New Developments in

Elastomeric Hose for Evolving Mobile Air Conditioning Systems

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Introduction

- Refrigerants
  - Historical progression
- Hose developments
  - Rubber and barrier progression
- CO_2 hose
  - Design & performance
- Summary

AC System Progression (~1990)

1 Reduced R-12 Permeation

2 Refrigerant change from R-12 to R-134a

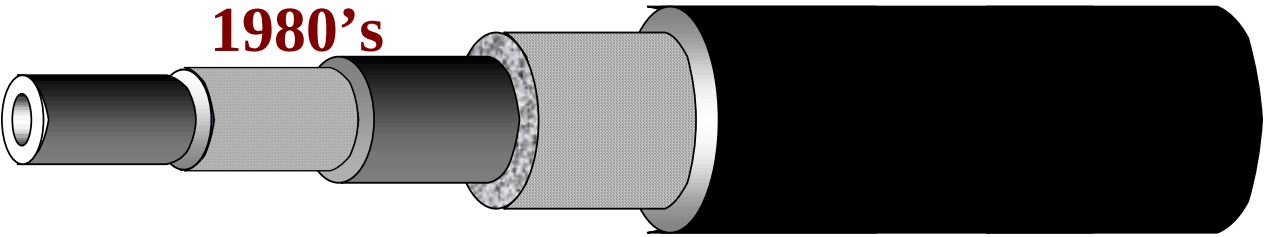
Technology Progression

Thermoplastic layer introduced in hoses

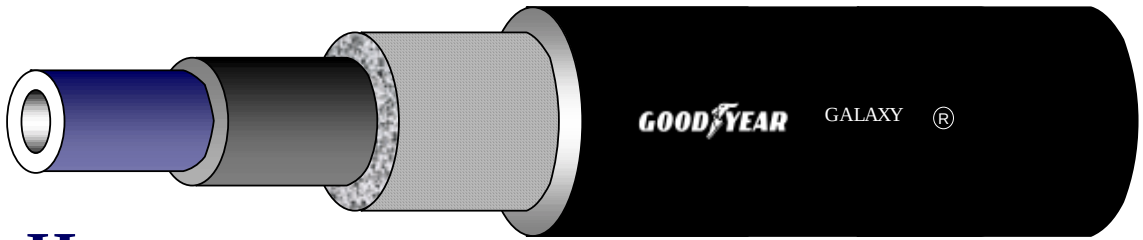
Hose Progression

1980's

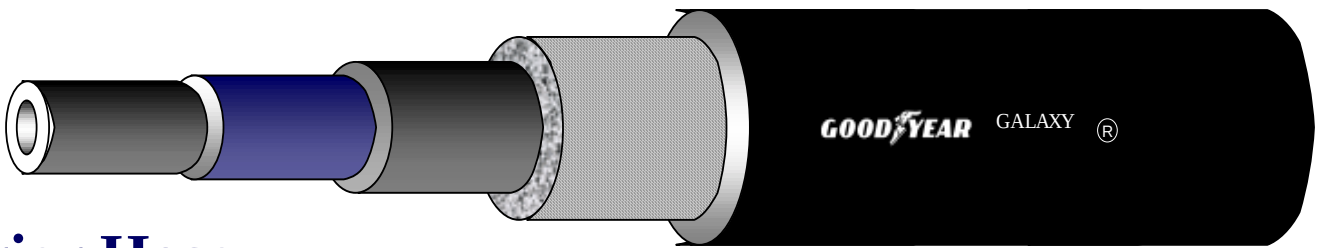
1990's



New Technology

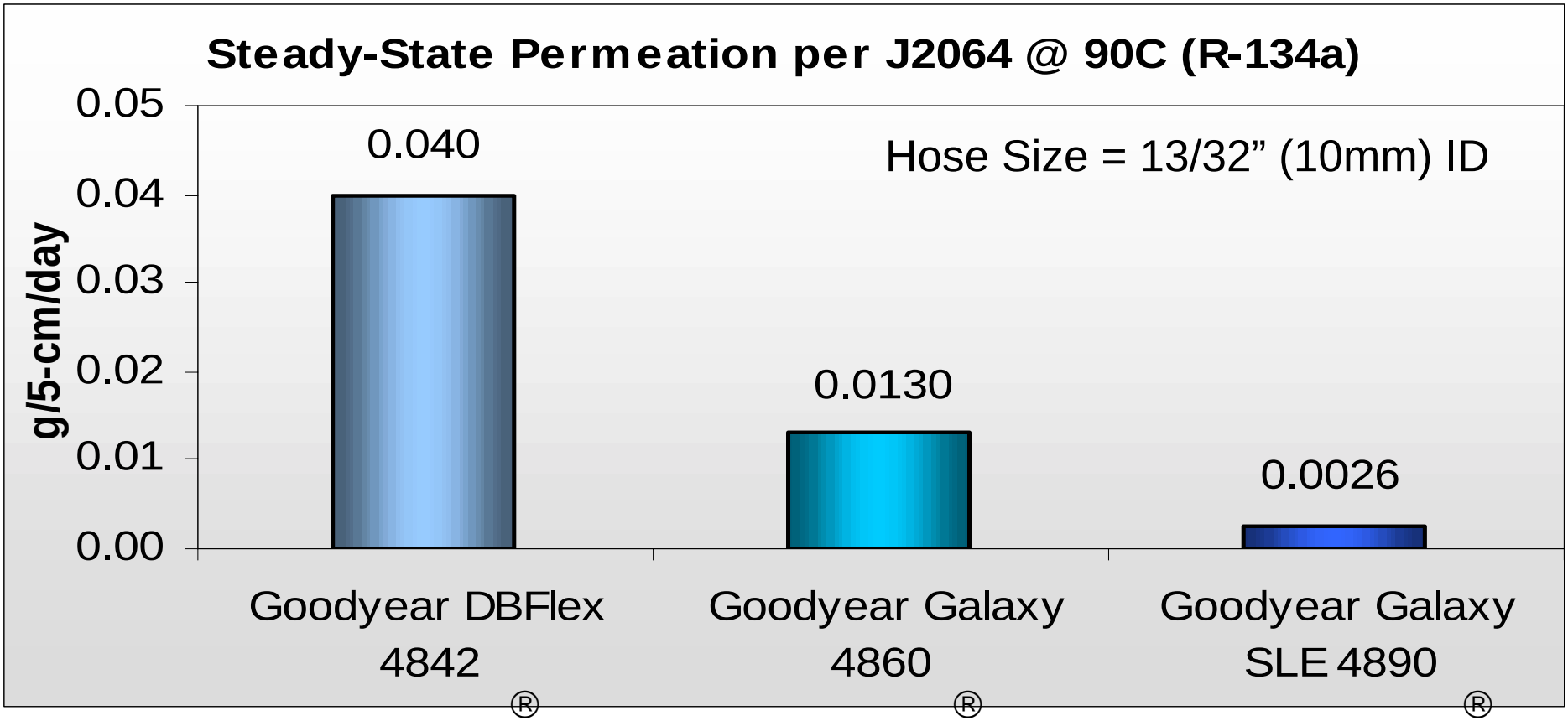


Veneer Hose



Barrier Hose

Permeation data



AC System Progression

1. Reduced R-134a Permeation

2. Refrigerant R-134a to CO_2

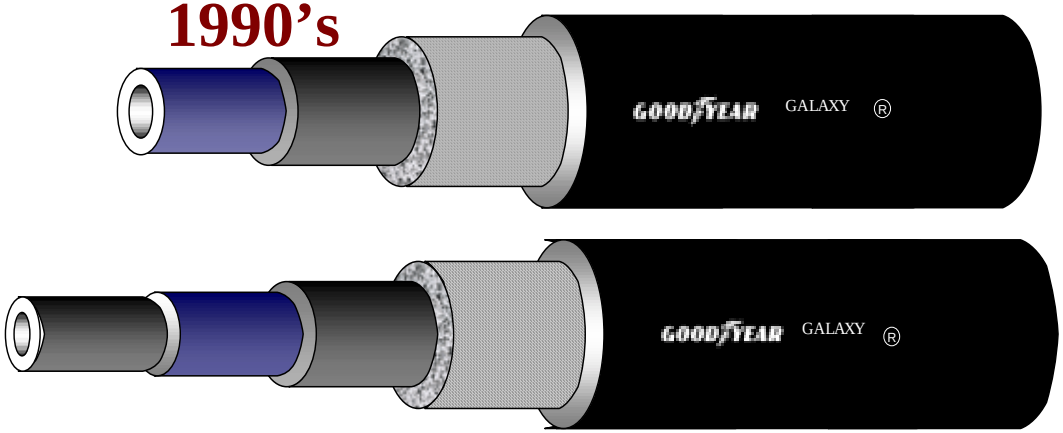
Technology Progression

Multi-layered barrier material development

Hose Progression

1990's

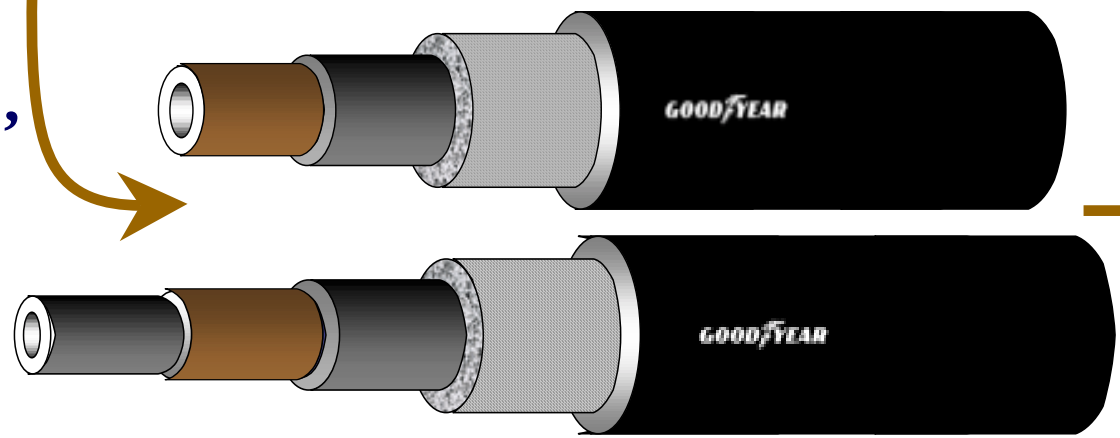
2003



New Technology

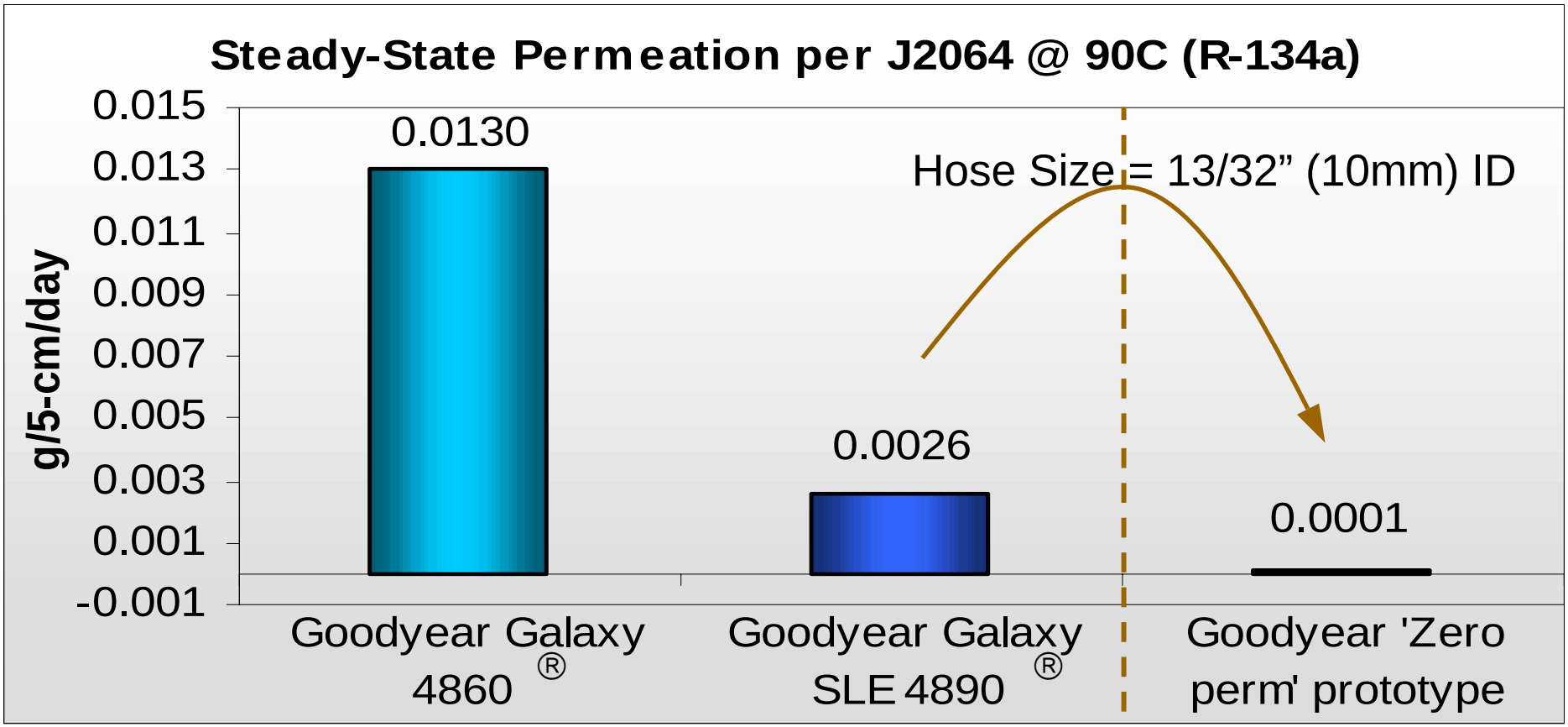
'Zero-perm'

R-134a

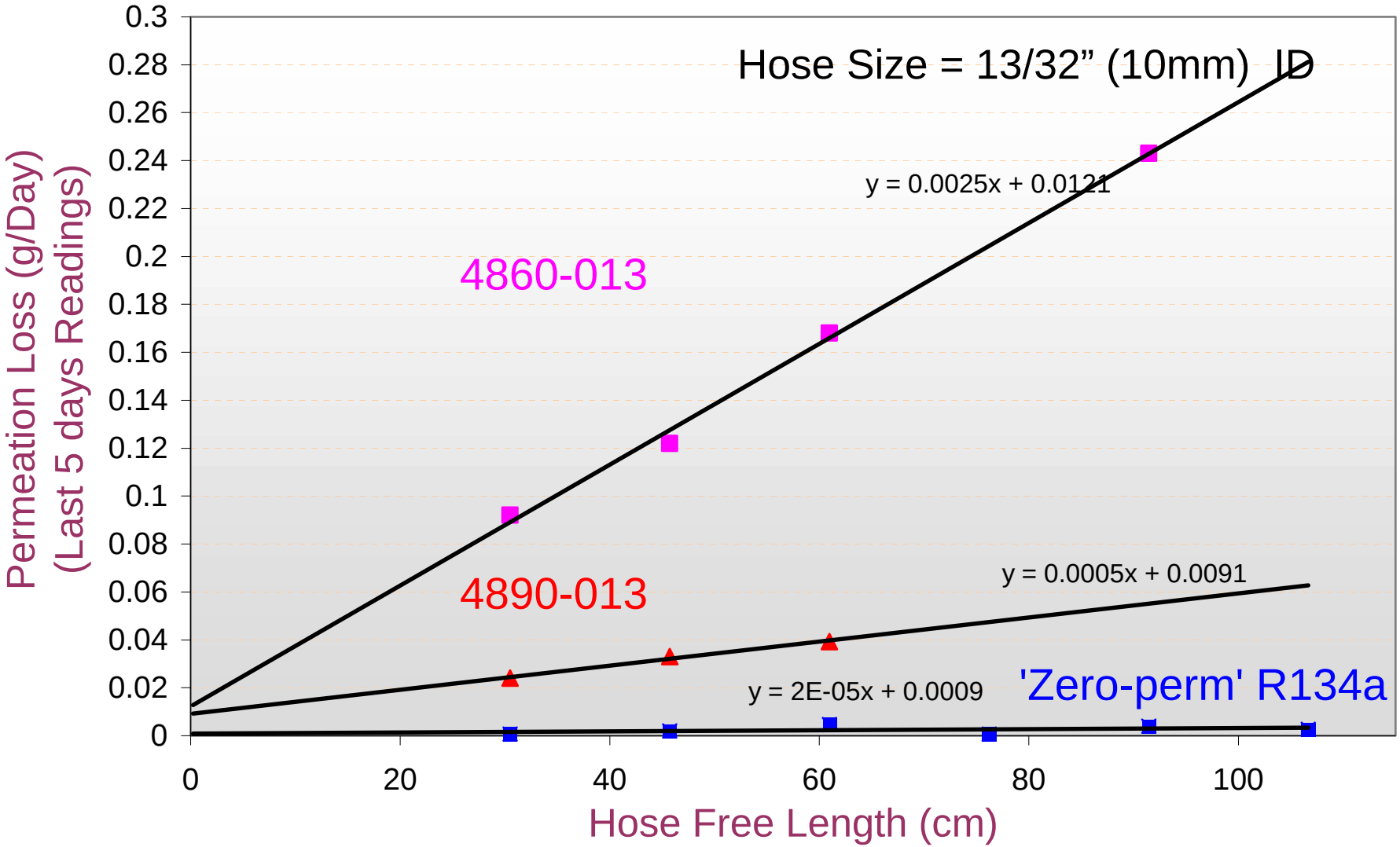


CO_2 Hose

‘Zero-134a’ Prototype



Comparison of Steady State Permeation Loss Vs Hose Length @ 90°C



Prototype CO_2 Veneer Hose Design

Multi-layered Tube | **Elastomer layer** | **Reinforcement** | **Elastomer Cover**

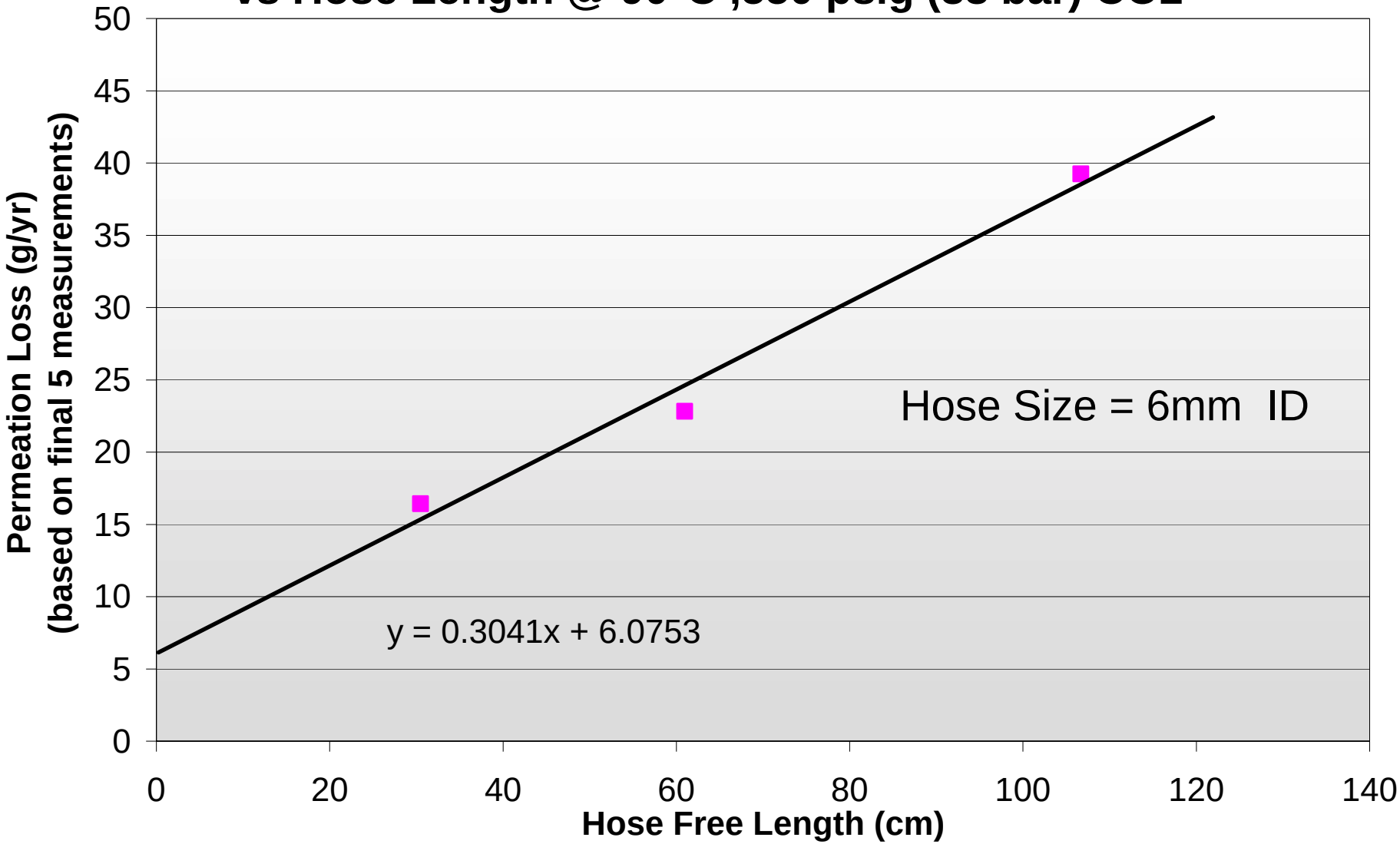
	Priority
Permeation	1
Temperature resistance	2
CO_2 & oil compatibility	3
Burst / Impulse	4

Permeation: CO_2 System Conditions*

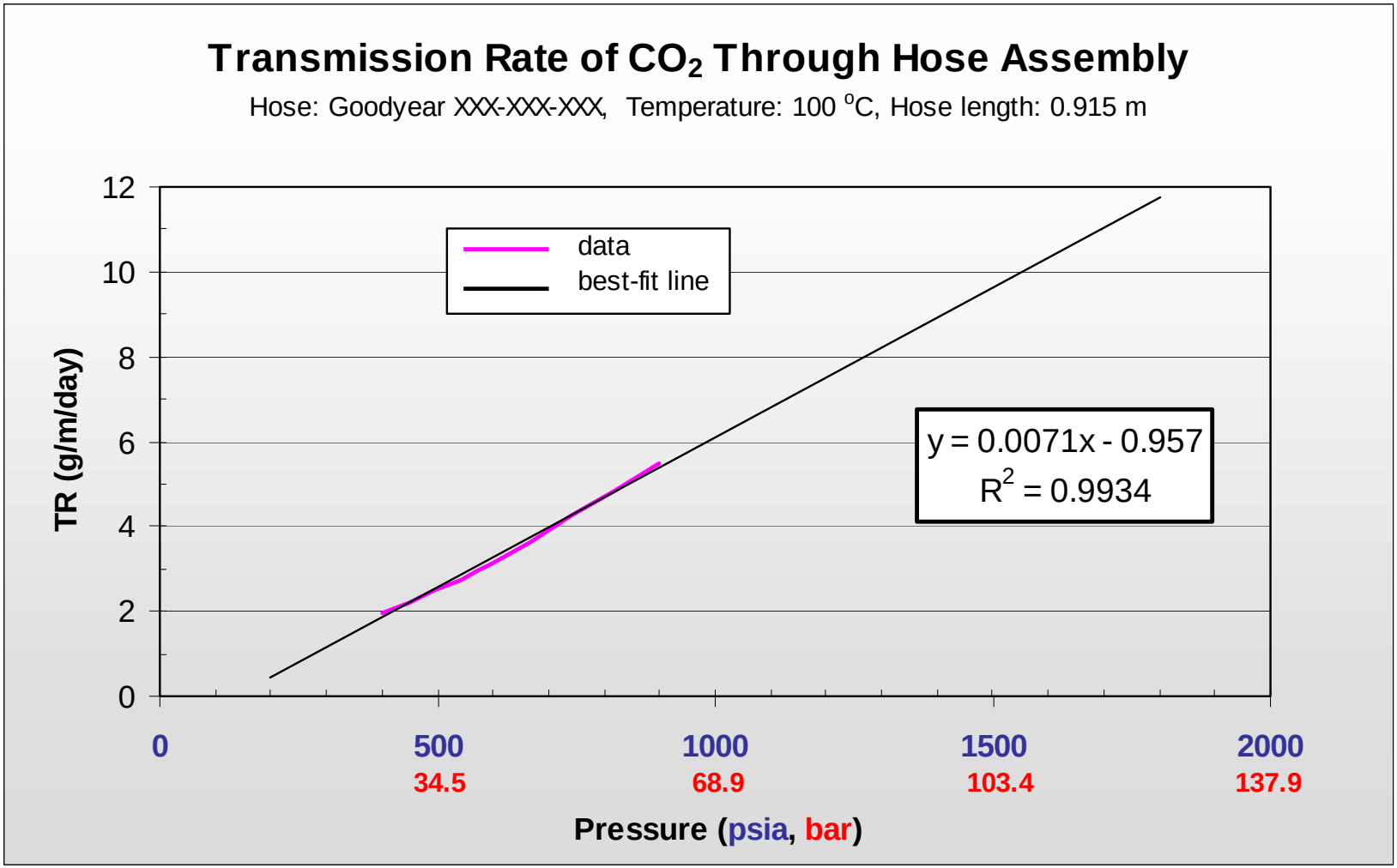
Pressure (psia, bar)	Temperature (C)	Low-side Line Duration (%)	High-side Line Duration (%)
100 (6.9)	-30	4.0	2.0
500 (34.5)	0	4.0	3.0
800 (55.2)	20	80.0	78.0
1160 (80.0)	40	7.0	9.0
1450 (100.0)	100	4.0	5.0
1450 (100.0)	150	1.0	2.0
2030 (140.0)	150	0.0	0.9
2030 (140.0)	180	0.0	0.1

* Estimates of moderate MAC operating conditions

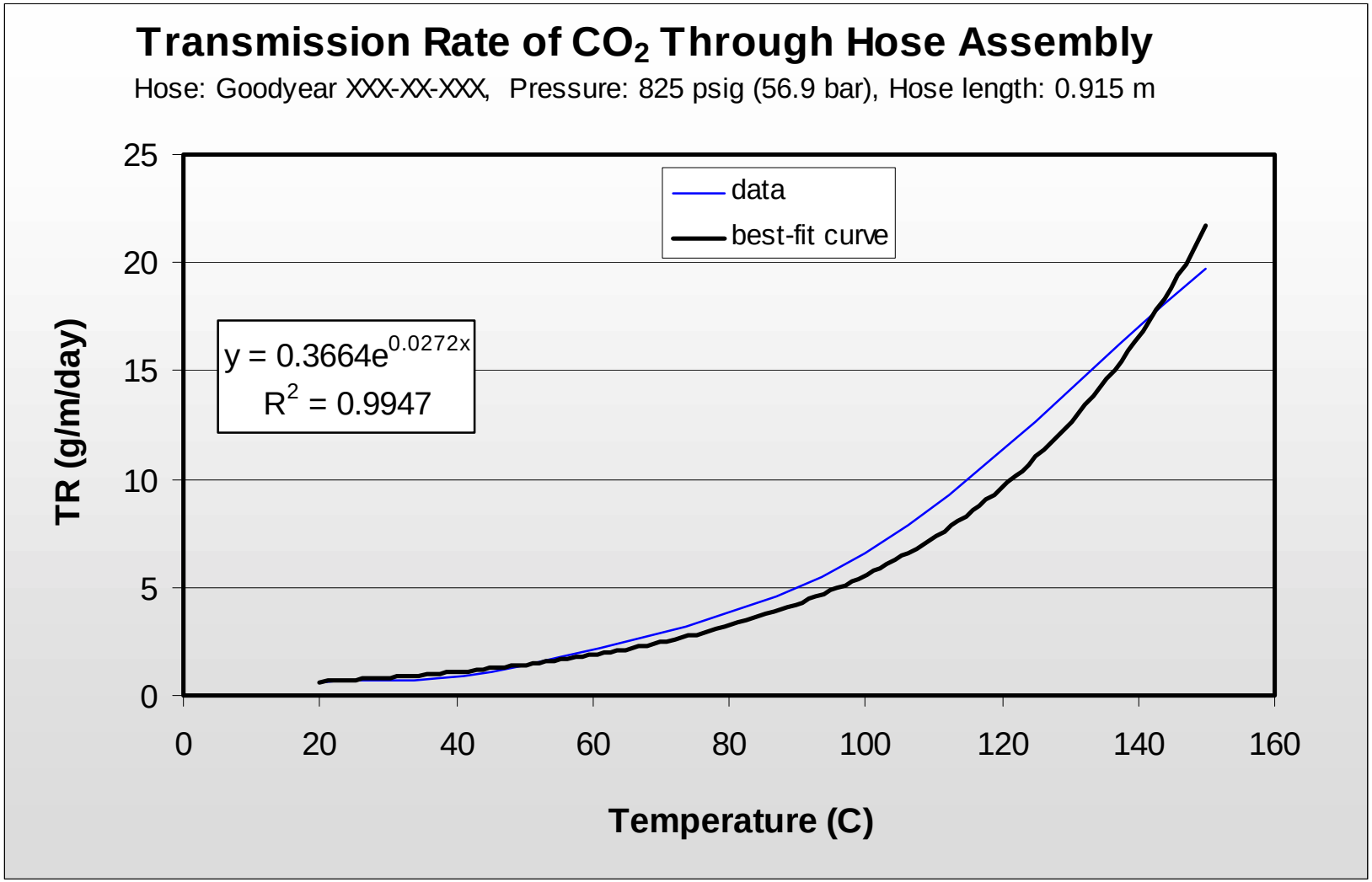
Comparison of Steady State Permeation Loss (J2064) vs Hose Length @ 90°C ,550 psig (38 bar) CO2



Permeation: Pressure Effect



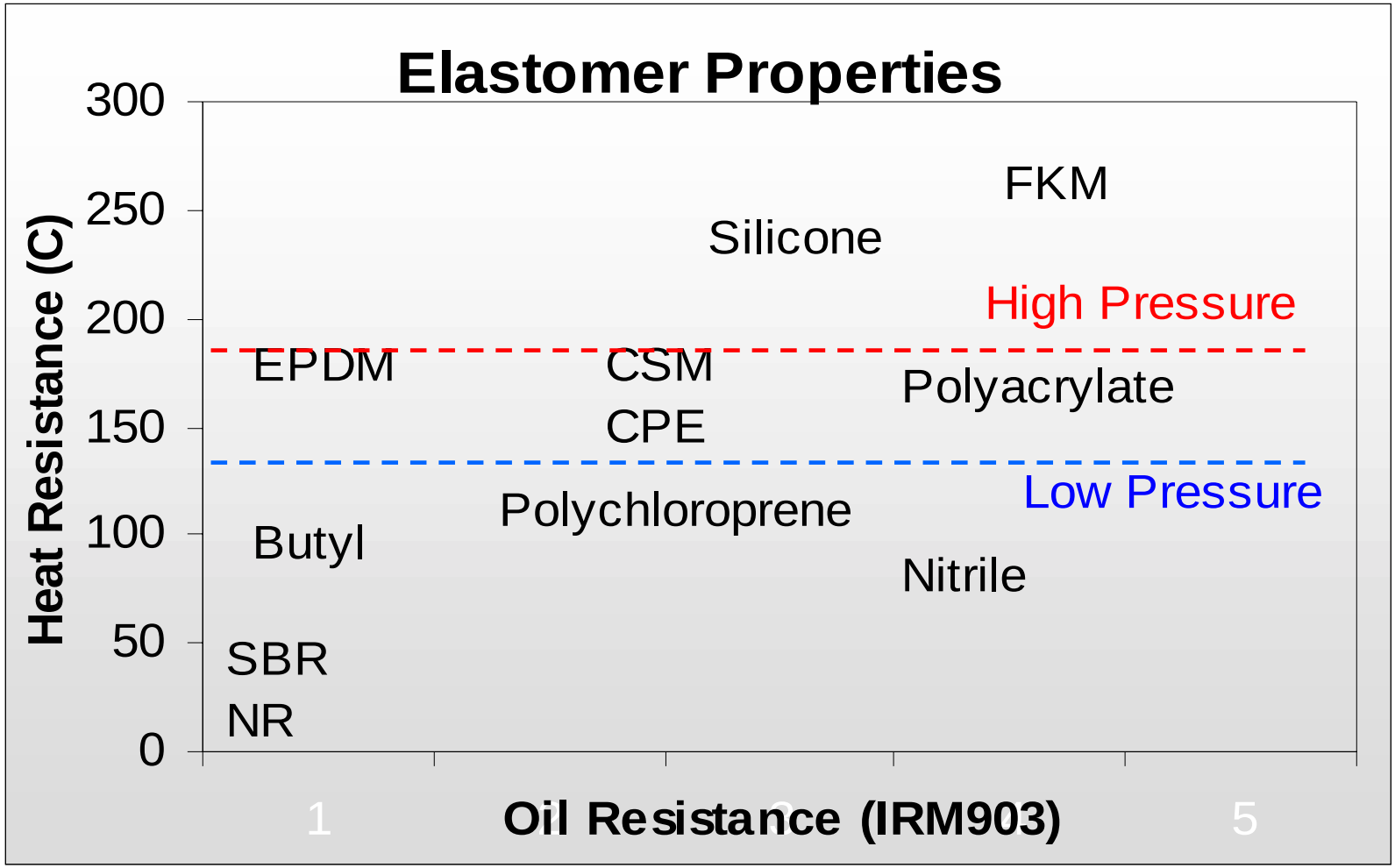
Permeation: Temperature Effect



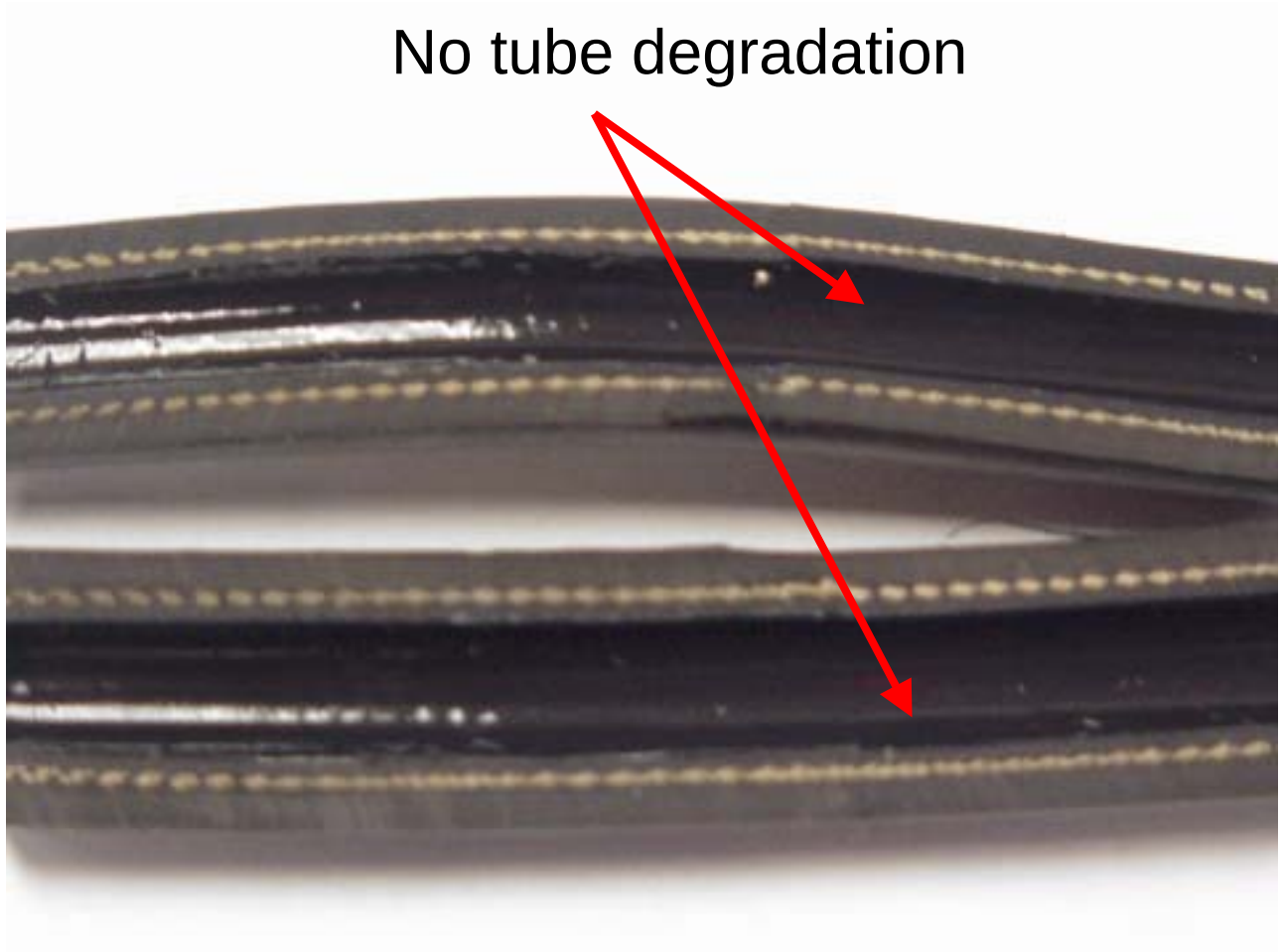
Permeation: CO_2 System Conditions

Pressure (psia, bar)	Temperature (C)	Low-side Line Duration (%)	Low-side Line (8mm) Estimated Permeation (g/m/yr)	High-side Line Duration (%)	High-side Line (6mm) Estimated Permeation (g/m/yr)
100 (6.9)	-30	4.0	0.002	2.0	0.0008
500 (34.5)	0	4.0	0.029	3.0	0.017
800 (55.2)	20	80.0	13.3	78.0	9.75
1160 (80.0)	40	7.0	2.23	9.0	2.15
1450 (100.0)	100	4.0	7.01	5.0	6.58
1450 (100.0)	150	1.0	7.56	2.0	11.3
2030 (140.0)	150	0.0	0	0.9	6.95
2030 (140.0)	180	0.0	0	0.1	20.8
		100.0	30.2	100.0	57.6

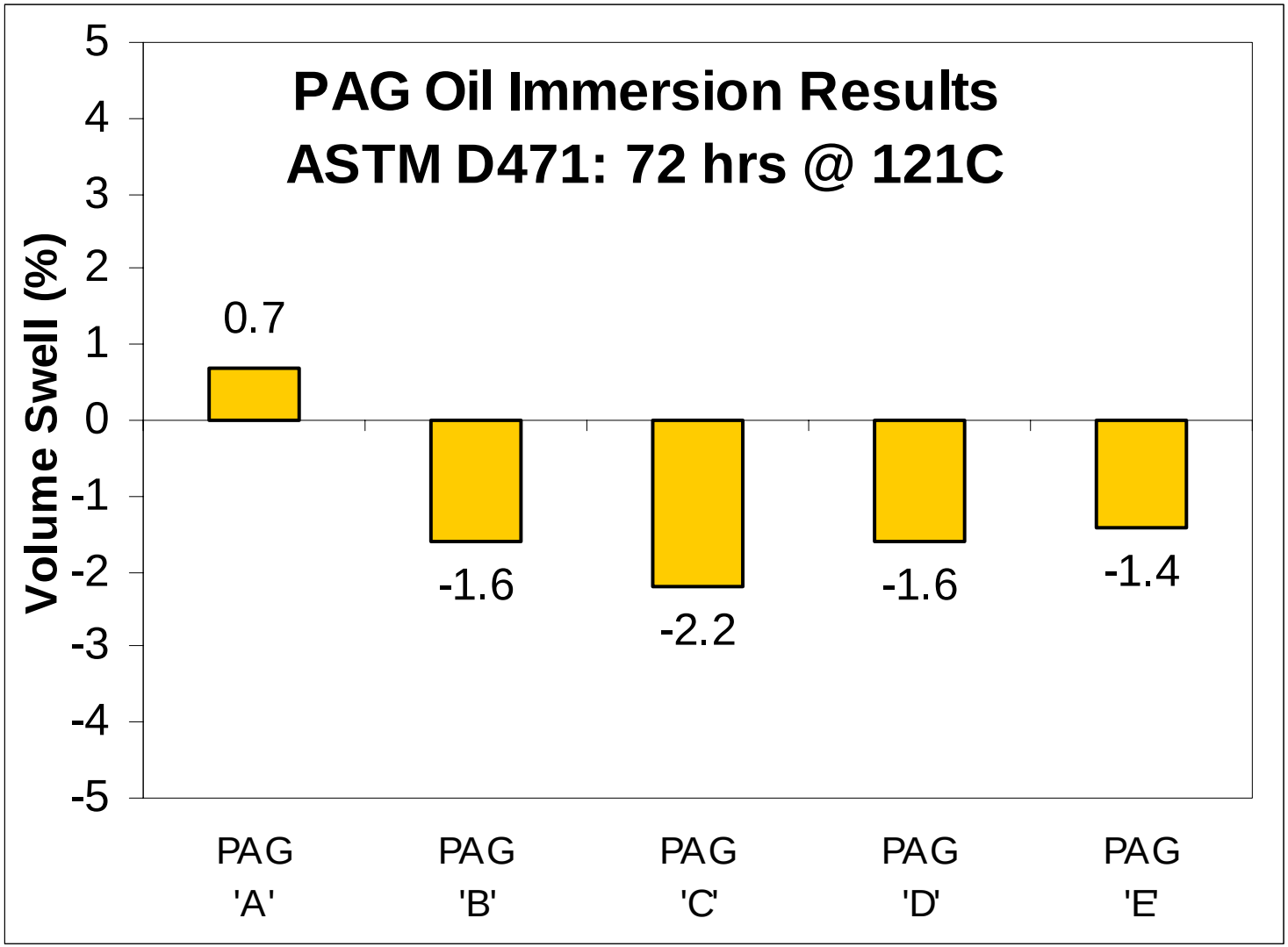
Temperature Resistance



CO_2 Compatibility



Oil Compatibility



Burst & Impulse

Burst Pressure:

Aramid reinforced design for a 4 - 5x safety margin

True hose burst at over 9000psi (620 bar)

Impulse Testing: (Testing in progress)

Conditions:	Temperature	140C
	Pressure	500 psi (34.5 bar)
	Impulse frequency	15 cycles/min

Durability Testing:

Modine CO_2 bench & Jeep Liberty

Summary

1 Reduced 134a Permeation

‘Zero-perm’ R-134a Hose

2 Refrigerant change from R-134a to CO_2

Viable CO_2 Suction Hose

Potential CO_2 Discharge Hose

Thank You