Lifecycle Refrigerant Management

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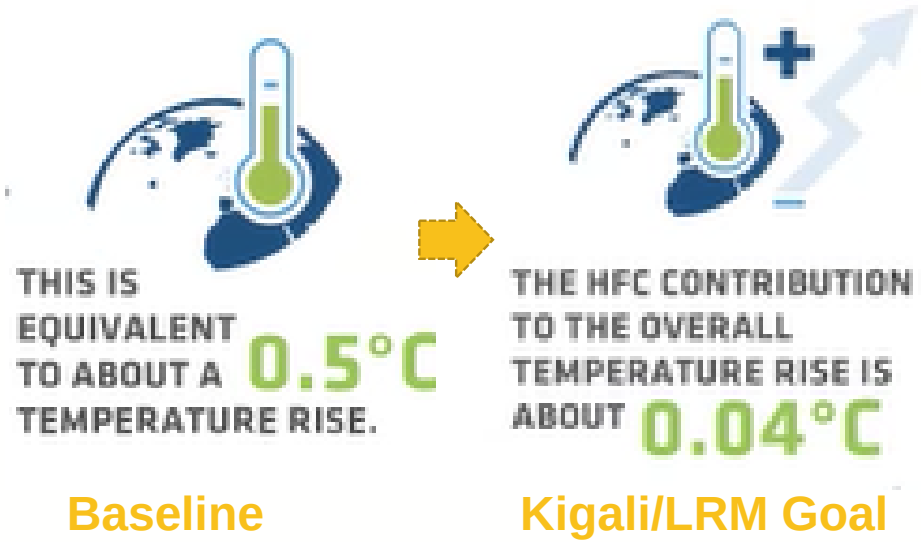
Presentation Overview

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)

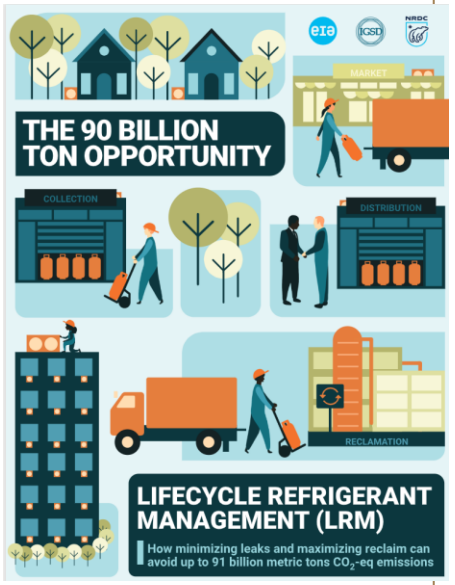


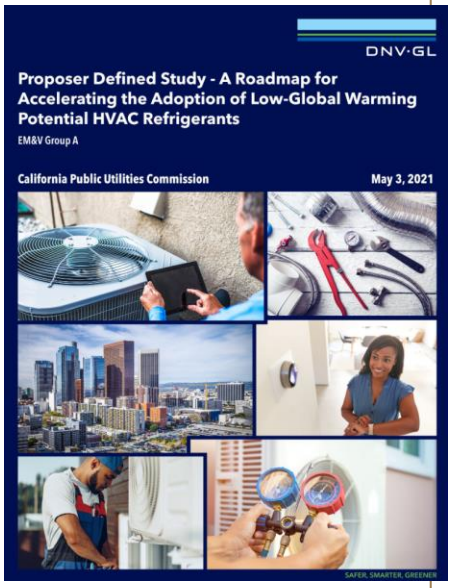
Lifecycle Refrigerant Management

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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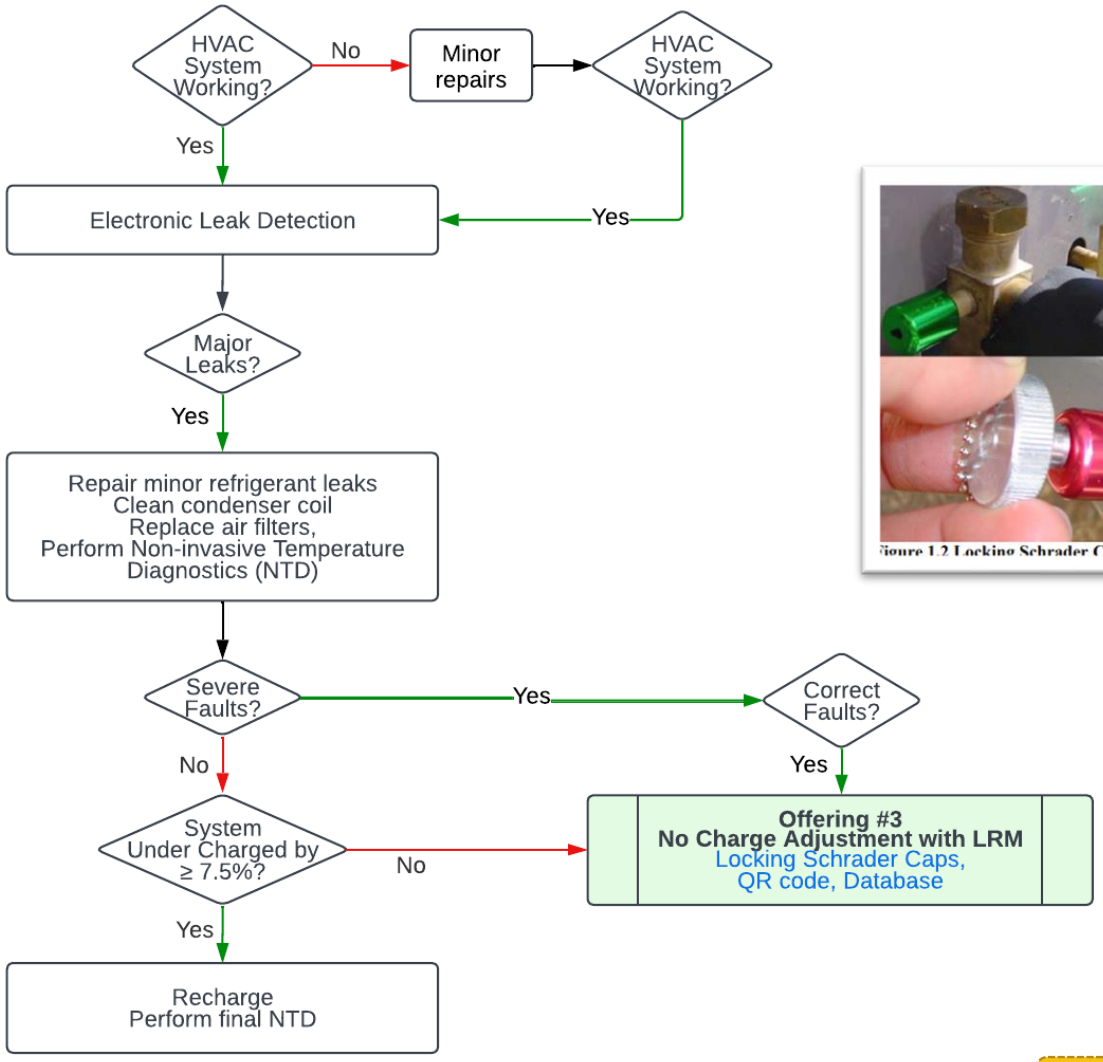
Lifecycle Refrigerant Management

Project Flow

Offering #3
No Charge Necessary

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

TRC ~ 1



NTD

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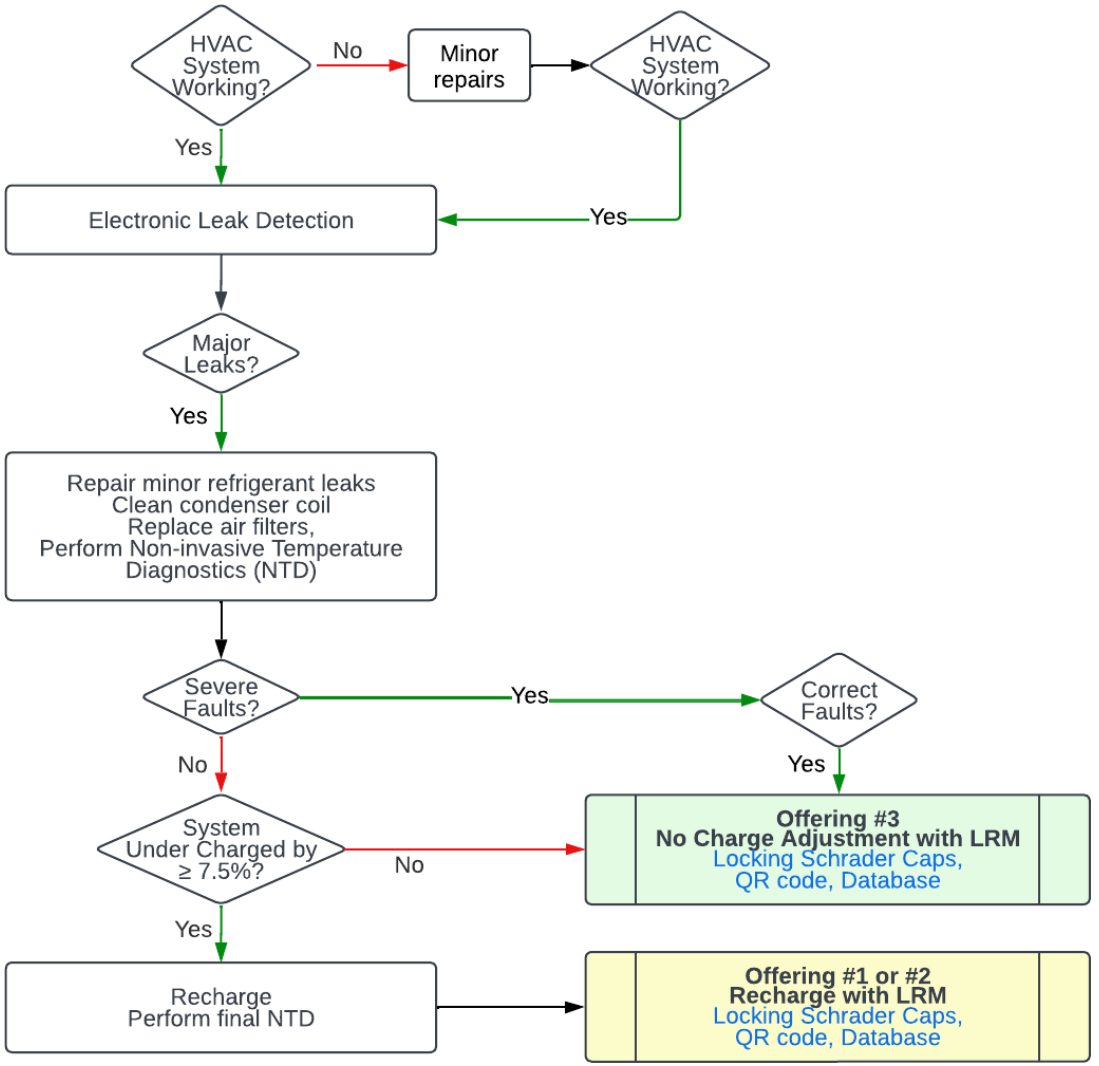
Project Flow

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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Lifecycle Refrigerant Management

Project Flow

Offering #4 Normal Replacement

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

TRC > 2.5

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Residential LRM Offering Summary

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%

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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

- 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

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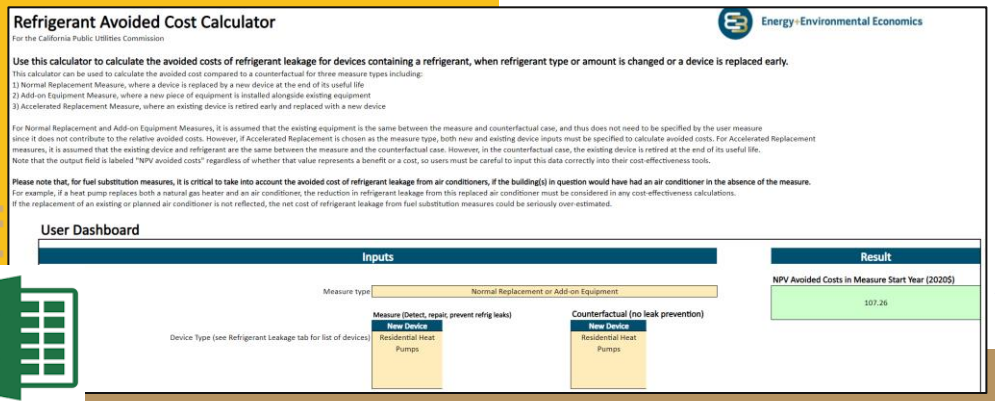
Assumptions in RACC

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*



LRM Training Manual

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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)

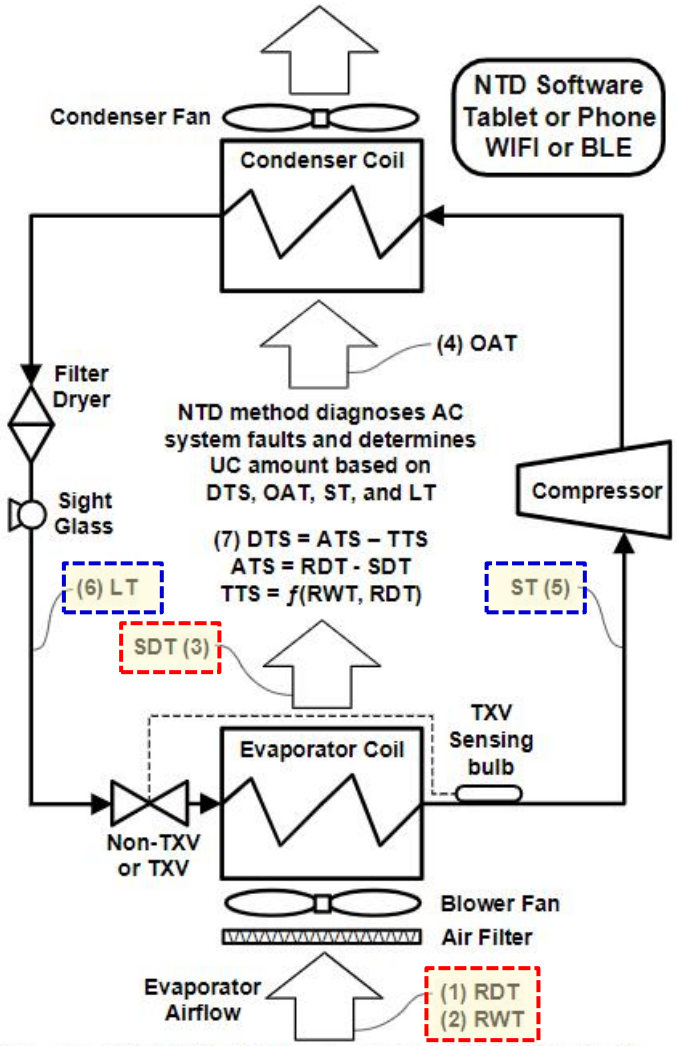

Figure 3.1 HVAC Schematic for NTD Method

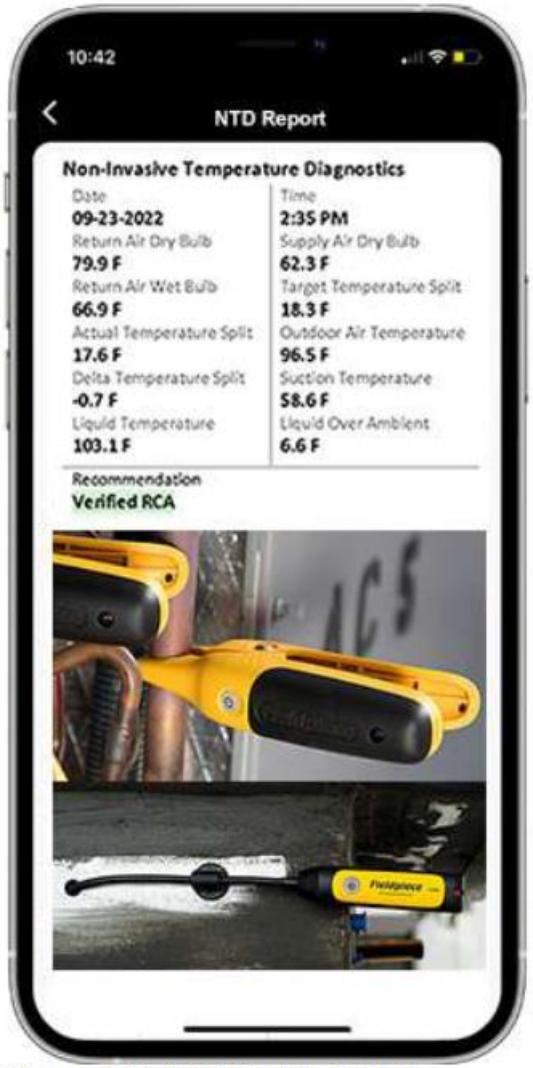

Figure 3.2 NTD Verified RCA

Back

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).

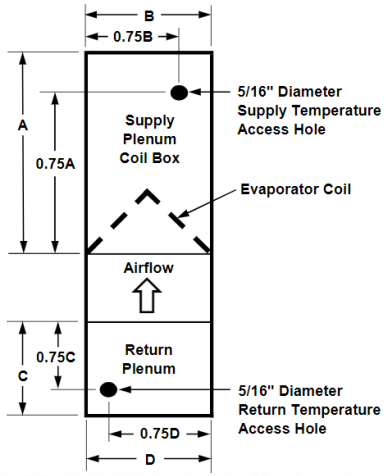

Table 2: LRM Uncertainty Analysis for NTD Method at 95F OAT (Intertek Data)

#	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