



Reducing R134a Automotive Air Conditioner Connector Leaks Under Customer Usage Conditions

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Automotive Air Conditioning Refrigerant Connections in North American Markets

- Projected total annual sales of cars and trucks ^{a/}

<u>1999</u>	<u>2000</u>
16.4 Million	17.8 Million

- Projected total annual air conditioned vehicle sales

14.8 Million	16.0 Million	(Estimated 90% air conditioning)
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- Estimated number of air conditioning connections made by manufacturers plant. ^{b/}

118.4 Million/year	128.0 Million/year
118.4 Million Male	128.0 Million Male
118.4 Million Female	128.0 Million Female

a/ Source: Wards Automotive Report, March, 2000

b/ Assumes eight Air Conditioning connections per vehicle



Automotive Air Conditioning R134a Connector Leakage in North America

Current Automotive Vehicle Assembly Plant Leak Rate Capability ^{c/}

- Current Technology - Leak rate less than 5 to 9 grams/year/connector, at $30 \pm 5^\circ\text{C}$ and 690 ± 105 kPa (100 ± 15) psig

Projected Total Annual R134a Leaked to Atmosphere (based on 118.4 million connections per year - from previous slide)

- 592,000 kg to 1,065,600 kg

OR

- 1.31 million lbs. To 2.35 million lbs. (One year's vehicle production)

Requires 2 recharges (estimated average) in 12 year lifetime

c/ Varies by vehicle manufacturer and assembly plant



Counter Measures to Reduce Leak Rates

- Determine Causal Factors for Leaks
- Determine Customer Usage Conditions
- Identify Connector Sealing Concepts Used in Marketplace
- Identify “Best” Connector Design Practices (Benchmarking)
- Design Improved Connector



Causal Factors for Leaks:

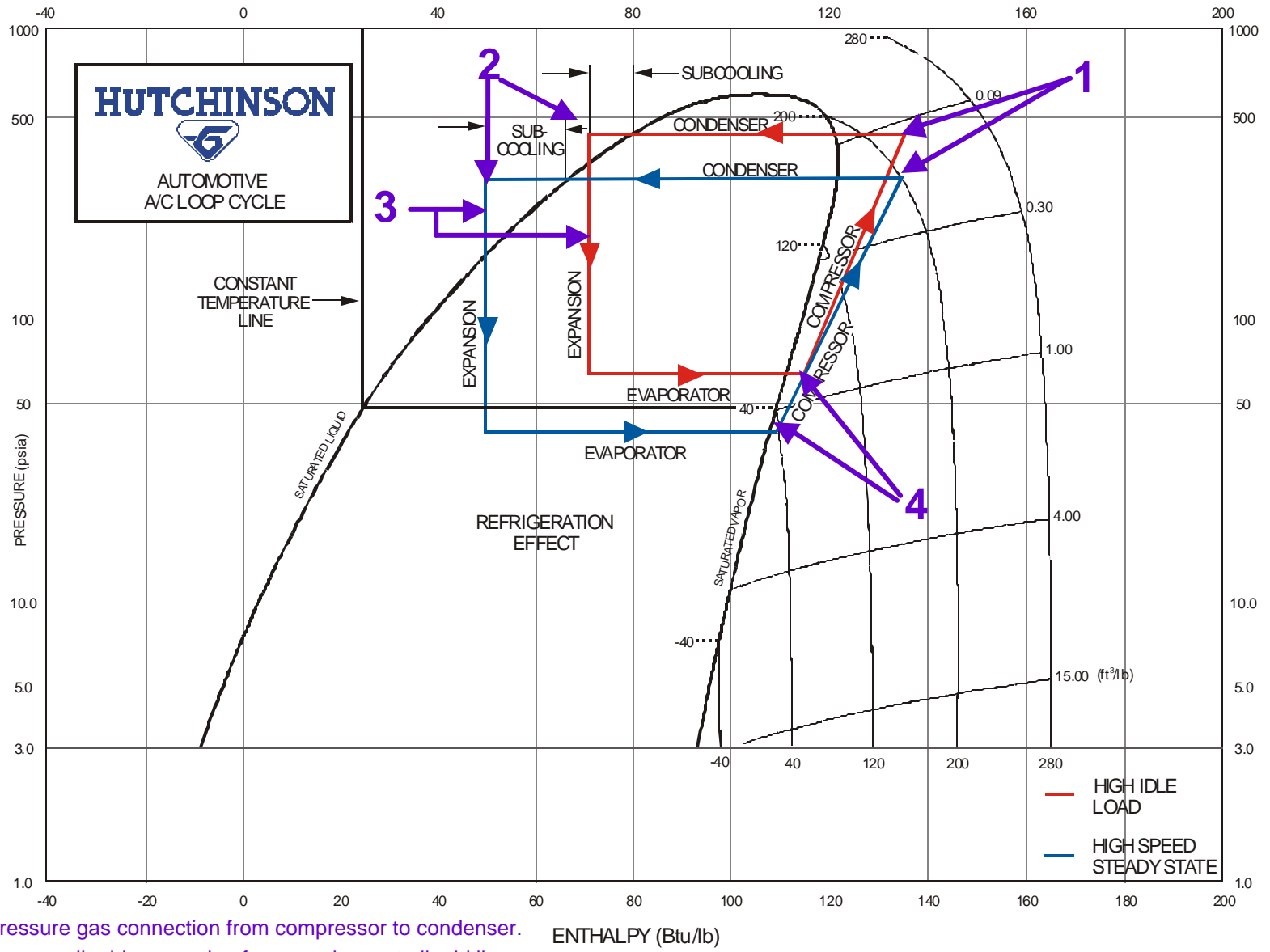
Refrigerant leaks are a function of:

1. Refrigerant temperature and pressure
Environmental factors (eg. vibration)
Connector geometry
Connector size
Sealing materials and design geometry
Connector manufacturing process
Contamination on sealing surfaces
Surface finish

2. Vehicle assembly plant process

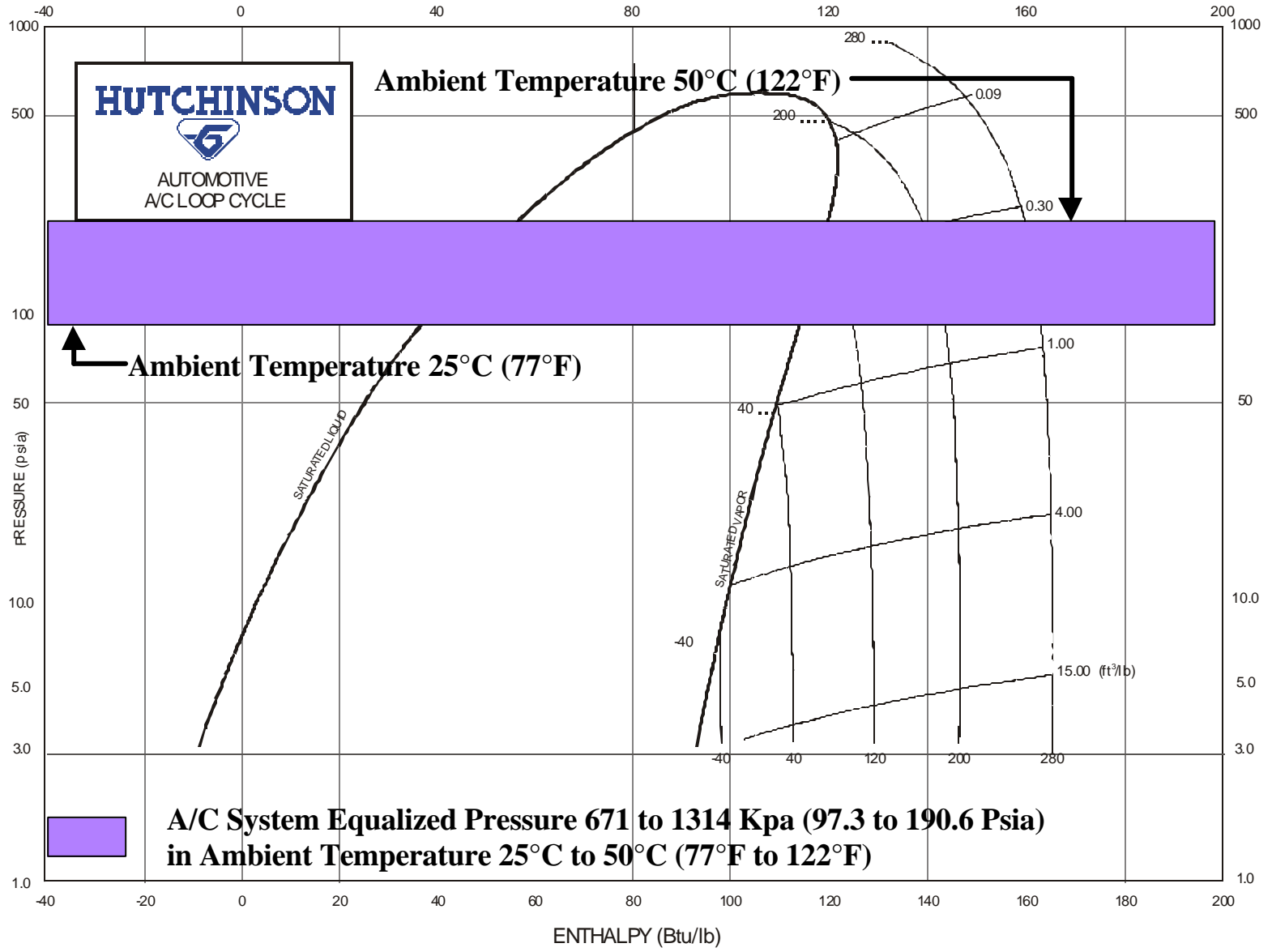
3. Field service

Customer Usage Conditions - Vehicle A/C System in Operation



1. High pressure gas connection from compressor to condenser.
2. High pressure liquid connection from condenser to liquid line.
3. High pressure to low pressure connection.
4. Low pressure connection from evaporator to compressor

Customer Usage Conditions - Vehicle Parked Longtime



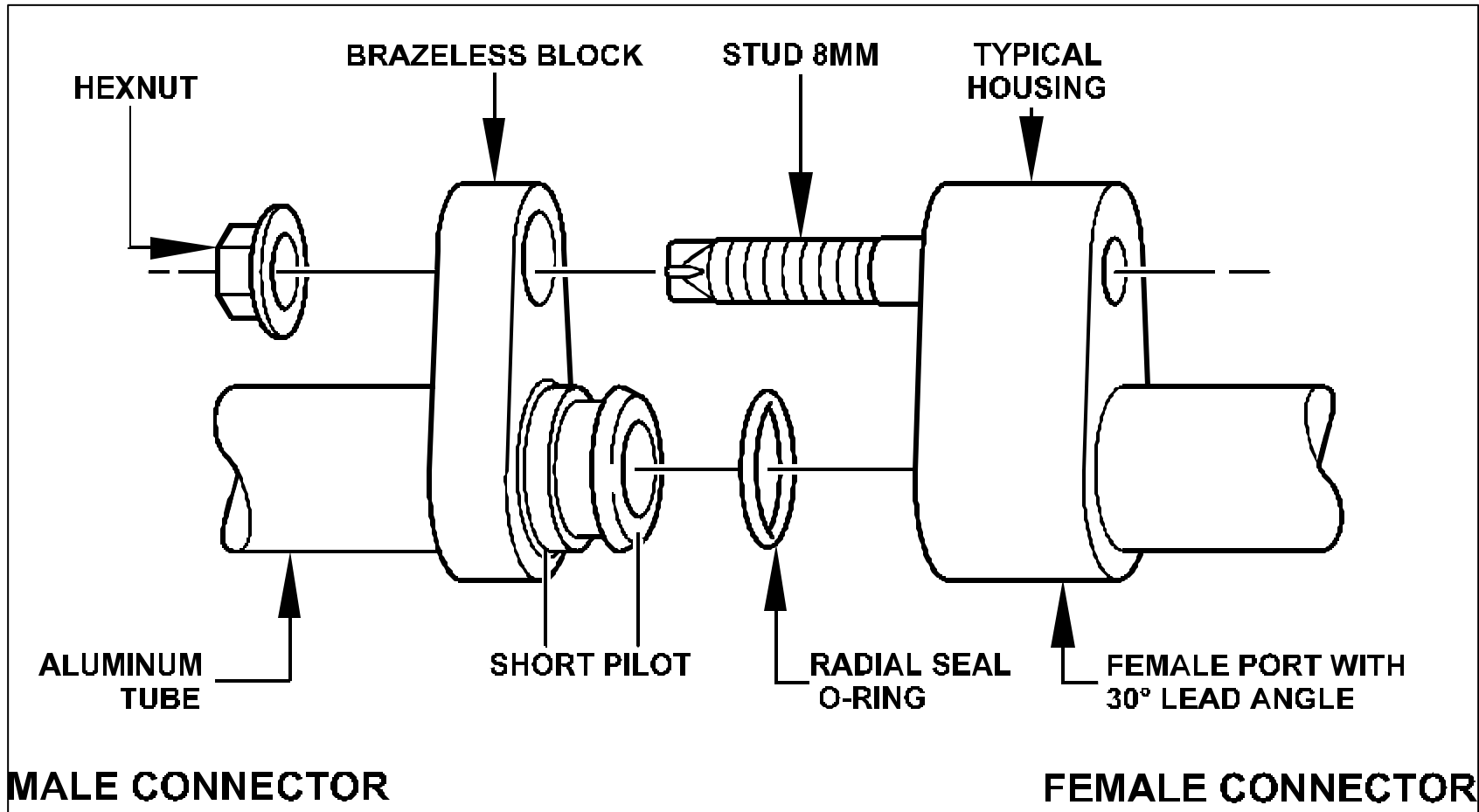


Connector Sealing Concepts in Marketplace

- Single O Ring - Circumferential Seal
- Single O Ring - Face Seal
- Double O Ring - Circumferential Seal
- Triple O Ring - Circumferential Seal
- Single Plane Gasket - Face Seal
- Single Sealing Washer - Face Seal
- Hutchinson DUAL PLANE SEALTM



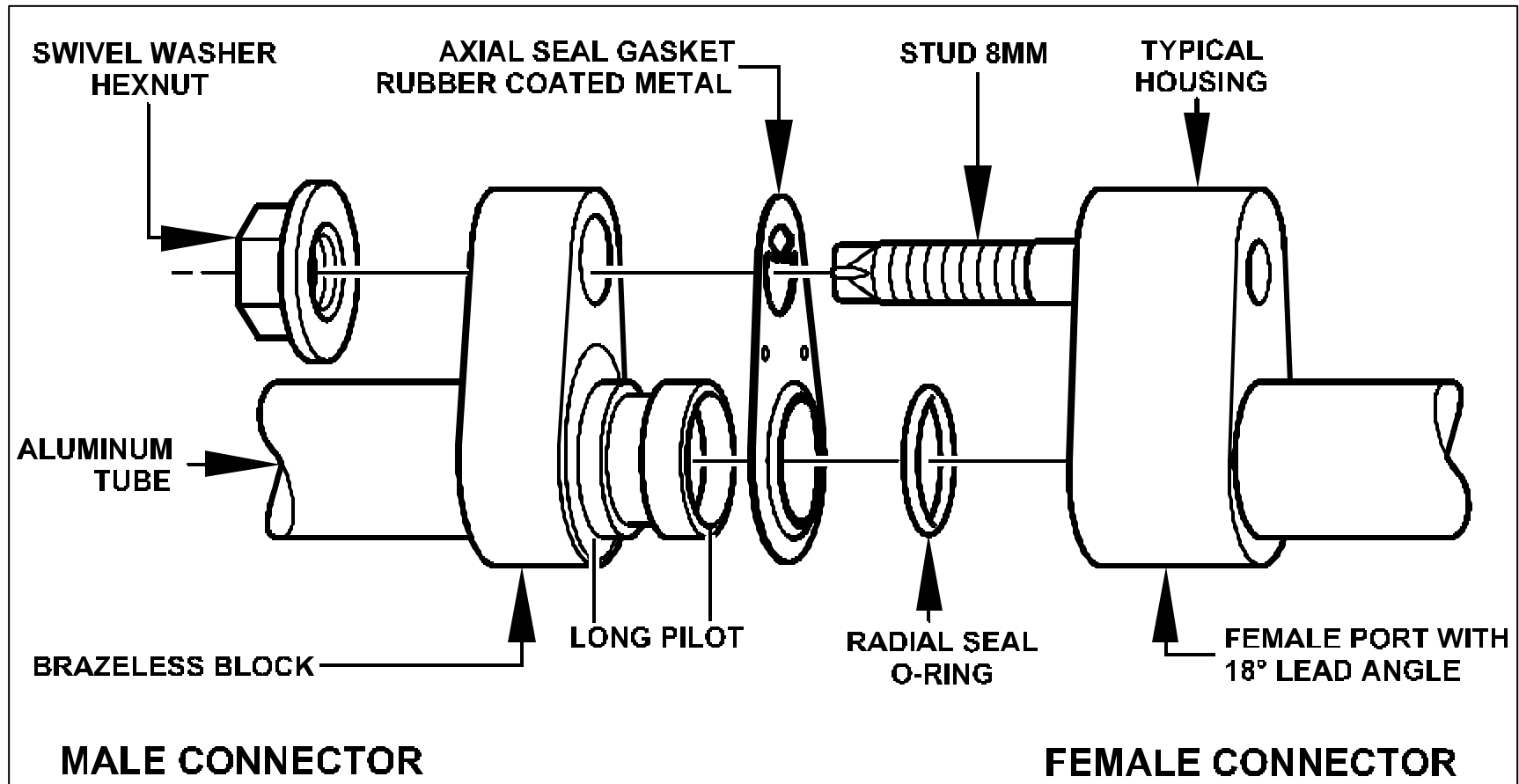
BENCHMARK CONNECTOR



SINGLE O-RING SEAL



IMPROVED CONNECTOR



PATENT PENDING

DUAL PLANE SEAL™



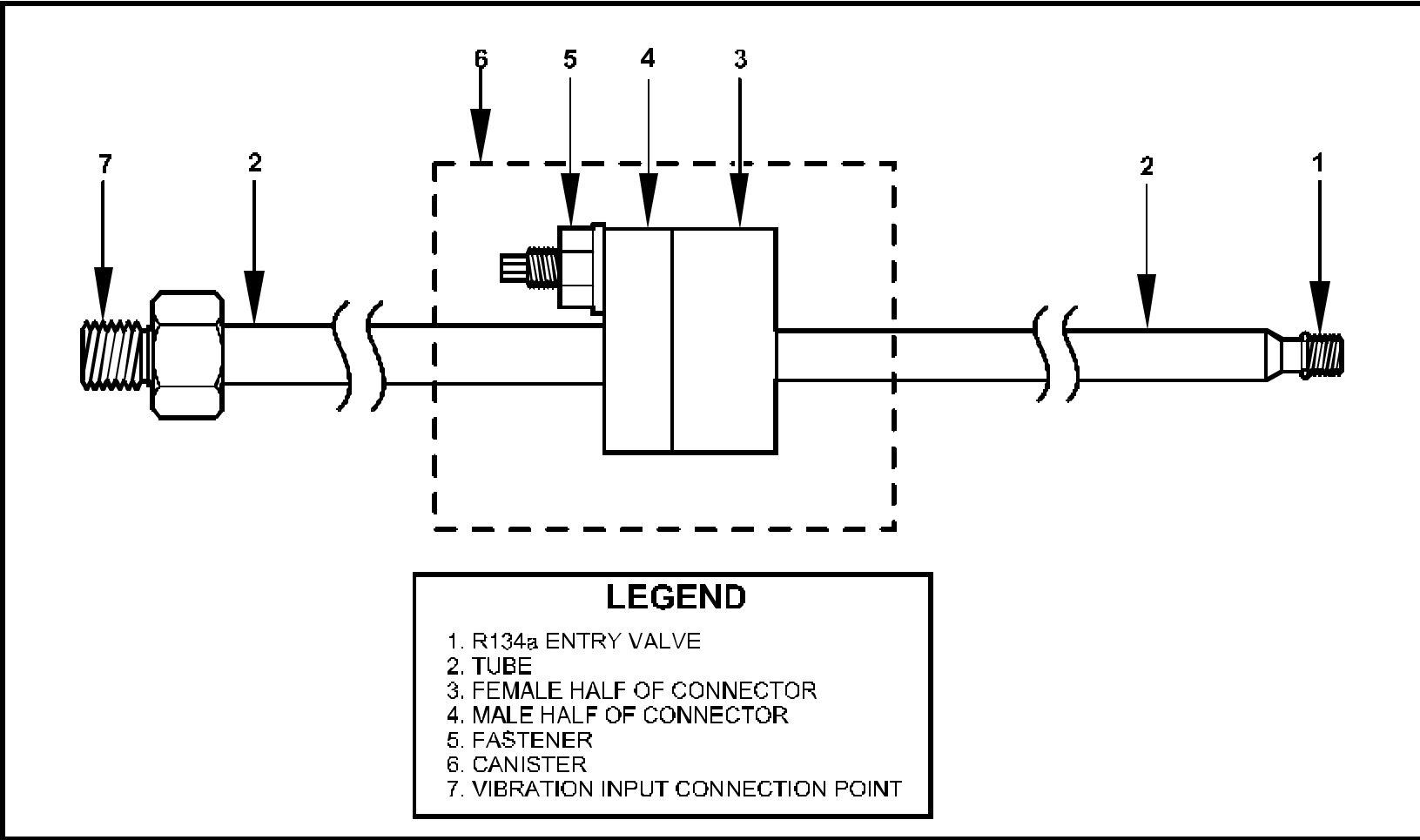
Leak Rate Measurement:

Measurement of minute R134a leaks under customer usage conditions is a significant challenge, requiring:

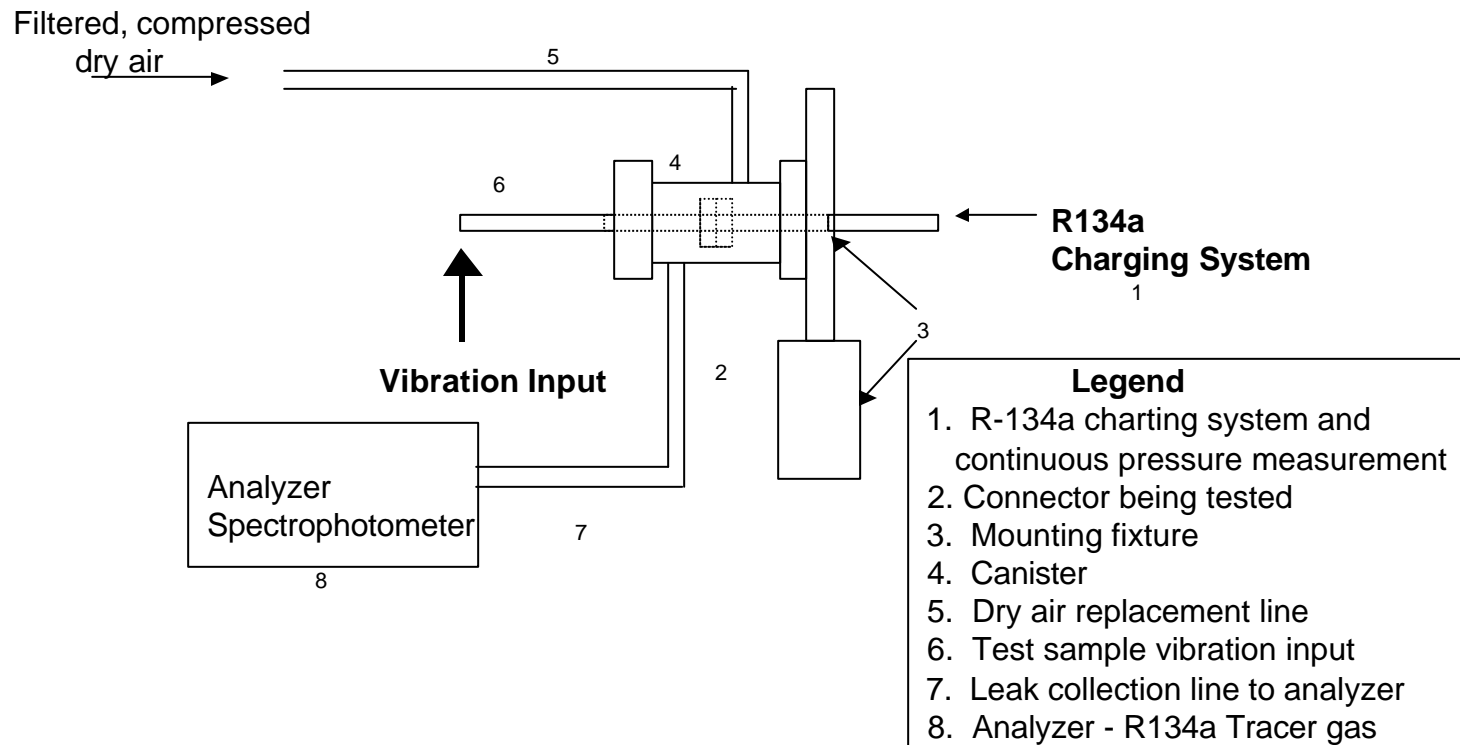
- Introduction of real world conditions of temperature, pressure and vibration - customer usage conditions
- Utilization of R134a as the tracer gas
- Development of measurement process
- Continuous testing of materials and design features

<u>Temperature</u>	<u>Pressure</u> <u>(Absolute)</u>
127 C (260 F)	3205 kPa (465 psia)
100 C (212 F)	2750 kPa (400 psia)
50 C (122 F)	1345 kPa (195 psia)
0 C (32 F)	285 kPa (41 psia)
-40 C (-40 F)	50 kPa (7 psia)

Typical Connector Test Sample

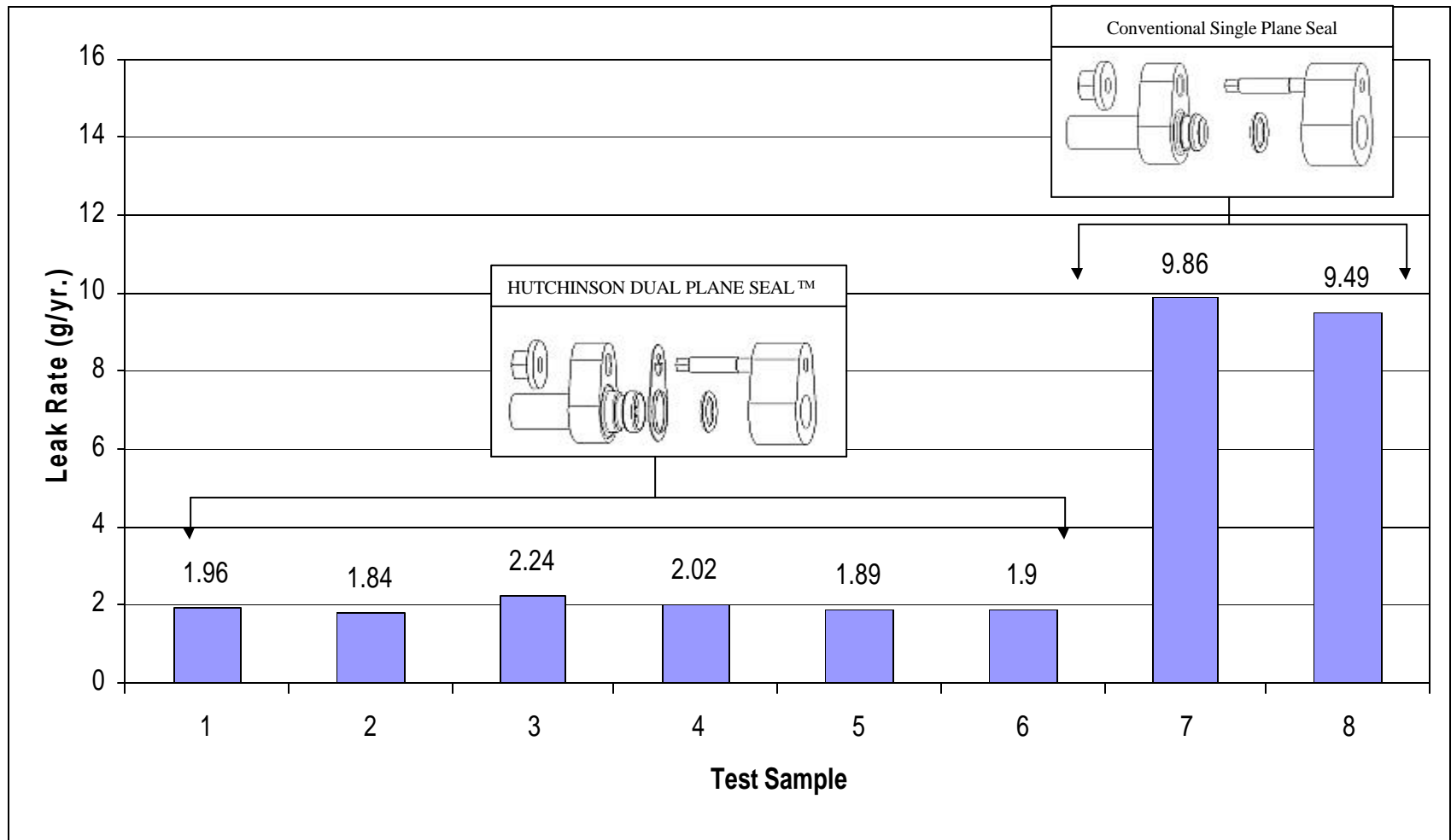


Test Sample Arrangement



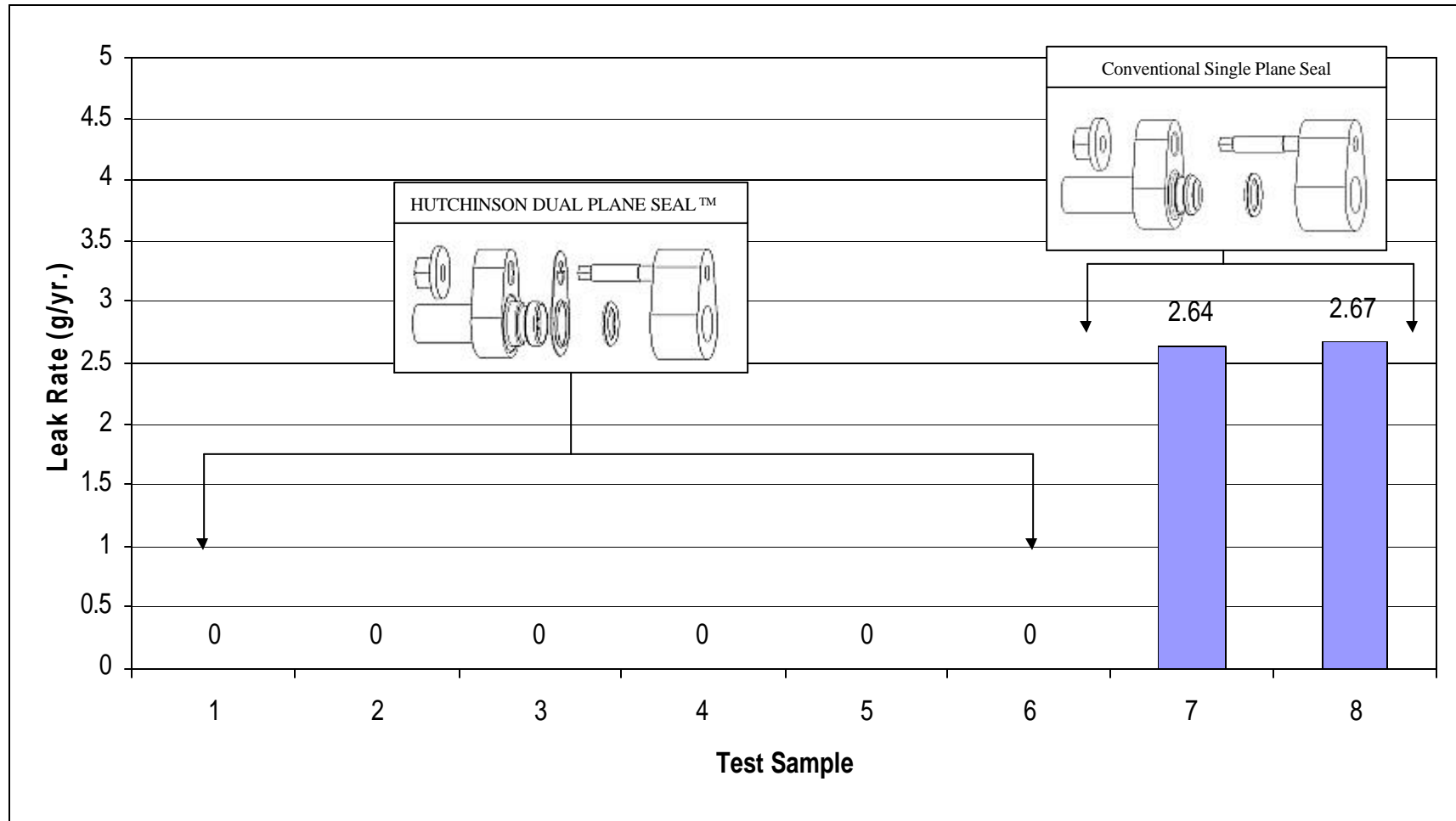


Sample Test Results - Leak Rate Data @127°C (260°F):
12.7 mm (1/2") Connector, Average Pressure = 3172 kPa (460 psi)
30 Day Average



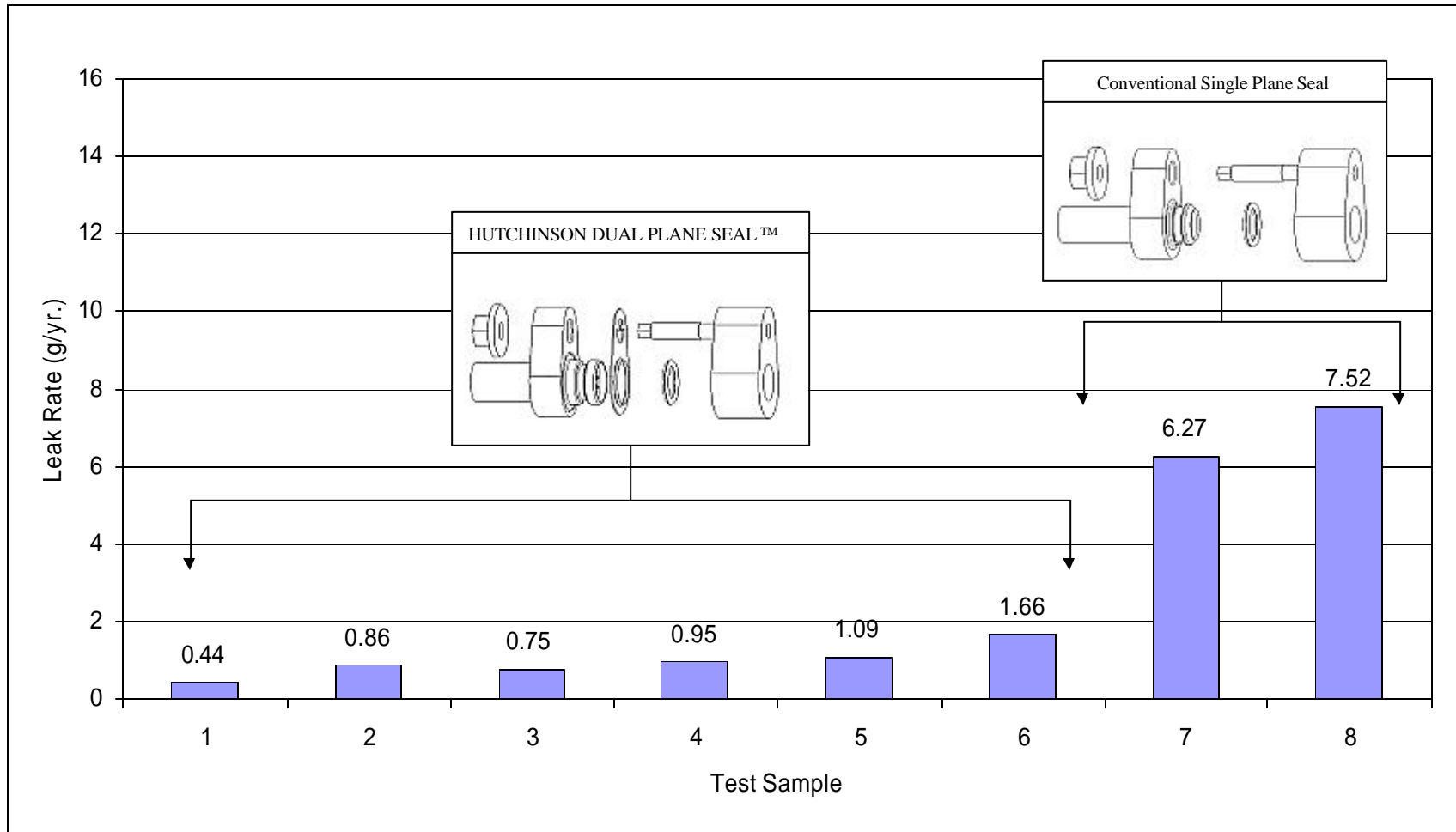


**Sample Test Results - Leak Rate Data @ 100°C (212°F):
12.7 mm (1/2") Connector, Average Pressure 2690 kPa (390 Psi)
30 Day Average**



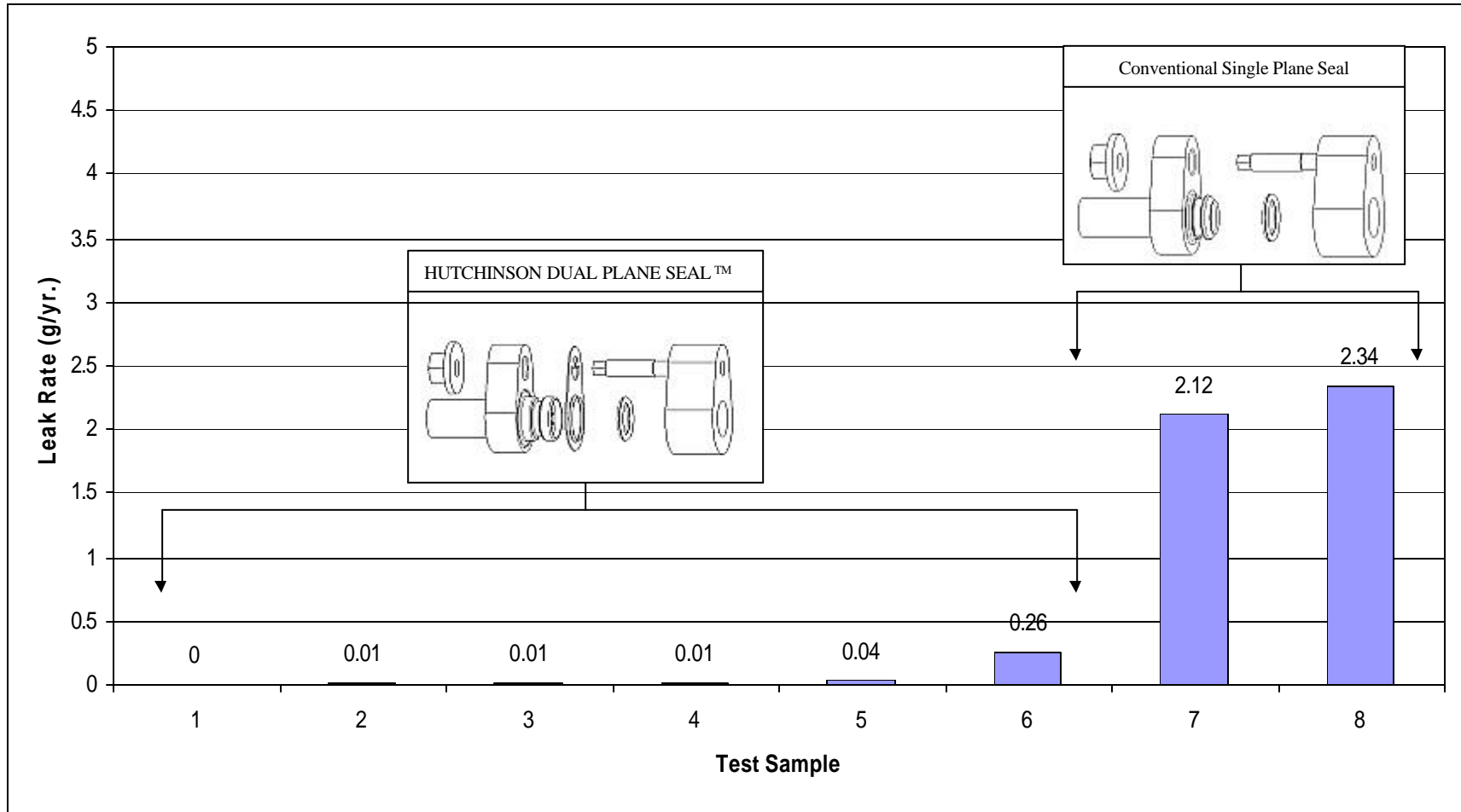


Sample Test Results - Leak Rate Data @ 127°C (260°F) 15.9 mm (5/8 inch) Connectors, Average Pressure 3172 kPa (460 PSI) 30 Day Average





**Sample Test Results - Leak Rate Data @ 100°C (212°F):
15.9 mm (5/8 inch) Connectors, Average Pressure 2690 kPa (390 PSI)
30 Day Average**





30 Day Test Cycle Results

DUAL PLANE SEAL™ Reduced Leak Rate by up to 80%
vs. Single Plane Circumferential Seal

This Means:

- Estimated connector leakage can be reduced by up to 80% under customer usage conditions
- Significant reduction in A/C system recharging requirements
- Significant increase in recovered refrigerant when vehicle scrapped
- Improved connector leakage allows lower R134a charge level tolerance in manufactures plant



30 Day Test Cycle Results

This Means (Continued)

- Improvement in system performance:
 - Reduced System Charge Cost In The Plant And The Field
 - Less Frequent Seal Replacement
 - Improved Compressor Life From Loss of R134a And Lubricant
- Less Frequent Repair = Improved Customer Satisfaction
- Significantly reduced atmospheric emission of R134a



Acknowledgements

Hutchinson FTS, Inc. would like to thank our customers, suppliers, competitors and employees for accepting the DUAL PLANE SEAL™ automotive air conditioning connector.