

Lifecycle Refrigerant Management



**ROBERT MOWRIS / VERIFIED
AYAD AL-SHAIKH / CAL TF STAFF
NOVEMBER 2022**

Presentation Overview

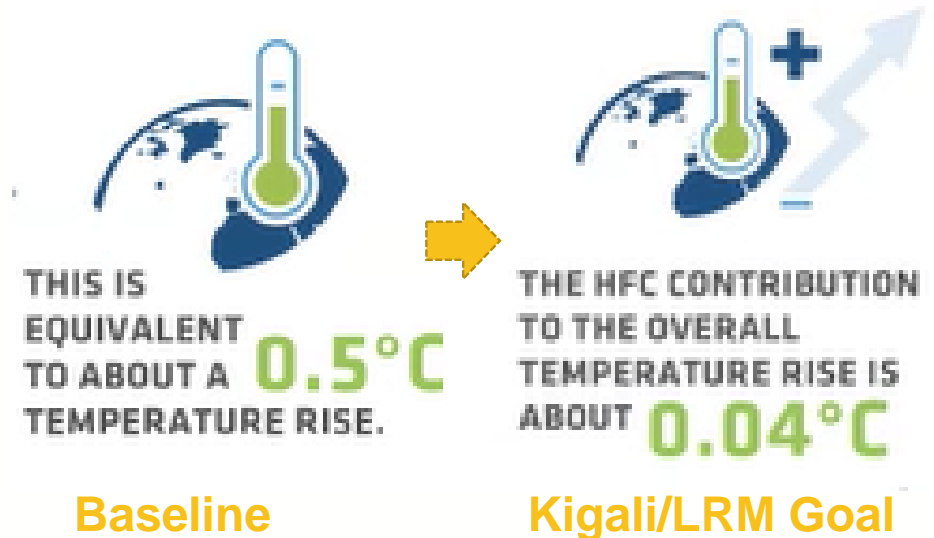
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Objective: Provide update on proposed measure package

- Lifecycle Refrigerant Management (LRM) Background
- Goals of LRM are to support the Kigali Amendment
- Flow Chart: Process and Measures

Background:

- Training
- Sensitivity analysis
- Assumptions in Refrigerant Avoided Cost Calc (RACC)
- Non-invasive Temperature Diagnostics (NTD)

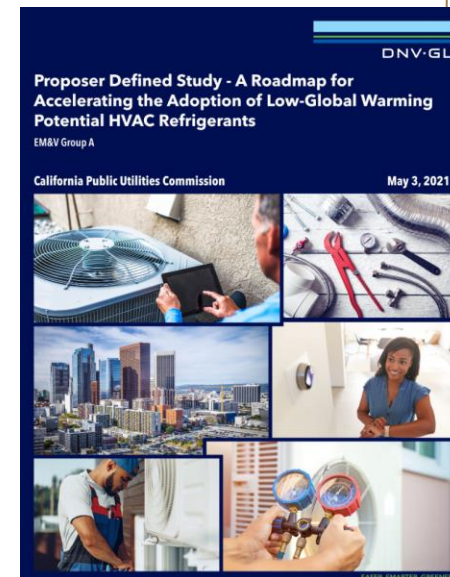
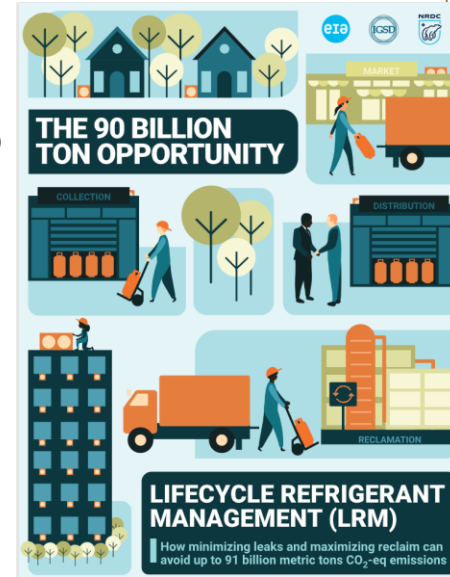


Lifecycle Refrigerant Management

Background

LRM Goal is to achieve 2016 Kigali Amendment of reducing warming due to HFC/HCFCs from 0.5°C to 0.04°C by year 2100.

- **LRM Report**
 - Enhanced refrigerant stewardship
 - Increase refrigerant recovery, reclamation and reuse
 - Leak reduction
 - Reporting and enforcement
 - Workforce development
 - Installation and servicing
- **DNV Evaluation**
 - Workforce training
 - Leak detection and repair
 - Non-invasive Temperature Diagnostics (NTD)
 - Leak prevention with locking Schrader caps
 - Significant recharge only



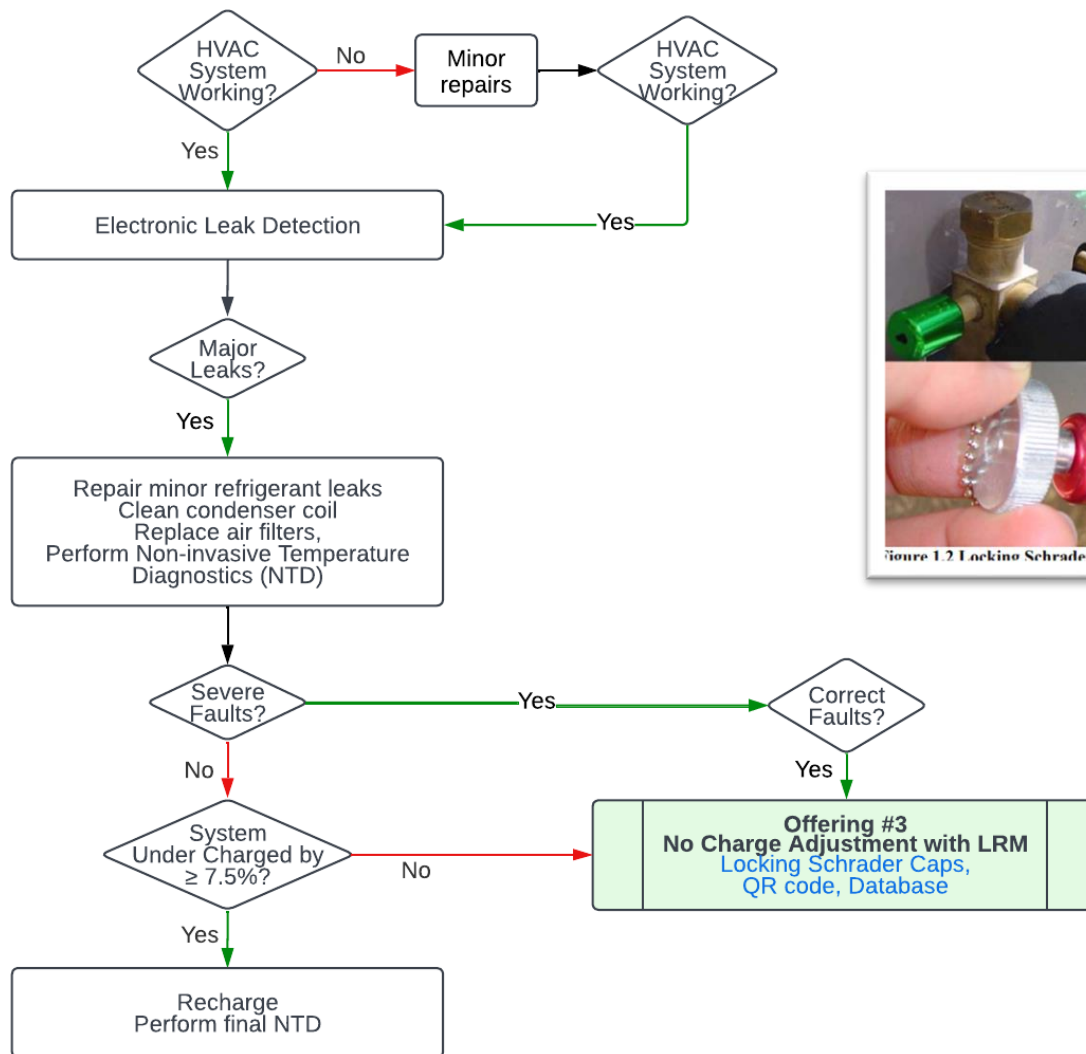
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Project Flow

Offering #3 No Charge Necessary

- Clean condenser
- New air filter
- Leak prevention
- Non-invasive test
- Database reporting

TRC ~ 1



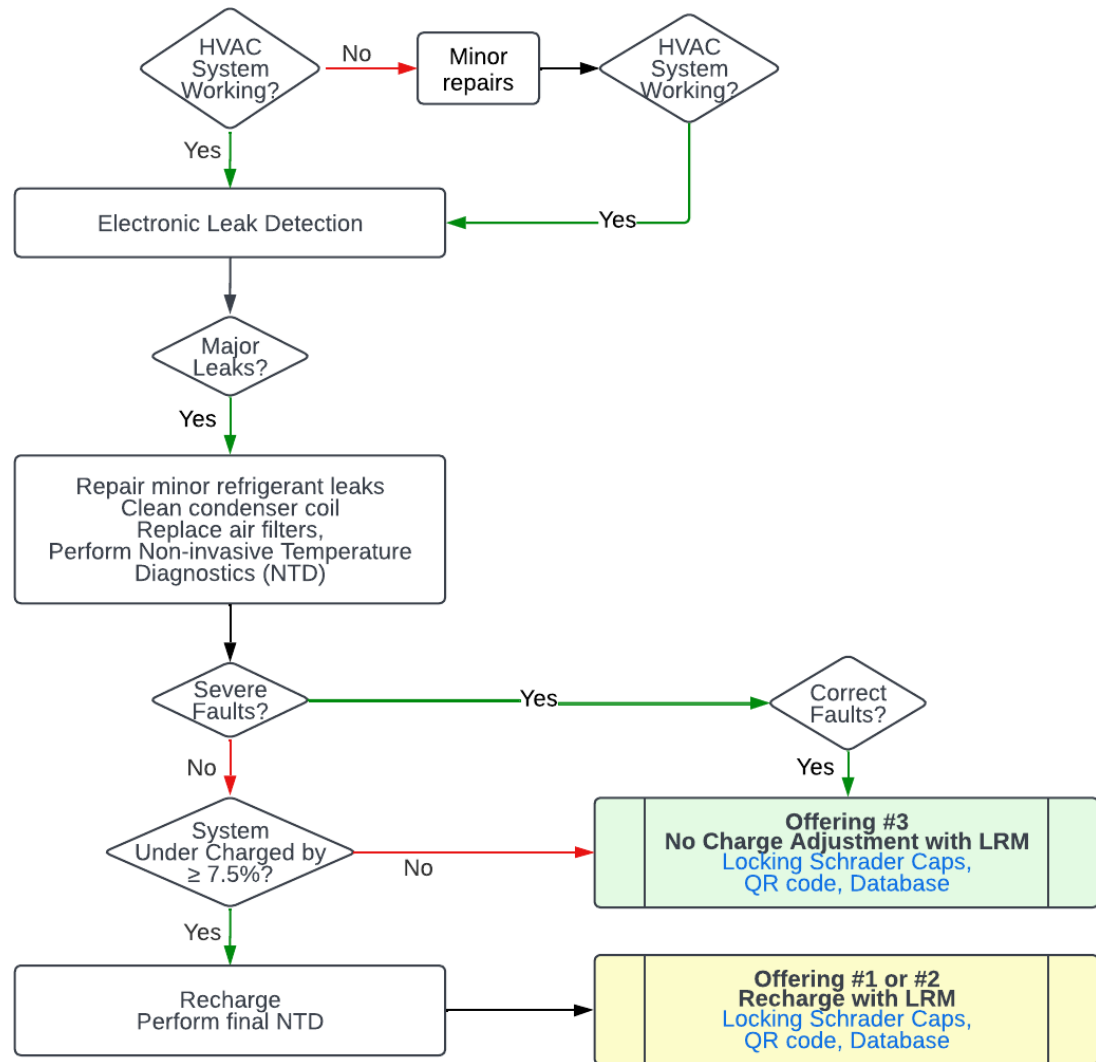
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Project Flow

Offering #1 or 2 Charge Added

- Clean condenser
- Clean filter
- Leak prevention
- Non-invasive test
- Database reporting
- Added refrigerant

TRC ~ 1



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Project Flow

Offering #4 Normal Replacement

- EOL Recovery from existing system
- New system
- Leak prevention
- Database reporting

TRC > 2.5

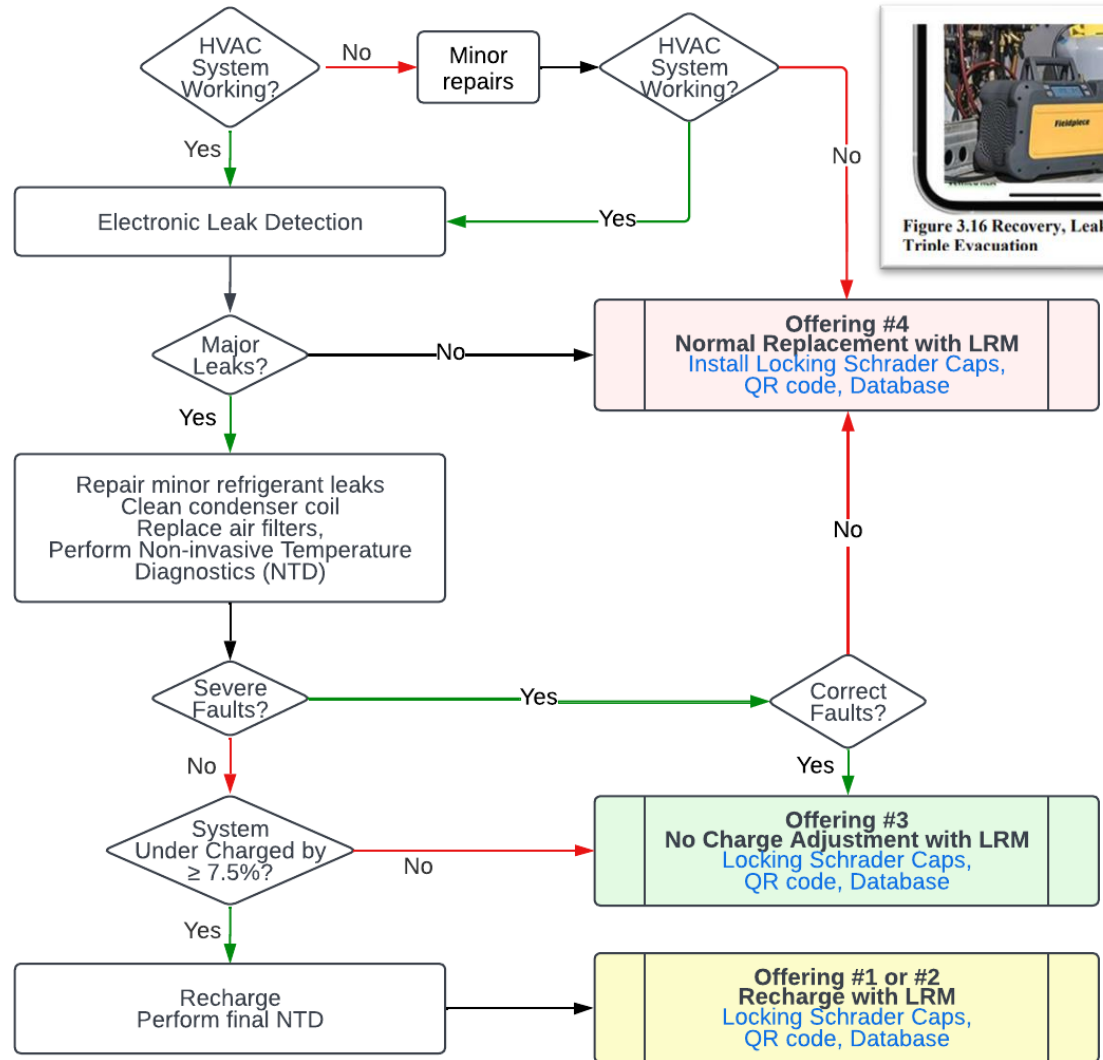


Figure 3.16 Recovery, Leak Tests, and Triple Evacuation

Residential LRM Offering Summary

7

Offering	Description CZ01-CZ16	kWh/y	kW	UnitRefBen	Material	Labor	TRC
1	Recharge with LRM, AC	177	0.12	\$156	\$100	\$175	0.9
2	Recharge with LRM, HP	285	0.12	\$156	\$100	\$175	1.1
3	No Recharge with LRM	0	0	\$156	\$50	\$100	1
4	Normal Replacement with LRM	0	0	\$764	\$50	\$100	> 2.5

Based upon 7.5% refrigerant recharge

Refrigerant Annual Leak reduced by 90%

Refrigerant Annual Leak reduced by 90%
And
End of Life Reclaim for existing equipment

Notes:

LRM = Lifecycle Refrigerant Management (*includes leak detection & repair, clean condenser coil, replace air filters, non-invasive temperature diagnostics, and locking Schrader caps.*)

All offering available for TxV and Non-TxV

All offering vary by climate zone

Additional offerings proposed for new construction (not shown).

Questions

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- Contact
 - Robert Mowris at: Robert@verified.co
 - Ayad Al-Shaikh at: Ayad.Al-Shaikh@futee.biz

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Back-up Topics

- Workforce training
- Sensitivity analysis
- Assumptions in RACC
- Noninvasive Temperature Diagnostics (NTD)
 - Measurement points / screen

Assumptions in RACC

Refrigerant Avoided Cost Calculator (RACC)

- Calculator Demo
 - First year: 2023
 - End of Life Leakage (no adjustment)
 - Annual Leakage: 5% -> 0.5%
 - ✦ 90% savings
 - ✦ Base upon locking Schrader cap retention study showing 99% after 2 years.
2006 Retention Study – Aloha Systems (CALMC)
https://www.calmac.org/publications/RCAVP_Final_EM&V_Report.pdf
- **Result: Refrigerant Cost/Benefit as NPV in 2020 dollars**

Refrigerant Avoided Cost Calculator

For the California Public Utilities Commission



Use this calculator to calculate the avoided costs of refrigerant leakage for devices containing a refrigerant, when refrigerant type or amount is changed or a device is replaced early.

This calculator can be used to calculate the avoided costs compared to a counterfactual for three measure types including:

- 1) Normal Replacement Measure, where a device is replaced by a new device at the end of its useful life
- 2) Add-on Equipment Measure, where a new piece of equipment is installed alongside existing equipment
- 3) Accelerated Replacement Measure, where an existing device is retired early and replaced with a new device

For Normal Replacement and Add-on Equipment Measures, it is assumed that the existing equipment is the same between the measure and counterfactual case, and thus does not need to be specified by the user measure since it does not contribute to the relative avoided costs. However, if Accelerated Replacement is chosen as the measure type, both new and existing device inputs must be specified to calculate avoided costs. For Accelerated Replacement measures, it is assumed that the existing device and refrigerant are the same between the measure and the counterfactual case. However, in the counterfactual case, the existing device is retired at the end of its useful life. Note that the output field is labeled "NPV avoided costs" regardless of whether that value represents a benefit or a cost, so users must be careful to input this data correctly into their cost-effectiveness tool.

Please note that, for fuel substitution measures, it is critical to take into account the avoided cost of refrigerant leakage from air conditioners, if the building(s) in question would have had an air conditioner in the absence of the measure. For example, if a heat pump replaces both a natural gas heater and an air conditioner, the reduction in refrigerant leakage from this replaced air conditioner must be considered in any cost-effectiveness calculations. If the replacement of an existing or planned air conditioner is not reflected, the net cost of refrigerant leakage from fuel substitution measures could be seriously over-estimated.

User Dashboard

Inputs		Result
Measure type: <input type="radio"/> Normal Replacement or Add-on Equipment		NPV Avoided Costs in Measure Start Year (2020\$) 107.26
Measure (Detect, repair, prevent refig leaks)		
Device Type (see Refrigerant Leakage tab for list of devices)	Counterfactual (no leak prevention)	
New Device Residential Heat Pumps	New Device Residential Heat Pumps	



LRM Training Manual

LIFECYCLE REFRIGERANT MANAGEMENT (LRM) TRAINING MANUAL: NON-INVASIVE TEMPERATURE DIAGNOSTICS (NTD)

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P.O. Box 2189, Olympic Valley, CA 96146 • CSLB #1929746 CDO, C36
Robert Moore, P.E. • 530-440-8240 • rob@verified.com
Ean Jones • 530-412-3864 • ean@verified.com

LRM Training Manual

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Non-Invasive Temperature Diagnostic (NTD)

RDT - Return-air Dry-bulb Temperature

RWT - Return-air Wet-bulb Temperature

SDT – Supply-air Dry-bulb Temperature

OAT – Outdoor Air Temperature

ST – Suction Temperature (refrigerant)

LT – Liquid Temperature (refrigerant)

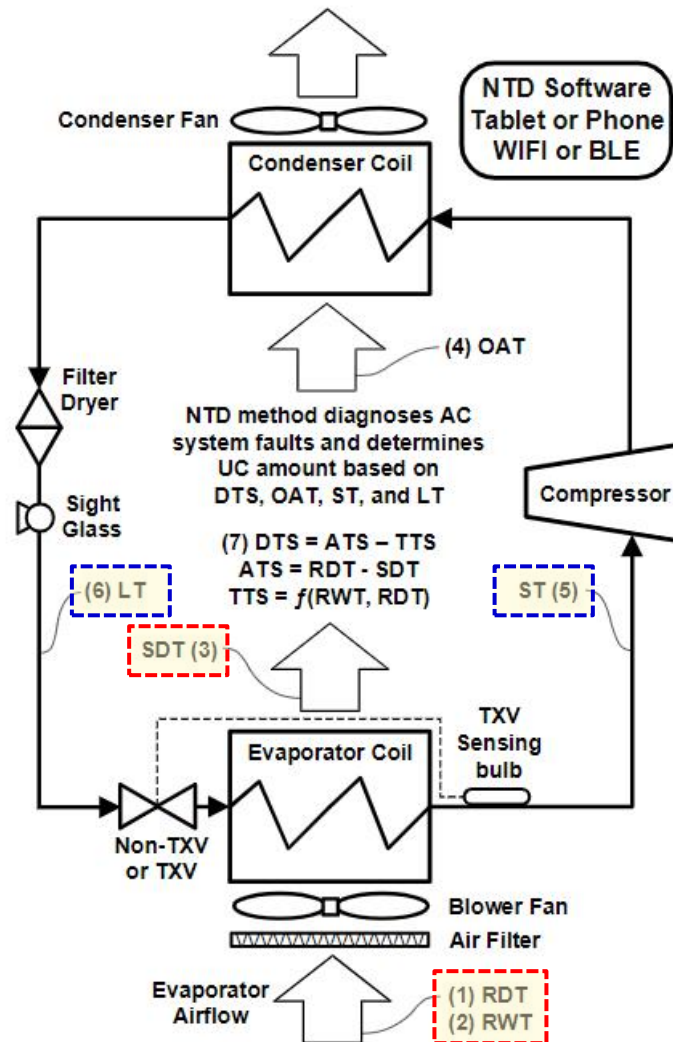


Figure 3.1 HVAC Schematic for NTD Method

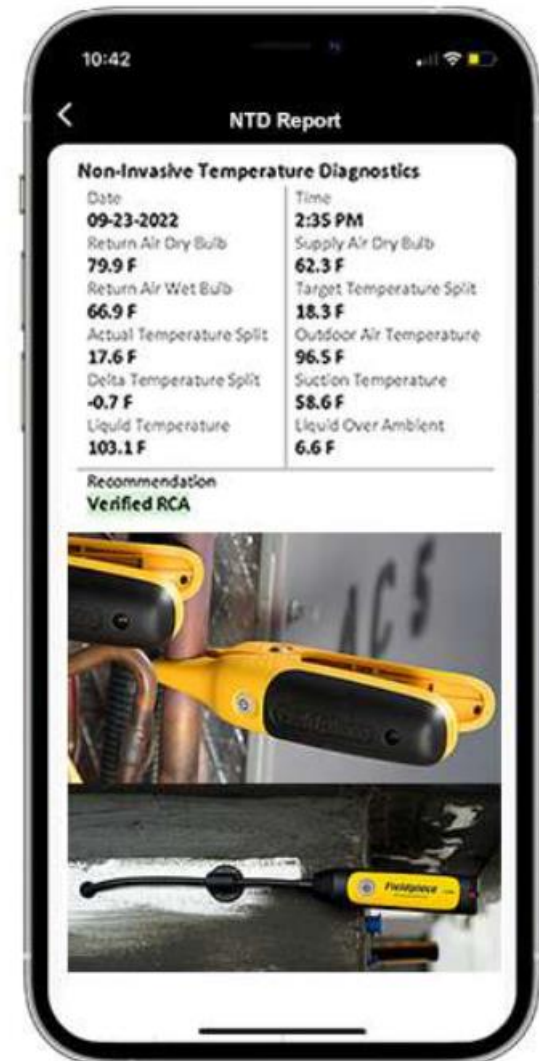


Figure 3.2 NTD Verified RCA

Sensitivity Analysis

- Conclusion: Calibration and choice of probes is important to result:
 - Return Wetbulb Temperature (RWT)
 - Return Drybulb Temperature (RDT)
 - Supply Drybulb Temperature (SDT)
- Sensitivity shows results are conservative, resulting in no charge (VRCA).

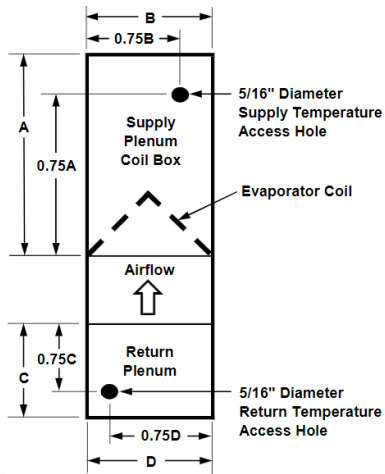


Table 2: LRM Uncertainty Analysis for NTD Method at 95F OAT (Intertek Data)

#	Intertek Test	NTD Method Uncertainty	LT	ST	RWT	RDT	SDT	DTS	
7	NT Base FC	No Recharge	-0.6% ± 1.2%	103	59	67	80	62	-0.6
8	NT UC -5%	No Recharge	-3.7% ± 2%	104	72	67	80	65	-3
9	NT UC -10%	Undercharged	-11.5% ± 3.4%	105	80	67	80	69	-7
10	NT UC -20%	Undercharged	-18.1% ± 4.1%	103	82	67	80	71	-8.9
11	NT UC -30%	Undercharged	-31.8% ± 5.5%	100	81	67	80	74	-12.7
12	NT UC -40%	Undercharged	-38.1% ± 6%	99	81	67	80	76	-14.1
22	TXV Base FC	No Recharge	3.7% ± 2%	104	50	67	80	62	-1
23	TXV UC -5%	No Recharge	2.8% ± 5%	107	61	67	80	63	-1.1
24	TXV UC -10%	Undercharged	-8.5% ± 4.7%	106	69	67	80	64	-2.4
25	TXV UC -20%	Undercharged	-20% ± 4.2%	104	77	67	80	67	-5.7
26	TXV UC -30%	Undercharged	28.7% ± 3.7%	102	81	67	80	70	-8.6
27	TXV UC -40%	Undercharged	-41.0% ± 3%	98	81	67	80	75	-12.9



Figure 4. Psychrometers to measure air temperatures provide +/-1F accuracy

Key:

TXV – Thermal expansion valve

NT – non-TXV

FC – Full charge

UC – Under-charge, recharge required

VRCA – Verified that no charge required