

Drying Alternative Refrigerants with Molecular Sieve Desiccants

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Outline

- Molecular Sieve Basics
- Water capacity
- Sizing a dryer
- Summary

Desiccant Selection: Why Use Molecular Sieve?

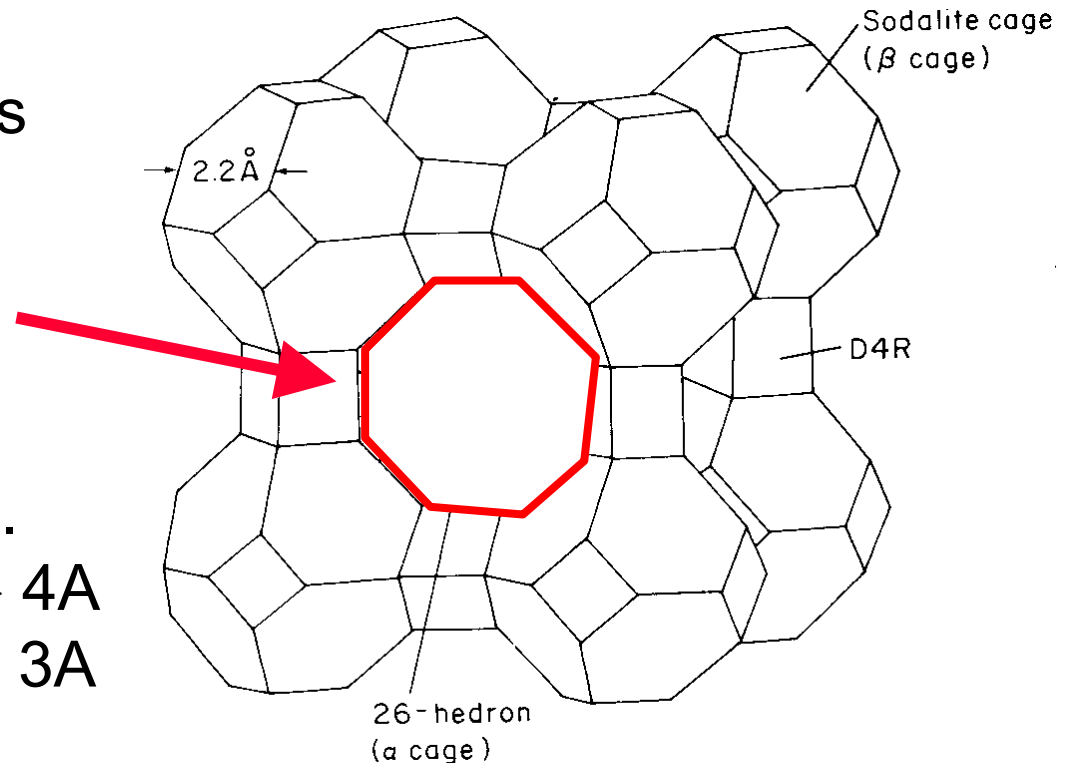
- Molecular sieve effect
- Refrigerant exclusion
 - High water capacity at low water concentrations
 - Chemical compatibility

Type "A" molecular sieves

Uniform crystalline structure

Opening size controls what molecules can enter the interior and adsorb.

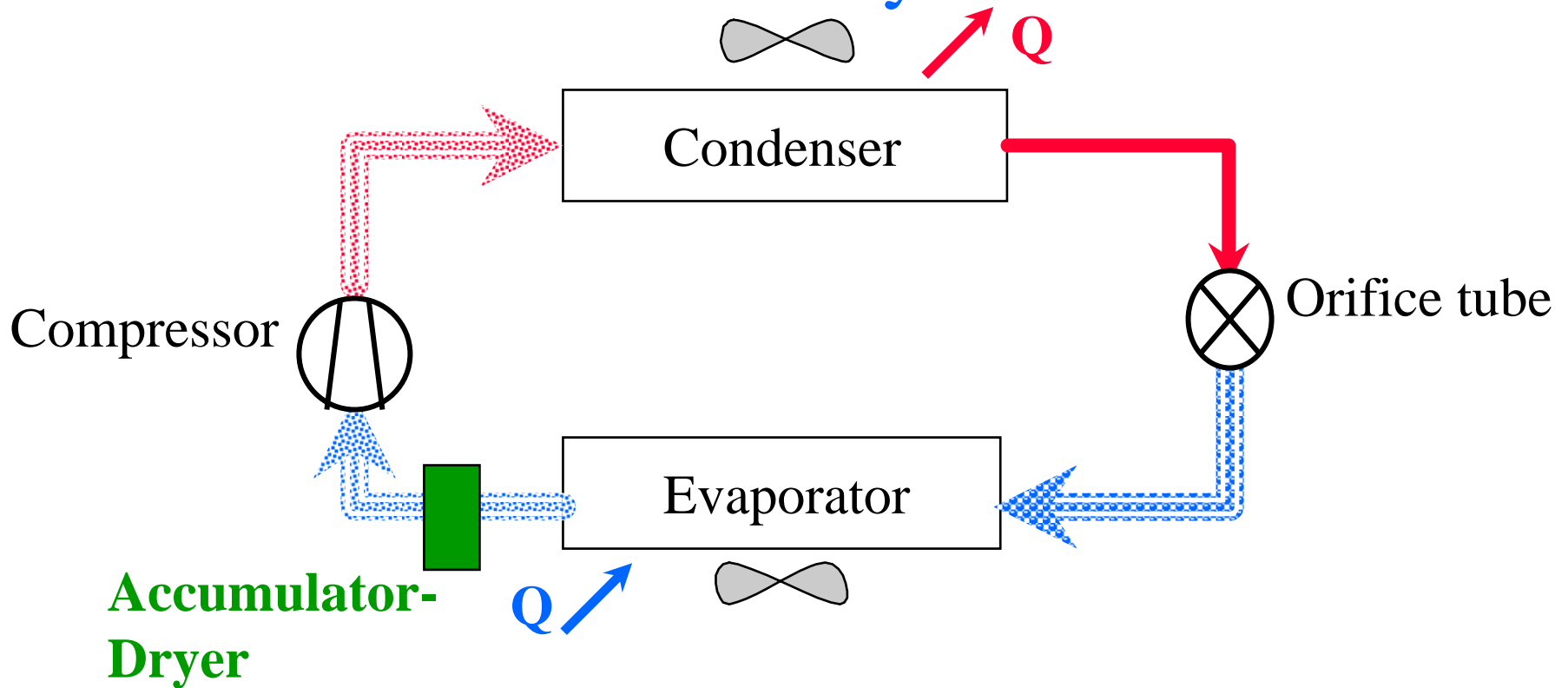
Opening is 0.5 nm wide.
Na⁺ cation → 0.4 nm → 4A
K⁺ cation → 0.3 nm → 3A



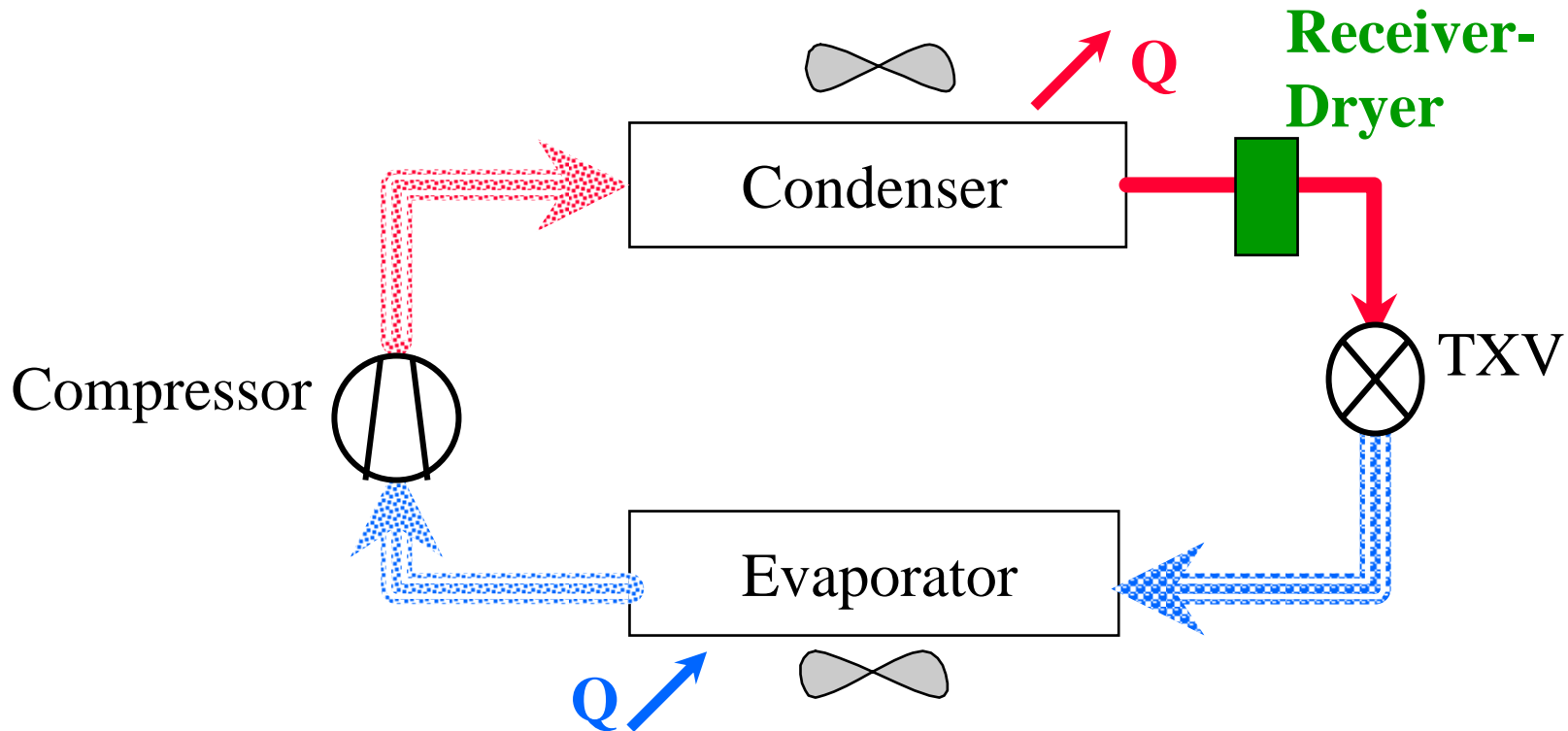
Dryer location

Vapor Compression Refrigeration

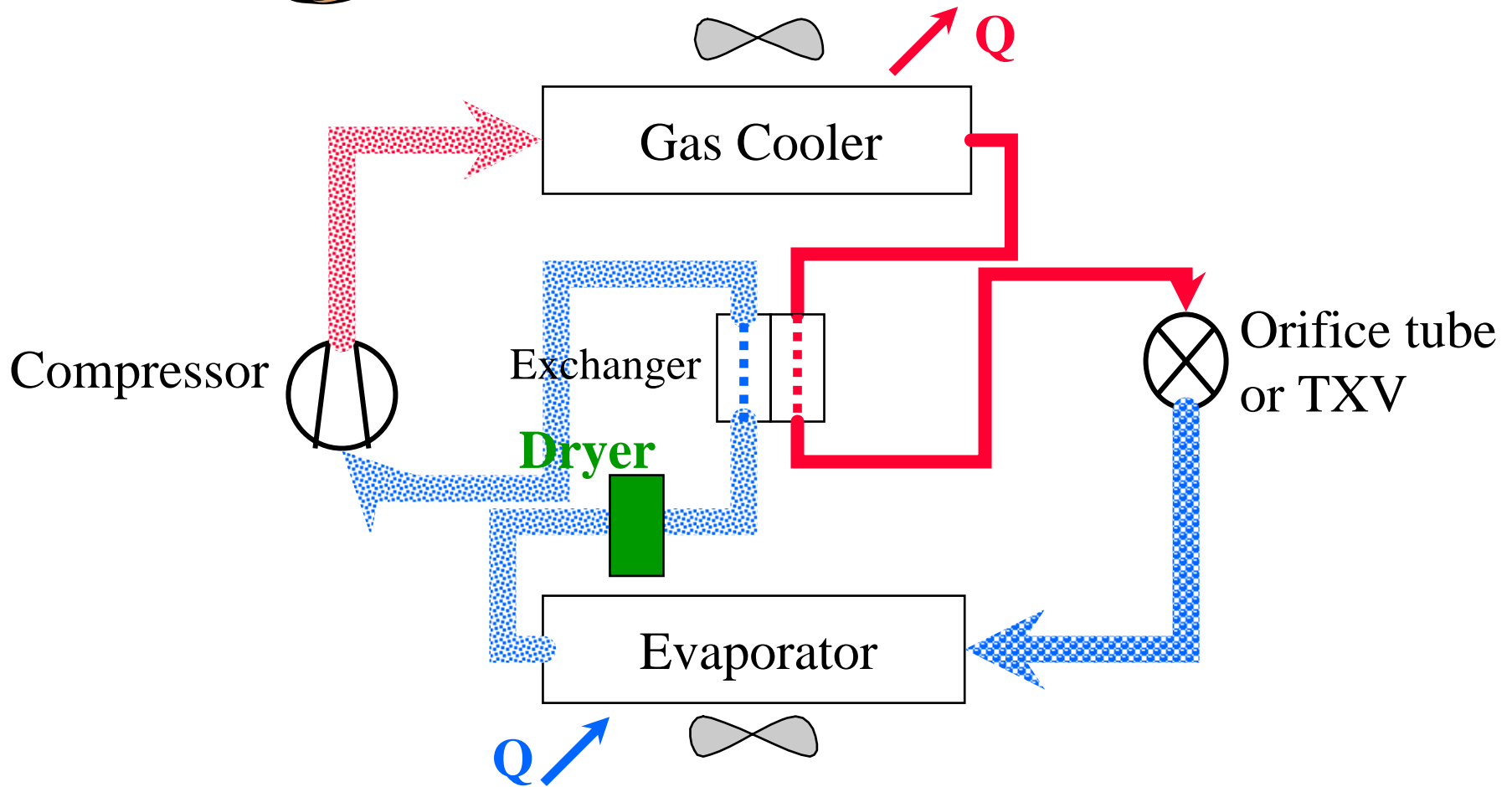
Auto A/C System



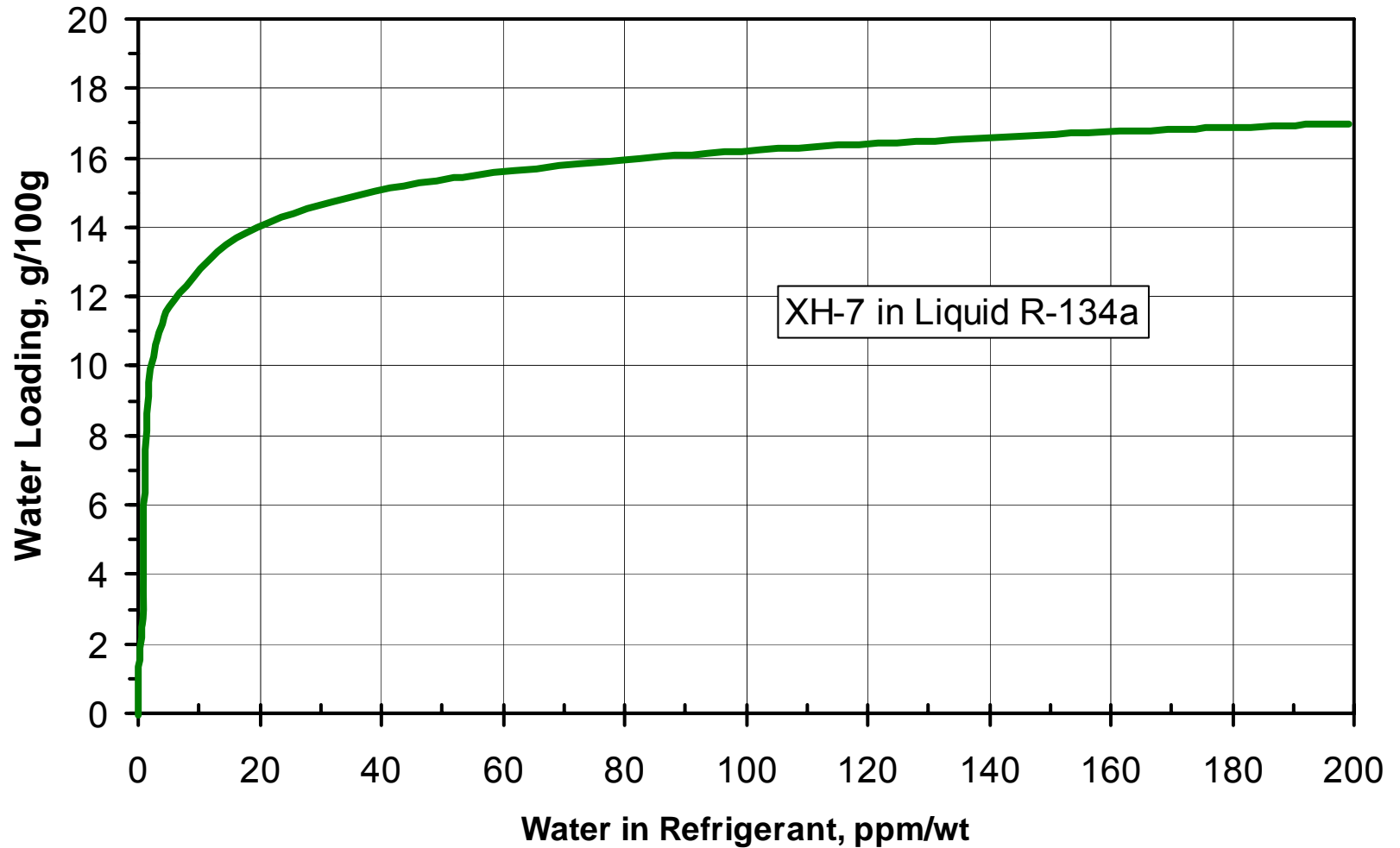
Vapor Compression Refrigeration Auto A/C System



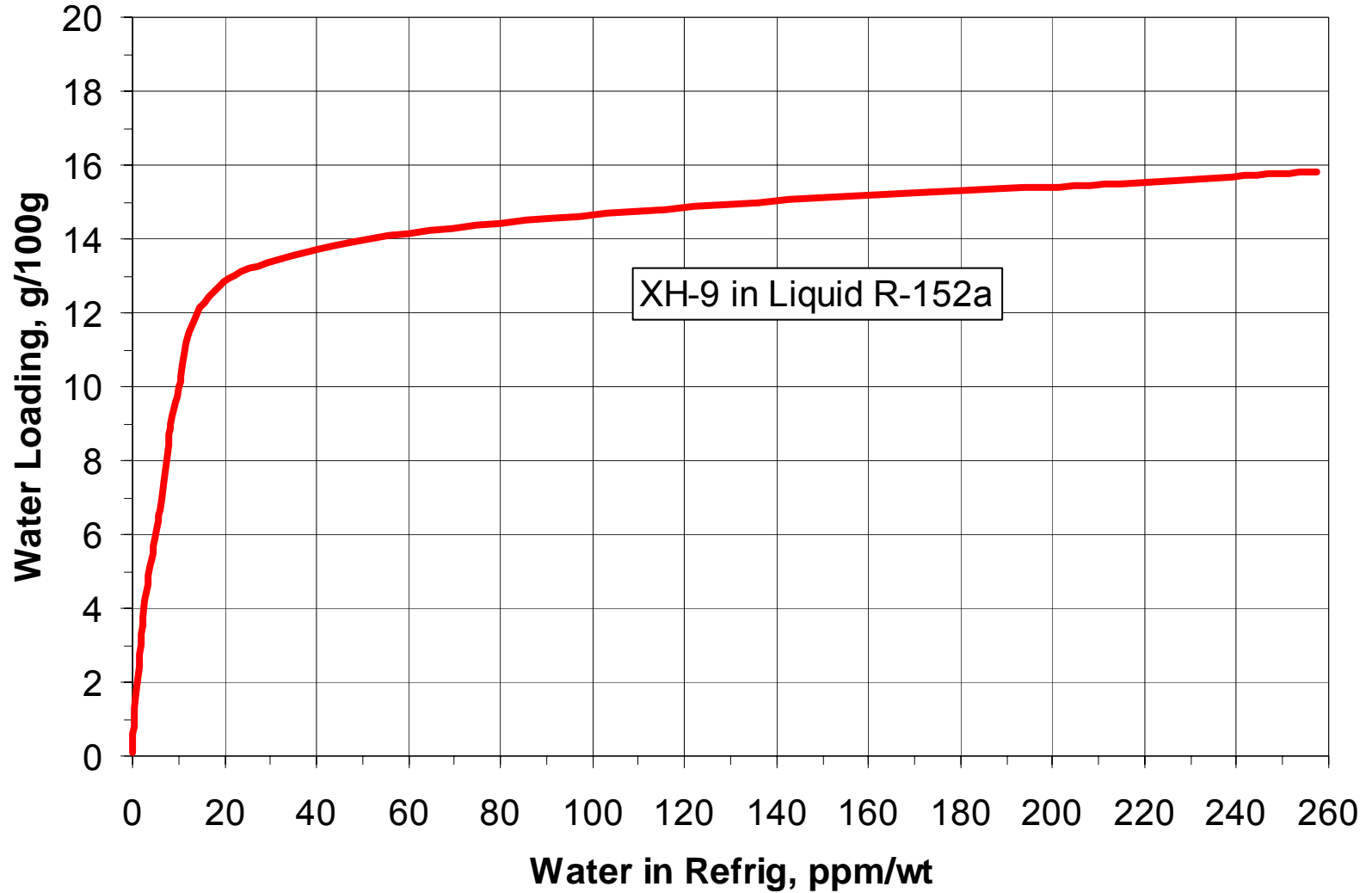
Trans-Critical Refrigeration Auto A/C System



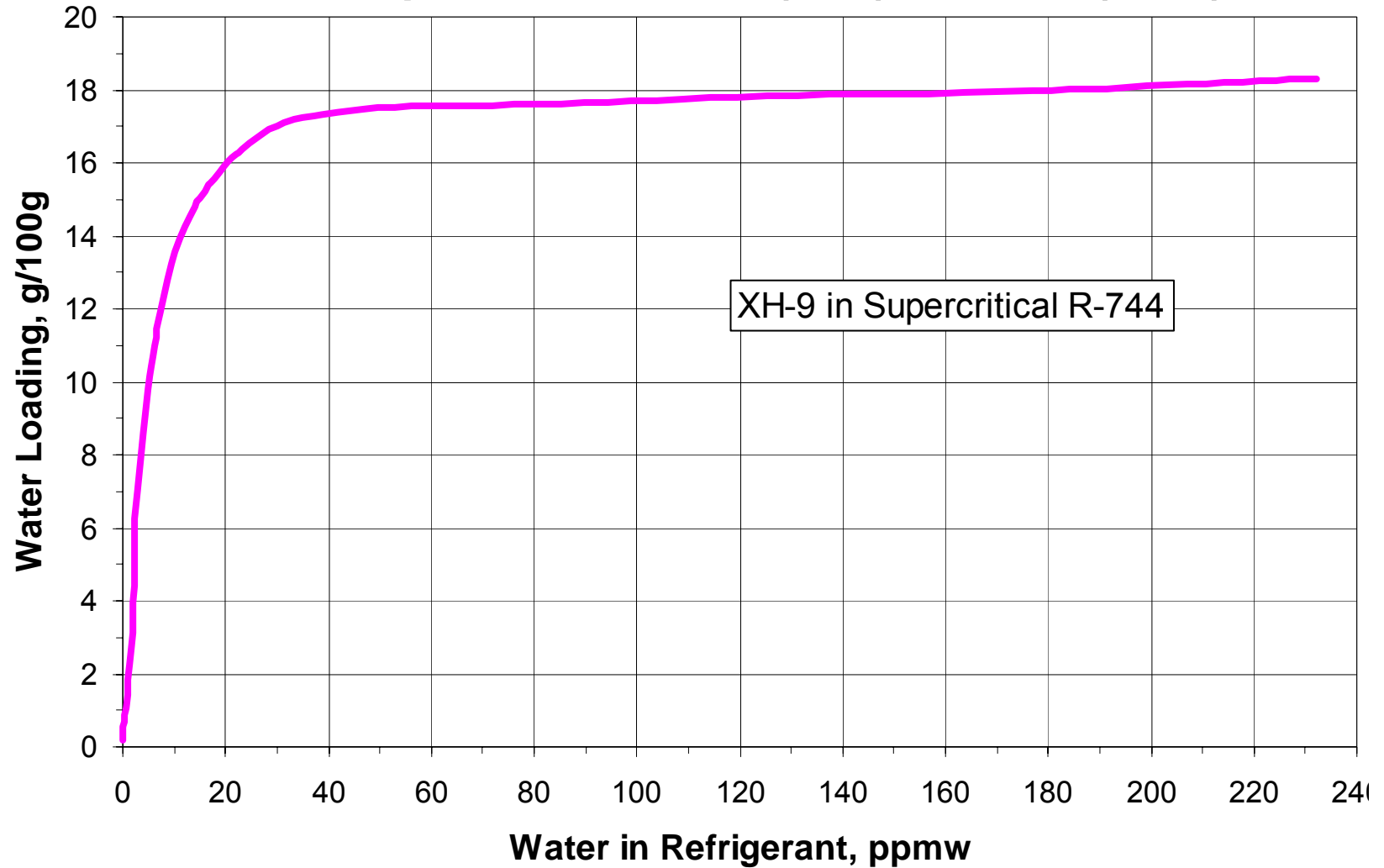
Water Capacity of Molsiv™ XH-7 Adsorbent in Liquid R-134a at 125°F (52°C)



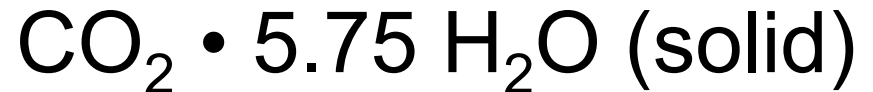
Water Capacity of Molsiv™ XH-9 Adsorbent In Liquid R-152a at 125°F (52°C)



Water Capacity of Molsiv™ XH-9 Adsorbent in Supercritical R-744 (CO₂) at 125°F (52°C)



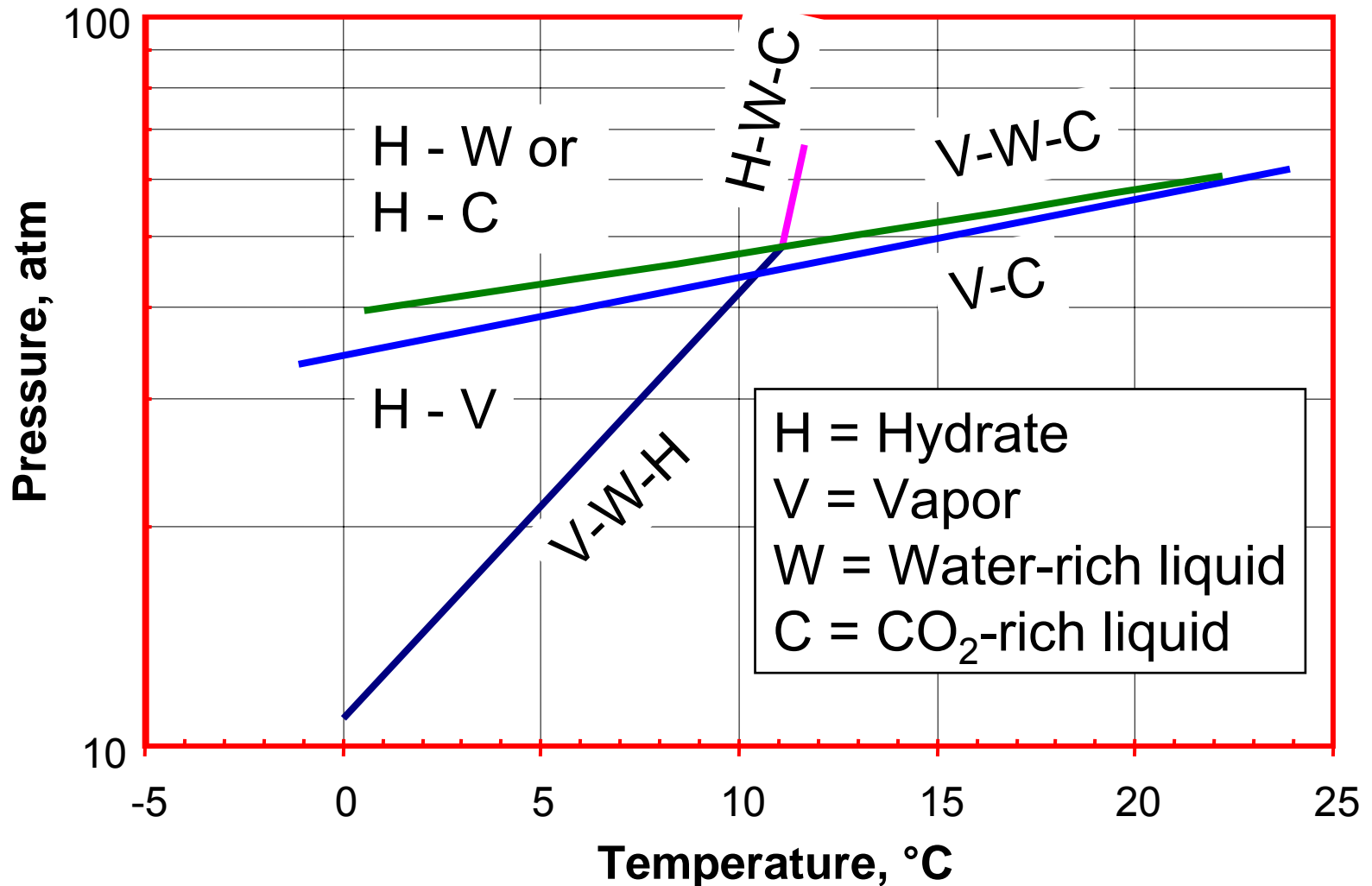
Hydrate Formation



At 11°C

Conditions for Hydrate Formation in CO₂-Water System.

Hydrates can form at 11°C in water saturated system.



Adapted from Chinworth & Katz. "Refrigerant Hydrates." J of ASRE. 1947. Used by permission.

Sizing a Dryer

- Desiccant amount depends on:
 - The amount of water to be removed
 - Required level of dryness (ppm water)
 - Water capacity of desiccant

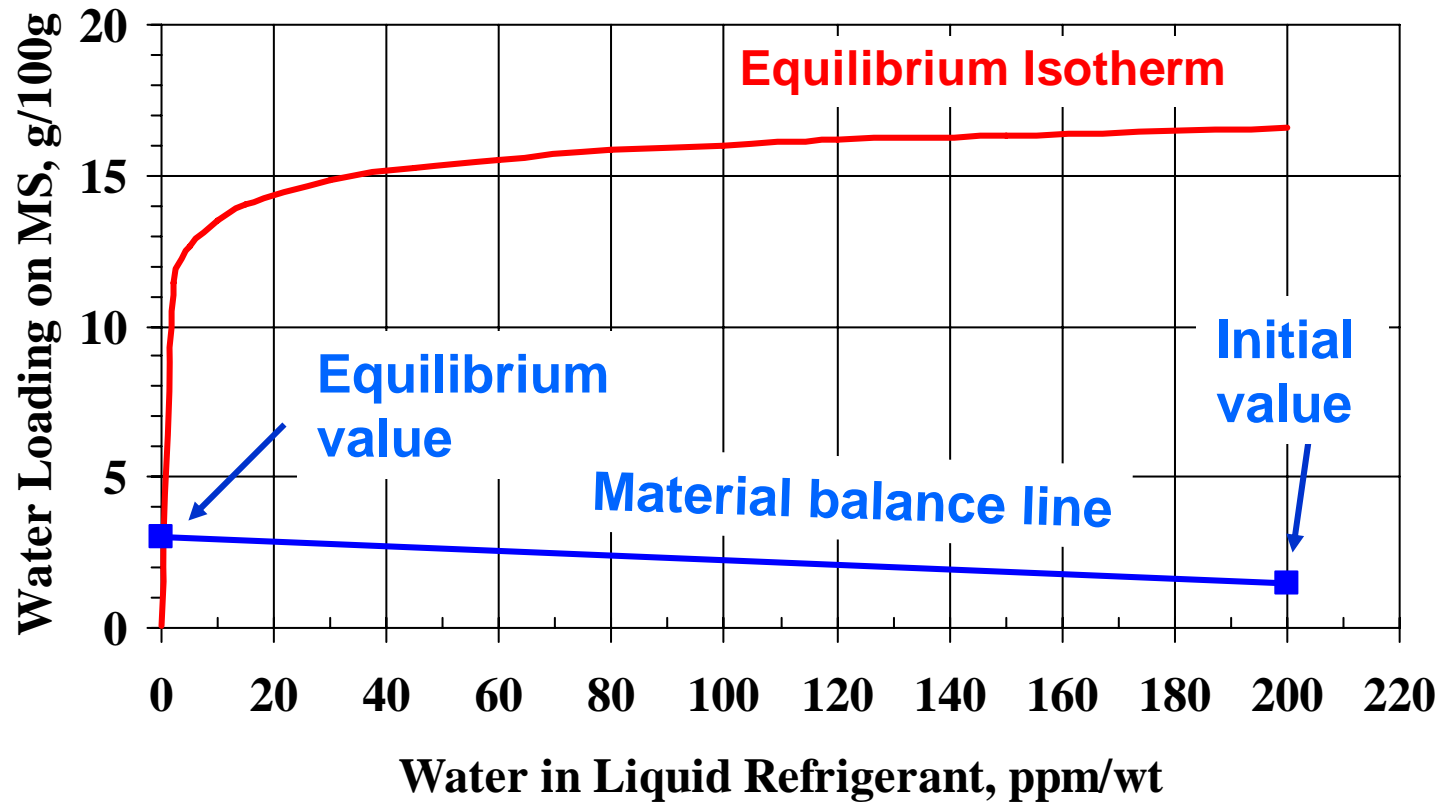
Sizing a Dryer:

Amount of water to be removed

- The initial water in system (small)
- Water ingress over the life of system (larger)

Initial Drying

Material Balance Line



The material balance equation gives relationship between amounts of materials and initial and final (equilibrium) water content during system dry-down.

$$X_f = X_i + (M_R/M_{MS})^* (C_i - C_f)$$

i = initial, f = final

X = water on desiccant, g/g

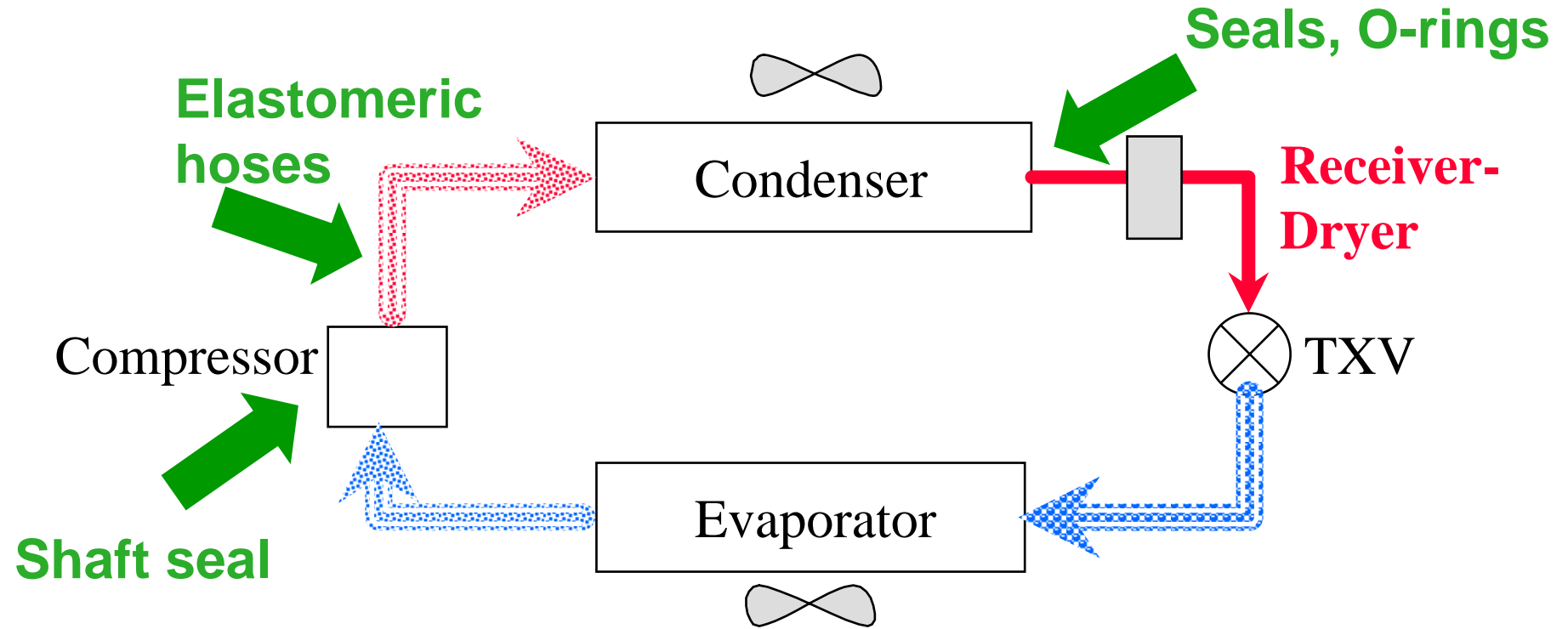
C = water in refrigerant, g/g

M_R = mass of refrigerant, g

M_{MS} = mass of molecular sieve, g

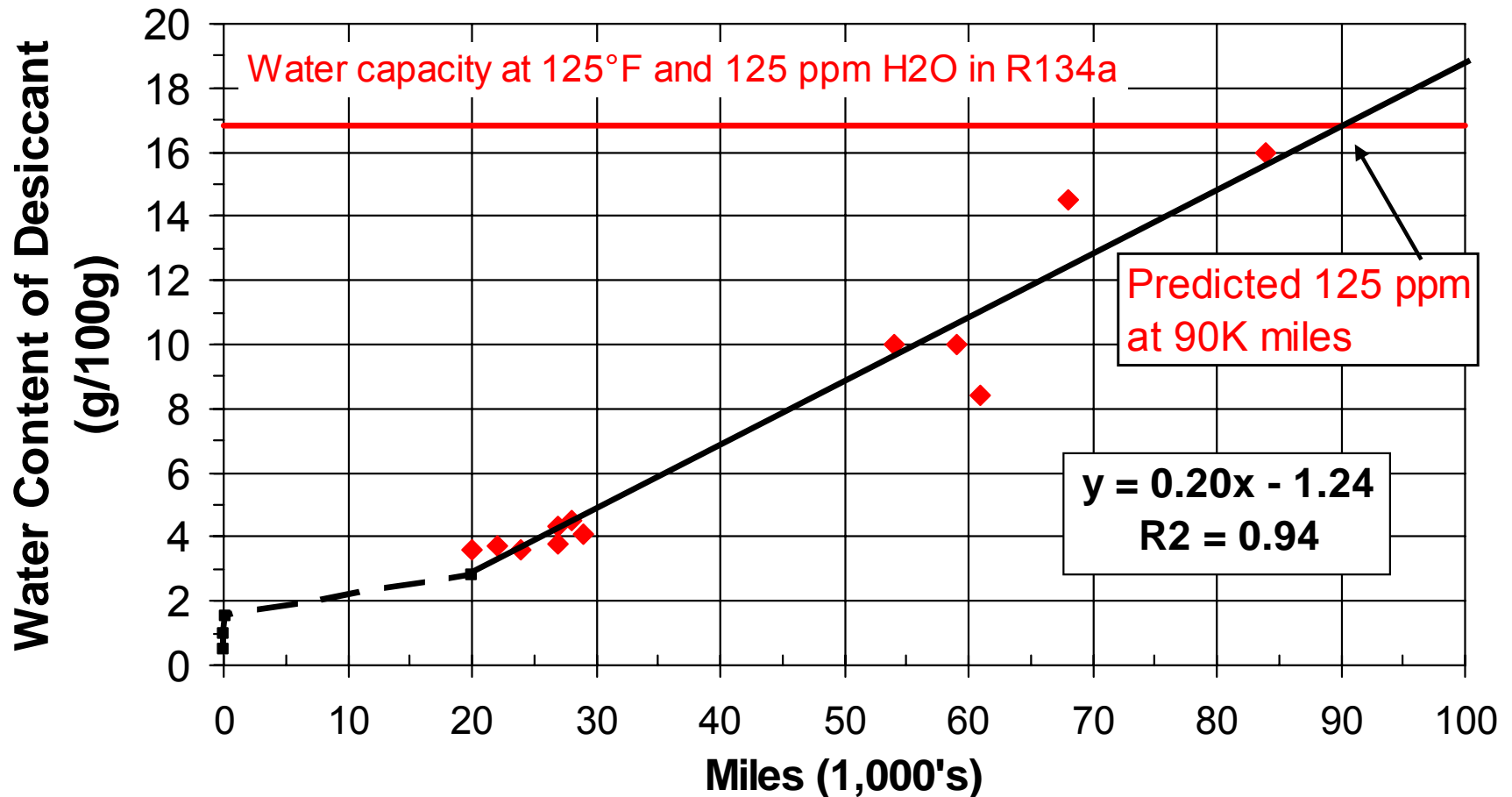
Ingression through seals and hoses

Water Ingression Points



Water Content of Desiccant vs. Mileage

Field Test Data

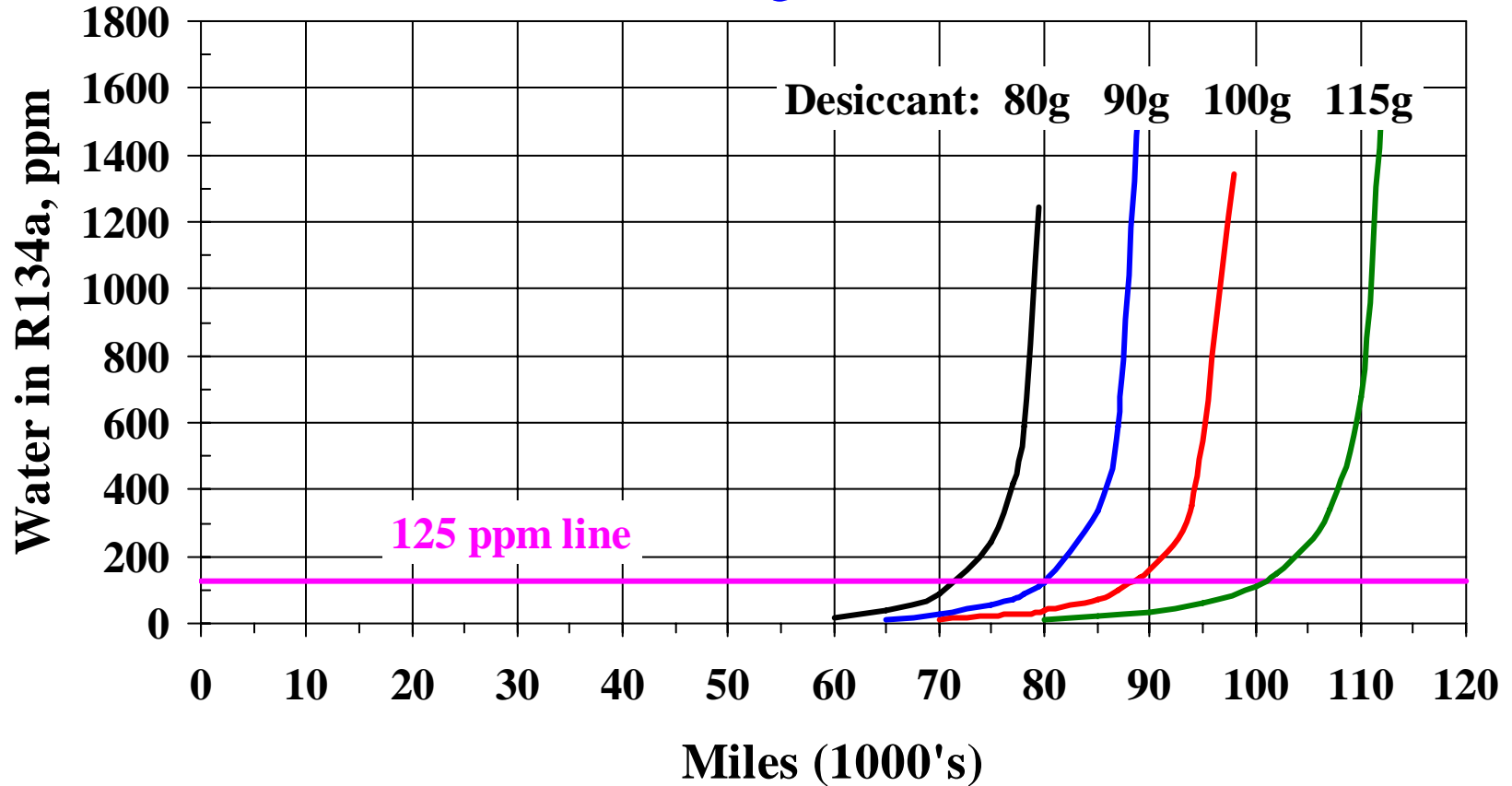


Dryers from dealer repair shop on US Gulf Coast.

All from one vehicle platform. A/C not previously repaired.

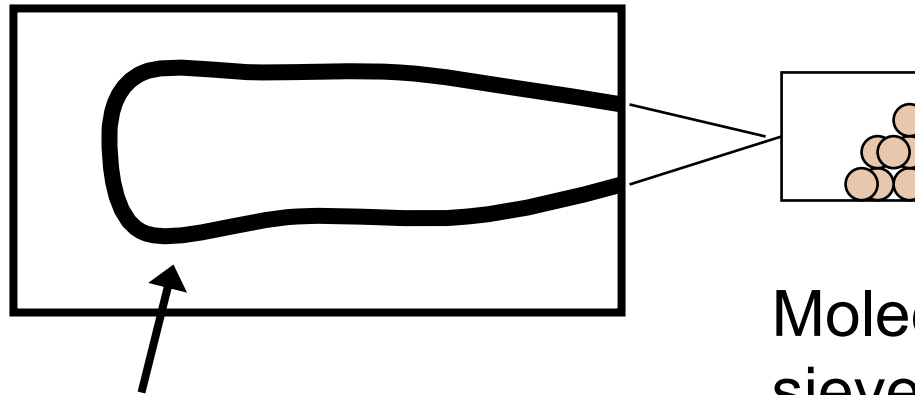
Water content of R134a v Miles for various desiccant loads

Calculated from water ingress date & isotherm



Lab Water Ingression Test for hoses and fittings

High Humidity Chamber



Evacuated hose
under test

Molecular
sieve
adsorbent

Weight gain of adsorbent
indicates water ingression.

Summary

- Molecular sieves are still the desiccant of choice for drying refrigerants
- Desiccants are available for current alternatives
- Amount of desiccant depends on initial dryness and water ingress over time
- Ingression can be measured in a field test or in lab

Q & A