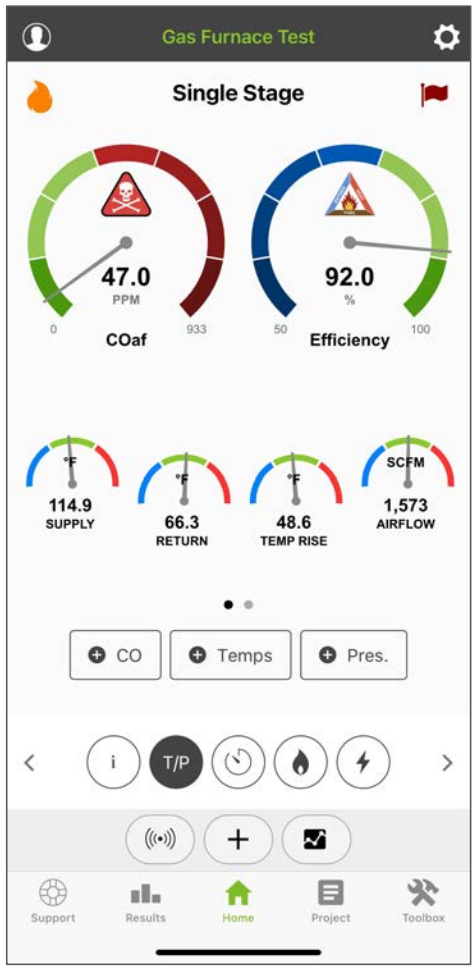
EEBA

App (only)

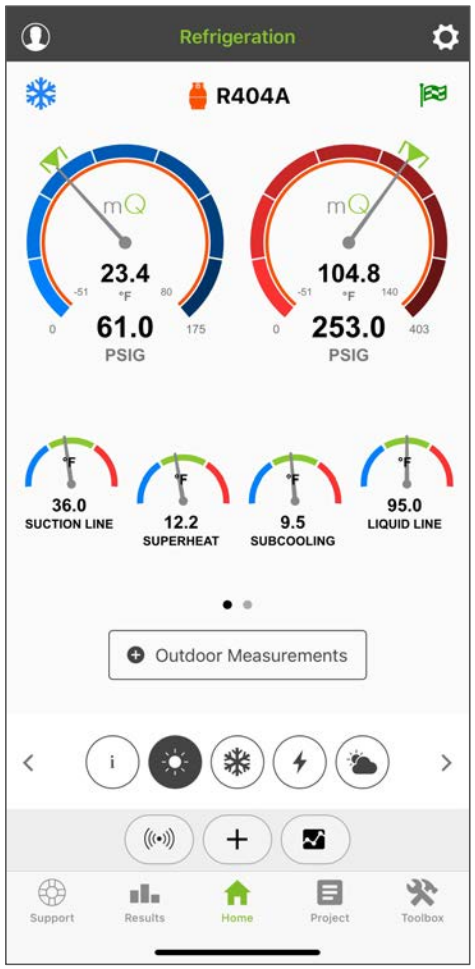




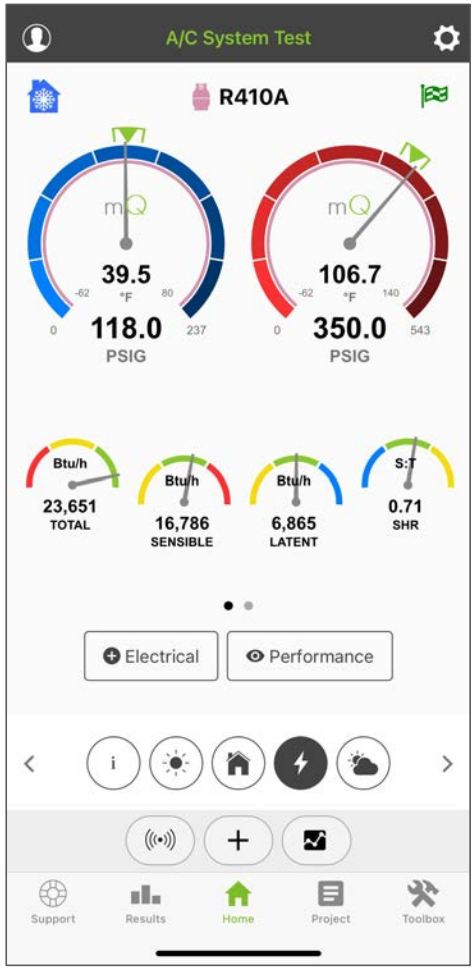
Heat pumps



Gas Furnaces



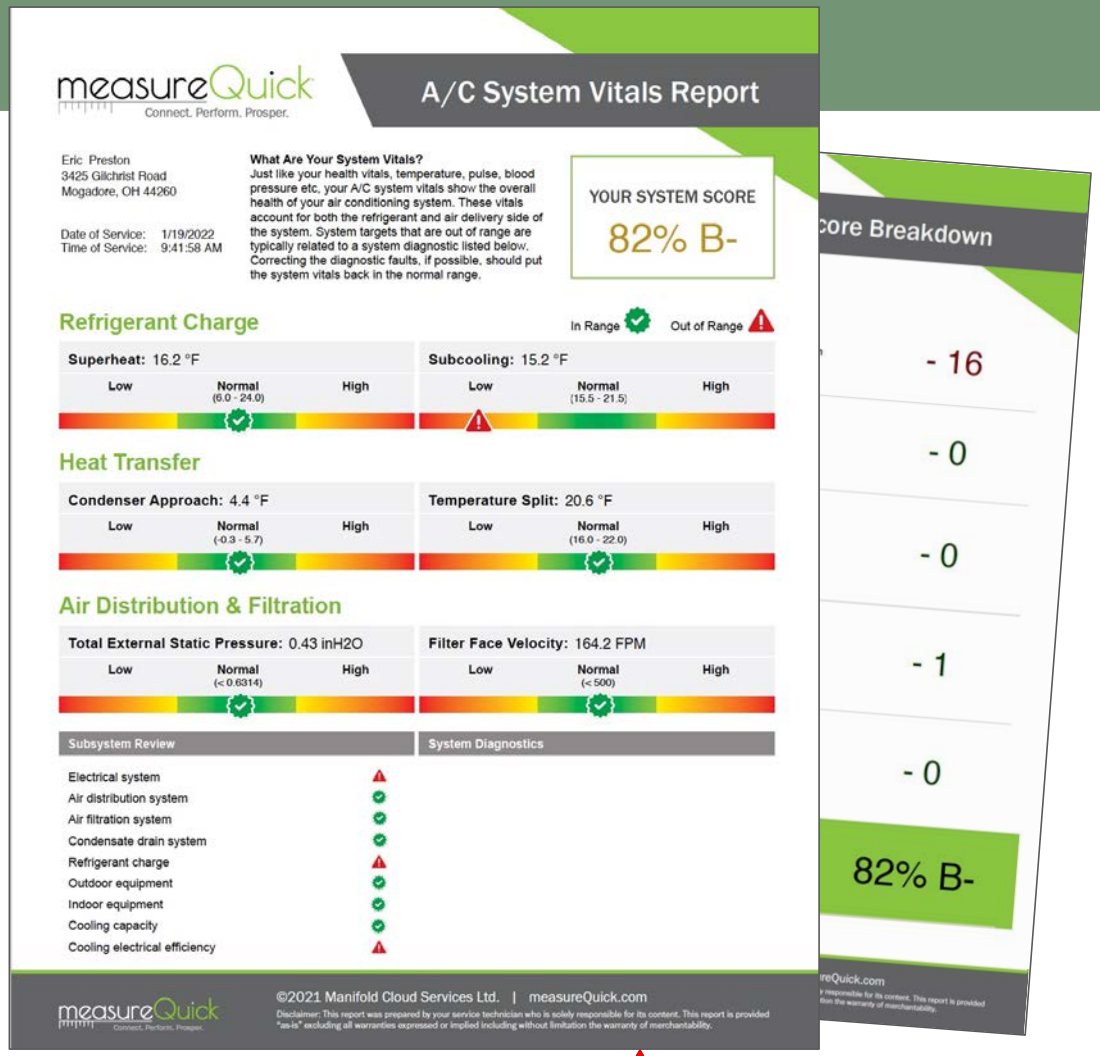
Refrigeration



Air Conditioning

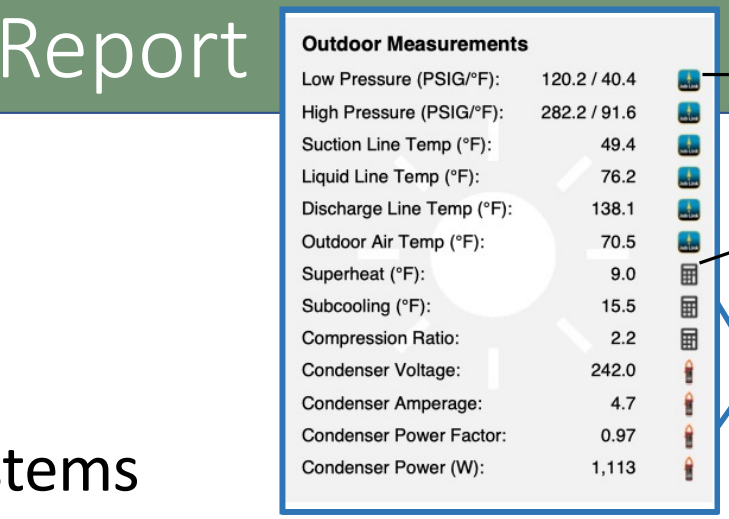
Reporting System

- Measurements and Calculations
- Pass/Fails for subsystems
- Confirm system performance
- Photo documentation
- Geo Location



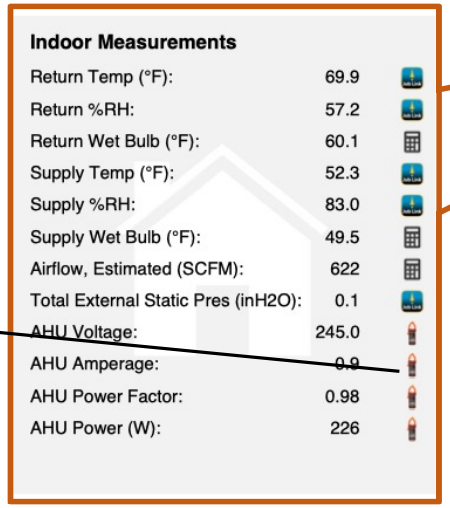
Commissioning Report

- Measurements and Calculations
- Pass/Fails for subsystems
- Corrective Actions
- Photo documentation
- Geo Location



Fieldpiece

Manually entered



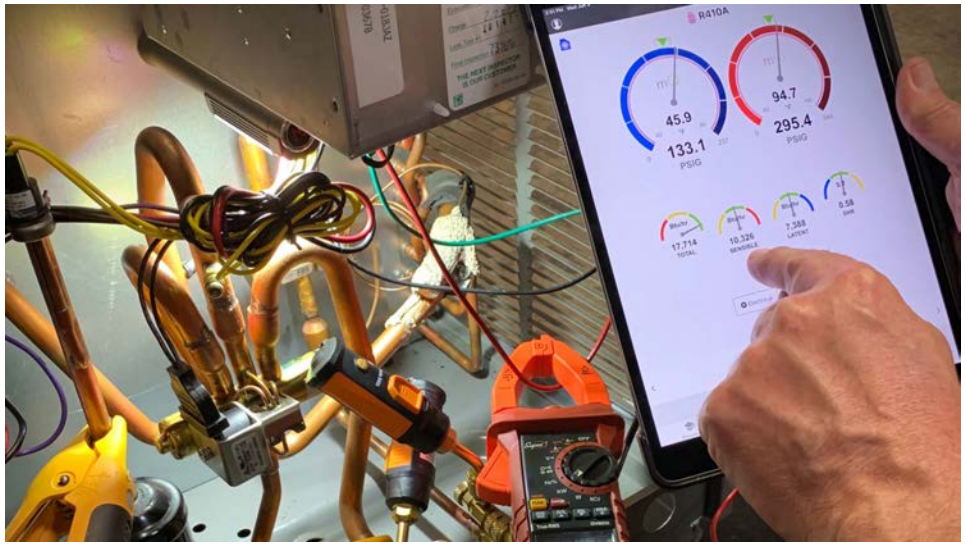
Red Fish
Electrical meter

EEBA

The Checklist Manifesto

“under conditions of complexity, not only are checklists a help, they are required for success.”
Atul Gawande

Checklists Don’t Give a Real-Time Picture



MITSUBISHI ELECTRIC
HEATING & AIR CONDITIONING

measureQuick

6 Steps to Installation Success

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
					
Select Location	Install Indoor Unit	Install Outdoor Unit	Interconnect System	Leak Test and Evacuate	Charge and Test

ANSI / RESNET / ACCA / ICC 310-2020

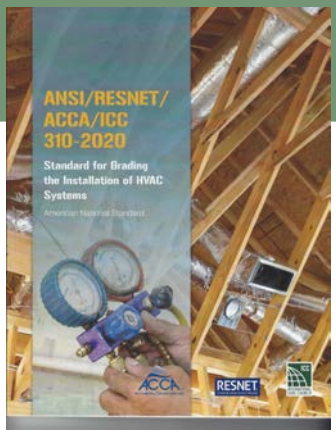
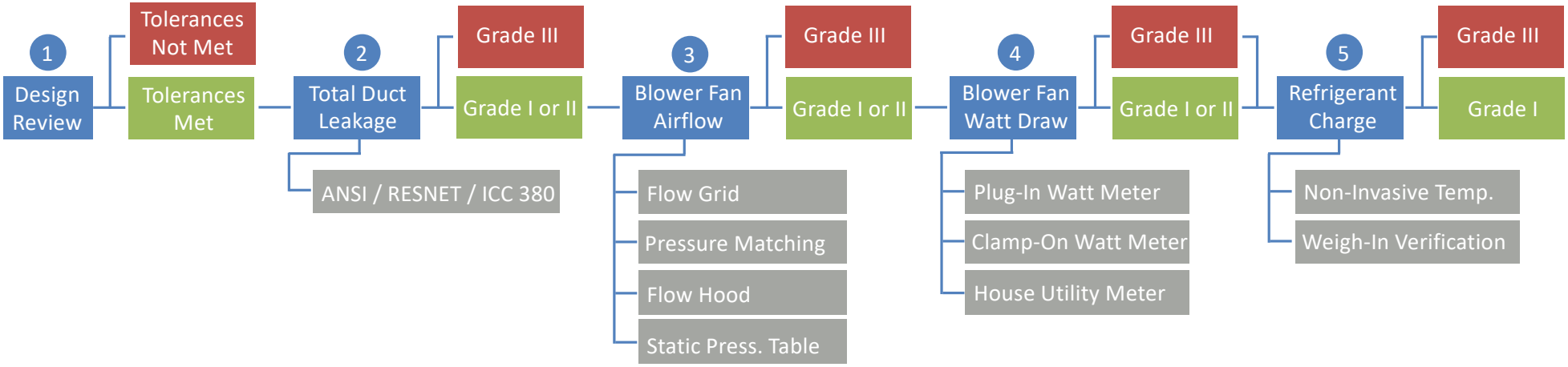


Figure 1: Illustration of Workflow and Diagnostic Test Methods



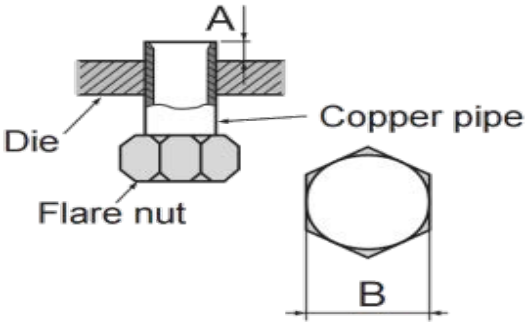
Appliance Fixation

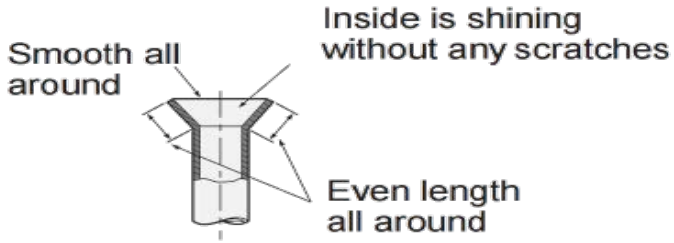
Refrigerant Charge

Temperature Split

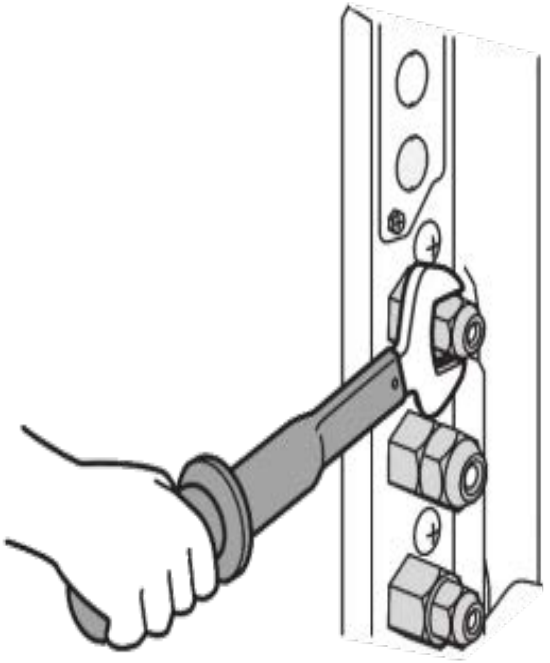
Supply and Return

Flair connections are the #1 service issue



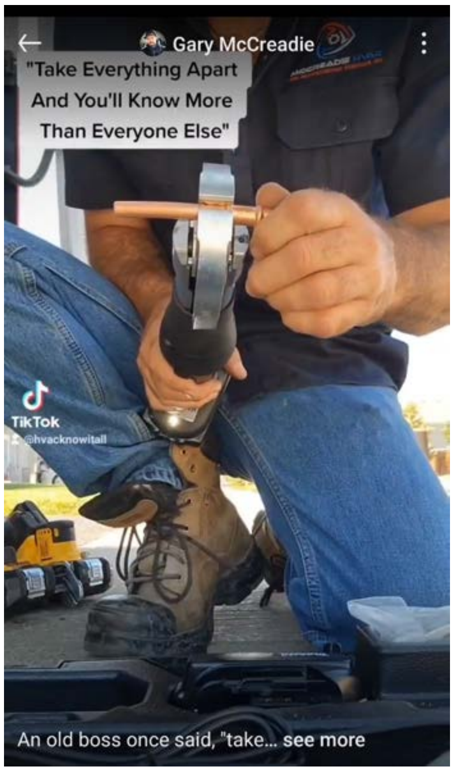


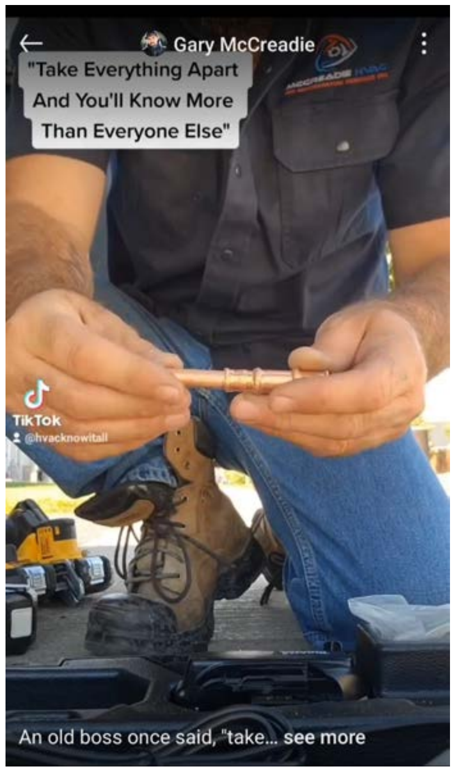
Tighten the flare nut with a torque wrench to specs.



Do It Right The First Time

Gary McCreadie - HVAC Know It All, hvacknowitall.com





HVAC KNOW IT ALL

The HVAC Know It All Podcast

https://www.linkedin.com/posts/gary-mccreadie-38217a77_hvac-pipefitting-hvacr-activity-6966484585320763392-lQwd?utm_source=share&utm_medium=member_desktop

Refrigerant leaks are bad…

R-410a =

2100 GWP (global warming potential)

10 lbs leaked =

21,000 lbs of CO2 equivalent

This is 125% of the CO2 footprint of the average person in the US.

https://www.nature.org/en-us/get-involved/how-to-help/carbon-footprint-calculator/

Design is the Foundation

Proper Design Correct Selection & Design Review

Charge It!

The refrigerant charge must be Exact.

14.2 lbs

Refrigerant Over Charged / Undercharged

Over Charged or Undercharged

... is a symptom, not always the problem

Basic rules for commissioning

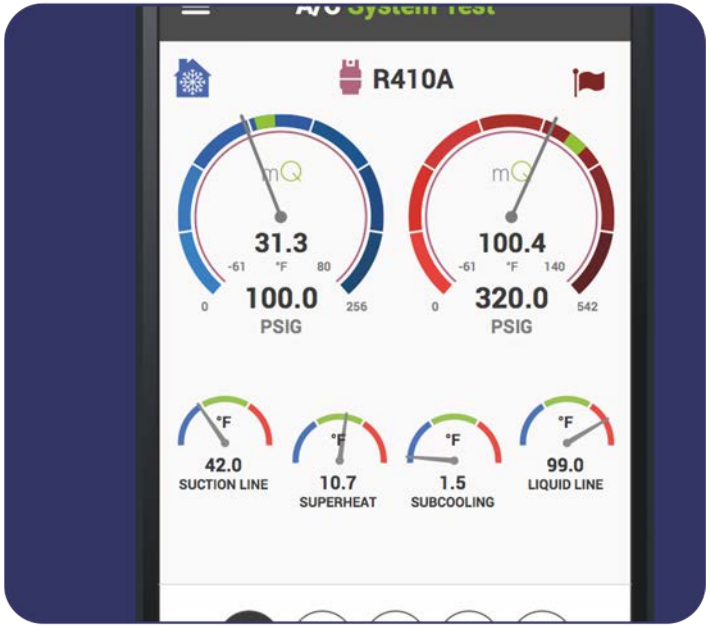
Airflow Before Charging

- **Let the system run for a little while before checking anything**
- **Check airflow BEFORE the charge**
  - Some of your readings will depend on airflow, so the airflow should be optimized before adding or recovering refrigerant
  - On furnaces, checking the combustion comes after airflow as well
  - Check the condensate after airflow
- **Use your senses to pick up on any system abnormalities before you pick up your gauges**
  - Listen to fan sounds
  - Put your hand over the condenser and in front of vents
- **Your two most valuable resources will be the manual and plain old common sense**

Special thanks to Bryan Orr

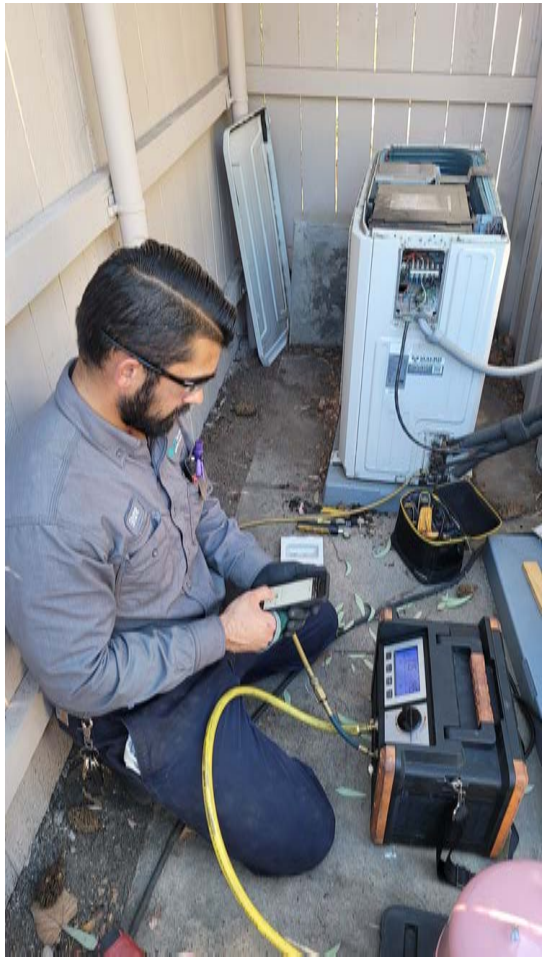
Checking the charge

- **Before checking charge, check the following:**
  - Airflow measurements
  - Metering device type
  - Blower technology
  - Return/indoor air temperature
  - Outdoor temperature in the shade
- **If you haven't already, WEIGH the charge**
- **Subcooling will be your primary charging indicator on TXV systems**
  - Subcooling is not your only indicator; keep superheat, split, and saturation temperature in mind



Special thanks to Bryan Orr

Winter Condition Installations - Anyone...



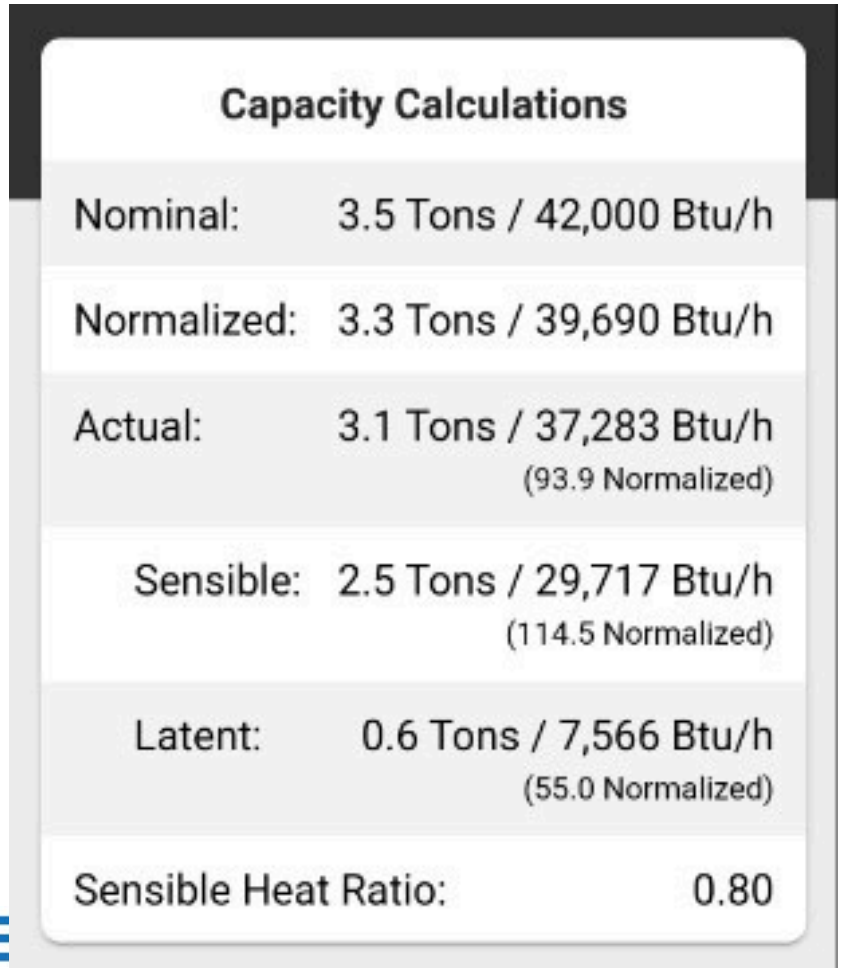
Systems that are charged using **Subcooling** should be verified when the outdoor temperatures are warm.

Are your contractors coming back to check the charge in the spring?

Did the Technician Measure for Static Pressure?

No holes in the air handler
= No static pressure measurements

Why would not use things that make you smarter



Capacity Calculations	
Nominal:	3.5 Tons / 42,000 Btu/h
Normalized:	3.3 Tons / 39,690 Btu/h
Actual:	3.1 Tons / 37,283 Btu/h (93.9 Normalized)
Sensible:	2.5 Tons / 29,717 Btu/h (114.5 Normalized)
Latent:	0.6 Tons / 7,566 Btu/h (55.0 Normalized)
Sensible Heat Ratio:	0.80

5729374694

x 28876

165,441,423,663,944

Maintain Control

- Thermostat settings and Setbacks and lockout settings.
- When does the secondary heat kick in?
- Heat strips on All the time or ...

Poor Thermostat Installation

- Air leakage
  - Temperature swings
  - Excessive run times
  - Incorrect temperature and humidity readings
  - **Plug with Thumb Gum**
  - Not paper products!

Confirm these conditions

System was designed and commissioned

Technician is skilled and trained

Technician has the installation manual

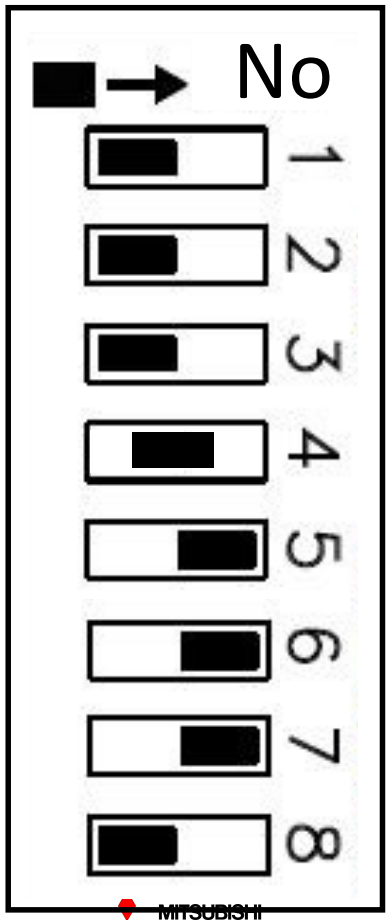
Technician followed the manual

Airflow was measured

Static pressure was measured

Builder received commissioning report

System was installed in the winter



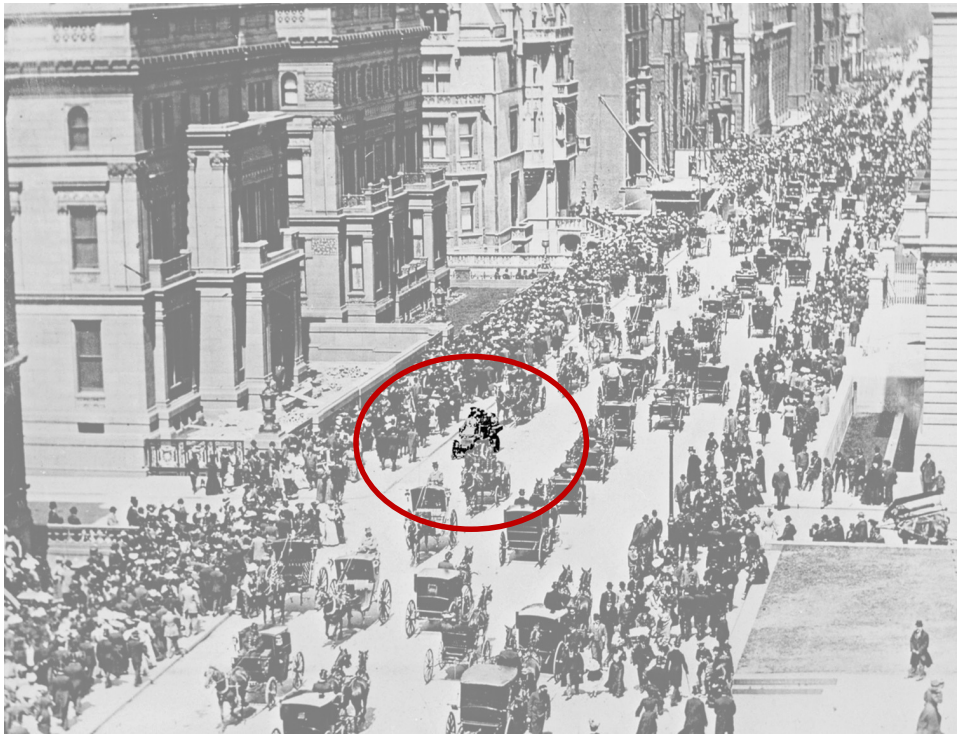
HVAC Industry Disruption – Are You In?

1900 NY City – Where is the Horseless Carriage?

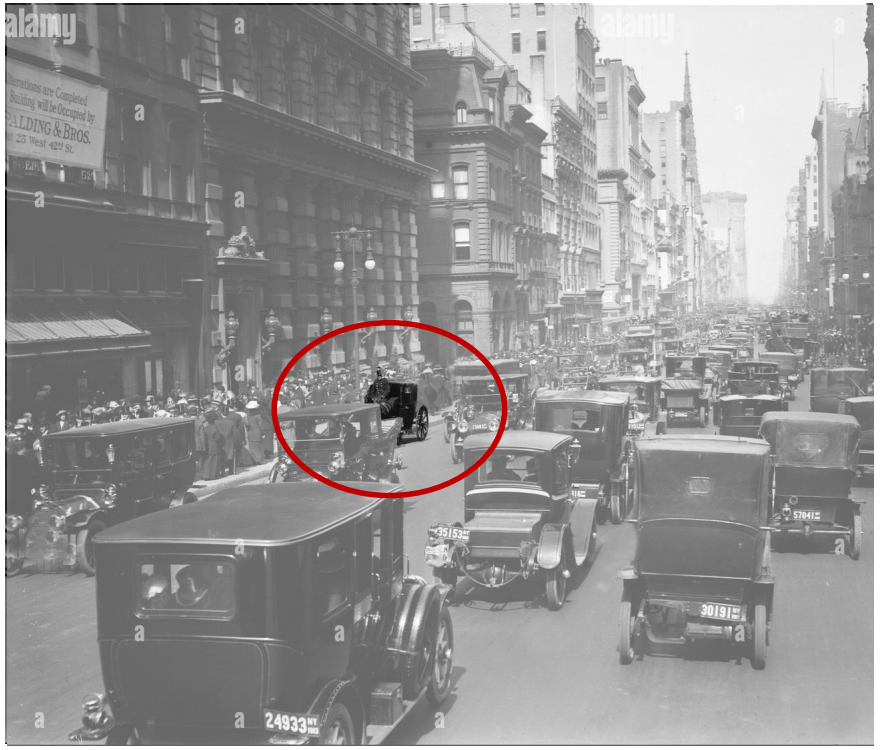
1915 NY City – Where is the Horse and Carriage?

Automobile

HVAC Industry Disruption – Are You In?



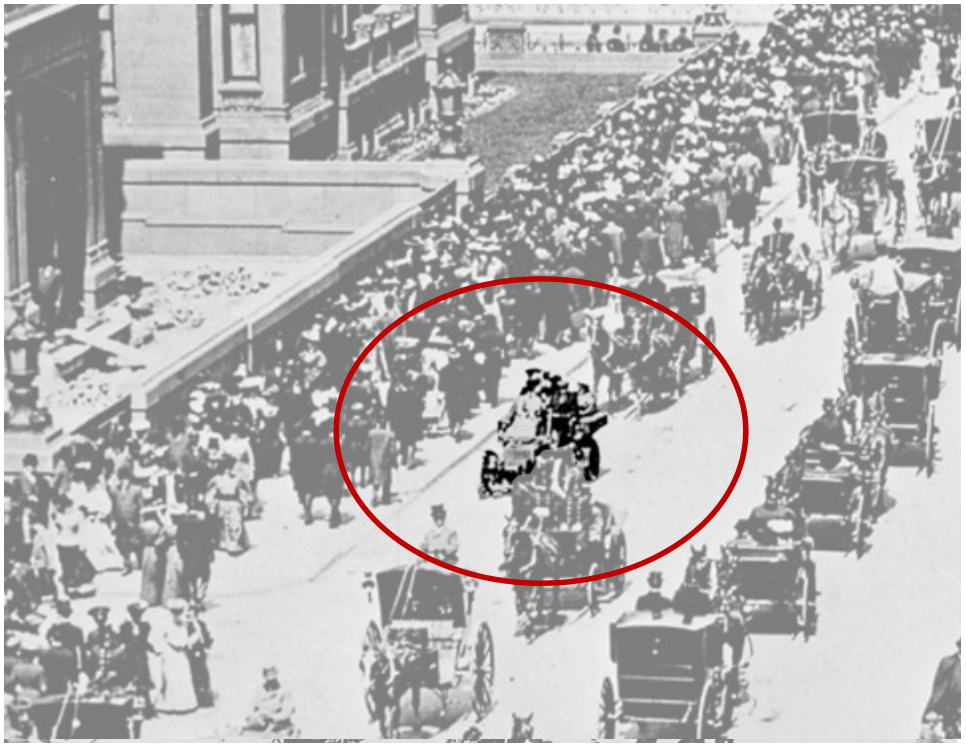
1900 NY City – Where is the Horseless Carriage?



1915 NY City – Where is the Horse and Carriage?

Automobile

HVAC Industry Disruption – Are You In?



1900 NY City – Where is the Horseless Carriage?

Automobile

1915 NY City – Where is the Horse and Carriage?

EEBA

Thank You

Joe Medosch

measureQuick

joe@measurequick.com

Shawn LeMons

MITSUBISHI ELECTRIC
HEATING & AIR CONDITIONING

slemons@hvac.mea.com