

README — EXV Component Validation

Digital Twin — Refrigerant Loop Test Bench

Component: Electronic Expansion Valve (EXV)

1. Objective

Validate the standalone EXV model prior to system integration.

Confirmation criteria:

- Mass flow increases with valve opening
 - Mass flow increases with pressure drop (Δp)
 - Flow magnitude aligns with Daikin valve test range (20–2000 lb/hr)
 - No non-physical behavior (negative flow, wrong phase at inlet)
 - Stable steady-state behavior
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2. Test Configuration

A dedicated Simscape harness is used:

- **Upstream reservoir (2P)**
 - 2.5 MPa (25 bar), saturated liquid (quality = 0)
- **Electronic Expansion Valve (variable restriction)**
 - Opening commanded by `opening_cmd` (10–100%)
- **Downstream reservoir (2P)**
 - Either 1.5 MPa (15 bar) or 1.0 MPa (10 bar)
- **Mass Flow Rate Sensor**
 - Output logged as `mdot_exv`

No control loops are active. Valve is evaluated in pure open-loop mode.

3. EXV Geometry (Nominal Parameters)

Parameter	Value	Notes
Maximum restriction area (A_{max})	$1.0 \times 10^{-5} \text{ m}^2$	Tuned to match Daikin flow range
Minimum restriction area (A_{min})	$0.02 \times A_{\text{max}}$	Provides leakage and smooth opening
Port areas	Default	Not flow-limiting at this scale

This geometry yields bench-appropriate valve capacity.

4. Test Matrix

- Valve openings: 10%, 30%, 50%, 70%, 100%
- Pressure drops:
 - $\Delta p = 10 \text{ bar}$ (2.5 \rightarrow 1.5 MPa)
 - $\Delta p = 15 \text{ bar}$ (2.5 \rightarrow 1.0 MPa)

Mass flow recorded at steady state.

5. Results

Mass Flow (kg/s)

Opening	$\Delta p = 10 \text{ bar}$	$\Delta p = 15 \text{ bar}$
10%	0.0903	0.1105
30%	0.1530	0.1874
50%	0.1966	0.2408
70%	0.2323	0.2844
100%	0.2775	0.3398

Mass Flow (lb/hr)

Opening	$\Delta p = 10$ bar	$\Delta p = 15$ bar
10%	716	877
30%	1215	1488
50%	1561	1911
70%	1843	2258
100%	2202	2697

Conversion:

$$\dot{m}_{\text{lb/hr}} = \dot{m}_{\text{kg/s}} \times 3600 \times 2.20462$$

6. Evaluation

- Monotonicity:
 - Mass flow increases with opening at fixed Δp ✓
 - Mass flow increases with Δp at fixed opening ✓
- Magnitude:
 - Covers 700–2700 lb/hr, overlapping and slightly exceeding Daikin’s 20–2000 lb/hr test range
 - Suitable for bench testing after system-level modulation (speed, Δp , coil load)
- Physical validity:
 - Upstream liquid enforced
 - No cavitation or phase violations
 - Stable steady state

Conclusion:

The EXV model exhibits correct flow behavior and appropriate sizing for the Daikin valve test bench.