(Note: This article was originally posted by **bunny** on HVAC-Talk.com on 6/5/2018)

There is definitely a lot of misinformation regarding R-22 replacements.

First, it should be noted that most of the R-22 replacements are NOT being used by OEMs for new equipment. This should be an indicator of what the industry thinks about which refrigerants are considered to be long term viable options. R-407A, R-407C, R-448A/R-449A, and to a lesser degree R-407F are the only R-22 replacements you'll see OEMs using.

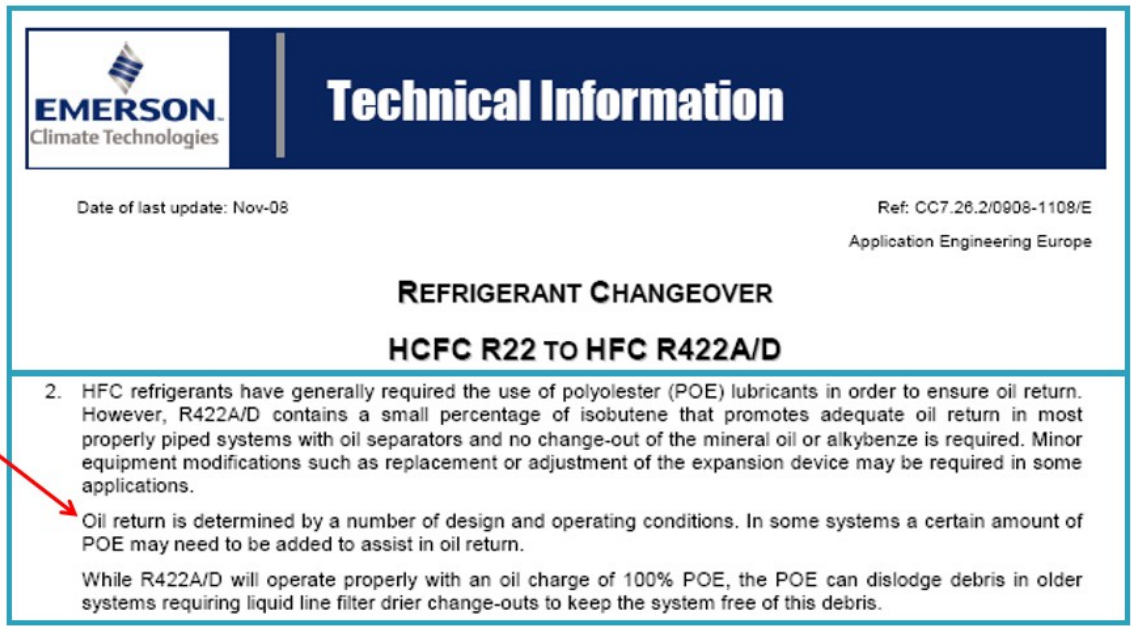
The first chart below shows the chemical composition of the various replacements that are available.

	Blend Component	Refrigerant (ASHRAE Number & GWP)																				
		HFC Blend Options																HFO-HFC Blend Options				
		R-32	R-404A	R-407A	R-407C	R-407F	R-410A	R-417A	R-421A	R-422A	R-422B	R-422D	R-424A	R-427A	R-428A	R-434A	R-438A	R-507	R-448A	R-449A	R-452B	R-454B	R-513A
		677	3943	1923	1624	1674	1924	2346	2600	3143	2525	2729	2440	2138	3607	3245	2265	3985	1273	1282	676	467	573
HFC	R-32 (677)	100.0%		20.0%	23.0%	30.0%	50.0%							15.0%			8.5%		26.0%	24.0%	67.0%	68.9%	
HFC	R-125 (3170)		44.0%	40.0%	25.0%	30.0%	50.0%	46.6%	58.0%	85.1%	55.0%	65.1%	50.5%	25.0%	77.5%	63.2%	45.0%	50.0%	26.0%	25.0%	7.0%		44.0%
HFC	R-134A (1300)		4.0%	40.0%	52.0%	40.0%		50.0%	42.0%	11.5%	52.0%	31.5%	47.0%	50.0%		18.0%	44.2%		21.0%	26.0%			
HFC	R-143A (4800)		52.0%											10.0%	20.0%	16.0%		50.0%					
HFO	R-1234YF (HFO) (4)																		20.0%	25.0%	26.0%	31.1%	56.0%
HFO	R-1234ZE (HFO) (6)																		7.0%				
HYDROCARBON COMPONENT	R-290 Propane														0.6%								
HYDROCARBON COMPONENT	R-601 NButane												1.0%				1.7%						
HYDROCARBON COMPONENT	R-600A IsoButane							3.4%		3.4%	3.0%	3.4%	0.9%		1.9%	2.8%							
HYDROCARBON COMPONENT	R-601A IsoPentane												0.6%				0.6%						

They can be broken down into 3 groups:

(1) HFC blends with a hydrocarbon component. HFCs are not miscible with mineral oil. While it's true that in some systems, with very simple piping arrangements (typically self contained package units), HFC systems will operate OK with mineral oil. But this goes against all compressor manufacturer's recommendations. There will likely be major oil return problems when the system has a receiver, and/or the piping is complex. The hydrocarbon component assists in the mineral oil returning to the compressor when used with an HFC.

It is of interest to note that Copeland recommends POE to be used in refrigeration applications with HFC_Hydrocarbon blends when using their compressors. I personally worked with Wal*Mart when they were using R-422D (with mineral oil) as an R-22 replacement, and experienced oil logging in the glass door freezers. Copeland's recommendation was to add 5% to 10% POE to the mineral. It serves the same function as the hydrocarbon component, and alleviated the oil logging issues.



EMERSON Climate Technologies

Technical Information

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Application Engineering Europe

REFRIGERANT CHANGEOVER

HCFC R22 TO HFC R422A/D

2. HFC refrigerants have generally required the use of polyolester (POE) lubricants in order to ensure oil return. However, R422A/D contains a small percentage of isobutene that promotes adequate oil return in most properly piped systems with oil separators and no change-out of the mineral oil or alkybenze is required. Minor equipment modifications such as replacement or adjustment of the expansion device may be required in some applications.

Oil return is determined by a number of design and operating conditions. In some systems a certain amount of POE may need to be added to assist in oil return.

While R422A/D will operate properly with an oil charge of 100% POE, the POE can dislodge debris in older systems requiring liquid line filter drier change-outs to keep the system free of this debris.

Many of the HFC blends with HC component have a capacity loss compared to R-22....some, a very significant capacity loss.

(2) HFC blends without the hydrocarbon component. While some refrigerant manufacturers will advertise that their HFC (without HC component) can be used with mineral oil, there is really no scientific basis to substantiate this claim, as again...the HFCs are not miscible with mineral oil. But, in simple piping arrangements (self contained package units), you might be lucky enough to cheat the science and get away with it. I know several contractors who will add 5% to 10% POE to the mineral oil when doing an HFC (without HC component) retrofit, and this seems to alleviate the oil return issues (per Copelands suggestion above).

(3) HFC-HFO blends. The main benefit here is that some portion of the R-134A (1300 GWP) component of the blend has been replaced with either Y-1234YF (4 GWP) and/or Y-1234ZF (6 GWP). There's no performance benefit from this component change...only a reduction in GWP. So, if you or your customer has GWP as their main driver in determining the R-22 replacement, then this might be your choice. All of these HFC-HFO blends are under patent, which means their distribution is more limited. Only Honeywell distributors will have R-448A, and only Chemours (DuPont) distributors will have R-449A. Also, being under patent, they will be more expensive.

There is so much information available online about R-22 replacements, one should always do the research to verify if your supplier/salesman/manufacturer's rep is telling the truth, or bending the truth to get "the sale".

Some of the important things to look into, when considering which replacement you should use, are:

(1) Capacity vs R-22. Especially, if the system is barely holding temperature when using R-22, you don't want to choose a replacement that is going to result in a

serious capacity loss.

The charts below show some of the common R-22 replacements, and their capacity (vs R-22), mass flow (vs R-22) and efficiency (vs R-22).

R-22 Replacements – MT Refrigeration

Refrigerant	Trade Name	Capacity Relative to R-22	Mass Flow Relative to R-22	Efficiency Relative to R-22	Recommended Lubricant Type
R-404A	HP62, FX-70	102%	143%	91%	POE
R-407A	Klea 60	103%	112%	96%	POE
R-407C	Suva 9000	99%	99%	97%	POE
R-407F	Performax LT	107%	110%	96%	POE
R-417A	MO59, NU22	81%	106%	95%	MO, AB, POE
R-421A	Choice	84%	117%	94%	MO, AB, POE
R-422A	MO79, OneShot	98%	163%	89%	MO, AB, POE
R-422B	NU22B	85%	116%	94%	MO, AB, POE
R-422C	One Shot B	97%	157%	90%	MO, AB, POE
R-422D	MO79	89%	129%	92%	MO, AB, POE
R-422E		87%	121%	91%	MO, AB, POE
R-424A	RS-44	82%	109%	95%	MO, AB, POE
R-427A	FX-100	94%	100%	97%	POE
R-428A	RS-52	104%	170%	88%	MO, AB, POE
R-434A	RS-45	96%	141%	91%	MO, AB, POE
R-438A	MO99	90%	107%	96%	MO, AB, POE
R-507A	AZ-50	103%	150%	90%	POE

105 F Cond / 20 F Evap / 20 F Subcool / 10 F Superheat

R-22 Replacements – LT Refrigeration

Refrigerant	Trade Name	Capacity Relative to R-22	Mass Flow Relative to R-22	Efficiency Relative to R-22	Disch Temp Relative to R-22	Recommended Lubricant Type
R-404A	HP62, FX-70	95%	143%	85%	-112°F.	POE
R-407A	Klea 60	95%	105%	93%	-61°F.	POE
R-407C	Suva 9000	91%	92%	95%	-48°F.	POE
R-407F	Performax LT	101%	101%	94%	-38°F.	POE
R-417A	MO59, NU22	72%	99%	90%	-116°F.	MO, AB, POE
R-421A	Choice	74%	109%	89%	-107°F.	MO, AB, POE
R-422A	MO79, OneShot	89%	160%	82%	-126°F.	MO, AB, POE
R-422B	NU22B	75%	108%	88%	-109°F.	MO, AB, POE
R-422C	One Shot B	87%	152%	83%	-124°F.	MO, AB, POE
R-422D	MO79	79%	123%	86%	-115°F.	MO, AB, POE
R-422E		77%	115%	87%	-111°F.	MO, AB, POE
R-424A	RS-44	72%	102%	89%	-75°F.	MO, AB, POE
R-427A	FX-100	86%	94%	94%	-64°F.	POE
R-428A	RS-52	97%	170%	81%	-125°F.	MO, AB, POE
R-434A	RS-45	87%	137%	85%	-91°F.	MO, AB, POE
R-438A	MO99	81%	100%	94%	-112°F.	MO, AB, POE
R-507A	AZ-50	97%	150%	85%	-88°F.	POE

105 F Cond / -20 F Evap / 10 F Subcool / 10 F Superheat

R-404A has great capacity compared to R-22 (in a MT application). But the 43% increase in mass flow guarantees a TEV replacement, and possibly a distributor nozzle replacement.

R-407F has good capacity vs R-22. It is marketed as the R-22 replacement that most closely resembles R-22....for good and for bad. It has the highest discharge temperature of all of the R-22 replacements on the chart (including R-407A and R-407C). There will be times during the summer months when the demand cooling will be in use, which will require compressor capacity to operate. This is a negative hit on the overall capacity vs R-22 during that time of the year when you need all available capacity.

The lower the SST, the greater the difference in capacity between a given blend and R-22 becomes. For example, R-417A has a 19% capacity loss vs R-22 in a MT application. That becomes a 28% capacity loss in a LT application. Really, neither of these applications are suitable for R-417A because of the great capacity loss.

Some have reported satisfaction with R-438A as a replacement. However; in MT/LT applications, it will have a respective 10%/19% capacity loss. Again, if there's extra compressor capacity, maybe this isn't an issue. But one should know the facts before diving in.

(2) Mass flow vs R-22. As the mass flow increases (vs R-22), eventually you reach a point where the R-22 TEV is no longer capable of providing the necessary capacity to

meet the load demand. At this point, a TEV replacement is required. In some cases, a distributor nozzle replacement is required too. Not only does this make the conversion more complicated and more time consuming, it is more expensive for your customer.

And, there's no rule of thumb as to what percentage increase in mass flow requirement of the replacement will require a TEV replacement. Why....cause it all depends on what TEV the original application engineer selected to be used with R-22. For example, in some Wal*Mart conversions I assisted with, there were some stores that had 2 ton valves in a particular model of dairy case, and others that had 3 ton valves in the same model of dairy case. And this is only one example. If the mass flow is of any significant increase compared to R-22, you really need to verify the capacity of the existing TEV with the new refrigerant....assuming can be a potential problem here. In addition, some of these R-22 replacement will require an R-404A TEV element...another thing to consider.

Below is a chart that assumes the 10 ton R-22 AC application is undergoing a refrigerant conversion. There are several R-22 replacements listed, and each shows the capacity of the original 10 ton R-22 TEV with the potential R-22 replacement. R-407A and R-407C have similar mass flow requirements to R-22, and both utilize the R-22 element...so, the TEV will perform fine with both. All of the other refrigerants have a greater mass flow requirement than R-22, and will require a TEV replacement.

R-434A utilizes an R-404A element. So, in addition to the existing R-22 TEV being seriously undersized, requiring replacement, the replacement TEV will need to be selected with the correct element.

R-438A is an interesting situation. It's mass flow requirement is greater than R-22, but less than the other refrigerants listed. This is where it becomes important to not assume, and actually check the existing TEV, and see how the capacity changes with the new refrigerant. If the original application engineer had selected a 12 ton R-22 valve, it would have been slightly oversized, but still would have been able to accurately control superheat. But the 12 ton valve would have sufficient capacity to allow its use with R-438A.

Thermostatic Expansion Valve Selection									
120,000 Btu Evaporator 45F SST / 105 SCT 100F Liquid Temp	**R-22**	**R-407A**	**R-407C**	**R-417A**	**R-421A**	**R-422B**	**R-424A**	**R-434A**	**R-438A**
TEV Selection (Using R-22 Dist/Nozzle)	OVE-10	OVE-10	OVE-10	OVE-10	OVE-10	OVE-10	OVE-10	OVE-10	OVE-10
Thermostatic Element Replacement Required?	-----	No	No	No		No		Yes	No
New Element (if required)	-----	-----	-----	-----	-----	-----	-----	SCP100	-----
Nominal TEV Capacity after Element Replacement	-----	-----	-----	-----	-----	-----	-----	6 Ton	-----
% Rated Capacity at 105F Condensing	99%	99%	92%	150%	151%	155%	151%	188%	123%
Valve Replacement Required?	-----	No	No	OVE-15	OVE-15	OVE-15	OVE-15	OSE-12	OVE-15

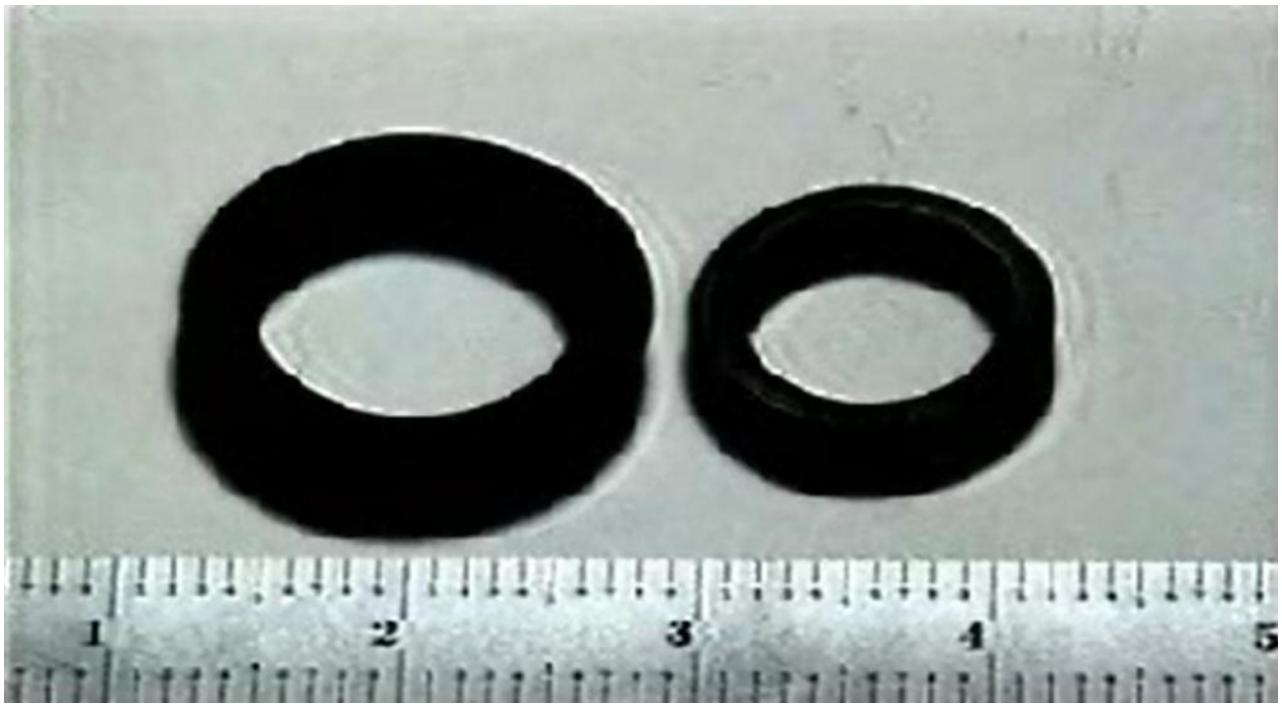
(3) Efficiency. This may not be a really big deal in a smaller package unit, or smaller split system. In a multi-compressor supermarket application, this could amount to a significant increase in power consumption if a refrigerant with substantial efficiency loss is chosen.

(4) Price and availability. Some of these blends have been out of patent for years (Such as R-407A and R-407C, which were introduced when R-502 was phased out). They are widely distributed, and very economically priced. Others blends which are still under patent (such as R-438A, or R0407F) are still under patent. They will not be as widely available, and will be more expensive.

(5) It's always a good indicator to see what the industry is doing. The majority of supermarkets are using R-407A for conversions, and for new installations. There is some activity with R-448A, and a lesser amount of activity with R-449A. These are primarily GWP driven choices. There are only a handful of markets using R-407F. I know of no major supermarket chains that are using any of the other refrigerants listed on the chart above for conversions, or new stores. As such, Copeland and Carlyle have approved the use of their compressors for this small handful of refrigerants. Not to say that their compressors wouldn't work with the other refrigerants on the chart....but there's been no testing done by either compressor manufacturer, so you have no idea what the actual compressor capacity will be with the other replacement refrigerants.

Regarding comfort cooling applications, R-407C seems to be the predominant choice. All of the major AC manufacturers (perhaps more so for the oversees market) are manufacturing R-407C equipment. Liebert has been using R-407C for years. There is certainly a smattering of other choices being used for comfort cooling conversions, but R-407C seems to be the majority choice.

(6) Seals: The photo below is from a video that DuPont released several years ago. The elastomer seal on the right is brand new. The seal on the left is identical to the seal on the right, except it's been soaked in R-22 for 24 hours. As many have posted, R-22 causes elastomer seals to swell. Elastomer seals swell in the presence of other refrigerants too, but not as much as in chlorinated refrigerants such as R-22. So, when you remove the R-22, and replace it with a non-chlorinated refrigerant, essentially the elastomer seal will shrink.

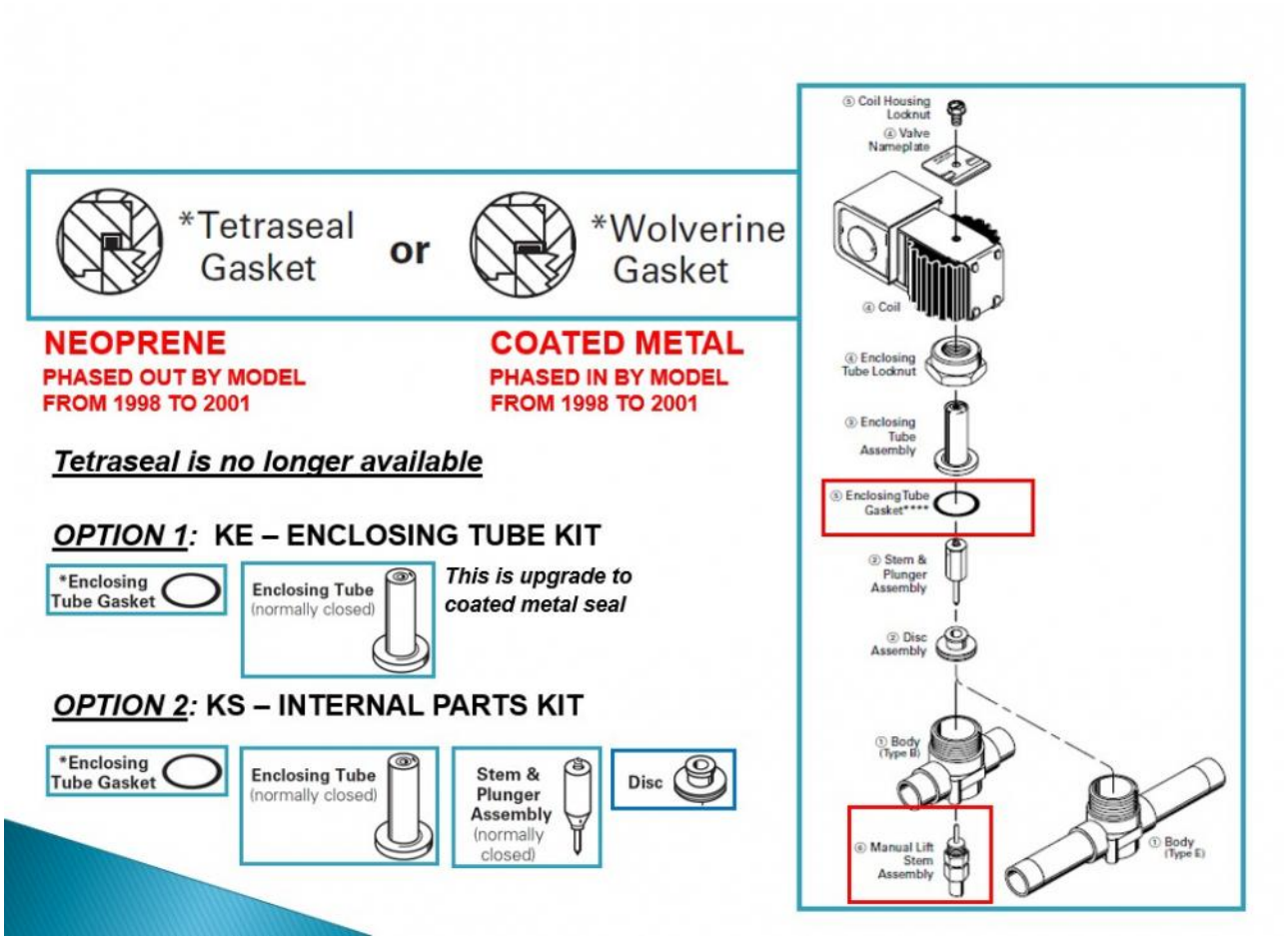


The swell issue is only part of the problem. The photo below compares a new O-Ring with an older O-Ring, which has been compressed, hardened from heat, and taken a set between the two mating seal surfaces, for in some cases years. Add the fact that the seal will "shrink" with the replacement refrigerant, and you have a good potential for a leak. There were several occasions when WM techs would come in the day after a conversion and find liquid dripping out of valves, due to this elastomer issue.

There were some that had questions about the Sporlan solenoids with Wolverine gaskets (PS....loved the wolverine photos!).

The older solenoid valves used a tetra-seal, which could be best described as an elastomer O-Ring with square sides. It fit into a groove in the brass bottom surface of the enclosing tube assembly that mates to the solenoid valve body. Between 1998 and 2001, all of their solenoid valves were upgraded to the Wolverine gasket...a rubberize metal gasket. Since they're not made of an elastomer, they will not suffer the same swell_shrink issue that elastomers will. Checking the valve's date code will verify whether the seal needs replacement or not.

If it's an older version with the tetraseal, these seals are no longer available. But you can upgrade the valve to the style seal by replacing the existing enclosing tube assembly with a new enclosing tube assembly.



Finally, here's a current bulletin from Sporlan that shows the parts kits and gasket kits for various valves that should be reworked during a refrigerant conversion.

http://sporlanonline.com/literature/misc/122-10 Replacement Parts for Refrig Retrofit.pdf