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Quality, Efficiency & Performance

A three-pronged method to improve the quality of HVAC installations while increasing code compliance

California Energy Commission
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CSLB 742178

Ways to improve the quality of HVAC installations while increasing code compliance:

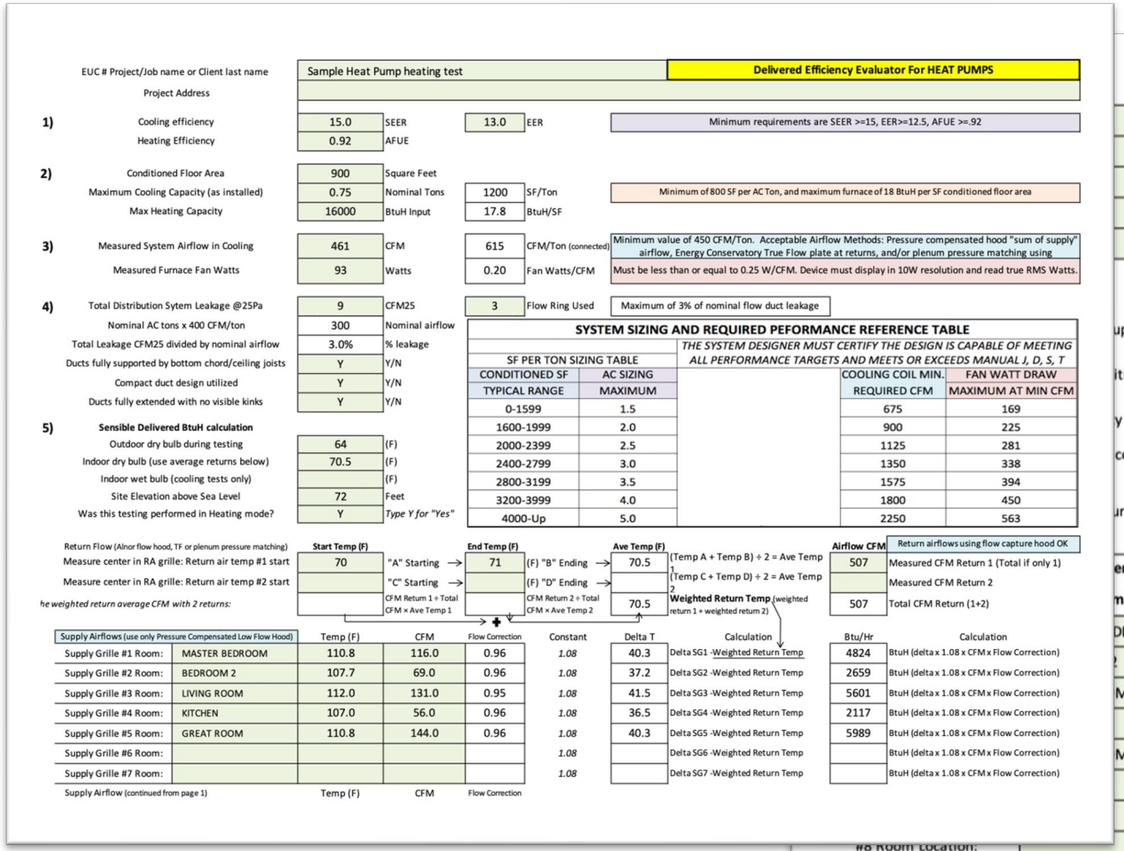
1. Create a *measured* performance pathway that *reduces* regulation
2. Transform the inspection paradigm and *simplify* it using technology
3. Suggest that warranties are only honored on *legal* installations

1. Create an alternate ”Measured Performance” compliance pathway that reduces regulation

- ✓ Utilities support “Certified High Performance HVAC” installations through contractor rebates, verification and directory listings
- ✓ Installers become excellent by being able to finally test and learn from their installations through feedback
- ✓ Customers don’t have to pay for 3rd party testing when systems meet Certified High Performance HVAC Metrics

Certified High Performance HVAC Metrics Summary

- System Efficiency Minimums are **SEER 15, EER 12.5, AFUE= 0.92**
- Air Conditioner sizing minimum of **800 SF per ton** AC Capacity
- Furnace maximum sizing of **18 BtuH per SF of conditioned floor area**
- Minimum airflow of **450 CFM per ton** at minimum of **4.0 CFM per Watt**
- Maximum of **3% duct leakage *to outside***
- Minimum of **85.0% delivered efficiency** as measured at supply & return grilles
- Maximum of **5 Pascal room pressure difference** throughout home
- Maximum of **3 degree F temperature difference** between warmest and coldest room
- 62.2 minimum ventilation at **2.2 CFM/W for HRV**, **5 CFM/Watt exhaust only** minimum



EUC # Project/Job name or Client last name: Sample Heat Pump heating test

Delivered Efficiency Evaluator For HEAT PUMPS

Project Address:

1) Cooling efficiency: 15.0 SEER; 13.0 EER — Minimum requirements are SEER >=15, EER>=12.5, AFUE >=.92

Heating Efficiency: 0.92 AFUE

2) Conditioned Floor Area: 900 Square Feet

Maximum Cooling Capacity (as installed): 0.75 Nominal Tons; 1200 SF/Ton — Minimum of 800 SF per AC Ton, and maximum furnace of 18 BtuH per SF conditioned floor area

Max Heating Capacity: 16000 BtuH Input; 17.8 BtuH/SF

3) Measured System Airflow in Cooling: 461 CFM; 615 CFM/Ton (connected) — Minimum value of 450 CFM/Ton. Acceptable Airflow Methods: Pressure compensated hood "sum of supply" airflow, Energy Conservatory True Flow plate at returns, and/or plenum pressure matching using

Measured Furnace Fan Watts: 93 Watts; 0.20 Fan Watts/CFM — Must be less than or equal to 0.25 W/CFM. Device must display in 10W resolution and read true RMS Watts.

4) Total Distribution Sytem Leakage @25Pa: 9 CFM25; 3 Flow Ring Used — Maximum of 3% of nominal flow duct leakage

Nominal AC tons x 400 CFM/ton: 300 Nominal airflow

Total Leakage CFM25 divided by nominal airflow: 3.0% % leakage

Ducts fully supported by bottom chord/ceiling joists: Y Y/N

Compact duct design utilized: Y Y/N

Ducts fully extended with no visible kinks: Y Y/N

SYSTEM SIZING AND REQUIRED PEFORMANCE REFERENCE TABLE

THE SYSTEM DESIGNER MUST CERTIFY THE DESIGN IS CAPABLE OF MEETING ALL PERFORMANCE TARGETS AND MEETS OR EXCEEDS MANUAL J, D, S, T

SF PER TON SIZING TABLE

CONDITIONED SF TYPICAL RANGE	AC SIZING MAXIMUM	COOLING COIL MIN. REQUIRED CFM	FAN WATT DRAW MAXIMUM AT MIN CFM
0-1599	1.5	675	169
1600-1999	2.0	900	225
2000-2399	2.5	1125	281
2400-2799	3.0	1350	338
2800-3199	3.5	1575	394
3200-3999	4.0	1800	450
4000-Up	5.0	2250	563

5) **Sensible Delivered BtuH calculation**

Outdoor dry bulb during testing: 64 (F)

Indoor dry bulb (use average returns below): 70.5 (F)

Indoor wet bulb (cooling tests only): (F)

Site Elevation above Sea Level: 72 Feet

Was this testing performed in Heating mode? Y *Type Y for "Yes"*

Return Flow (Alnor flow hood, TF or plenum pressure matching) — Start Temp (F) — End Temp (F) — Ave Temp (F) — Airflow CFM — Return airflows using flow capture hood OK

Measure center in RA grille: Return air temp #1 start: 70 "A" Starting → 71 (F) "B" Ending → 70.5 (Temp A + Temp B) ÷ 2 = Ave Temp 1 — 507 Measured CFM Return 1 (Total if only 1)

Measure center in RA grille: Return air temp #2 start: "C" Starting → (F) "D" Ending → (Temp C + Temp D) ÷ 2 = Ave Temp 2 — Measured CFM Return 2

he weighted return average CFM with 2 returns: CFM Return 1 ÷ Total CFM × Ave Temp 1 + CFM Return 2 ÷ Total CFM × Ave Temp 2 = **Weighted Return Temp** (weighted return 1 + weighted return 2) 70.5 — 507 Total CFM Return (1+2)

Supply Airflows (use only Pressure Compensated Low Flow Hood)		Temp (F)	CFM	Flow Correction	Constant	Delta T	Calculation	Btu/Hr	Calculation
Supply Grille #1 Room:	MASTER BEDROOM	110.8	116.0	0.96	1.08	40.3	Delta SG1 -Weighted Return Temp	4824	BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #2 Room:	BEDROOM 2	107.7	69.0	0.96	1.08	37.2	Delta SG2 -Weighted Return Temp	2659	BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #3 Room:	LIVING ROOM	112.0	131.0	0.95	1.08	41.5	Delta SG3 -Weighted Return Temp	5601	BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #4 Room:	KITCHEN	107.0	56.0	0.96	1.08	36.5	Delta SG4 -Weighted Return Temp	2117	BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #5 Room:	GREAT ROOM	110.8	144.0	0.96	1.08	40.3	Delta SG5 -Weighted Return Temp	5989	BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #6 Room:					1.08		Delta SG6 -Weighted Return Temp		BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Grille #7 Room:					1.08		Delta SG7 -Weighted Return Temp		BtuH (delta x 1.08 x CFM x Flow Correction)
Supply Airflow (continued from page 1)		Temp (F)	CFM	Flow Correction					

				1.08	Delta SG8 -Weighted Return Temp — BtuH (delta x 1.08 x CFM x Flow Correction)
				1.08	Delta SG9 -Weighted Return Temp — BtuH (delta x 1.08 x CFM x Flow Correction)
				1.08	Delta SG10 -Weighted Return Temp — BtuH (delta x 1.08 x CFM x Flow Correction)
				1.08	Delta SG11 -Weighted Return Temp — BtuH (delta x 1.08 x CFM x Flow Correction)
				1.08	Delta SG12 -Weighted Return Temp — BtuH (delta x 1.08 x CFM x Flow Correction)
		516.0	**CFM Total (Indicated airflow)**		21190 **Total Btu/Hr Delivered** (sum entire column)

upply grilles: 21190 BtuH (1)

itions): 12000 BtuH (2)

y BtuH(2): 177% % Sensible Delivered energy

condition: 850 Watts → Manuf. EER 14.1 — Manuf capacity divided by kW (x1000) — Measured System Power 1636 — Measured System Pwr (Watts) → Delivered EER 13.0 — Delivered BtuH divided by measured power (kW x 1000) = Delivered EER

urer EER: 91.7% Delivered Efficiency — 15.3 Typical Heat Pump Heating EER at Test Conditions

(AC Only)

erature stratification testing at 3' AFF, center of all rooms

minimum 15 minutes of system operation, system running, all doors open

DROOM	74.5	(F)	4.8	Pascals across door	#2 Room:
	74.5	(F)	0.5	Pascals across door	#3 Room:
M	75.0	(F)	3.3	Pascals across door	#4 Room:
	76.0	(F)	1.7	Pascals across door	#5 Room:
M	76.5	(F)	4.8	Pascals across door	#6 Room:
		(F)		Pascals across door	#7 Room:
		(F)		Pascals across door	#8 Room:
		(F)		Pascals across door	
#9 Room Location:		(F)		Pascals across door	
#10 Room Location:		(F)		Pascals across door	
Central Pt. 1' up Room:	73.5	(F)	PASS	All <5 Pa is a pass	
Central 1' down ceiling	76.0	(F)			
Difference between coldest and warmest-all:	3.0	(F) Difference of 3.0 degrees or less is a pass			

7) Measure all exhaust flows and mark type and whether continuous or demand controlled

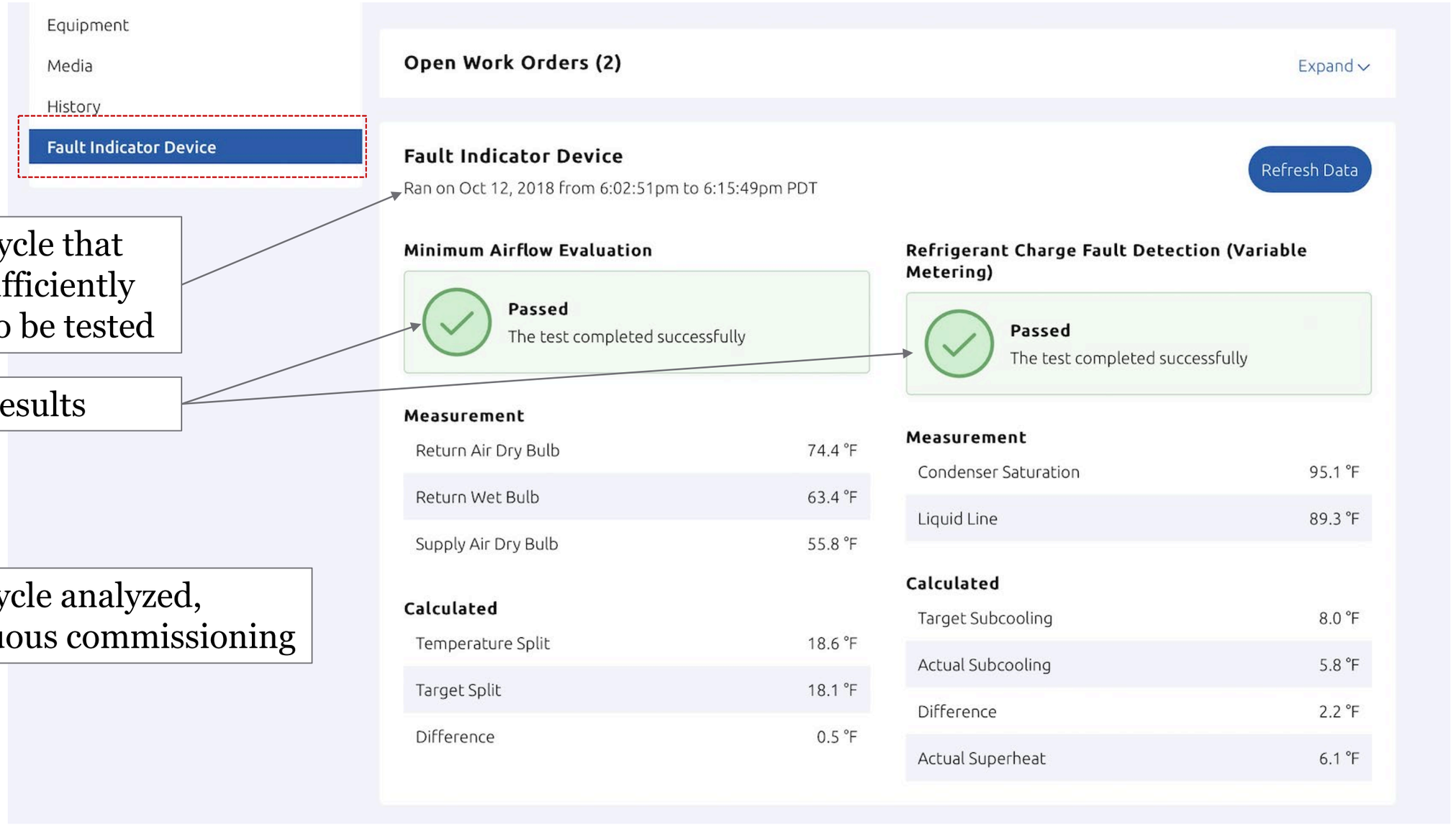
	Ventilation Location	CFM Flow	Supply or Exhaust / continuous or switched
#1 Room:	LAUNDRY	52	Exhaust / Switched
#2 Room:			
#3 Room:			
#4 Room:			
#5 Room:			
#6 Room:			
#7 Room:			
#8 Room:			
	PASS	52	Total CFM of all continuous ventilation
		45	Total required ventilation CFM (ASHRAE 62.2)
		10	Total Watts of all continuous ventilation
	PASS	0.19	Watts / CFM of all continuous ventilation
		N	Is this system an HRV? (Y or N)

Continuous ventilation exceeds required *plus* : HRV <=0.45W/CFM passes or exhaust fans <=0.20 W/CFM is a pass

By signing below, I _____ (Print name) certify that I am the lead installing technician on this project and performed all measurements listed herein. I certify that all numbers listed herein have been measured, are true, and are of the best ability of my equipment and self to accurately measure and calculate. _____(Signature) (Company Name) _____ (Date)

Installing Contractor must attach a signed copy of the ACCA Manual J, D, S, and T "as builts" forms to this form, with the system designer's name and signature.

Other devices create the alternate measured performance compliance pathway:



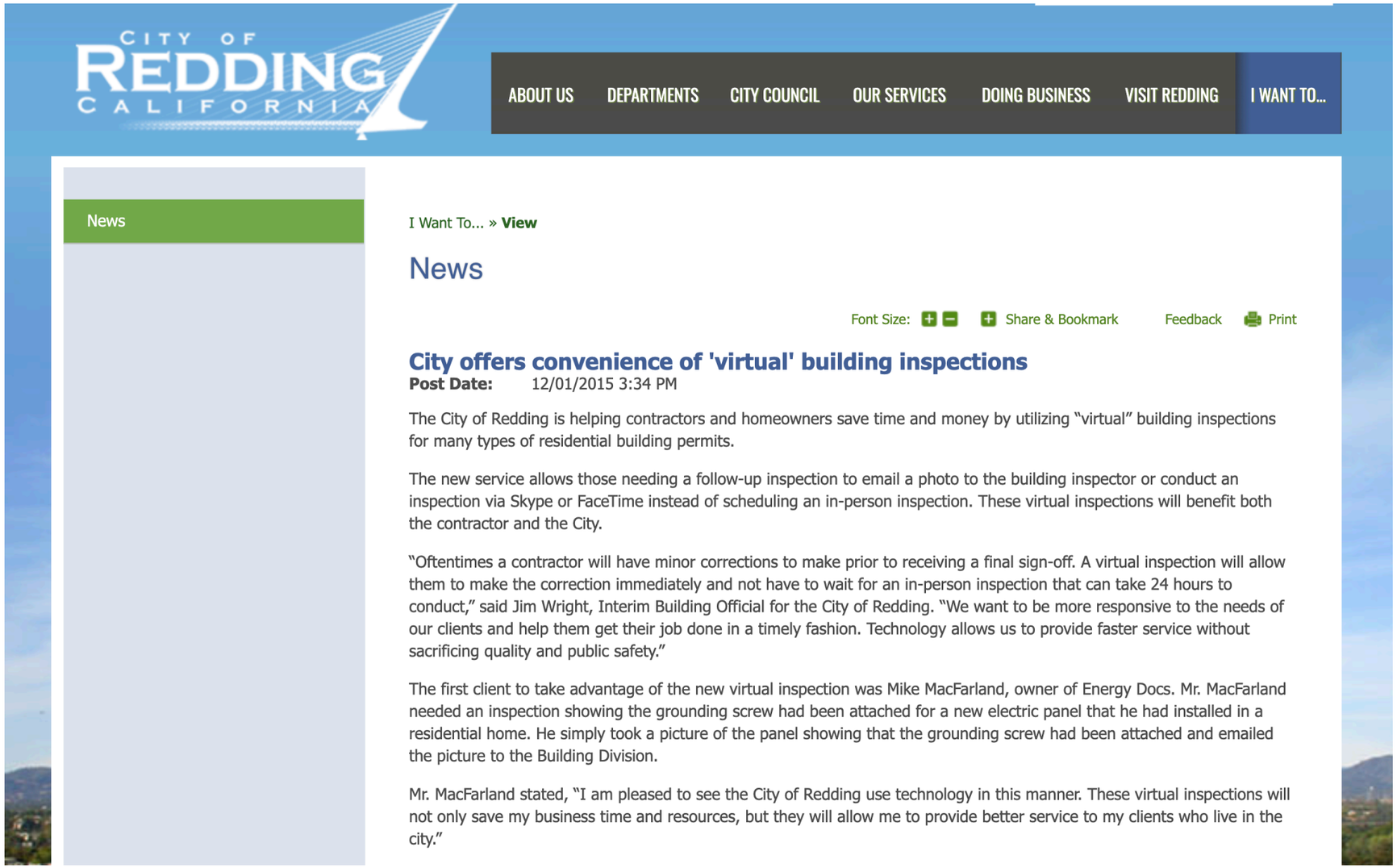
Last cycle that ran sufficiently long to be tested

FID Results

Every cycle analyzed, Continuous commissioning

2. Transform the permit and inspection process using technology.

- Explore ways to virtually inspect installations using video and images
- Facetime
- Skype



Paradigm Shift- Inspectors are **Teammates** not **Adversaries**

Inspectors are encouraged to adopt the attitude of *coming alongside the workforce as an assistant towards code-compliant installations* rather than an attitude of being an inspector or judge of minimum compliance.

Field inspectors need to be incentivized to complete permit inspections same day.

Building Departments need to place a high value on tracking the percentage of successful inspections for each day.

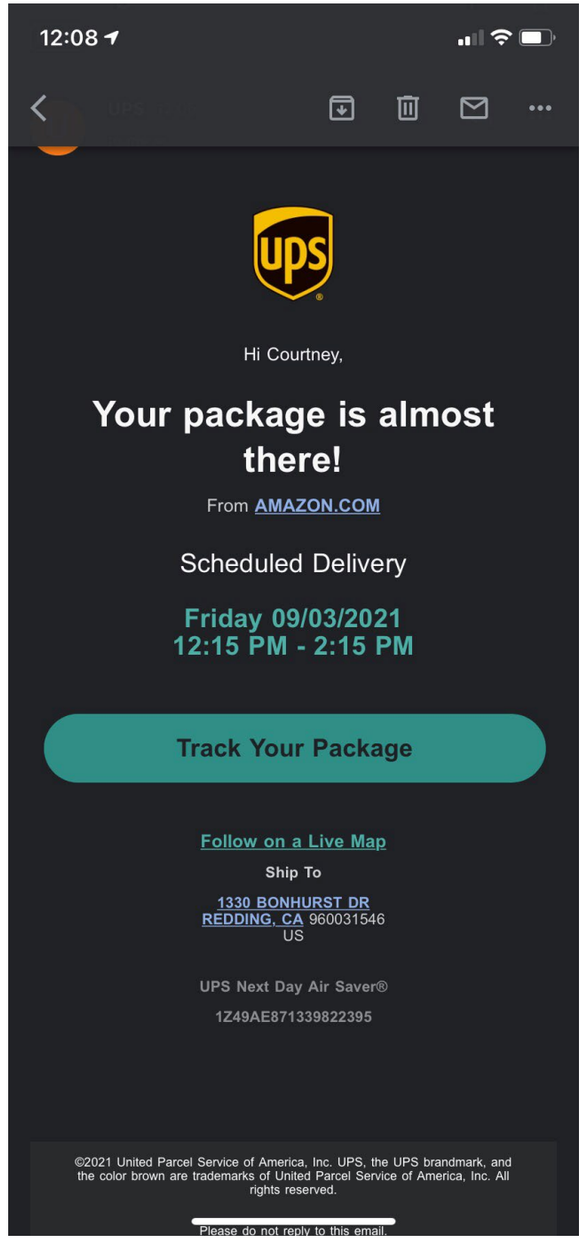
Your inspector is succeeding if they're saying things like:

"Text me a picture of that installed fuse (smoke detector, etc) by 4pm today we'll get this finished up."

"Let's connect by Facetime between 4 and 5 today and we'll get this signed off."

2. Transform the inspection process with technology

- Explore ways to help contractors manage scheduled appointments and help installers be ready for appointments
  - "Inspector tracker" systems with estimated time of arrival like what package delivery services use.
  - These systems would greatly benefit in correction visit scenarios



3. **Suggest to equipment manufacturers they warranty equipment installed in CA <u>only</u> when it is a legal installation.**

All equipment changeouts require a permit, warranties should too.

Evaluate and streamline the processes for simple, single component changes (like replacing an outdoor unit) to bring them into compliance.

- These must be able to be scheduled and signed off on same day
- Perhaps trade off a requirement (like 3rd party) for a benefit (like downsizing at least 1 ton AC).
- Success will be obvious when you're seeing regular permits pulled

Further Ways to Incentivize and Improve Quality

Base HVAC retrofit permit fees only on fixed units= same for all

Any company that provides extensive commissioning services & ACCA Standard V Quality Installations- MUST charge more than standard.

A competitive disadvantage created for doing the job properly.

Customer has to pay more fees for the work to be done better?

Retrofit permit fees should ALWAYS be based on units and NEVER with a contract cost “kicker”.

https://www.acca.org/viewdocument/hvac-quality-installation-specification-english

Summary

Improving the quality of HVAC installations while increasing code compliance:

1. Suggest that equipment warranties are only honored on legal installations
2. Transform the permit and inspection process using new attitudes and technology
3. Create a measured performance path that reduces regulation and boosts performance

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