README — Compressor Component Validation (Phase 1)

Digital Twin Development — Refrigerant Loop Test Bench

Component: Positive Displacement Compressor (2P, Simscape)

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1. Objective

This document summarizes the **Phase 1 validation** of the compressor model used in the refrigerant-loop digital twin.

The purpose of this phase is to verify the **standalone physical behavior** and **scaling** of the compressor prior to integrating it into the full system model.

Validation focuses on:

- Correct **mass-flow response** to shaft-speed variation
- Correct **mass-flow sensitivity** to discharge pressure
- Enforcement of **vapor-only suction conditions**
- Confirmation that the compressor operates in the **Daikin EXV valve test flow range (20–2000 lb/hr)**
- Stability, consistency, and absence of numerical or physical anomalies

This validation establishes that the compressor model is suitable for subsequent system-level phases.

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2. Test Configuration

A dedicated Simscape harness was used to isolate the compressor and apply controlled boundary conditions.

Components

- **Suction Reservoir (2P)**
  - Pressure held at target suction condition

    - Temperature set to provide ~10 K superheat (ensures fully vapor suction)
- **Positive Displacement Compressor (2P)**
    - Tuned using nominal parameters (Section 4)
- **Ideal Angular Velocity Source**
    - Shaft angular velocity commanded via the variable `N_cmd`
- **Discharge Reservoir (2P)**
    - Pressure set by variable `p_dis_set`
- **Mass Flow Rate Sensor (2P)**
    - Output logged as `mdot_comp`

All fluid properties remain in SI units. Final results are converted to Daikin reporting units.

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3. Test Conditions

Shaft-Speed Sweep (Actual Operating Speed)

Three compressor speeds were evaluated:

- 0.5 × nominal
- 1.0 × nominal
- 1.5 × nominal

Discharge Pressure Sweep

Two representative condensing pressures were applied:

- **2.2 MPa** (≈ **22 bar**)
- **2.8 MPa** (≈ **28 bar**)

These pressures reflect typical operating conditions for an R-32 system.

Suction Condition

- Fully vapor

- Superheat maintained to eliminate two-phase suction violations

4. Nominal Parameter Configuration

The following nominal parameters were selected to ensure physically realistic scaling and appropriate mass-flow magnitude for EXV testing:

Parameter	Value	Purpose
Nominal mass flow rate	**0.013 kg/s**	Sets correct flow magnitude (~0.15 kg/s at nominal speed)
Nominal shaft speed	60 (unit-consistent with drive input)	Reference point for internal scaling
Nominal suction pressure	0.8 MPa	Reference suction condition
Nominal discharge pressure	2.5–2.8 MPa	Reference discharge condition
Refrigerant	R-32	Consistent with full-system model

Nominal values are used strictly for **model scaling** and do not represent mechanical compressor design parameters.

5. Results

Mass Flow — SI Units (kg/s)

Speed Level	22 bar	28 bar
50%	0.0782	0.0775
100%	0.1566	0.1552
150%	0.2354	0.2332

Mass Flow — Daikin Reporting Units (lb/hr)

Speed Level	22 bar	28 bar
50%	**620.8**	**615.0**
100%	**1243.1**	**1231.5**

Speed Level	22 bar	28 bar
150%	**1868.5**	**1850.8**

Conversion used:

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

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6. Evaluation

The compressor model demonstrates:

Correct Physical Trends

- Mass flow increases proportionally with shaft speed
- Mass flow decreases with increased discharge pressure, reflecting reduced volumetric efficiency under higher pressure ratios

Appropriate Flow Magnitude

- Actual flow rates fall within the **Daikin EXV test range (20–2000 lb/hr)**
- Nominal flow (~1250 lb/hr) is positioned in the usable center of the test window

Stable & Physically Consistent Operation

- Suction fluid remains fully vapor across all cases
- No solver warnings, two-phase violations, or unphysical values

Conclusion

The compressor model is **validated** and approved for integration into the full refrigerant loop (Open-Loop Cycle Validation).