DuPont™ Suva®
refrigerants

ART-25

Retrofit Guidelines for HFC-23

Introduction

HFC-23 refrigerant (also known as Freon® 23) is a commercially available, CFC-free alternative to R-503 and R-13. Because R-503 and R-13 are ozone depleters (both contain chlorine), they will be phased out as part of the Montreal Protocol and U.S. Clean Air Act. HFC-23 does not contain chlorine and therefore has a zero Ozone Depletion Potential (ODP).

This bulletin will outline the procedure needed to retrofit existing equipment from R-503 and R-13 to HFC-23.

To retrofit the high side of a cascade, please refer to DuPont technical bulletin ART-9 and ART-22 if R-502 is being used, or ART-5 and ART-16 if R-12 is present.

There are significant differences in performance between HFC-23, R-13, and R-503. For reference, please review DuPont technical bulletin ART-21. ART-21 outlines the expected performance of equipment retrofitted to HFC-23 as well as important physical properties. An abbreviated physical property and operating performance table is shown below.

Table 1
HFC-23 Physical Properties and Operating Performance

Physical Property	Units	HFC-23	R-503	R-13
Boiling Pt @ 1 atm	°C °F	–80.01 –115.7	–88.7 –127.6	–81.4 –114.6
Critical Temperature	°C °F	25.8 78.5	19.4 67.0	28.8 83.9
Critical Pressure	kPa psia	4820 701.4	4330.9 627.4	3872.6 561
Sat'd Liquid Density @ –29°C (–20°F)	kg/cu m lb/cu ft	1217 75.98	1228 76.68	1293.3 80.71
Sat'd Vapor Density @ –29°C (–20°F)	kg/cu m lb/cu ft	44.1 2.75	68.7 4.29	53.4 3.33
Vapor Pressure @ 25°C (77°F)	kPa psia	4728.6 685	NA NA	3603.4 522
Capacity*	% R-503	80	100	68
Suction/Discharge Temperature*	°C °F	–84.4/28 –120/82	–84.4/3.3 –120/38	–84.4/8.3 –120/17
Compression Ratio*	—	10.5	8.5	9.25
Coefficient of Performance*	% R-503	101	100	104

*Evaporator Temperature = –84.4°C (–120°F); Condenser Temp = –33°C (–27°F); No superheat or subcooling.

Overview of Retrofit Process

Retrofit of existing R-503 and R-13 systems with HFC-23 can be accomplished using service practices and equipment commonly used by trained mechanics or service contractors.

The key steps are:

1. Establish system baseline performance with R-13 or R-503.
2. Recover R-13 or R-503 from the system.
3. Remove mineral oil or alkylbenzene lubricant from the compressor and oil separator.
4. Charge with new lubricant.
5. Replace filter drier.
6. Evacuate system.
7. Charge system with HFC-23.
8. Start up system and adjust charge and/or controls to achieve desired operation.

Retrofit Procedure

Prior to the retrofit, review HFC-23's Material Safety Data Sheets for safety information on the use of HFC-23.

1. **Establish Baseline Performance.** It is important to establish baseline performance before the retrofit. Frequently, problems existing before the retrofit are aggravated upon changeout of the refrigerant.

   A suggested baseline system data sheet is attached.

2. **Recover R-13 or R-503 Charge.**

   Note: Before removing the CFC charge, determine whether the compressor can be isolated, i.e., does it have service valves? If it does, go to step 3.

   R-13 and R-503 should be removed from the system and collected in a recovery cylinder using a recovery device capable of handling high pressure refrigerants. Measure the static pressure before removal. The static pressure will be used to charge HFC-23.

3,4. **Remove Lubricant from Compressor and Charge with New Lubricant.** If the existing lubricant is mineral oil or alkylbenzene, it will be necessary to remove 95% or more of the existing oil and replace it with a polyol ester (POE) such as Mobil Arctic® EAL™ 22 or CPI® Engineering Solest® LT32. This is necessary because HFC-23 is not miscible (soluble) with mineral oil or alkylbenzene. Failure to remove a significant portion of the old oil may result in poor heat transfer in the evaporator and condenser, as well as poor compressor lubrication. Consult with the OEM for specific lubricant recommendations.

Compressor Can Be Isolated

To remove the lubricant, the following procedure may be followed if the compressor can be isolated.

- Isolate compressor from system.
- Remove lubricant from crankcase. Measure the volume of lubricant removed.
- Remove lubricant from the oil separator and suction line accumulator if possible. Measure the volume of oil removed.
- Add polyol ester lubricant equal to the volume of oil removed.
- Close compressor crankcase port and evacuate compressor to full vacuum.
- Open compressor to the system and start up.
- Allow system to run long enough to mix the POE and residual mineral oil or alkylbenzene thoroughly. Typically this will take 24 hrs.
- Repeat this procedure until the level of mineral oil or alkylbenzene is 5% or less. This level is usually reached after four oil changes.
- Recover the CFC charge as mentioned in step 2 using standard recovery techniques.

Compressor Cannot Be Isolated

To remove the lubricant, the following procedure may be followed if the compressor does not have service ports.

- Recover R-13 or R-503 per step 2.
- Remove lubricant from compressor, oil separator, and suction line accumulator. Measure the volume of lubricant removed.
- Add POE lubricant equal to the volume removed.
- Evacuate system to full vacuum.
- Charge system with R-13 or R-503 recovered in step 2.
- Start up system and allow it to run long enough to mix the POE and residual oil thoroughly.
- Repeat this procedure until the mineral oil or alkylbenzene level is 5% or less. This level is typically reached after four oil changes.
- Recover R-13 or R-503 per step 2.

5. **Replace Filter Drier.** It is routine practice to replace the filter drier following system maintenance. Filter driers compatible with R-13 and R-503 are compatible with HFC-23.
6. **Evacuate System.** Reconnect system and evacuate to full vacuum using normal service practices. During this time it is advisable to check for system leaks.
7. **Charge System with HFC-23.** Charge the system to the same static pressure as was used with R-13 and R-503.

   Because of HFC-23's higher specific volume relative to R-13 and R-503, ~20–40% less HFC-23 will be used on a *weight* basis.

   Charging HFC-23 to the same static pressure will ensure the standby pressure never exceeds the design safety limit.
8. **Start Up System and Adjust.** Start up the system and allow the system to stabilize. Check the superheat and adjust the expansion device to give the appropriate amount of superheat.

   Typically for direct expansion systems, no adjustments are needed for R-13 systems, but minor adjustments may be needed for R-503 systems. For cap tube systems, it may be necessary to shorten the tube when replacing R-13 with HFC-23. R-503 cap tube systems typically do not require adjustments.

   Label the system as containing HFC-23 and POE lubricant.

Summary

With the phase out of CFCs, existing refrigeration equipment will need to be replaced with new equipment or retrofitted to allow them to be used with alternative refrigerants. Using the procedure described above, existing R-13 and R-503 systems can be retrofitted for use with HFC-23.

Attached is a retrofit checklist, system data sheet, and pressure–temperature chart for HFC-23, R-13, and R-503.

Retrofit Checklist for HFC-23

_____ 1. Establish baseline performance with R-13 or R-503. (See data sheet for recommended data.)

_____ 2. If the compressor cannot be isolated with service valves, recover R-13/R-503 charge. If the compressor can be isolated, isolate compressor and proceed to *Step 3*.
- – Use recovery cylinder/*Do Not Vent to Atmosphere.*
- – Measure R-13/R-503 Static Charge Pressure: _____
- – Weigh amount removed (if possible): _____

_____ 3. Drain lubricant charge from the refrigerant system (unless polyol ester lubricant is already in the system).
- – Remove lubricant from the system.
- – Measure amount of lubricant removed and record. _____ (*Steps 2, 3, 4, 5*, and *6* may have to repeated to remove the recommended 95% of lubricant.)

_____ 4. Charge polyol ester lubricant.
- – Recharge with amount equivalent to what was removed in *Step 3.*

_____ 5. Charge with refrigerant evacuated in *Step 2*. If the compressor has service ports, evacuate compressor and open service port.

_____ 6. Start up system and allow it to run long enough to mix the POE and residual oil thoroughly.

_____ 7. Repeat *Steps 2* through *6* until the residual oil is less than or equal to 5%. This typically requires four oil changes.

_____ 8. Recover R-13/R-503 charge. See *Step 2*.

_____ 9. Replace filter drier.

_____ 10. Reconnect system and evacuate with vacuum pump.

_____ 11. Leak check system. (Reevacuate system following leak check.)

_____ 12. Charge system with HFC-23 to the same static pressure as R-13 or R-503.

_____ 13. Start up equipment and adjust charge superheat settings until desired operating conditions are achieved.

_____ 14. Label components and system for type of refrigerant (HFC-23) and lubricant (polyol ester).

System Data Sheet

Type of System/Location: _____

Equipment Mfg.: _____ Compressor Mfg.: _____

Model No.: _____ Model No.: _____

Serial No.: _____ Serial No.: _____

R-503 or R-13 Charge Size: _____ Lubricant Type: _____

R-503 or R-13 Static Pressure: _____ Charge Size: _____

Drier Mfg.: _____ Drier Type (check one):

Model No.: _____ Loose Fill: _____

Solid Core: _____

High Stage Refrigerant:: _____

Expansion Device (check one): Capillary Tube: _____

Expansion Valve: _____

If Expansion Valve:

Manufacturer: _____

Model No.: _____

Control/Set Point: _____

Location of Sensor: _____

Other System Controls (ex.: head press control), Describe: _____

_____

(Circle units used where applicable)

Date/Time				
Refrigerant				
Charge Size (lbs/grams)				
Static Pressure (psig, psia/kPa, bar)				
Ambient Temp. (°F/°C)				
Relative Humidity				
Compressor:				
Suction T (°F/°C)				
Suction P (psig, psia/kPa, bar)				
Discharge T (°F/°C)				
Discharge P (psig, psia/kPa, bar)				
Box/Fixture T (°F/°C)				
Evaporator:				
Refrigerant Inlet T (°F/°C)				
Refrigerant Outlet T (°F/°C)				
Coil Air/H_2O In T (°F/°C)				
Coil Air/H_2O Out T (°F/°C)				
Refrigerant T @ Superht. Ctl. Pt. (°F/°C)				
Interstage Condenser:				
Refrigerant Inlet T (°F/°C)				
Refrigerant Outlet T (°F/°C)				
High Side Refrigerant In T (°F/°C)				
High Side Refrigerant Out T (°F/°C)				
Exp. Device Inlet T (°F/°C)				
Motor Amps				
Run/Cycle Time				

Comments: _____

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Table 2
Pressure–Temperature Chart—HFC-23 (psig/°F)

T (°F)	Pressure (psig)	T (°F)	Pressure (psig)	T (°F)	Pressure (psig)
–200	29.22*	–106	5	–12	161
–198	29.13*	–104	6	–10	168
–196	29.03*	–102	8	–8	174
–194	28.91*	–100	9	–6	181
–192	28.79*	–98	10	–4	188
–190	28.65*	–96	12	–2	195
–188	28.50*	–94	13	0	203
–186	28.34*	–92	15	2	210
–184	28.16*	–90	17	4	218
–182	27.96*	–88	18	6	226
–180	27.74*	–86	20	8	234
–178	27.51*	–84	22	10	242
–176	27.25*	–82	24	12	250
–174	26.97*	–80	26	14	259
–172	26.67*	–78	28	16	268
–170	26.34*	–76	31	18	277
–168	25.99*	–74	33	20	286
–166	25.61*	–72	35	22	296
–164	25.19*	–70	38	24	306
–162	24.75*	–68	40	26	316
–160	24.27*	–66	43	28	326
–158	23.75*	–64	46	30	337
–156	23.20*	–62	49	32	347
–154	22.60*	–60	52	34	358
–152	21.97*	–58	55	36	370
–150	21.29*	–56	58	38	381
–148	20.56*	–54	61	40	393
–146	20*	–52	65	42	405
–144	19*	–50	69	44	417
–142	18*	–48	72	46	430
–140	17*	–46	76	48	443
–138	16*	–44	80	50	456
–136	15*	–42	84	52	470
–134	14*	–40	88	54	484
–132	13*	–38	92	56	498
–130	12*	–36	97	58	513
–128	10*	–34	101	60	528
–126	9*	–32	106	62	543
–124	7*	–30	111	64	559
–122	6*	–28	116	66	575
–120	4*	–26	121	68	591
–118	2*	–24	126	70	608
–116	0	–22	132	72	625
–114	1	–20	138	74	643
–112	2	–18	143	76	661
–110	3	–16	149	78	680
–108	4	–14	155		

*Inches Mercury Below One Atmosphere

Table 3
Pressure–Temperature Chart—HFC-23 (kPa, abs/°C)

T (°C)	Pressure (kPa)	T (°C)	Pressure (kPa)	T (°C)	Pressure (kPa)
–130	2	–78	127	–26	1157
–129	2	–77	134	–25	1195
–128	3	–76	142	–24	1234
–127	3	–75	150	–23	1274
–126	3	–74	158	–22	1315
–125	4	–73	166	–21	1358
–124	4	–72	175	–20	1401
–123	4	–71	184	–19	1445
–122	5	–70	194	–18	1490
–121	5	–69	204	–17	1536
–120	6	–68	214	–16	1583
–119	7	–67	225	–15	1632
–118	7	–66	236	–14	1681
–117	8	–65	248	–13	1732
–116	9	–64	260	–12	1783
–115	9	–63	273	–11	1836
–114	10	–62	286	–10	1890
–113	11	–61	299	–9	1945
–112	12	–60	313	–8	2002
–111	13	–59	327	–7	2059
–110	15	–58	342	–6	2118
–109	16	–57	358	–5	2178
–108	17	–56	374	–4	2240
–107	19	–55	390	–3	2302
–106	20	–54	407	–2	2366
–105	22	–53	425	–1	2432
–104	24	–52	443	0	2499
–103	25	–51	462	1	2567
–102	27	–50	481	2	2637
–101	29	–49	501	3	2708
–100	32	–48	522	4	2781
–99	34	–47	543	5	2855
–98	37	–46	565	6	2931
–97	39	–45	587	7	3008
–96	42	–44	611	8	3088
–95	45	–43	634	9	3168
–94	48	–42	659	10	3251
–93	51	–41	684	11	3335
–92	55	–40	710	12	3421
–91	59	–39	737	13	3509
–90	62	–38	764	14	3599
–89	67	–37	793	15	3691
–88	71	–36	822	16	3785
–87	75	–35	851	17	3881
–86	80	–34	882	18	3979
–85	85	–33	913	19	4079
–84	90	–32	946	20	4181
–83	96	–31	979	21	4285
–82	101	–30	1012	22	4392
–81	108	–29	1047	23	4501
–80	114	–28	1083	24	4613
–79	120	–27	1119	25	4727

Table 4
Pressure–Temperature Chart—R-13 (psig/°F)

T (°F)	Pressure (psig)	T (°F)	Pressure (psig)	T (°F)	Pressure (psig)
–200	29.02*	–106	4	–12	131
–198	28.91*	–104	5	–10	136
–196	28.80*	–102	6	–8	141
–194	28.67*	–100	8	–6	146
–192	28.53*	–98	9	–4	152
–190	28.38*	–96	10	–2	157
–188	28.22*	–94	11	0	163
–186	28.03*	–92	13	2	169
–184	27.84*	–90	14	4	174
–182	27.63*	–88	16	6	180
–180	27.39*	–86	17	8	187
–178	27.14*	–84	19	10	193
–176	27.87*	–82	21	12	199
–174	26.58*	–80	22	14	206
–172	26.26*	–78	24	16	212
–170	25.92*	–76	26	18	219
–168	25.56*	–74	28	20	226
–166	25.16*	–72	30	22	233
–164	24.74*	–70	32	24	241
–162	24.29*	–68	34	26	248
–160	23.80*	–66	37	28	256
–158	23.29*	–64	39	30	264
–156	22.73*	–62	41	32	271
–154	22.14*	–60	44	34	280
–152	21.51*	–58	46	36	288
–150	20.85*	–56	49	38	296
–148	20.13*	–54	52	40	305
–146	19.38*	–52	55	42	314
–144	18.57*	–50	57	44	323
–142	18*	–48	60	46	332
–140	17*	–46	64	48	341
–138	16*	–44	67	50	350
–136	15*	–42	70	52	360
–134	14*	–40	73	54	370
–132	13*	–38	77	56	380
–130	11*	–36	80	58	390
–128	10*	–34	84	60	401
–126	9*	–32	88	62	412
–124	8*	–30	92	64	423
–122	6*	–28	96	66	434
–120	5*	–26	100	68	445
–118	3*	–24	104	70	457
–116	1*	–22	108	72	469
–114	0	–20	112	74	481
–112	1	–18	117	76	493
–110	2	–16	122	78	506
–108	3	–14	126		

*Inches Mercury Below One Atmosphere

Table 5
Pressure–Temperature Chart—R-13 (kPa, abs/°C)

T (°C)	Pressure (kPa)	T (°C)	Pressure (kPa)	T (°C)	Pressure (kPa)
–130	3	–78	121	–26	958
–129	3	–77	128	–25	988
–128	3	–76	134	–24	1019
–127	4	–75	141	–23	1050
–126	4	–74	149	–22	1081
–125	4	–73	156	–21	1114
–124	5	–72	164	–20	1147
–123	5	–71	172	–19	1181
–122	6	–70	180	–18	1216
–121	6	–69	189	–17	1251
–120	7	–68	198	–16	1287
–119	8	–67	207	–15	1324
–118	8	–66	217	–14	1361
–117	9	–65	227	–13	1400
–116	10	–64	237	–12	1439
–115	11	–63	248	–11	1478
–114	12	–62	259	–10	1519
–113	13	–61	270	–9	1561
–112	14	–60	282	–8	1603
–111	15	–59	294	–7	1646
–110	16	–58	306	–6	1690
–109	17	–57	319	–5	1735
–108	19	–56	332	–4	1780
–107	20	–55	346	–3	1827
–106	22	–54	360	–2	1874
–105	23	–53	375	–1	1922
–104	25	–52	390	0	1972
–103	27	–51	405	1	2022
–102	29	–50	421	2	2073
–101	31	–49	438	3	2125
–100	33	–48	454	4	2178
–99	35	–47	472	5	2231
–98	38	–46	489	6	2286
–97	40	–45	508	7	2342
–96	43	–44	526	8	2399
–95	46	–43	546	9	2457
–94	49	–42	565	10	2516
–93	52	–41	586	11	2576
–92	55	–40	607	12	2637
–91	59	–39	628	13	2699
–90	62	–38	650	14	2763
–89	66	–37	672	15	2827
–88	70	–36	695	16	2893
–87	74	–35	719	17	2960
–86	79	–34	743	18	3028
–85	83	–33	768	19	3098
–84	88	–32	793	20	3169
–83	93	–31	819	21	3241
–82	98	–30	846	22	3315
–81	104	–29	873	23	3390
–80	109	–28	901	24	3467
–79	115	–27	929	25	3545

Table 6
Pressure–Temperature Chart—R-503 (psig/°F)

T (°F)	Pressure (psig)	T (°F)	Pressure (psig)	T (°F)	Pressure (psig)
–200	28.14*	–106	13	–12	186
–198	27.96*	–104	14	–10	193
–196	27.75*	–102	16	–8	200
–194	27.54*	–100	17	–6	207
–192	27.30*	–98	19	–4	215
–190	27.04*	–96	21	–2	222
–188	26.76*	–94	23	0	230
–186	26.47*	–92	24	2	238
–184	26.14*	–90	26	4	246
–182	25.79*	–88	28	6	254
–180	25.42*	–86	31	8	263
–178	25.02*	–84	33	10	272
–176	24.59*	–82	35	12	281
–174	24.13*	–80	38	14	290
–172	23.63*	–78	40	16	299
–170	23.10*	–76	43	18	309
–168	22.54*	–74	45	20	319
–166	21.93*	–72	48	22	328
–164	21.29*	–70	51	24	339
–162	20.60*	–68	54	26	349
–160	19.87*	–66	57	28	360
–158	19.10*	–64	60	30	371
–156	18.27*	–62	63	32	382
–154	17.40*	–60	67	34	393
–152	16.47*	–58	70	36	404
–150	15.49*	–56	74	38	416
–148	14.45*	–54	77	40	428
–146	13.35*	–52	81	42	440
–144	12.18*	–50	85	44	453
–142	11*	–48	89	46	466
–140	10*	–46	93	48	479
–138	8*	–44	98	50	492
–136	7*	–42	102	52	505
–134	5*	–40	107	54	519
–132	4*	–38	111	56	533
–130	2*	–36	116	58	547
–128	0	–34	121	60	561
–126	1	–32	126	62	576
–124	2	–30	132	64	590
–122	3	–28	137	66	605
–120	4	–26	143		
–118	5	–24	148		
–116	6	–22	154		
–114	7	–20	160		
–112	8	–18	167		
–110	10	–16	173		
–108	11	–14	179		

*Inches Mercury Below One Atmosphere

Table 7
Pressure–Temperature Chart—R-503 (kPa, abs/°C)

T (°C)	Pressure (kPa)	T (°C)	Pressure (kPa)	T (°C)	Pressure (kPa)
–130	5	–78	176	–26	1319
–129	6	–77	185	–25	1360
–128	6	–76	194	–24	1402
–127	7	–75	204	–23	1445
–126	8	–74	213	–22	1489
–125	8	–73	224	–21	1534
–124	9	–72	234	–20	1580
–123	10	–71	245	–19	1627
–122	11	–70	257	–18	1675
–121	12	–69	268	–17	1725
–120	13	–68	281	–16	1775
–119	14	–67	293	–15	1826
–118	15	–66	306	–14	1878
–117	16	–65	320	–13	1932
–116	17	–64	334	–12	1986
–115	19	–63	348	–11	2042
–114	20	–62	363	–10	2098
–113	22	–61	379	–9	2156
–112	23	–60	394	–8	2215
–111	25	–59	411	–7	2276
–110	27	–58	428	–6	2337
–109	29	–57	445	–5	2400
–108	31	–56	463	–4	2463
–107	33	–55	482	–3	2528
–106	36	–54	501	–2	2595
–105	38	–53	521	–1	2662
–104	41	–52	541	0	2731
–103	43	–51	562	1	2801
–102	46	–50	584	2	2872
–101	49	–49	606	3	2945
–100	52	–48	629	4	3019
–99	56	–47	652	5	3094
–98	59	–46	677	6	3170
–97	63	–45	701	7	3248
–96	67	–44	727	8	3327
–95	71	–43	753	9	3407
–94	75	–42	780	10	3489
–93	80	–41	808	11	3572
–92	84	–40	836	12	3656
–91	89	–39	865	13	3742
–90	94	–38	895	14	3829
–89	100	–37	926	15	3917
–88	105	–36	958	16	4006
–87	111	–35	990	17	4097
–86	117	–34	1023	18	4189
–85	124	–33	1057	19	4281
–84	130	–32	1092	20	4375
–83	137	–31	1128	21	4470
–82	144	–30	1164	22	4565
–81	152	–29	1202	23	4660
–80	160	–28	1240		
–79	168	–27	1279		

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