Supplement

Cold Energy Utilization in LNG Regasification System Using Organic Rankine Cycle and Trilateral Flash Cycle

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Table S1 A list of the potential working fluids at the upper-lower temperature of 283–153 K, ranked by the hypothetical expander efficiency required for them to minimize droplet erosion with the smallest loss of net efficiency.

No	CAS no.[1]	Name	Type of working fluid[2]	ASHRAE designation[3]	ODP[3]	GWP[3]	Safety[3]	Critical point[1]		Normal boiling temperature[1] (K)	Range of applicable temperature[4] (K)		x (-)[5]	η (%)[5]
								T (K)	p (MPa)		min	max		
1	76-19-7	Perfluoropropane	ANCMZ	R-218	0	8830	A1	345.02	2.64	236.36	125.45	440	1	100
2	431-89-0	Propane, 1,1,1,2,3,3,3-heptafluoro-	ANCMZ	R-227ea	0	3220	A1	375.95	3.00	256.73	146.35	-	1–0.9861	82–87
3	109-66-0	Pentane	ANCMZ	R-601	0	5	A3	469.70	3.37	309.21	143.47	600	1–0.98961	68–72
4	75-28-5	Isobutane	ACNMZ	R-600a	0	3	A3	407.81	3.63	261.40	113.73	575	1–0.98827	68–71
5	107-83-5	Pentane, 2-methyl-	ANCMZ	-	-	-	-	497.70	3.04	333.36	119.60	550	1–0.99179	67–71
6	106-97-8	Butane	ACNMZ	R-600	0	4	A3	425.13	3.80	272.66	134.90	575	1–0.99326	67–70
7	78-78-4	Butane, 2-methyl-	ANCMZ	R-601a	0	5	A3	460.35	3.40	300.97	112.65	500	1–0.99169	67–70
8	74-98-6	Propane	ACZ	R-290	0	3	A3	369.83	4.25	231.06	85.53	650	1–0.99546	60–62
9	115-07-1	Propene	ACZ	R-1270	0	2	A3	365.57	4.66	225.46	87.95	575	1–0.99516	54–56
10	75-37-6	Ethane, 1,1-difluoro-	ACZ	R-152a	0	124	A2	386.41	4.52	249.13	154.56	500	0.99594	50

[1] CAS numbers, critical point, and normal boiling temperature are taken from NIST "NIST Standard Reference Database Number 69", In: NIST Chemistry WebBook, National Institute of Standards and Technology, U.S. Department of Commerce, Washington, DC, USA, 2018. https://doi.org/10.18434/T4D303

[2] Classification data (the type of working fluid) are taken from Györke, G., Deiters, U. K., Groniewsky, A., Lassu, I., Imre, A. R. "Novel classification of pure working fluids for Organic Rankine Cycle", Energy, 145, pp. 288–300, 2018. https://doi.org/10.1016/j.energy.2017.12.135

[3] ASHRAE, ODP, GWP and safety data are taken from United Nations Environment Programme "GWP-ODP Calculator", [online] Available at: https://www.unenvironment.org/ozonaction/gwp-odp-calculator [Accessed: 04 April 2020]

[4] Range of applicable temperature data are taken from NIST "NIST/TRC Web Thermo Tables (WTT) (thermophysical and thermochemical data)", [online] Available at: https://wtt-pro.nist.gov/wtt-pro/ [Accessed: 04 April 2020]

[5] The fraction of vapor phase/quality (x) and internal efficiency (η) are based on calculation (see the paper)

Table S2 A list of the potential working fluids at the upper-lower temperature of 283–173 K, ranked by the hypothetical expander efficiency required for them to minimize droplet erosion with the smallest loss of net efficiency.

No	CAS no.[1]	Name	Type of working fluid[2]	ASHRAE designation[3]	ODP[3]	GWP[3]	Safety[3]	Critical point[1]		Normal boiling temperature[1] (K)	Range of applicable temperature[4] (K)		x (-)[5]	η (%)[5]
								T (K)	p (MPa)		min	max		
1	431-89-0	Propane, 1,1,1,2,3,3,3-heptafluoro-	ANCMZ	R-227ea	0	3220	A1	375.95	3.00	256.73	146.35	-	1–0.98724	90–96
2	76-16-4	Ethane, hexafluoro-	ACNMZ	R-116	0	12200	A1	293.03	3.05	195.06	173.10	425	1–0.98833	86–90
3	109-66-0	Pentane	ANCMZ	R-601	0	5	A3	469.70	3.37	309.21	143.47	600	1–0.98972	74–78
4	107-83-5	Pentane, 2-methyl-	ANCMZ	-	-	-	-	497.70	3.04	333.36	119.60	550	1–0.99037	74–78
5	354-33-6	Ethane, pentafluoro-	ACZ	R-125	0	3599	A1	339.17	3.62	225.06	172.52	500	0.99879–99468	77–78
6	78-78-4	Butane, 2-methyl-	ANCMZ	R-601a	0	5	A3	460.35	3.40	300.97	112.65	500	1–0.98966	74–77
7	106-97-8	Butane	ACNMZ	R-600	0	4	A3	425.13	3.80	272.66	134.90	575	1–0.99089	72 - 76
8	75-28-5	Isobutane	ACNMZ	R-600a	0	3	A3	407.81	3.63	261.40	113.73	575	1–0.99289	73–76
9	74-98-6	Propane	ACZ	R-290	0	3	A3	369.83	4.25	231.06	85.53	650	1–0.99585	64–66
10	811-97-2	Norflurane	ACZ	R-134a	0	1430	A1	374.21	4.06	247.08	169.85	455	1–0.99389	63–65
11	420-46-2	Ethane, 1,1,1-trifluoro-	ACZ	R-143a	0	4470	A2L	345.86	3.76	225.91	161.34	650	1–0.99679	62–64
12	115-07-1	Propene	ACZ	R-1270	0	2	A3	365.57	4.66	225.46	87.95	575	1–0.99565	57–59
13	75-37-6	Ethane, 1,1-difluoro-	ACZ	R-152a	0	124	A2	386.41	4.52	249.13	154.56	500	1–0.99627	51–53

[1] CAS numbers, critical point, and normal boiling temperature are taken from NIST "NIST Standard Reference Database Number 69", In: NIST Chemistry WebBook, National Institute of Standards and Technology, U.S. Department of Commerce, Washington, DC, USA, 2018. https://doi.org/10.18434/T4D303

[2] Classification data (the type of working fluid) are taken from Györke, G., Deiters, U. K., Groniewsky, A., Lassu, I., Imre, A. R. "Novel classification of pure working fluids for Organic Rankine Cycle", Energy, 145, pp. 288–300, 2018. https://doi.org/10.1016/j.energy.2017.12.135

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[4] Range of applicable temperature data are taken from NIST "NIST/TRC Web Thermo Tables (WTT) (thermophysical and thermochemical data)", [online] Available at: https://wtt-pro.nist.gov/wtt-pro/ [Accessed: 04 April 2020]

[5] The fraction of vapor phase/quality (x) and internal efficiency (η) are based on calculation (see the paper)

Table S3 A list of the potential working fluids at the upper-lower temperature of 283–223 K, ranked by the hypothetical expander efficiency required for them to minimize droplet erosion with the smallest loss of net efficiency.

No	CAS no.[1]	Name	Type of working fluid[2]	ASHRAE designation[3]	ODP[3]	GWP[3]	Safety[3]	Critical point[1]		Normal boiling temperature[1] (K)	Range of applicable temperature[4] (K)		x (-)[5]	η (%)[5]
								T (K)	p (MPa)		min	max		
1	690-39-1	Propane, 1,1,1,3,3,3-hexafluoro-	ACNMZ	R-236fa	0	9810	A1	398.07	3.20	271.71	179.52	500	1	99–100
2	107-83-5	Pentane, 2-methyl-	ANCMZ	-	-	-	-	497.70	3.04	333.36	119.60	550	1–0.99336	91–97
3	110-54-3	n-Hexane	ANZCM	-	-	-	-	507.82	3.03	341.86	177.83	600	1–0.99304	90–96
4	142-82-5	Heptane	ANZCM	-	-	-	-	540.13	2.74	371.53	182.55	600	1–0.99357	91–96
5	111-65-9	Octane	ANZCM	-	-	-	-	569.32	2.50	398.77	216.37	600	1–0.99375	90–96
6	111-84-2	Nonane	ANZCM	-	-	-	-	594.55	2.28	423.91	219.70	600	1–0.99433	92–96
7	2551-62-4	Sulfur hexafluoride	ACZ	-	0	22800	-	318.73	3.75	204.90	223.56	625	0.99974	95
8	109-66-0	Pentane	ANCMZ	R-601	0	5	A3	469.70	3.37	309.21	143.47	600	1–0.99353	89–94
9	78-78-4	Butane, 2-methyl-	ANCMZ	R-601a	0	5	A3	460.35	3.40	300.97	112.65	500	1	90–94
10	76-16-4	Ethane, hexafluoro-	ACNMZ	R-116	0	12200	A1	293.03	3.05	195.06	173.10	425	1	86–93
11	75-28-5	Isobutane	ACNMZ	R-600a	0	3	A3	407.81	3.63	261.40	113.73	575	1–0.9941	87–92
12	106-97-8	Butane	ACNMZ	R-600	0	4	A3	425.13	3.80	272.66	134.90	575	1–0.99523	86–90
13	354-33-6	Ethane, pentafluoro-	ACZ	R-125	0	3599	A1	339.17	3.62	225.06	172.52	500	1–0.99899	88–89
14	460-73-1	Propane, 1,1,1,3,3-pentafluoro	ACNMZ	R-245fa	0	1030	B1	427.20	3.64	288.05	171.05	440	1–0.99404	84–89
15	679-86-7	Propane, 1,1,2,2,3-pentafluoro-	ANCMZ	R-245ca	0	693	-	447.57	3.93	298.28	200.00	500	1–0.99506	82–87
16	74-98-6	Propane	ACZ	R-290	0	3	A3	369.83	4.25	231.06	85.53	650	1–0.99773	73–75
17	811-97-2	Norflurane	ACZ	R-134a	0	1430	A1	374.21	4.06	247.08	169.85	455	1–0.99723	73–75
18	420-46-2	Ethane, 1,1,1-trifluoro-	ACZ	R-143a	0	4470	A2L	345.86	3.76	225.91	161.34	650	1–0.99914	70–71
19	115-07-1	Propene	ACZ	R-1270	0	2	A3	365.57	4.66	225.46	87.95	575	1–0.99926	63–64
20	75-37-6	Ethane, 1,1-difluoro-	ACZ	R-152a	0	124	A2	386.41	4.52	249.13	154.56	500	1–0.99816	58–59
21	354-33-6	Ethane, pentafluoro-	ACZ	R-125	0	3500	A1	339.17	3.62	225.06	172.52	500	1	51
22	124-38-9	Carbon dioxide	ACZ	R-744	0	1	A1	304.13	7.37	194.75	216.59	2000	> 0.88197	< 50

[1] CAS numbers, critical point, and normal boiling temperature are taken from NIST "NIST Standard Reference Database Number 69", In: NIST Chemistry WebBook, National Institute of Standards and Technology, U.S. Department of Commerce, Washington, DC, USA, 2018. https://doi.org/10.18434/T4D303

[2] Classification data (the type of working fluid) are taken from Györke, G., Deiters, U. K., Groniewsky, A., Lassu, I., Imre, A. R. "Novel classification of pure working fluids for Organic Rankine Cycle", Energy, 145, pp. 288–300, 2018. https://doi.org/10.1016/j.energy.2017.12.135

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[5] The fraction of vapor phase/quality (x) and internal efficiency (η) are based on calculation (see the paper)