Material Compatibility of Seal Materials with Low GWP Refrigerants and Lubricant

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ABSTRACT

Elastomers and gaskets are critical materials used in the construction of heating ventilation, air conditioning and refrigeration (HVAC&R) equipment since they prevent the loss of refrigerant. These materials can take the form of O-rings, sealing rings, flat gaskets and used in fiber reinforced gaskets. Understanding of the compatibility of these materials with new low global warming potential (GWP) refrigerants and lubricants is necessary to ensure leak tight equipment operation over 10-20 years. AHRTI (Air-Conditioning Research Technology Institute), with funding from the US Department of Energy Building Technology Office, and NYSERDA (New York State Energy Research & Development Authority) sponsored the second phase of the AHRTI Project 9016 to continue the study of Low GWP (global warming potential) refrigerants. Phase II of this project expanded upon the chemical stability testing with more system materials of construction and included material compatibility of common non-metallic materials (elastomers, plastics and motor materials) used in refrigerant containing systems.

This paper will focus on the material compatibility results of elastomer and flat sheet gasket sealing materials, with R-1233zd(E) and R-1224yd(Z) with and without mineral oil, R-1336mzz(E), R-514A, R-515B, R-516A, and R-454B with and without PAG (polyalkylene glycol), POE (polyol ester), and PVE (polyvinyl ether) lubricants.

1. INTRODUCTION

A comprehensive understanding of chemical stability and material compatibility of a refrigerant and lubricant with the materials used in HVAC&R equipment is critical to ensure reliable operation over the lifetime of the equipment. Phase I of the AHRTI 9016 research program was completed in 2021 to investigate chemical and thermal stability of a wide range of new low GWP refrigerants (Sorenson et al., 2021). Based on the findings in this study, Phase II of the AHRTI 9016 research program was started in 2022, focusing on expanding the chemical stability and materials compatibility understanding of low GWP refrigerants with additional materials. Material compatibility evaluations were conducted with various elastomers, gaskets, polymers & motor materials to further characterize these refrigerant systems as part of this project.

A similar program screening material compatibility was completed under AHRI MCLR Project #08007 which assessed the compatibility of R-1234yf and R-1234ze(E) with comparable materials tested under the AHRTI 9016 test program (Majurin et al., 2014a). This study revealed that many elastomers, gaskets, and polymers that were used in HFC (hydrofluorocarbon) systems are suitable for use with low GWP HFO (hydrofluoroolefin) refrigerants; however, the project recommended additional motor material studies for R-1234ze(E) to better understand system level implications. The same recommendations were not made with R-1234yf since it showed satisfactory compatibility with all evaluated materials. AHRTI Project 9016 Phase II included assessments of 8 elastomers, 3 flat sheet gaskets, 9 polymers and 7 motor materials with HCFO (hydrochlorofluoroolefins), HFO, and HFO blended refrigerants (R-1233zd(E), R-1224yd(Z), R-514A, R-1336mzz(E), R-515B, R-516A, and R-454B and limited materials were evaluated with R-466A). Materials selected were the same or similar to materials evaluated in AHRI MCLR Project #08007. Most refrigerants were evaluated with PAG, POE, and PVE lubricants, with the exception of R-1233zd(E) and R-1224yd(Z), which were evaluated with a white naphthenic mineral oil (MO), and R-466A, which was evaluated with an additized POE. The POE was unadditized except for low levels of an antioxidant, common in synthetic lubricants, while the PVE and PAG lubricants were evaluated with additive packages designed to stabilize the lubricant with the refrigerant.

This paper will focus on the material compatibility results of seal materials, specifically elastomers and flat sheet gaskets, with R-1233zd(E) and R-1224yd(Z) with and without mineral oil, R-1336mzz(E), R-514A, R-515B, R-516A, and R-454B with and without PAG, POE, and PVE lubricants. These results will be summarized and further discussed in the AHRTI 9016 Phase II final report.

2. EXPERIMENTAL

Table 1 summarizes the times and temperatures for the exposures of these seal materials. Test conditions for the exposure of these seal materials deviate slightly from testing performed in AHRI MCLR Project #08007. Lubricant free conditions were tested at temperatures lower than the critical temperature of the refrigerant to ensure the material was fully submerged in liquid refrigerant at the test temperature. Lubricant containing conditions were tested at higher temperatures to align with previous studies of materials used in hermetic motors (Doerr and Kujak, 1993) than conditions selected in AHRI MCLR Project #08007 (Majurin et al., 2014a). Specifically, lubricant containing conditions were tested at 90°C in 2014, whereas this study conducted testing of all materials at the elevated motor material temperature of 127°C to align with studies by Doerr and Kujak in 1993.

Table 1: Refrigerant – Lubricant Test Conditions

HCFO Conditions		HFO Conditions		HFO-Containing Blend Conditions		
Description	Exposure Conditions	Description	Exposure Conditions	Description	Exposure Conditions	Nominal Composition (% wt.)
100% R-1233zd(E)	90°C 21 Days	100% R-1336mzz(E)	90°C 21 Days	100% R-514A	90°C 21 Days	R-1336mzz(Z) (74.7%) R-1130(E) (25.3%)
50% R-1233zd(E) 50% Mineral Oil	127°C 21 Days	50% R-1336mzz(E) 50% PAG Oil	127°C 21 Days	50% R-514A 50% PAG Oil	127°C 21 Days	
100% R-1224yd(Z)	90°C 21 Days	50% R-1336mzz(E) 50% POE Oil		50% R-514A 50% POE Oil		
50% R-1233zd(E) 50% Mineral Oil	127°C 21 Days	50% R-1336mzz(E) 50% PVE Oil		50% R-514A 50% PVE Oil		
		100% R-1234yf[1]	90°C 21 Days	100% R-515B	90°C 21 Days	R-1234ze(E) (91.1%) R-227ea (8.9%)
		50% R-1234yf[1] 50% POE Oil	90°C 21 Days	50% R-515B 50% PAG Oil	127°C 21 Days	
		50% R-1234yf[1] 50% PVE Oil	90°C 21 Days	50% R-515B 50% POE Oil		
		100% R-1234ze(E)[1]	90°C 21 Days	50% R-515B 50% PVE Oil		
		50% R-1234ze(E)[1] 50% POE Oil	90°C 21 Days	100% R-516A	90°C 21 Days	R-1234yf (77.5%) R-134a (8.5%) R-152a (14.0%)
		50% R-1234ze(E)[1] 50% PVE Oil	90°C 21 Days	50% R-516A 50% PAG Oil	127°C 21 Days	
				50% R-516A 50% POE Oil		
				50% R-516A 50% PVE Oil		
				100% R-454B	60°C 21 Days	R-32 (68.9%) R-1234yf (31.1%)
				50% R-454B 50% PAG Oil	127°C 21 Days	
				50% R-454B 50% POE Oil		
				50% R-454B 50% PVE Oil		

[1]Data collected in AHRI MCLR Project #08007 (Majurin et al, 2014a).

The samples selected for study are either materials that are currently in use or have been previously assessed for use in HVAC&R systems. Table 2 summarizes the seal materials selected for this work. Elastomers were received as o-rings and gaskets were received in flat sheets. All materials were exposed in their condition as received, after being cut to an appropriate size for testing. The elastomers and flat sheet gaskets were exposed to test conditions in individual test vessels, with the exception of four materials. Following the test procedure outlined in AHRI MCLR Project #08007, both neoprene materials (C0873 and C1276) and both nitrile-based materials (HNBR N1173 and NBR NA151) were exposed in the same vessel (Majurin et al., 2014a). After exposure, seal materials were evaluated for physical changes such as appearance, weight, volume, and hardness changes, and a determination of the amount of extract content was completed in lubricant free conditions.

Table 2: Materials and Testing Summary of Seal Materials

Seal Material		Appearance Change	Weight Change	Volume Change	Hardness Change	Extract Content[1]	Post-Bakeout Appearance Change	Post-Bakeout Weight Change
Elastomers	Neoprene 1 (CR 1) Parker C0873-70	X	X	X	X	X	X	X
	Neoprene 2 (CR 2) Parker C1276-70	X	X	X	X	X	X	X
	Hydrogenated Nitrile (HNBR) Parker N1173-70	X	X	X	X	X	X	X
	Acrylonitrile-Butadiene (NBR) Parker NA151-70	X	X	X	X	X	X	X
	Fluorocarbon (FKM) Parker VA075-75	X	X	X	X	X	X	X
	Ethylene Propylene Rubber (EPDM) Parker E0893-80	X	X	X	X	X	X	X
	Epichlorohydrin (ECO) Parker YB146-75	X	X	X	X	X	X	X
	Butyl Rubber (IIR) Parker B0612-70	X	X	X	X	X	X	X
Flat Gaskets	Garlock® 3300 Aramid Fibers with a Neoprene Binder	X	X	X	-	X	X	X
	Armstrong N-8092 Cellulose Fibers with a NBR Binder	X	X	X	-	X	X	X
	Klingersil® C-4401 Aramid Fibers with a Nitrile Binder	X	X	X	-	X	X	X

[1]Extract content was tested only after exposure in 100% refrigerant conditions.

3. ELASTOMER RESULTS AND DISCUSSION

Materials tested in this study were assessed and given risk levels as defined in Table 3, which are directly related to the tables published in previous literature (Majurin et al., 2014b). The authors of that study created the risk levels based on results from critical tests and experience from system applications. It is noted that, in addition to the general requirements listed in Table 3, other factors should be considered during material selection, such as application intent and other material specifications, e.g compression set and load. Other original equipment manufacturers (OEMs) and test labs may have different ranking criteria and selection processes than those reported here. A full presentation of results will be published in the AHRTI Project #9016 Phase II final report, which will provide more detail on the test results for those who would require that information to better select materials for their application. A summary of risk level results for all the materials and conditions tested in this study is provided in Table 4, while noteworthy trends and detailed results are presented in the following subsections by material. As a note, materials noted as high risk for a given attribute may also have additional attributes that would fall under medium or low risk categories.

For comparison purposes, HFO-containing blend results are compared against results for R-1234ze(E) and R-1234yf (where applicable) published in the AHRI MCLR Project #08007 report (Majurin et al., 2014a).

Table 3: Classification of elastomer materials.

Material Risk Category	Weight & Volume Change	Hardness Change	Appearance Change
High	>30% Increase or >0% Decrease	>15% (±)	Significant material changes such as cracking, crazing, or blistering
Medium	20% - 30% Increase	10% - 15% (±)	Marginal material changes such as color change or minor extractables (>5% by weight)
Low	0% - 20% Increase	0 - 10% (±)	No notable material changes

3.1 Neoprene 1 (CR1) Parker C0873

In general, minimal appearance changes were noted after exposure with the exception of the 100% R-1336mzz(E) condition, where a white residue was observed on the surface of the material; this condition also exhibited a notable extract content at 9% by weight. A few conditions were noted as medium risk due to volume swell – both mineral oil conditions, and three POE conditions (R-514A, R-516A, R-454B). All conditions tested showed minimal change in hardness with a decrease occurring in most conditions; any increases in hardness were marginal.

The blends containing R-1234yf and R-1234ze(E) showed a larger weight and volume change from control than the single components previously tested. In the lubricant containing conditions, R-1336mzz(E) and R-514A showed similar behavior in weight and volume change; however, the 100% R-514A condition showed more change than the 100% R-1336mzz(E) condition indicating the chlorinated component (R-1130(E)) in R-514A may have an impact on the compatibility of this material.

3.2 Neoprene 2 (CR2) Parker C1276

No notable appearance changes were observed with the C1276 neoprene material; however, three 100% refrigerant conditions exhibited approximately 6% by weight extract after exposure (R-1233zd(E), R-1224yd(Z), R-514A). Select conditions experienced a decrease in weight and volume after exposure resulting in a high risk classification (100% R-1336mzz(E), R-1336mzz(E)/PAG, R-515B/PAG, R-516A/PAG, R-454B/PAG). The 100% R-1224yd(Z), 100% R-515B, and 100% R-454B conditions, also high risk, showed a volume decrease, but no corresponding decrease in weight. All conditions were low risk in hardness change.

In general, R-1234yf and R-1234ze(E) blends showed a larger weight, volume, and hardness change from control when compared to the single components tested previously tested. Similar behavior of R-514A and R-1336mzz(E) was observed with the C1276 material as the C0873 material.

Table 4: Risk classification of elastomer materials with refrigerants.

Test Condition		**CR 1**	**CR 2**	**HNBR**	**NBR**	**FKM**	**EPDM**	**ECO**	**IIR**
Refrigerant	**Oil**	**C0873**	**C1276**	**N1173**	**NA151**	**VA075**	**E0893**	**YB146**	**B0612**
HCFO Refrigerants									
R-1233zd(E)	No Oil	Low	Med.[4]	High[1,2]	Med.[1,4]	High[1,2]	Low	Low	High[3]
	Mineral	Med.[2]	Low	Med.[1,2]	Med.[3]	Med.[1,2]	High[1,2,3]	Low	High[1,2,3]
R-1224yd(Z)	No Oil	Low	High[2]	High[1]	Low	High[1,2]	Low	Low	High[3]
	Mineral	Med.[2]	Low	Med.[1,2]	Low	High[2]	High[1,2,3]	Low	High[1,2,3]
HFO Refrigerants									
R-1336mzz(E)	No Oil	Med.[4]	High[1,2]	Low	Low	High[2]	Low	Low	Low
	PAG	Low	High[1,2]	Low	Low	Med.[1,2]	Low	Low	Low
	POE	Low	Low	Med.[1,2]	Low	High[1]	Low	Low	Med.[3]
	PVE	Low	Low	Low	Low	High[2]	Low	Low	High[3]
HFO Blended Refrigerants									
R-514A	No Oil	Low	Med. [4]	High[1,2]	High[1,2]	High[1,2]	Med.[1,2,3]	Med.[2]	High[3]
	PAG	Low	High[1,2]	Med.[1,2]	Low	High[2]	Low	Low	Med.[3]
	POE	Med.[2]	Low	High[1,2]	High[1,3]	High[1,2]	Med.[3]	Low	High[3]
	PVE	Low	Low	Med.[1,2]	High[3]	High[2]	Med.[3]	Low	Med.[3]
R-515B	No Oil	Low	High[2]	Low	Low	High[2]	Low	Low	Low
	PAG	Low	High[1,2]	Low	Low	Med.[2]	Low	Low	Low
	POE	Low	Low	Med.[1,2]	Low	High[2]	Low	Low	Med.[3]
	PVE	Low	Low	Low	Low	Med.[2]	Low	Low	High[3]
R-516A	No Oil	Low	Low	Low	Low	High[2]	Low	Low	Low
	PAG	Low	High[1,2]	Low	Low	Med.[2]	Low	Low	Low
	POE	Med.[2]	Low	Med.[1,2]	Low	High[1,2]	Med.[3]	Low	High[3]
	PVE	Low	Low	Low	Low	Med.[2]	Low	Low	High[3]
R-454B	No Oil	Low	High[2]	Low	Low	High[2]	Low	Low	Med.[3]
	PAG	Low	High[1,2]	Low	Low	Low	Low	Low	Low
	POE	Med.[2]	Low	High[1,2]	High[2]	High[1,2]	Med.[3]	Med.[2]	Med.[3]
	PVE	Low	Low	Low	Low	Med.[2]	Med.[3]	Low	High[3]

[1]Placed in this risk category due to weight change.
[2]Placed in this risk category due to volume change.
[3]Placed in this risk category due to hardness change.
[4]Placed in this risk category due to appearance change.

3.3 Hydrogenated Nitrile (HNBR) Parker N1173

Visual swelling was observed in several conditions, mainly conditions containing chlorinated refrigerants (R-1233zd(E), R-1224yd(Z), and R-514A) as well as all POE containing conditions; this appearance change was also accompanied by weight and volume changes resulting in a medium or high risk classification. Despite the increase in weight and volume, a minimal change in hardness was observed in these conditions. No notable appearance changes, and minimal weight, volume, and hardness changes were observed in the fluorinated refrigerants (R-1336mzz(E), R-515B, R-516A, R-454B) in both the lubricant free condition or conditions containing PAG or PVE resulting in a low risk classification.

The blends containing R-1234yf and R-1234ze(E) showed a similar weight and volume change from control than the single components previously tested. In general, R-1336mzz(E) showed much less weight, volume, and hardness change than the R-514A conditions, indicating the R-1130(E) component likely has a significant impact on the compatibility of this material.

3.4 Acrylonitrile-Butadiene (NBR) Parker NA151

The NA151 NBR material was found to have a powdery residue on the samples after exposure in all 100% refrigerant conditions; however, no notable appearance changes were observed in the lubricant containing conditions. Two refrigerants showed moderate extract (5-6% by weight) after exposure (R-1233zd(E) and R-514A).

Select conditions (100% R-1233zd(E), 100% R-514A, R-514A/POE, R-454B/POE) showed increased risk in weight and/or volume change after exposure. All conditions resulted in a decrease in hardness, however only a few conditions resulted in an increased risk (R-514A/POE, R-514A/PVE, R-1233zd(E)/MO, R-454B/POE) due to a change in hardness.

In general, single component R-1234yf and R-1234ze(E) showed less weight, volume, and hardness change than the blends tested in this study. Two exceptions are R-516A and R-515B which showed similar changes in hardness to the single components tested in 2013. The NBR material exhibited similar behavior in R-1336mzz(E) and R-514A as the HNBR material previously discussed.

3.5 Fluorocarbon (FKM) Parker VA075

In general, the fluorocarbon VA075 showed visible swelling (volume change) in nearly all conditions tested, resulting in a risk category of either medium or high; however, the only exception was R-454B/PAG, which did not experience a significant change in weight or volume and is classified as a low risk. All conditions decreased in hardness, but only the POE containing conditions decreased to medium risk levels.

The R-1234yf and R-1234ze(E) containing blends showed similar weight and volume change compared to the single components previously tested, but the blends showed less hardness change than the single components (single components were found to have high risk hardness change vs. the blends that exhibited low to medium risk). Similar results for weight, volume, and hardness change were observed between the R-1336mzz(E) and R-514A conditions.

3.6 Ethylene Propylene Rubber (EPDM) Parker E0893

The lubricant free R-1224yd(Z), R-1336mzz(E), R-515B, and R-516A conditions showed a residue on the samples after exposure, but no significant extract was collected in any test condition. The EPDM E0893 material had minor appearance changes noted apart from visual swelling (volume change) noted in select conditions (R-1233zd(E)/MO, R-1224yd(Z)/MO, 100% R-514A), see Figure 1. These conditions were accompanied by a moderate to severe increase in weight and volume, resulting in an increase in the risk classification. Most conditions resulted in a small, low risk decrease in hardness with the exception of select conditions with more significant decreases in hardness resulting in an increase in risk category (R-1233zd(E)/MO, R-1224yd(Z)/MO, 100% R-514A, R-514A/POE, R-514A/PVE, R-516A/POE, R-454B/POE, R-454B/PVE).

The R-1234yf and R-1234ze(E) containing blends performed similarly to their single components previously tested. Overall, lubricant containing R-514A and R-1336mzz(E) conditions showed similar weight, volume, and hardness changes; however, the 100% R-514A condition showed more change than the 100% R-1336mzz(E) condition indicating the R-1130(E) component likely has an impact on the compatibility of this material.

3.7 Epichlorohydrin (ECO) Parker YB146

Overall, YB146 performed the best of the elastomer types tested across all refrigerants. In general, no notable appearance changes or significant amounts of extract were observed after exposure; additionally, weight and hardness changes remained low. Only two conditions resulted in a volume increase significant enough to result in classification of medium risk (100% R-514A and R-454B/POE conditions) while remaining conditions increased <20%.

The R-1234yf and R-1234ze(E) containing blends performed similarly or better than (less change from control) their single components previously tested. Overall, lubricant containing R-514A and R-1336mzz(E) conditions showed similar weight, volume, and hardness changes; however, the 100% R-514A condition showed more change than the 100% R-1336mzz(E) condition indicating the chlorinated component (R-1130(E)) in R-514A may have an impact on the compatibility of this material.

3.8 Butyl Rubber (IIR) Parker B0612

Extreme swelling was observed in the R-1233zd(E)/MO and R-1224yd(Z)/MO conditions with the Butyl Rubber B0612 material with a weight and volume increase between 150-170% and decrease in hardness of 55% resulting in a high risk classification (Figure 1). Several other conditions also were visually swollen with a weight and volume change in the medium risk category; however, these same conditions also experienced a significant change in hardness, resulting in an overall risk assessment of high risk. In addition to moderate weight and volume change, as well as significant change in hardness, the 100% R-1233zd(E) condition also showed moderate extract at 6.5% by weight. Only select conditions (100% R-1336mzz(E), R-1336mzz(E)/PAG, 100% R-515B, R-515B/PAG, 100% R-516A, R-516A/PAG, R-454B/PAG) were determined to be low risk conditions for this material.

Overall, R-1234yf and R-1234ze(E) containing blends behaved similarly to the single components previously. The R-1336mzz(E) and R-514A conditions behaved differently in all conditions except for the PVE conditions, where they showed similar changes.

Figure 1. Example of swelling observed in EPDM (left) and IIR (right) after exposure to R-1233zd(E)/MO. For reference, unexposed material is on the left in each photograph.

4. FLAT SHEET GASKET RESULTS AND DISCUSSION

Similar to the elastomer materials, the gaskets tested in this study were assessed and given risk levels as defined in Table 5. All risk levels for the materials and conditions tested in this study are summarized in Table 6, while noteworthy trends and results are discussed in the following subsections.

For comparison purposes, HFO-containing blend results are compared against results for R-1234ze(E) and R-1234yf (where applicable) published in the AHRI MCLR Project #08007 report (Majurin et al., 2014a).

Table 5: Classification of gasket materials.

Material Risk Category	Weight & Volume Change	Appearance Change
High	>25% Increase or >0% Decrease	Significant material changes, such as delamination
Medium	20% - 25% Increase	Marginal material changes such as color change or minor extractables (>5%)
Low	0-20% Increase	No notable material changes

4.1 Garlock® 3300

In most Garlock® 3300 conditions, no notable material changes or extract were observed after exposure with the exception of the 100% R-454B and R-454B/POE conditions which showed blistering after exposure on at least one of the three replicates tested, and therefore was categorized as high risk. All weight and volume changes were determined to be low risk. It was observed that all gaskets tested in a lubricant containing condition generally showed much higher weight and volume change than the 100% refrigerant exposure, however, based on observations recorded with 100% lubricant exposures in AHRI MCLR Project #08007 (Majurin et al., 2014a), this is likely due to the lubricant saturating the gasket material; this was not confirmed with physical testing as part of this study. Additionally, the fact that post-bakeout weights of gaskets exposed to lubricant remain elevated also suggests that the lubricant entrained in the gasket is the reason for higher weight and volume change, as seen in Figure 2.

R-1234yf and R-1234ze(E) containing blends also showed similar changes to their single components previously tested. Additionally, R-514A and R-1336mzz(E) showed similar changes.

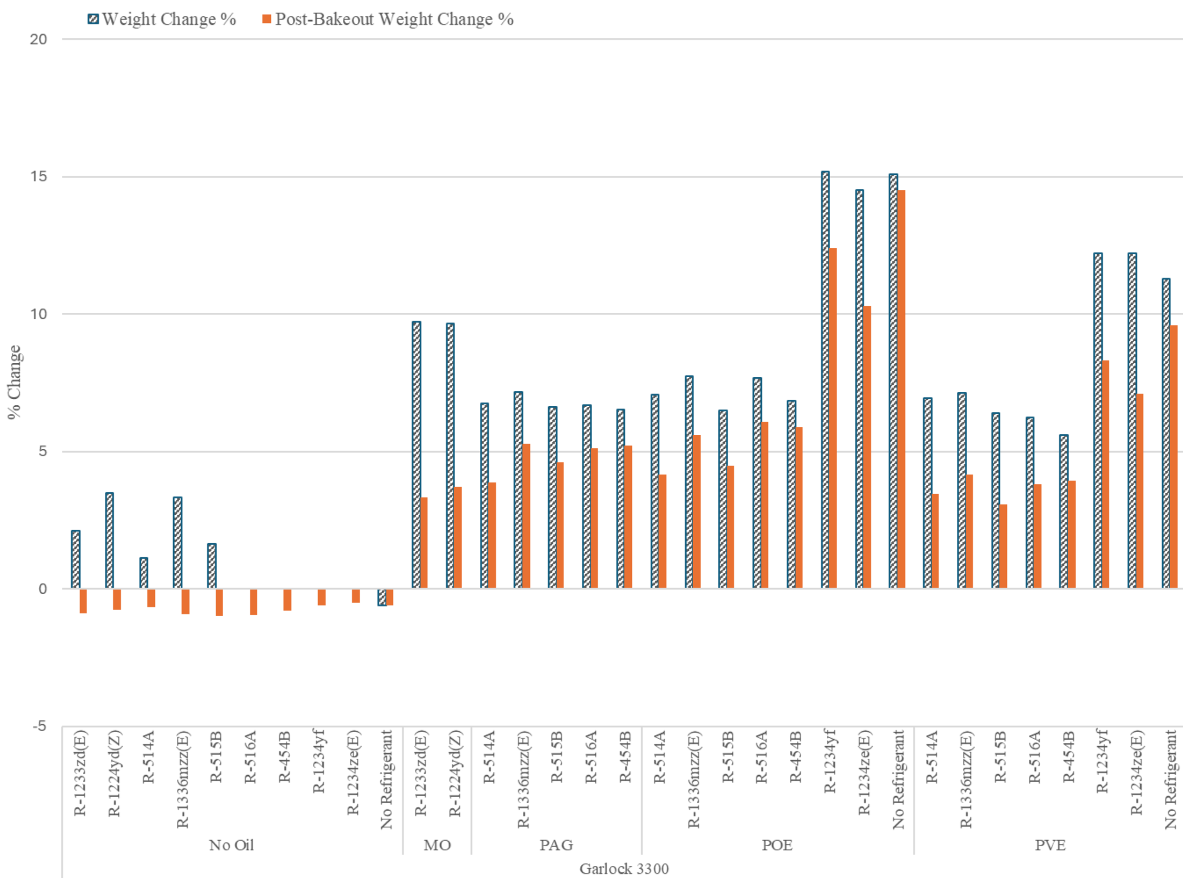

Figure 2. A graphical comparison of post-exposure weight change and post-bakeout weight change.

4.2 Armstrong N-8092

The Armstrong N-8092 gasket material showed an orange/brown discoloration along the edges of the samples in mineral oil containing conditions, otherwise, there were no notable appearance changes or extract observed after exposure in the remaining conditions. All lubricant free conditions were categorized as high risk due to a decrease in weight change; additionally, the R-1233zd(E), R-1224yd(Z), and R-1336mzz(E) lubricant free conditions also exhibited decreases in volume change (high risk). All lubricant containing conditions were categorized as high risk due to the increase in volume change; however, this increase is likely due to lubricant absorption into the material.

In most cases, R-1234yf and R-1234ze(E) blends showed similar results to single components previously tested, with the exception of the lubricant free conditions. Previously, single component testing showed decreases in volume, whereas the blends showed slight increases in volume in this study. It was concluded in the previous study (Majurin et al., 2014a) that the Armstrong N-8092 was the only gasket material to show high risk weight and volume change behavior. That study performed testing in 100% POE and 100% PVE conditions and found similar high risk weight and volume change results to conclude that the refrigerant was likely not responsible for the increases in weight and volume. Although 100% PAG was not tested for this study, it can be assumed that the increases seen in the PAG condition are also due to the presence of the lubricant versus an impact of the refrigerant.

4.3 Klingersil® C-4401

In most Klingersil® C-4401 conditions, no notable material changes or extract were observed after exposure with the exception of the R-516A/PAG, R-516A/POE, R-454B/POE, and R-454B/PVE conditions which showed blistering after exposure, and therefore were categorized as high risk. All weight and volume changes were noted to be low risk, with the exception of the 100% R-516A condition which exhibited a weight decrease of approximately 1%, which is considered high risk per Table 5.

Overall, no significant differences were noted between R-1234yf and R-1234ze(E) blends and their single components when compared to previous test data. Additionally, no differences were noted between R-514A and R-1336mzz(E) test conditions.

Table 6: Risk classification of flat sheet gaskets with refrigerants.

Test Condition		**Garlock® 3300**	**Armstrong N-8092**	**Klingersil® C-4401**
Refrigerant	**Oil**			
HCFO Refrigerants				
R-1233zd(E)	No Oil	Low	High[1,2]	Low
	Mineral	Low	High[2]	Low
R-1224yd(Z)	No Oil	Low	High[1,2]	Low
	Mineral	Low	High[2]	Low
HFO Refrigerants				
R-1336mzz(E)	No Oil	Low	High[1,2]	Low
	PAG	Low	High[2]	Low
	POE	Low	High[2]	Low
	PVE	Low	High[2]	Low
HFO Blended Refrigerants				
R-514A	No Oil	Low	High[1]	Low
	PAG	Low	High[2]	Low
	POE	Low	High[2]	Low
	PVE	Low	High[2]	Low
R-515B	No Oil	Low	High[1]	Low
	PAG	Low	High[2]	Low
	POE	Low	High[2]	Low
	PVE	Low	High[1,2]	Low
R-516A	No Oil	Low	High[1]	High[1]
	PAG	Low	High[2]	High[3]
	POE	Low	High[2]	High[3]
	PVE	Low	High[2]	Low
R-454B	No Oil	High[3]	High[1]	Low
	PAG	Low	High[2]	Low
	POE	High[3]	High[1,2]	High[3]
	PVE	Low	High[2]	High[3]

[1]Placed in this risk category due to weight change.
[2]Placed in this risk category due to volume change.
[3]Placed in this risk category due to appearance change.

5. CONCLUSIONS

Elastomers and flat gaskets were tested to identify material compatibility concerns of materials typically used in HVAC construction. They were tested with refrigerants R-1233zd(E), R-1224yd(Z), R-514A, R-1336mzz(E), R-515B, R-516A, and R-454B with and without lubricant. Risk criteria were determined and applied to each test condition. All materials tested (Neoprenes 1 & 2, HNBR, NBR, FKM, EPDM, ECO, IIR, Garlock® 3300, Armstrong N-8092, and Klingersil® C-4401) were found to have medium risk behavior in at least one condition tested. Overall, the ECO elastomer and the Garlock® 3300 gasket performed the best across all refrigerants when compared against similar material types. Additionally, comparisons were made between test results from R-514A and R-1336mzz(E) containing conditions, where it was found that most elastomers showed more property changes in the lubricant free condition of R-514A, suggesting that lubricant reduces interactions between elastomers and R-

1130(E). Similar comparisons were made between R-1234yf and R-1234ze(E) containing blends and the results of the single components tested in AHRI MCLR Project #08007. It was found that in most cases for elastomers and gaskets, the blended refrigerants showed similar or better performance than the single components previously tested. The results suggest that seal materials in HVAC construction should be properly assessed for their application before use with these low GWP refrigerants.

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NOMENCLATURE

Med.	Medium Risk

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