Low Refrigerant Permeation Connections

- Dual Seal - Slim line with O ring
- Dual Seal Slim Line *New*
- Metal Seal Fitting *New*

Gene Dianetti

Parker Hannifin Corp.

Mobile Climate Systems Div.

SAE J2727 Seal Design Ratings

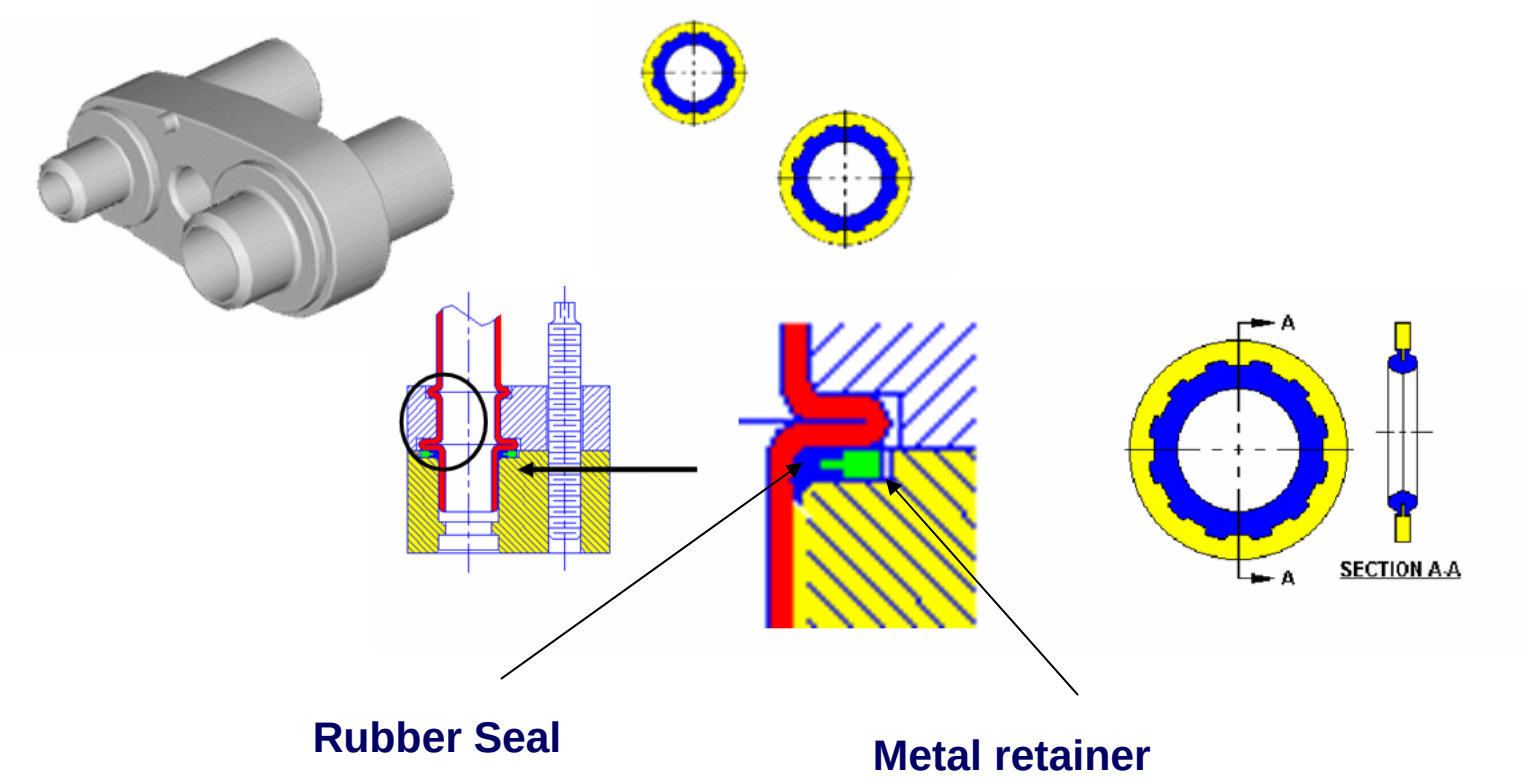
- Seal washer - 10
- Dual Seal - Slim line with O ring -5
- Dual Seal Slim Line *New - 5*
- Metal Seal Fitting *New - 1*

SAE J2727 TEMPLATE

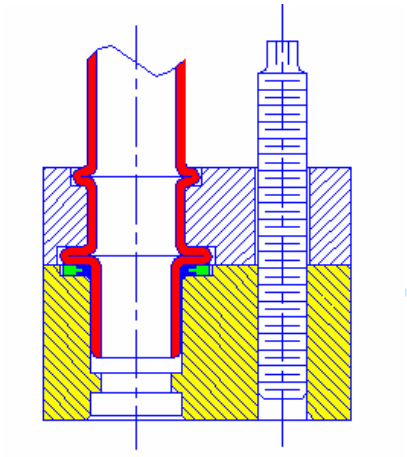
Leakage Chart

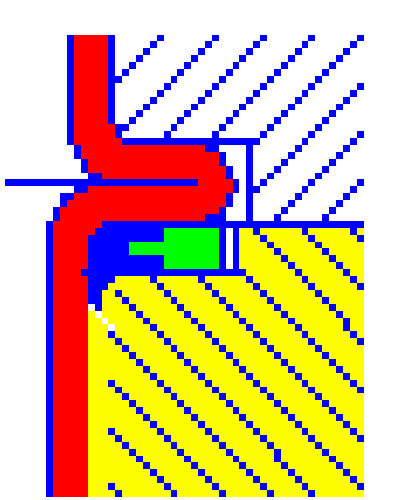
System Component Connection							Calculated Value
Fittings							
Rigid Pipe connections	Single O-ring	Single Captured O-ring	Multiple O-ring	Seal Washer	Seal Washer with O-ring	Metal Gasket	**Do Not Enter Data**
Total Emissions	125	75	50	10	5	1	
Number of fittings:							0.000

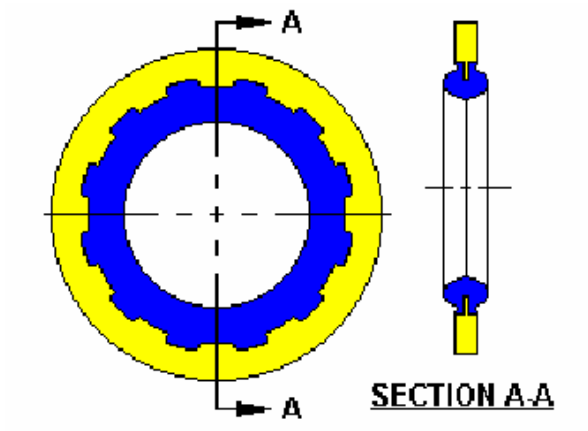
Slim Line (Seal Washer) Design



Sealing Features

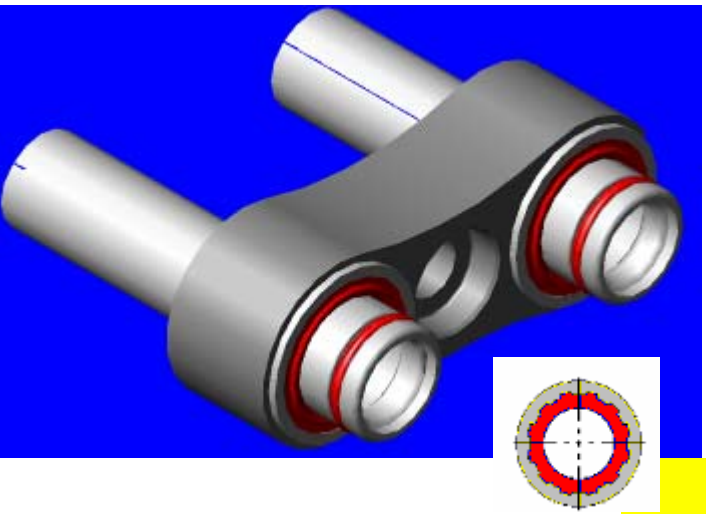


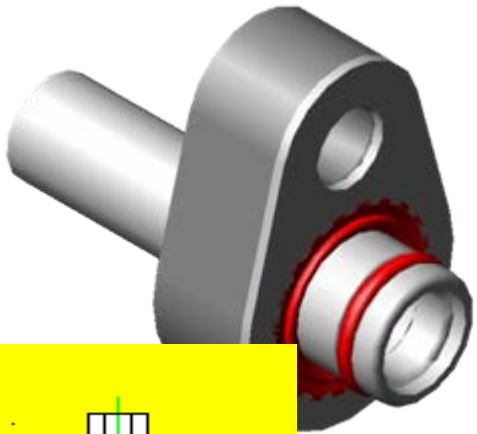




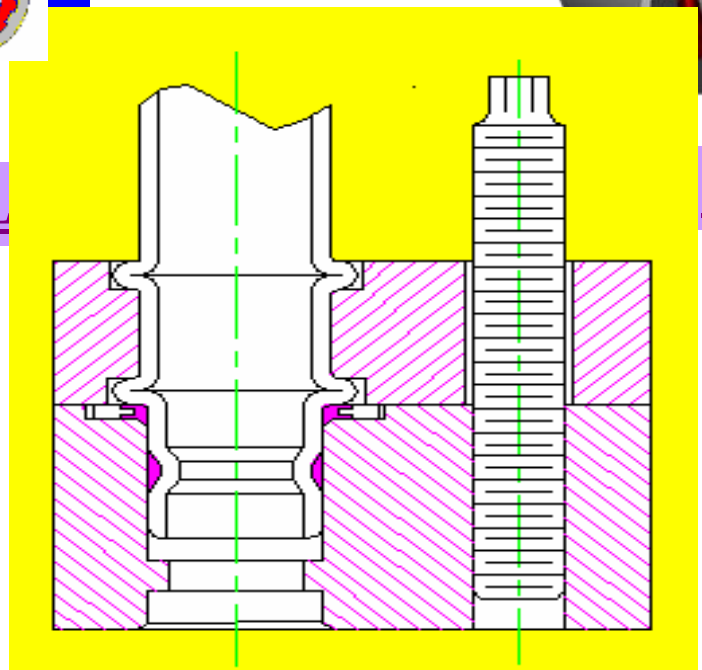
- Rubber sealing material located inside a metal retainer
- Rubber compression controlled by Metallic washer
  - Maximum Compression achieved all the time
- Seal is self Centering – No lubrication required
- Sealing --- Primary-- Static Face—Secondary-Radial

Dual Seal Design



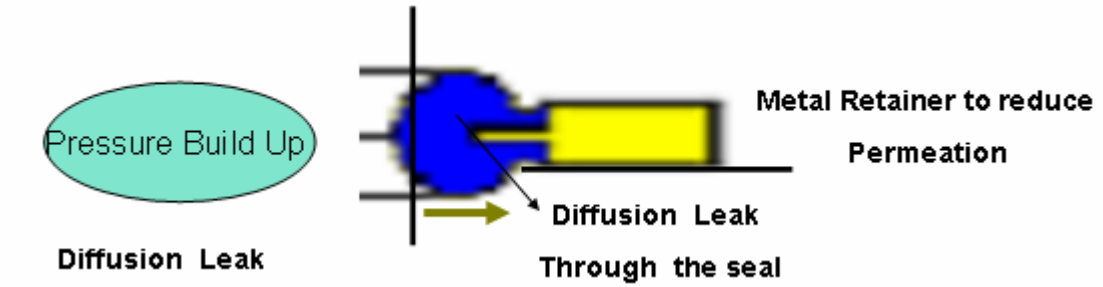


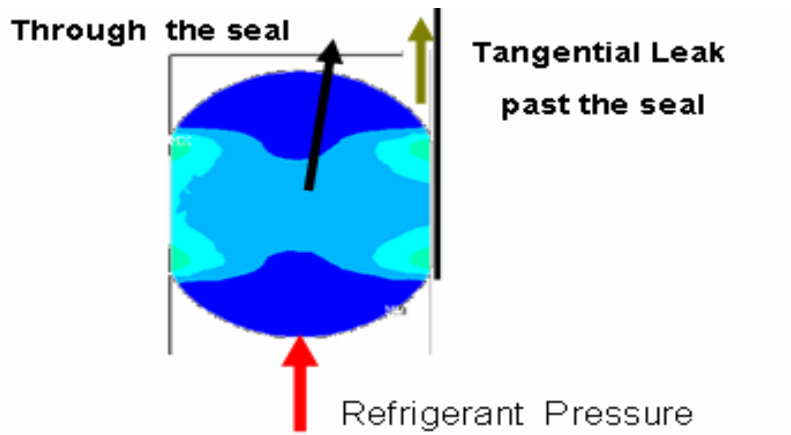
COMPRESSOR DETAIL



CONDENSOR DETAIL

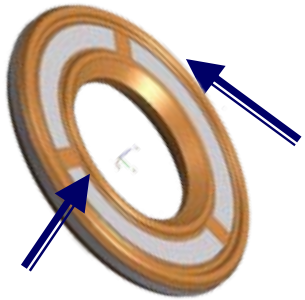
Dual Seal


Pressure Build Up
Diffusion Leak
Metal Retainer to reduce
Permeation
Diffusion Leak
Through the seal


Through the seal
Tangential Leak
past the seal
Refrigerant Pressure

Dual Seal Slim Line Design

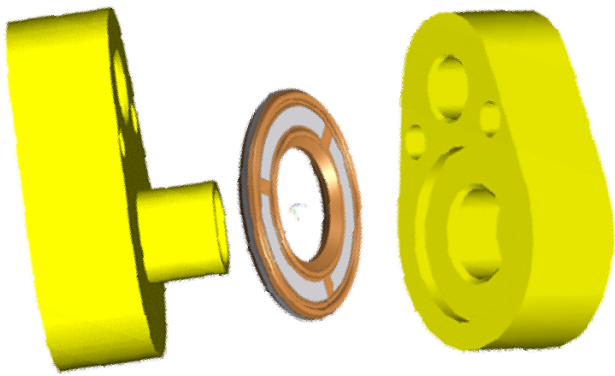
Existing Slim Line Design



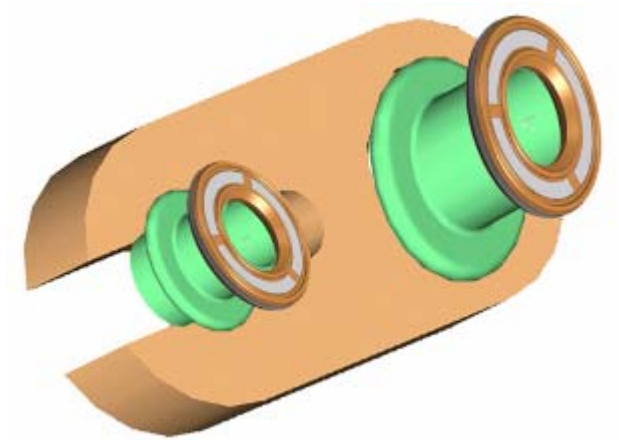
Existing rubber profile for slim line sealing

Added new rubber profile for Face sealing

Single Tube



Dual Tube



Design Benefits

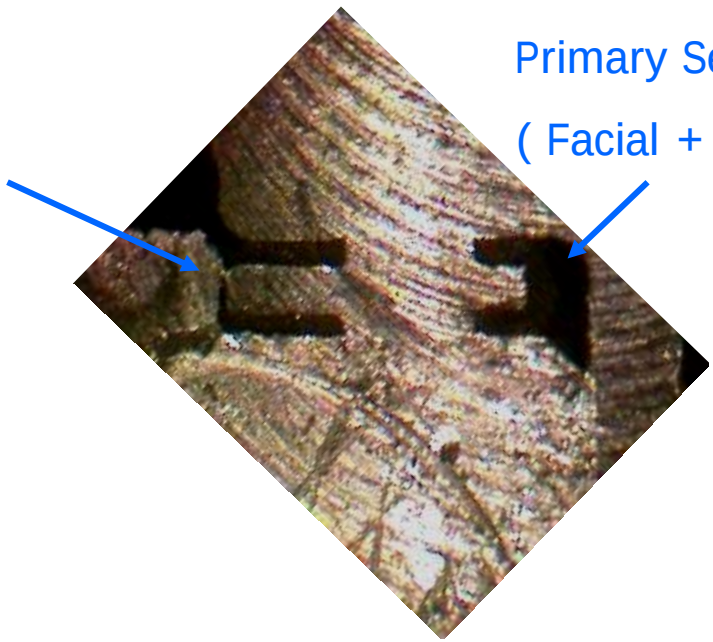
Dual seal design will provide

- Lower Permeation / Leak Rate vs. standard slimline seal
- Functions as a Secondary Backup Seal
  - Provides a full face seal
  - Joint design similar to standard slimline seal (known technology)

Secondary Seal

Primary Seal

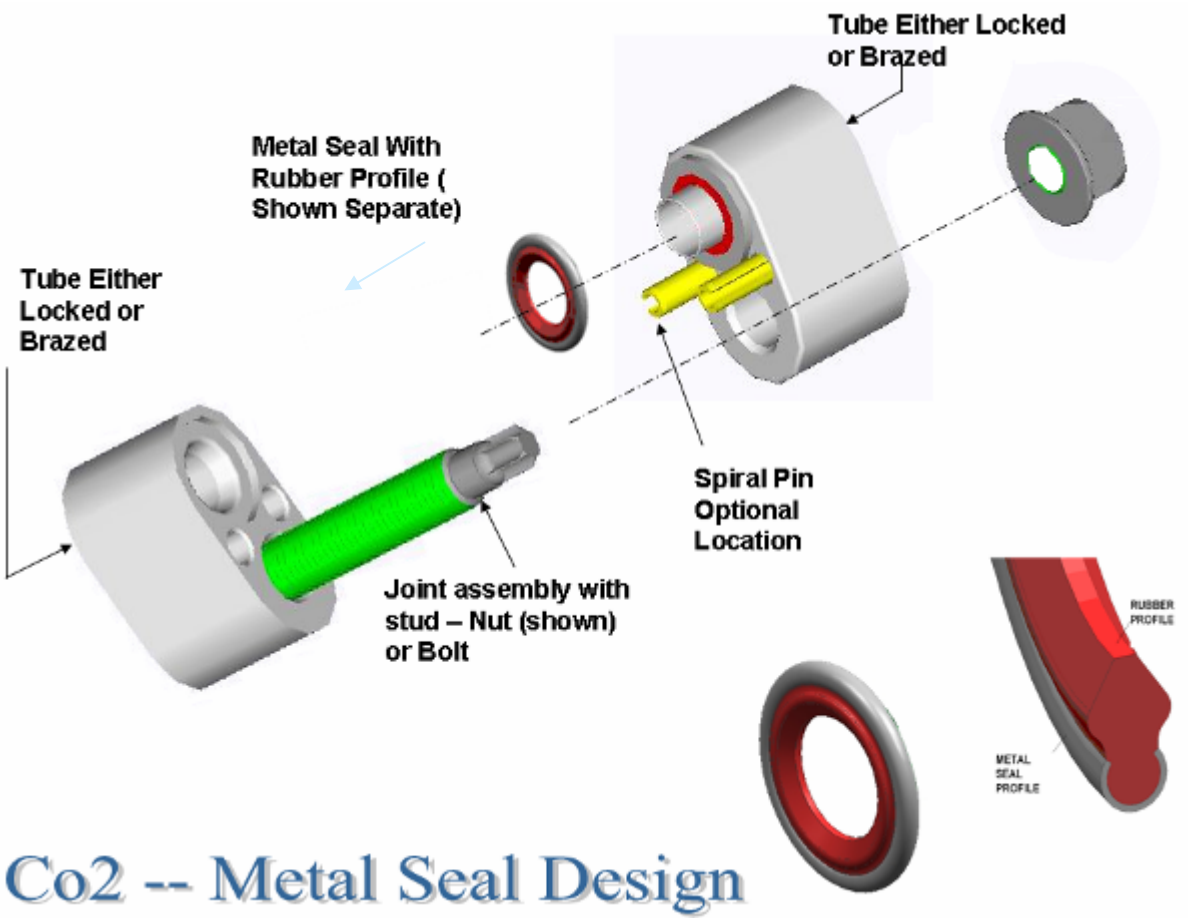
(Facial + Radial)



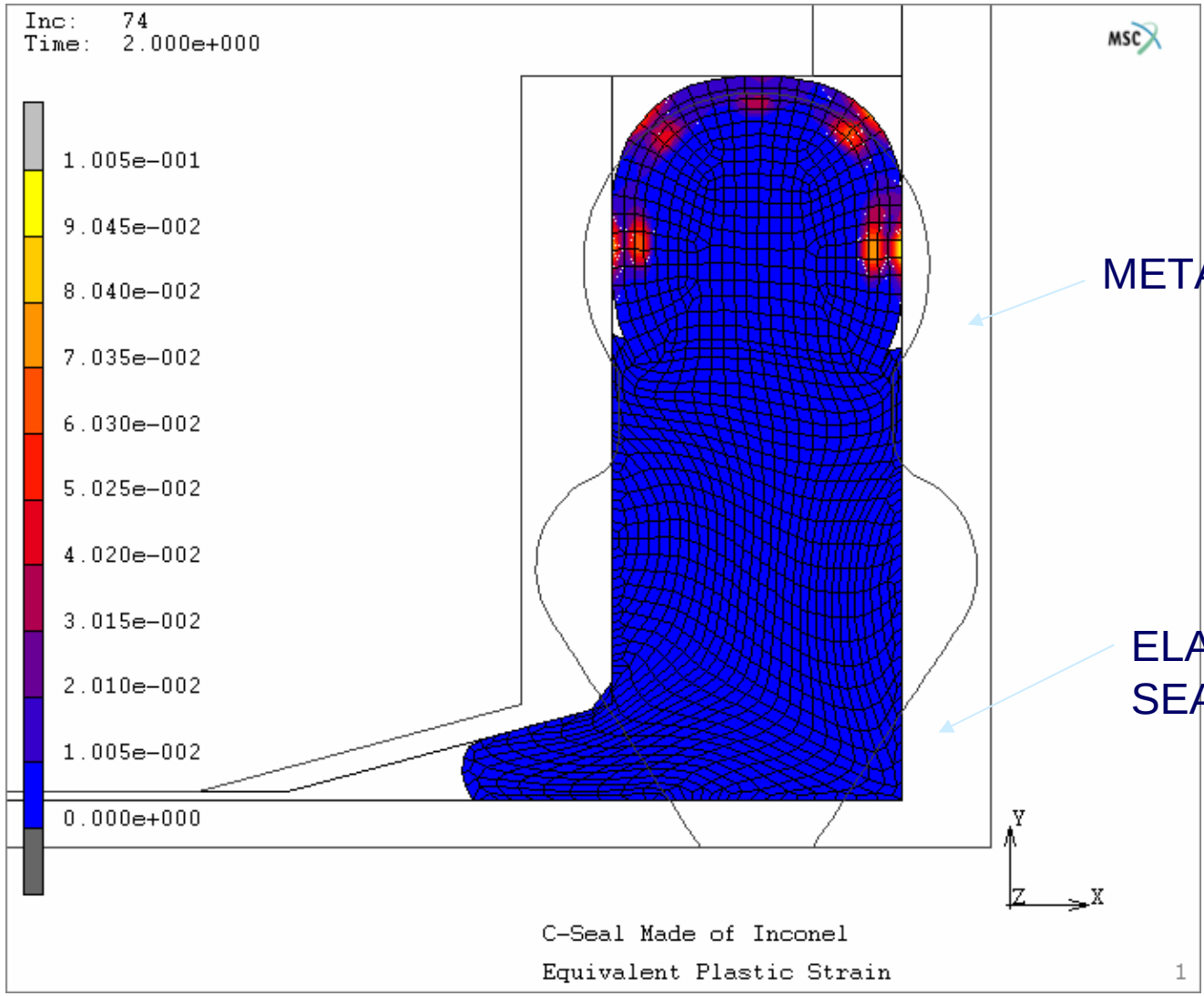
Dual Slimline vs. Slimline + Oring Comparison

- Dual slimline – one component
- Dual slimline - No lubrication required
- Slimline + oring – oring must be lubricated for assembly
- Slimline + oring - requires additional machining / forming
- Slimline + oring – oring can be damaged during assembly and can be affected by contamination. If the oring is compromised, the slimline will still seal the joint, however, the dual sealing capability is lost
- Dual slimline – can be used on existing mating components which use standard slimline seals today without modification

Metal C-ring with Elastomeric Seal Design



FEA MODEL



METAL C SEAL

ELASTOMER SEAL

Metal Seal Design Features

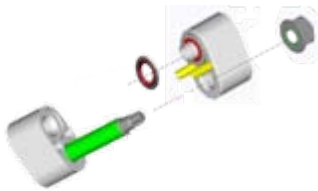
- Elastomeric Seal provides retention feature for part in assembly (PIA)
- Metal “C-ring” seal significantly reduces permeation
- Fewer Components to handle during assembly process
- Maintains long term performance under high temperature
- Designed for R134a or R744

Performance Test: Metal Seal Design –R744 (CO_2)

Gas Pressure Tightness per VDA Spec.

- RGA Gas Analysis Method

No.:	Load state:	p [MPa]	psi	t[°C]	Test Duration	Leak Rate
1	Standstill -30°C	1.43	203	-30	96 Hrs	< 0.2 gram / yr
2	Standstill 0°C	3.5	508	0	96 Hrs	< 0.2 gram / yr
3	Standstill 30°C	7	1015	30	96 Hrs	< 0.2 gram / yr
4	Driving state 30°C	10	1450	130	96 Hrs	< 0.2 gram / yr
5	Idle 35°C	13	1886	150	96 Hrs	< 0.2 gram / yr
6	Idle 45°C	13.3	1929	165	96 Hrs	< 0.2 gram / yr

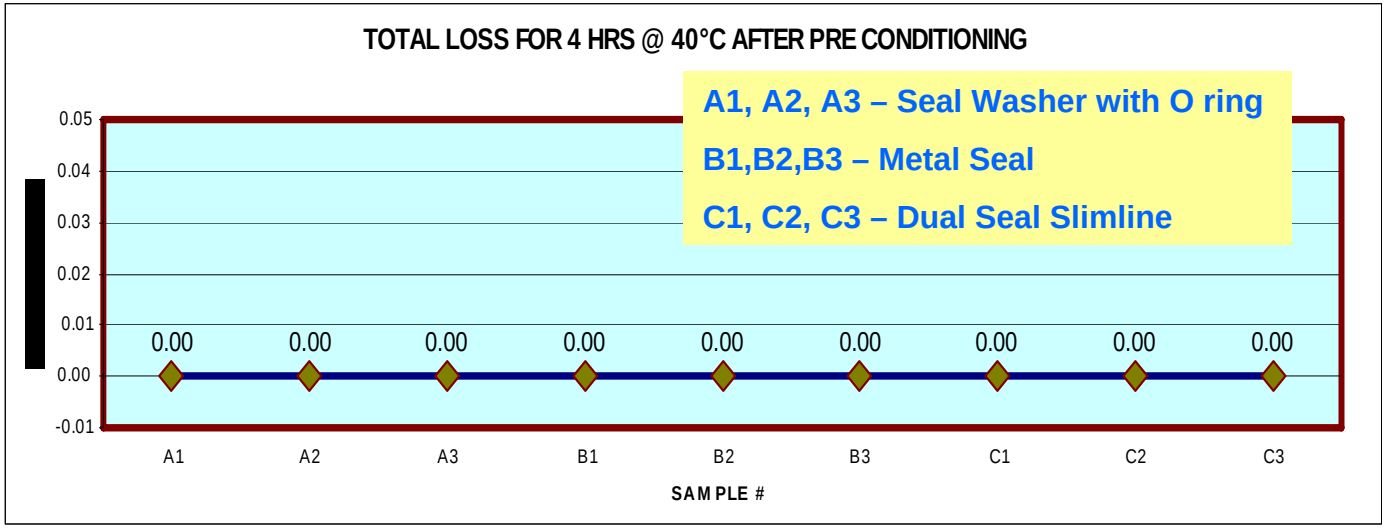


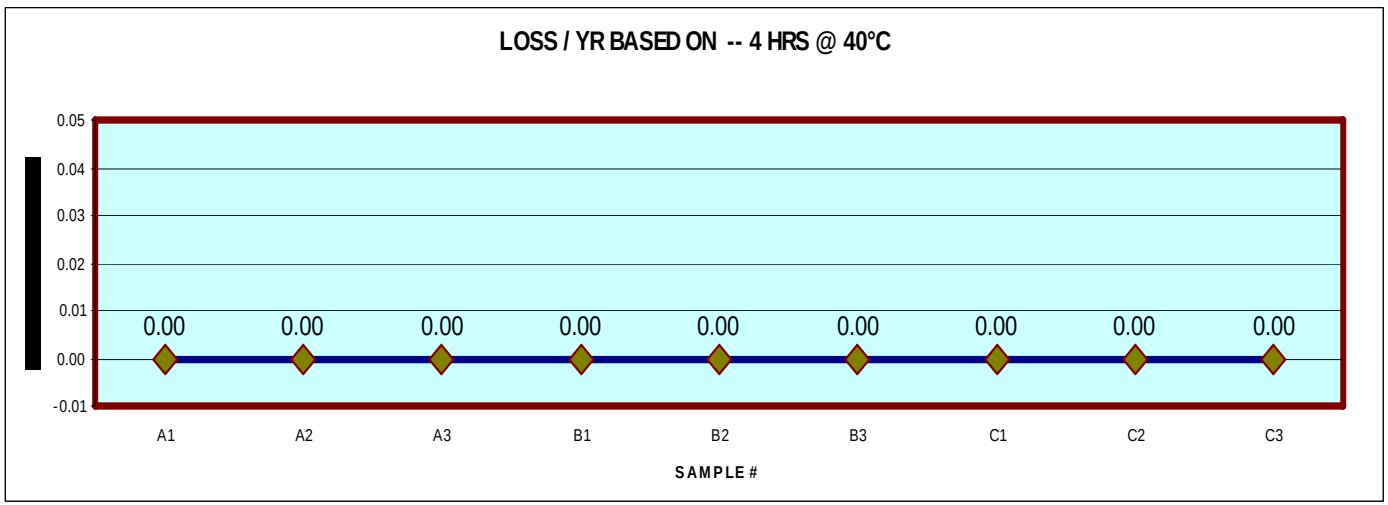
R134a Lab Test - Data

Components Testing per SAE (Pre Release) – Weight Loss Method

- Charge Pressure 147.5 psi @ 40°C
- Preconditioning of joint for 96 Hrs

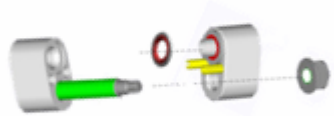
Performance Test: Weight Loss Method



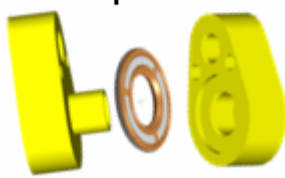


Sample A

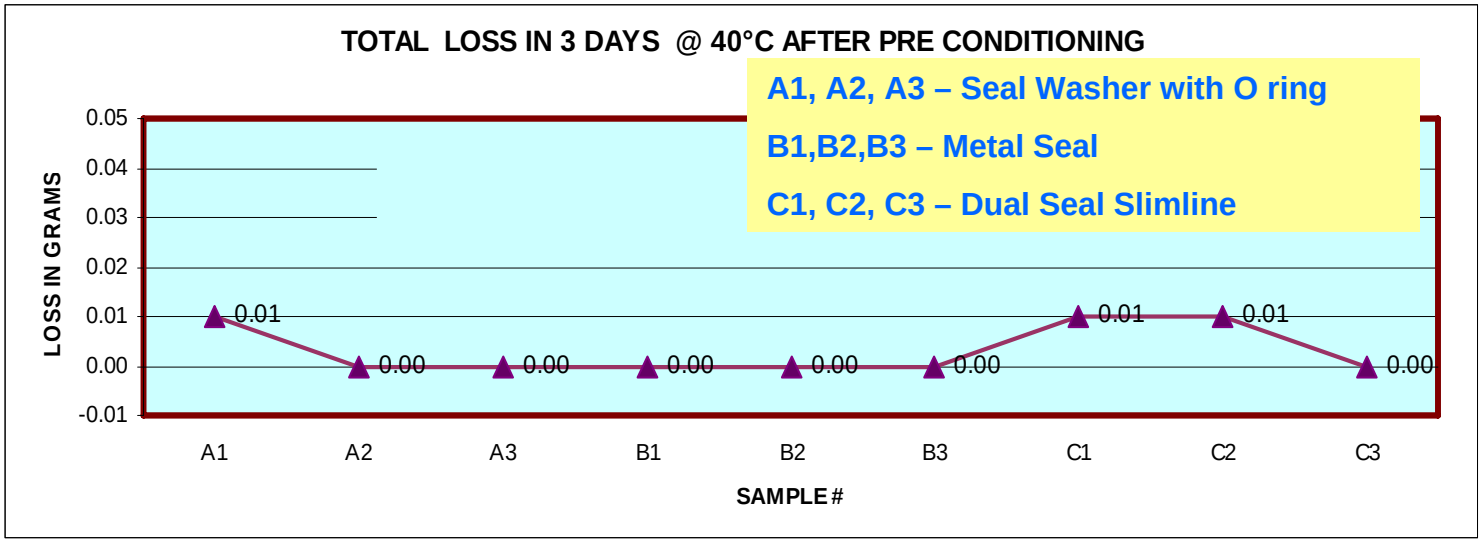
Sample B

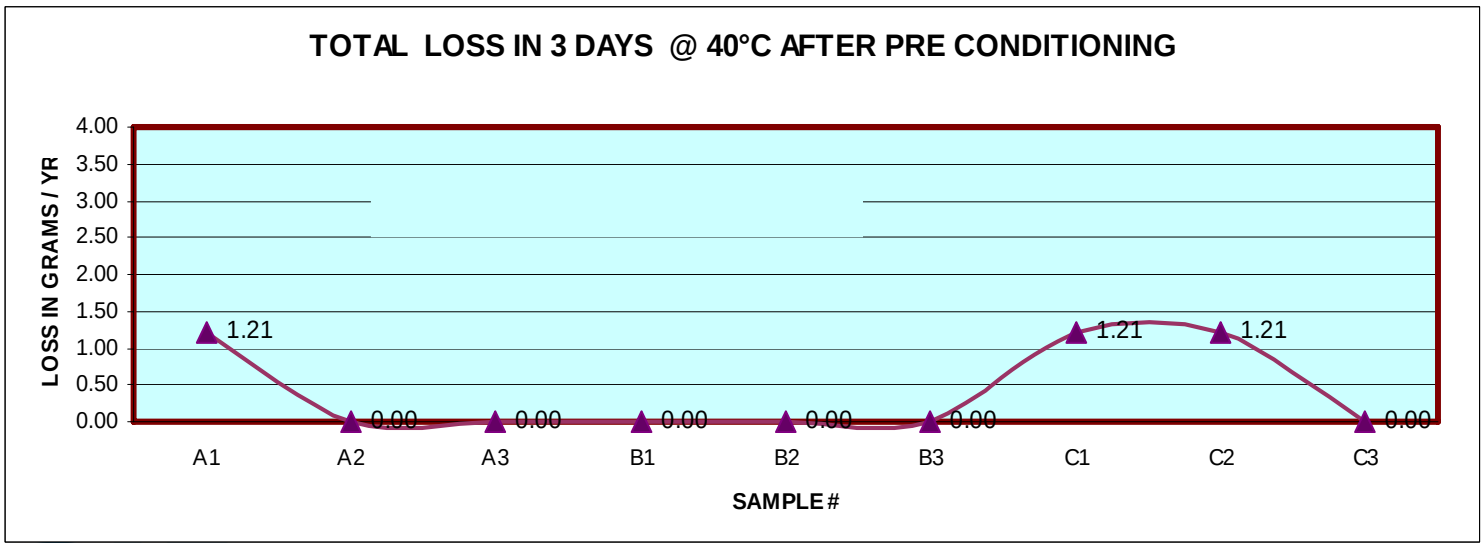


Sample C



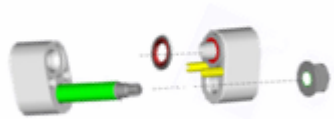
Performance Test: Weight Loss Method



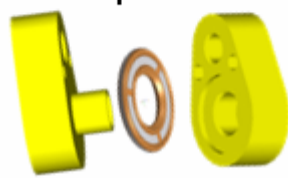


Sample A

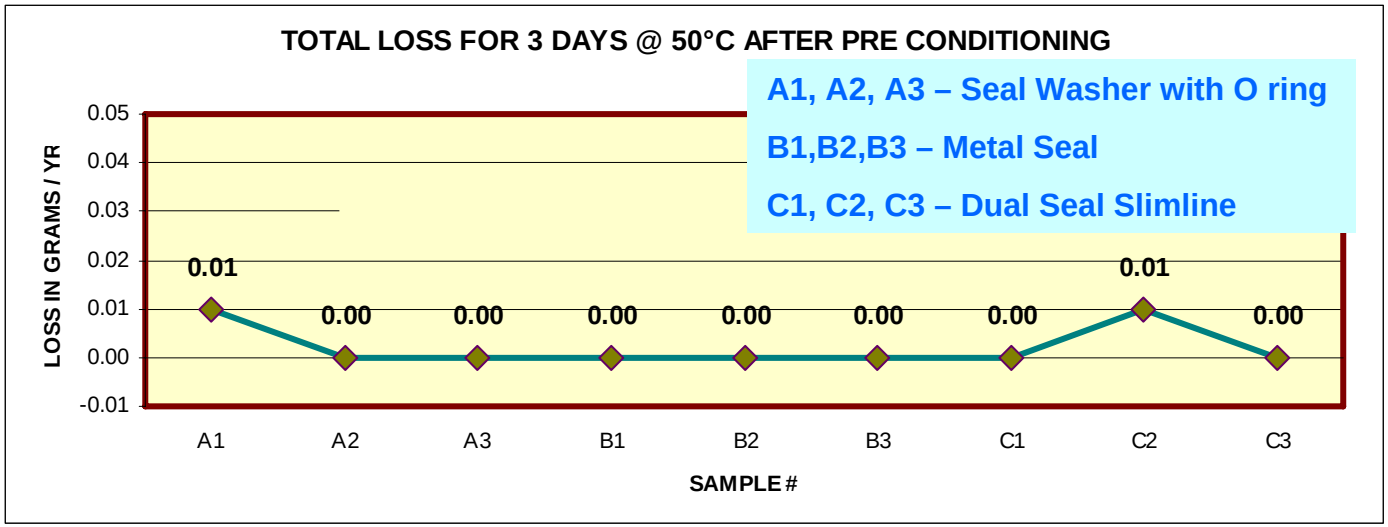
Sample B

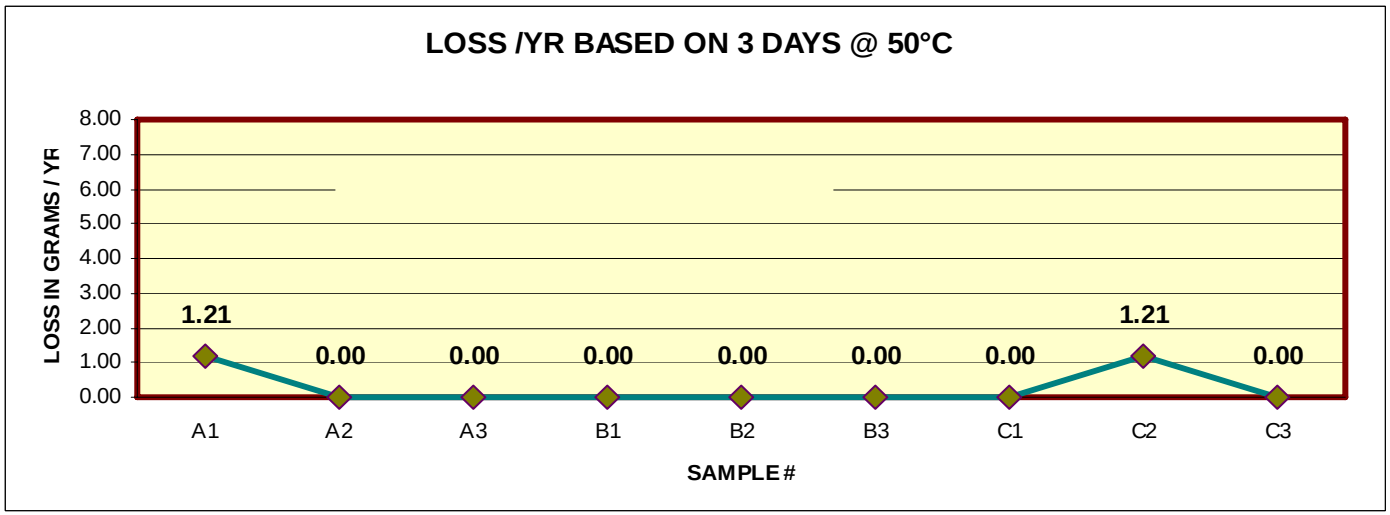


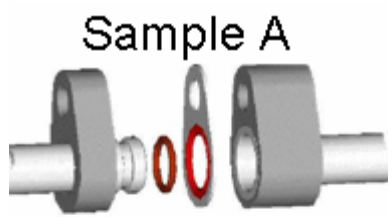
Sample C

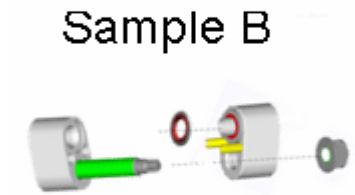


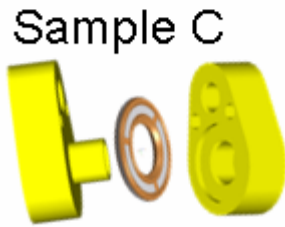
Performance Test: Weight Loss Method



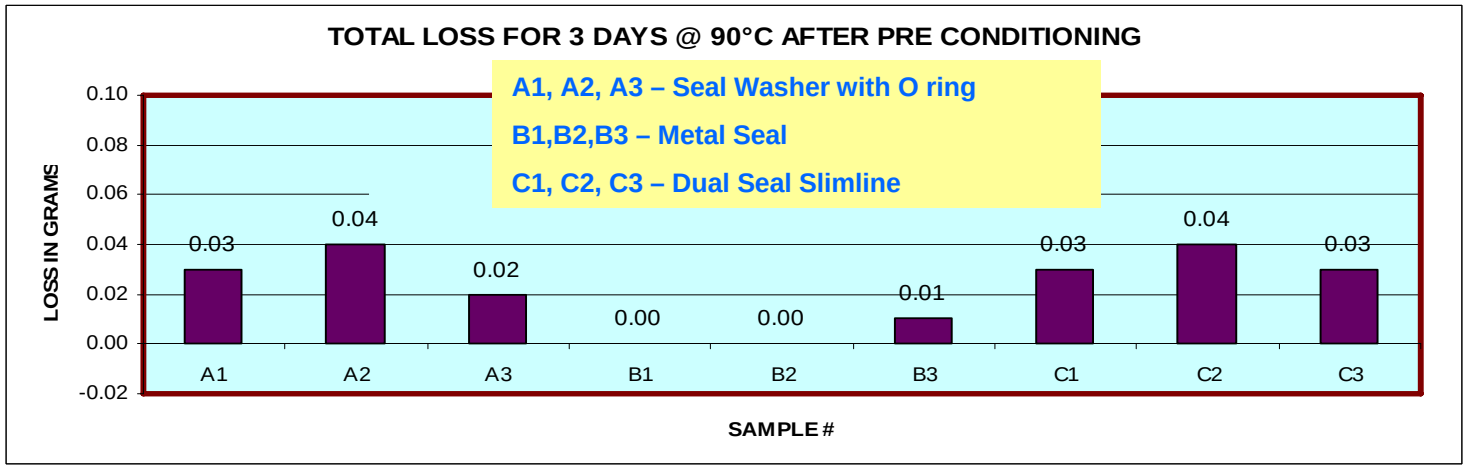


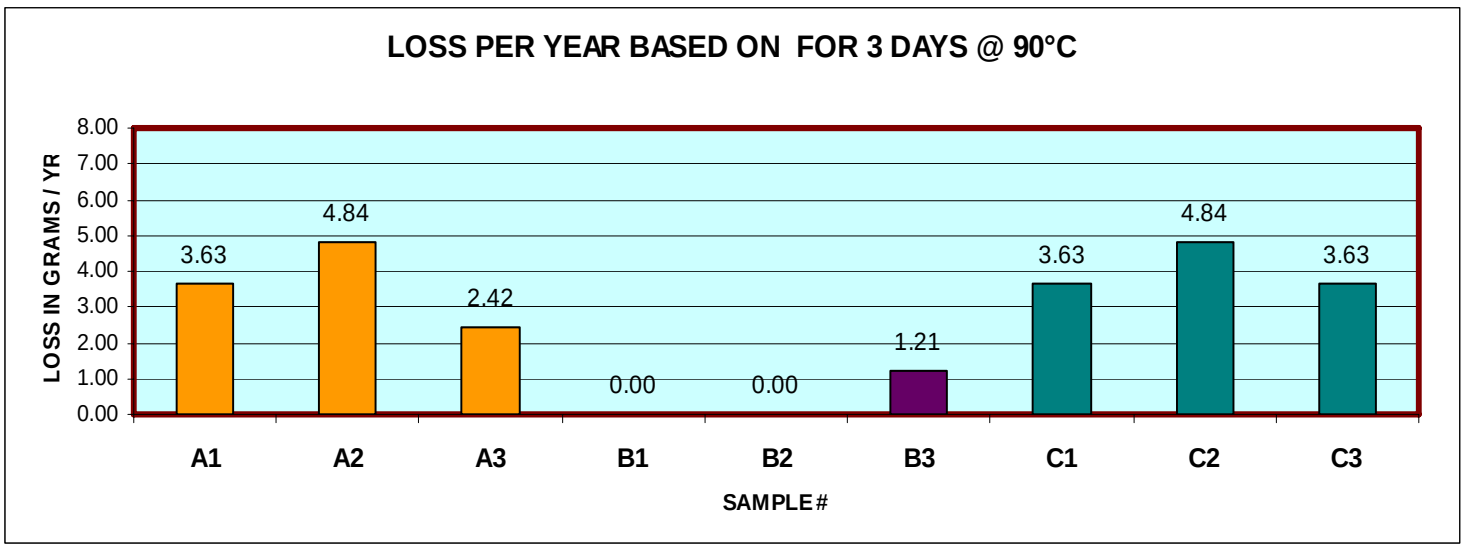






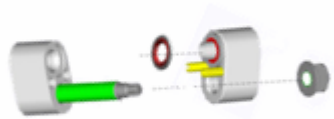
Performance Test: Weight Loss Method



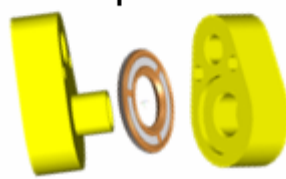


Sample A

Sample B



Sample C



Performance Test: - R134a

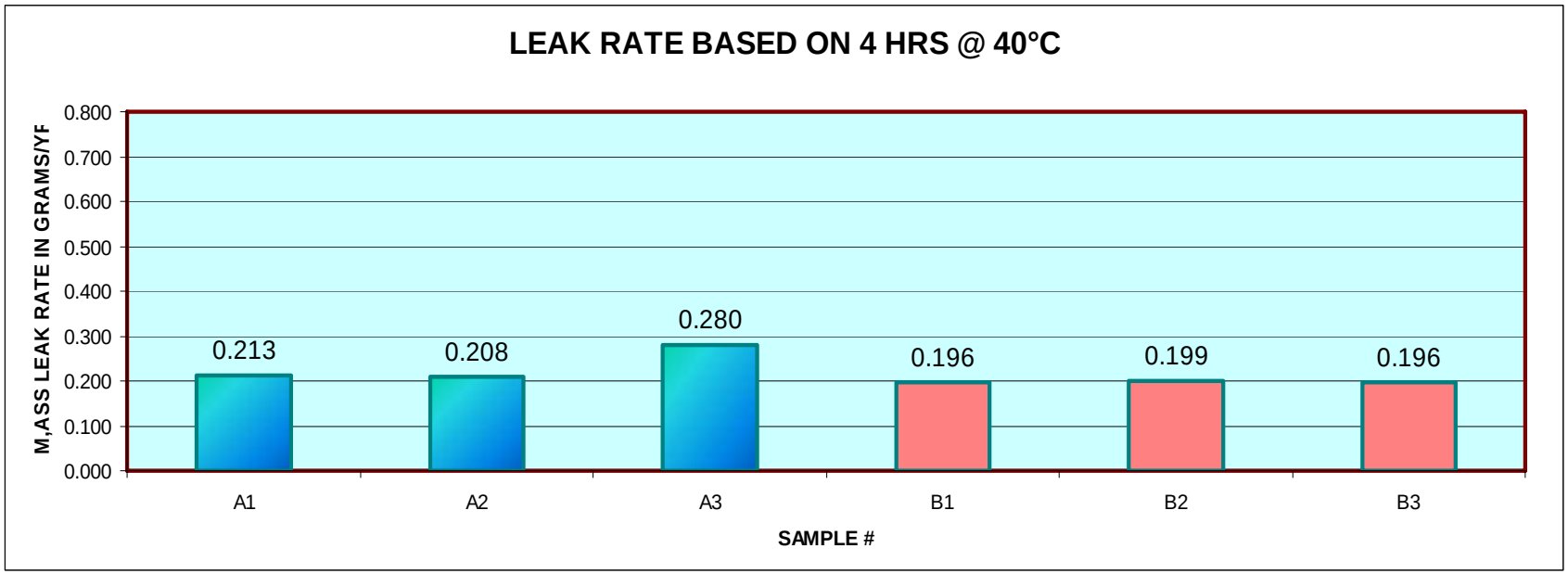
Components Testing per SAE (Pre Release) – GAS ANALYSIS METHOD

- Charge Pressure 147.5 psi @ 40°C
- Precondition joints for 96 Hrs

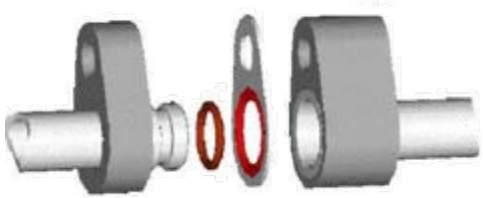
Performance Test: - RGA GAS ANALYSIS METHOD

A1, A2, A3 – Seal Washer with O ring

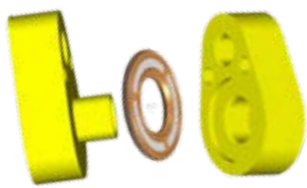
D1, D2, D3 – Dual Seal Slimline



SAMPLE A



SAMPLE B



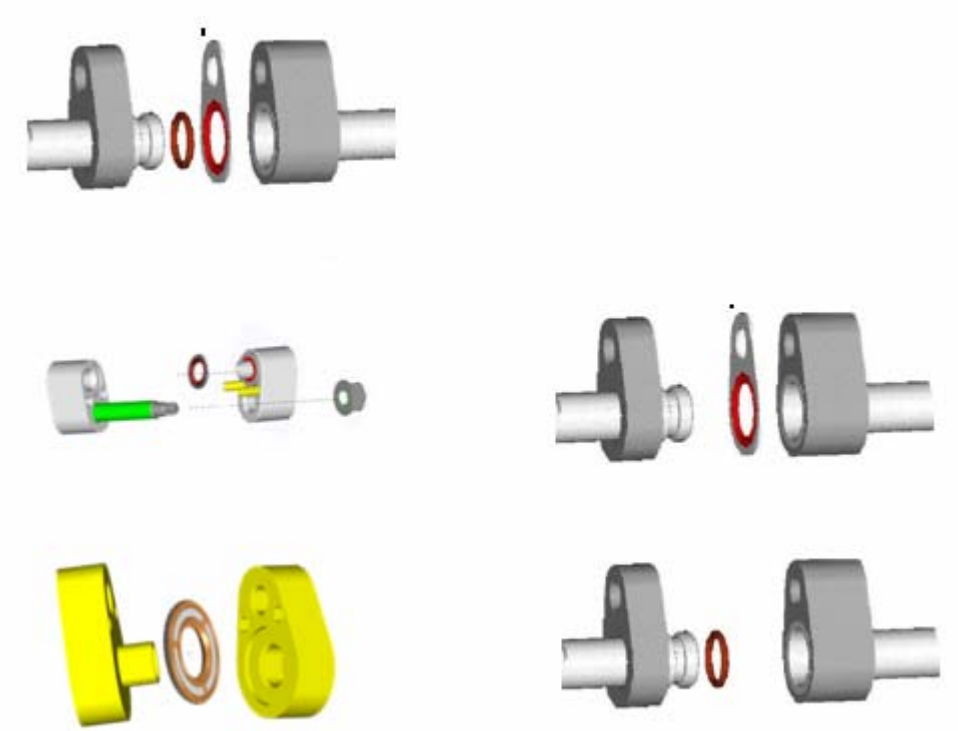
Annual emissions in grams per year using 0.526 Correction Factor for static testing

- Dual Seal slimline – 0.103 grams/yr at 40 C 4 hours
- Slimline+ O ring - .122 grams/yr at 40 C 4 hours

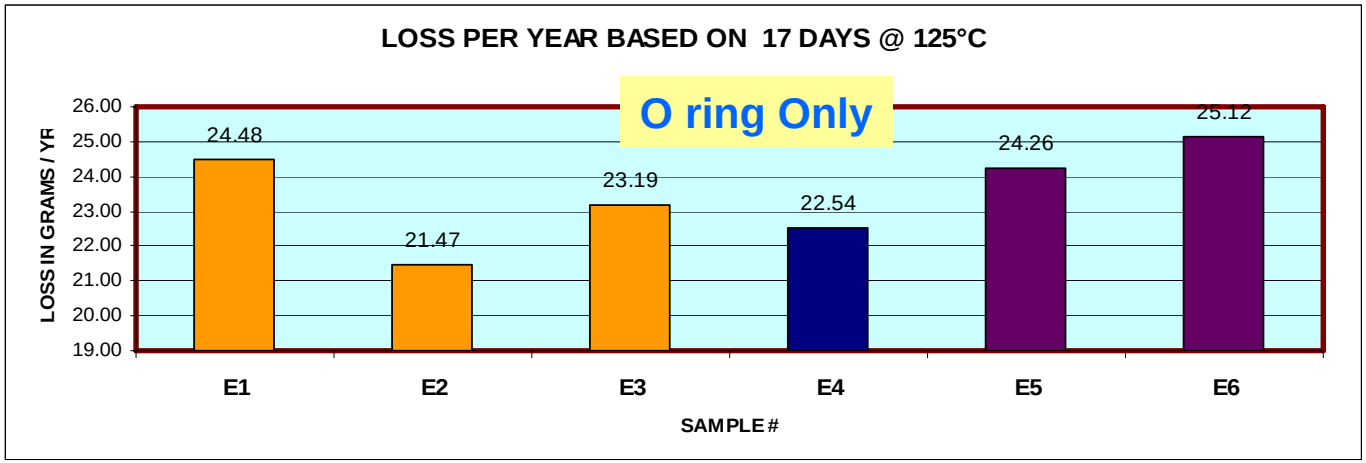
Performance Test: - RGA GAS ANALYSIS METHOD

Planned Testing: For all joints

- Continue Seal Washer + oring, Dual Seal Slimline at 50°C, 90 ° C
- Test remaining J2727 joint designs at 40°C, 50°C, 90°C

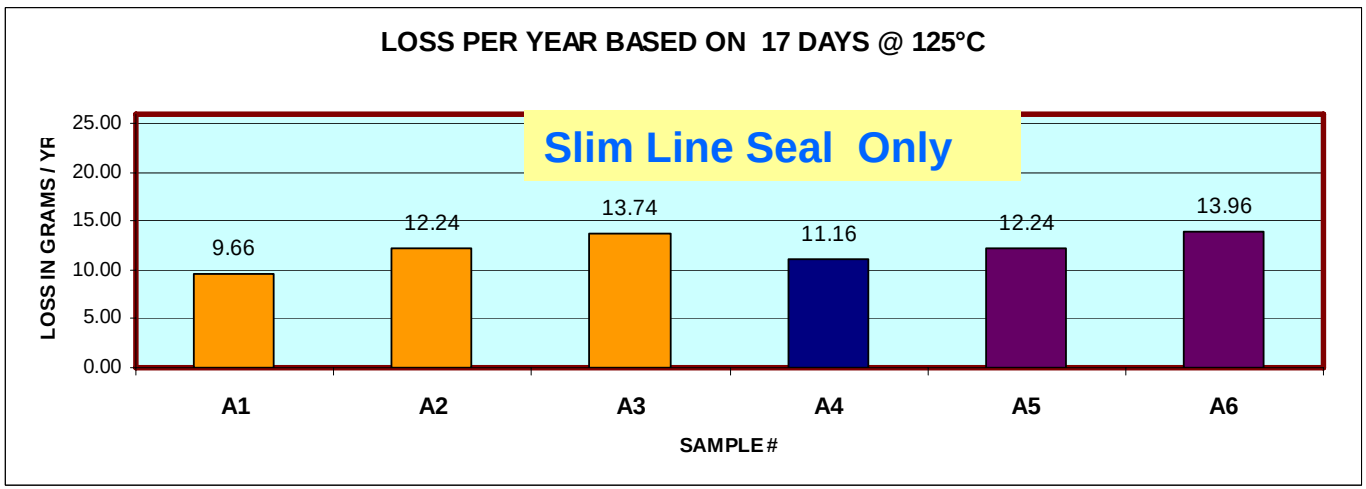


Performance Test: Weight Loss Method



Weight loss in 408 hrs

1.14
1.00
1.08
1.05
1.13
1.17



Weight loss in 408 hrs

0.45
0.57
0.64
0.52
0.57
0.65

Initial Study Conclusions

- IMAC Team 1 work suggests fittings account for roughly 30% of total system emissions
- System emissions from fittings can be reduced by greater than 50% by using dual sealing designs vs. single oring designs
- Weight loss method is a good predictor of relative comparison between seal designs and should be tested at high temperatures
- Gas analysis method is a more accurate predictor of annual refrigerant emissions
- Dual Seal slimline performance is similar to Slimline+ O ring Design
- Metal Seal testing with CO2 at 160°C provides a very low leak rate (less than 0.2 grams per year).
- Metal seal performs best with R134a (Weight Loss method) – Near zero leak