GUIDELINES ON AIRFLOW AND REFRIGERANT CHARGE VERIFICATION AND DIAGNOSTICS

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Context

- Airflow and refrigerant charge defects in existing air conditioning systems are well documented
- Failure to address these problems represents a missed opportunity for home performance contractors
- To ensure cost-effective solutions, a systematic approach is needed to *quickly* and *accurately* diagnose and resolve problems
- Target:
  - Home performance contractors
  - HVAC contractors & technicians

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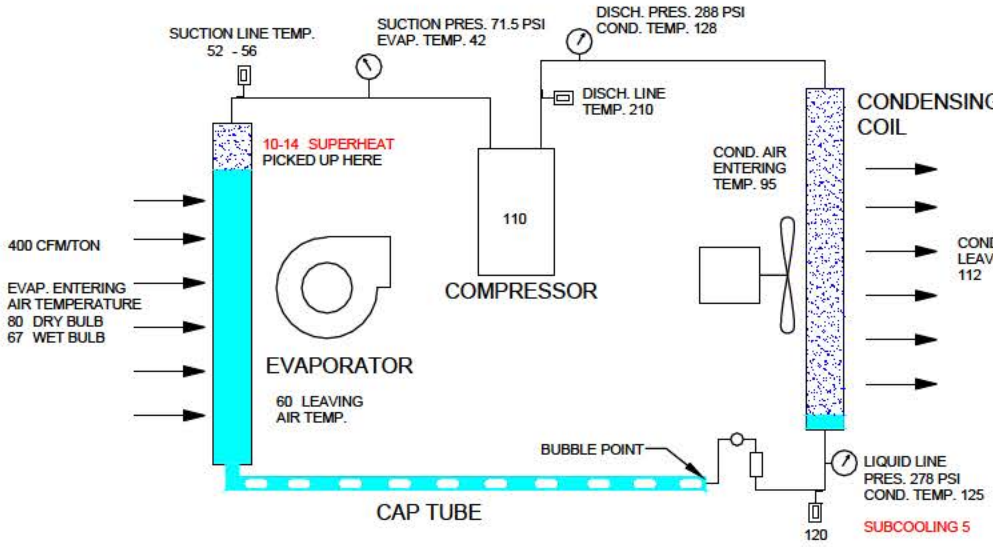
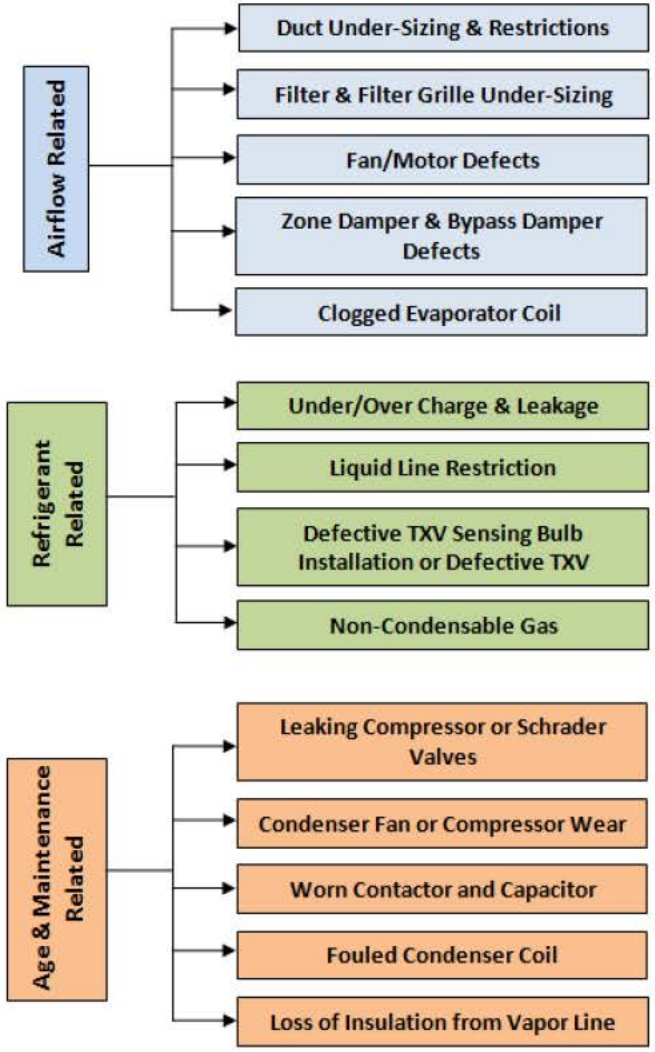
Refrigerant systems are complex, measured parameters are interrelated, and faults can be difficult to identify





The Impact of Defects

Condition	EER Impact	
	Non-TXV	TXV
15% duct leakage[1]	-18.10%	
23% low airflow	-4.70%	
50% condenser coil blockage	-5.80%	
50% evaporator coil blockage[2]	-4.60%	-4.20%
20% overcharge	-3.50%	-7.90%
20% undercharge	-29.40%	-13.80%
0.3% non-condensable	-18.20%	-12.20%
Liquid line restriction	-29.70%	-36.10%
Ducts, evap, 50' line in attic[3]	-10.50%	
Attic equipment, 25% low airflow, 10% undercharge, 30% duct leakage, 50% coil blockage	-53.50%	

[1]2% duct leakage baseline, 118°F attic

[2]Equipment in conditioned space

[3]118°F attic, compared to ducts & equipment in conditioned space

Reference: R. Mowris, Jones, E., Eshom, R. 2012. "Laboratory Measurements of HVAC Installation and Maintenance Faults" ASHRAE Transactions, Vol. 188, Pt. 2

Technical Approach

- Preliminary Diagnostic by Home Performance Contractor
  - Correct serious duct leakage
  - Inspect overall system for obvious problems & correct or refer
  - Measure/verify airflow and check filter sizing
  - Measure Temperature Split (*key diagnostic*)
  - Referral to HVAC technician if warranted
- Comprehensive Diagnostic by HVAC Tech to identify & repair defects including:
  - Incorrect charge & refrigerant leaks
  - Liquid line restrictions
  - Non-condensables
  - Defective or improperly installed expansion device
  - Fouled evaporator coil
  - Equipment problems (contactor, capacitor, compressor)

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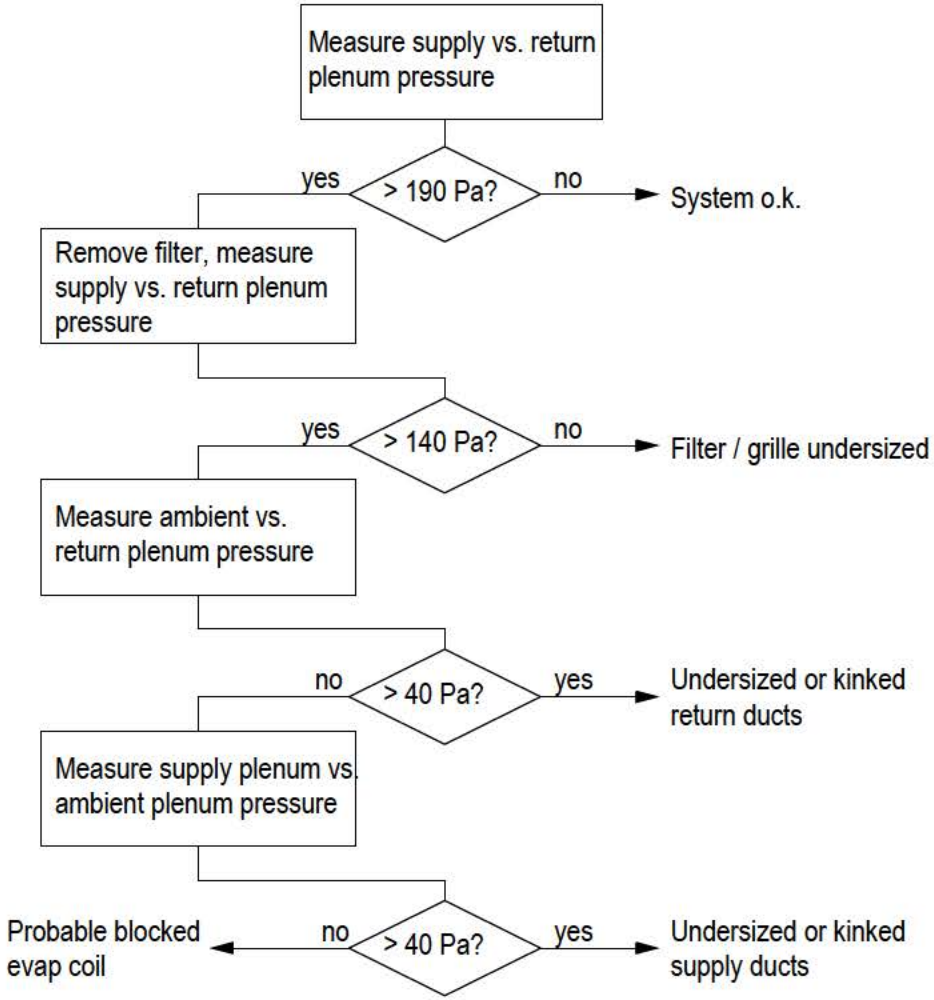
Preliminary Diagnostic

by Home Performance Contractor

- Seal ducts (<15%)
- System inspection
  - Condenser coil
  - Exp. device & lines
- Calculate filter velocity (<300 fpm)
- Measure/diagnose airflow (>300 cfm/ton)
- Measure temperature split (±3°F of target)
- Documentation/referral

Airflow Diagnostic



Temperature Split

Temperature split (between return & supply plenums) is easy to measure and is used to determine whether refrigerant or other system defects are significantly affecting capacity and performance.

Return Air Dry–Bulb (°F) ($T_{return, db}$)	Return Air Wet-Bulb (°F) ($T_{return, wb}$)																											
	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	20.9	20.7	20.6	20.4	20.1	19.9	19.5	19.1	18.7	18.2	17.7	17.2	16.5	15.9	15.2	14.4	13.7	12.8									
71	21.4	21.3	21.1	20.9	20.7	20.4	20.1	19.7	19.3	18.8	18.3	17.7	17.1	16.4	15.7	15.0	14.2	13.4	12.5								
72	21.9	21.8	21.7	21.5	21.2	20.9	20.6	20.2	19.8	19.3	18.8	18.2	17.6	17.0	16.3	15.5	14.7	13.9	13.0	12.1							
73	22.5	22.4	22.2	22.0	21.8	21.5	21.2	20.8	20.3	19.9	19.4	18.8	18.2	17.5	16.8	16.1	15.3	14.4	13.6	12.6	11.7						
74	23.0	22.9	22.8	22.6	22.3	22.0	21.7	21.3	20.9	20.4	19.9	19.3	18.7	18.1	17.4	16.6	15.8	15.0	14.1	13.2	12.2	11.2					
75	23.6	23.5	23.3	23.1	22.9	22.6	22.2	21.9	21.4	21.0	20.4	19.9	19.3	18.6	17.9	17.2	16.4	15.5	14.7	13.7	12.7	11.7	10.7				
76	24.1	24.0	23.9	23.7	23.4	23.1	22.8	22.4	22.0	21.5	21.0	20.4	19.8	19.2	18.5	17.7	16.9	16.1	15.2	14.3	13.3	12.3	11.2	10.1			
77	-	24.6	24.4	24.2	24.0	23.7	23.3	22.9	22.5	22.0	21.5	21.0	20.4	19.7	19.0	18.3	17.5	16.6	15.7	14.8	13.8	12.8	11.7	10.6	9.5		
78	-	-	-	24.7	24.5	24.2	23.9	23.5	23.1	22.6	22.1	21.5	20.9	20.2	19.5	18.8	18.0	17.2	16.3	15.4	14.4	13.4	12.3	11.2	10.0	8.8	
79	-	-	-	-	-	24.8	24.4	24.0	23.6	23.1	22.6	22.1	21.4	20.8	20.1	19.3	18.5	17.7	16.8	15.9	14.9	13.9	12.8	11.7	10.6	9.4	8.1
80	-	-	-	-	-	-	25.0	24.6	24.2	23.7	23.2	22.6	22.0	21.3	20.6	19.9	19.1	18.3	17.4	16.4	15.5	14.4	13.4	12.3	11.1	9.9	8.7
81	-	-	-	-	-	-	-	25.1	24.7	24.2	23.7	23.1	22.5	21.9	21.2	20.4	19.6	18.8	17.9	17.0	16.0	15.0	13.9	12.8	11.7	10.4	9.2
82	-	-	-	-	-	-	-	-	25.2	24.8	24.2	23.7	23.1	22.4	21.7	21.0	20.2	19.3	18.5	17.5	16.6	15.5	14.5	13.4	12.2	11.0	9.7
83	-	-	-	-	-	-	-	-	-	25.3	24.8	24.2	23.6	23.0	22.3	21.5	20.7	19.9	19.0	18.1	17.1	16.1	15.0	13.9	12.7	11.5	10.3
84	-	-	-	-	-	-	-	-	-	25.9	25.3	24.8	24.2	23.5	22.8	22.1	21.3	20.4	19.5	18.6	17.6	16.6	15.6	14.4	13.3	12.1	10.8

Comprehensive Diagnostic

by Qualified HVAC Technician

- Quick system inspection
  - Expansion valve
  - Refrigerant lines & site glass
  - Condenser & evaporator coils
- Take measurements (or obtain from PD)
  - Airflow (watch out for zoning)
  - Temperature Split
  - Subcooling & Superheat
  - Condensing over Ambient (COA)
  - Evaporation saturation temperature (EST)
  - Compressor power/current
- Compare to target values
- Diagnose & repair
- Retest & verify

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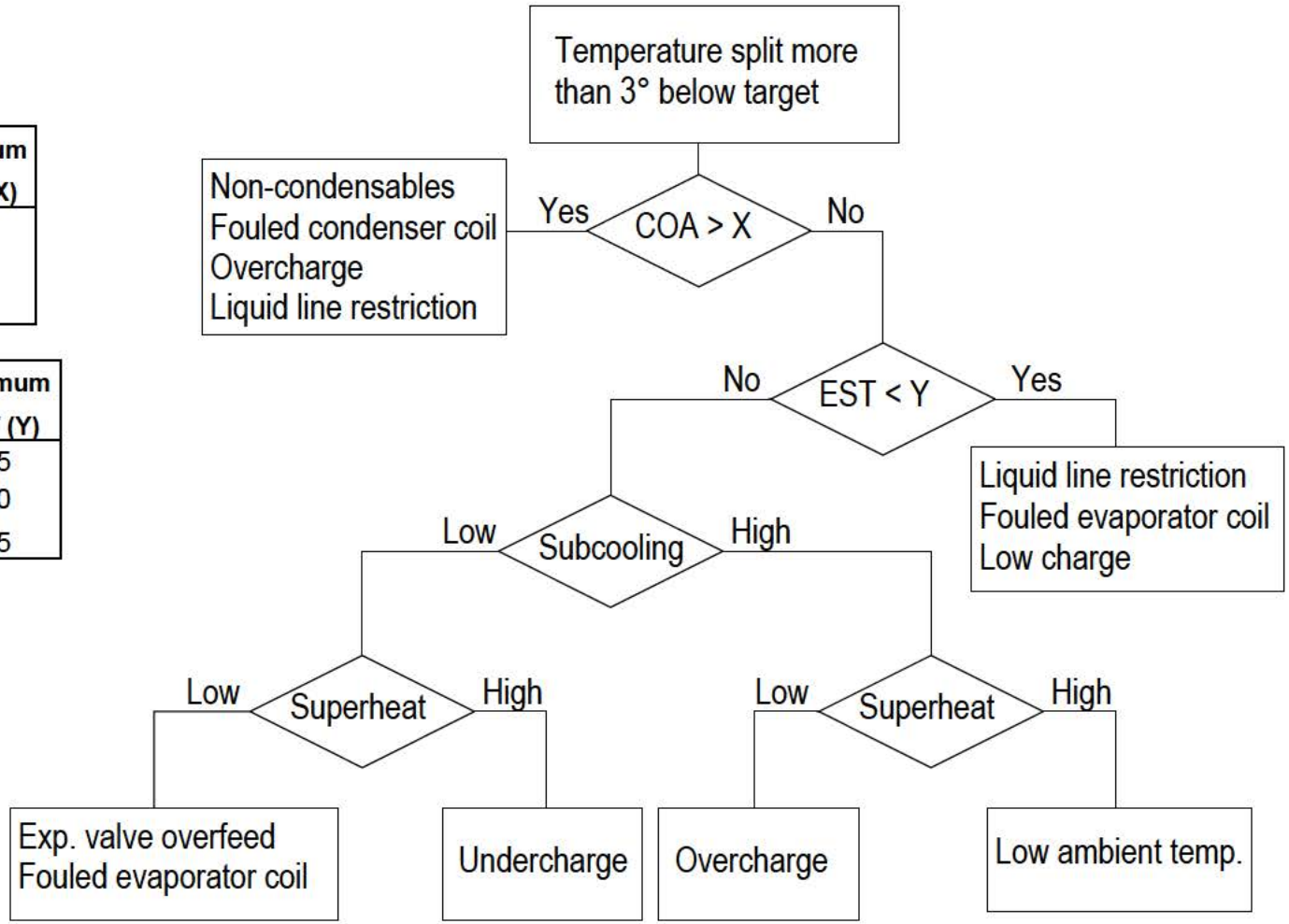
Comprehensive Diagnostic

Fixed Orifice Systems

System SEER	Maximum COA (X)
>12	25
10-12	30
<10	35

Indoor Wet Bulb Temp.	Minimum EST (Y)
62-63	35
64-65	40
66-67	45



Recommended Guidance

- Use accurate test equipment (calibrate regularly)
- Use proper measurement procedures
- Apply diagnostic methods published in the Guideline document & fine tune
- Use proper refrigerant charge procedures
- Train technicians
- In-the-field follow-up

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Value

- Value to practitioners
  - Small time investment (< 1 hour for prelim. diagnostic)
  - Full realization of projected energy savings
  - Reduced liability through identification of health & safety risks
  - Increased per project revenues
- Value to end users
  - Improved comfort through improved system capacity and better air distribution
  - Reduced energy costs (average > 30% reduction in cooling energy)
  - Longer equipment life, reduced equipment replacement costs

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Market Readiness

- Field trials completed but more needed
- Diagnostic procedures can be implemented using available tools and minimal additional training
- Key considerations:
  - Accuracy of test equipment
  - Correct test practices, charge procedures, and equipment maintenance
  - Training and follow-up
- Market ready? YES

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Pros and Cons

- Pros
  - Eliminates missed opportunity for energy savings in course of home performance improvement projects
  - The cost is coincident with improvements that are needed to maintain proper system operation and therefore comfort
  - Easy sell for home performance contractors that yields more revenue
  - Requires minimal training
- Cons (or barriers)
  - Need programmatic support for training and field follow-up
  - Difficulty in getting techs to follow protocols
  - Pressure on techs to keep visits short

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