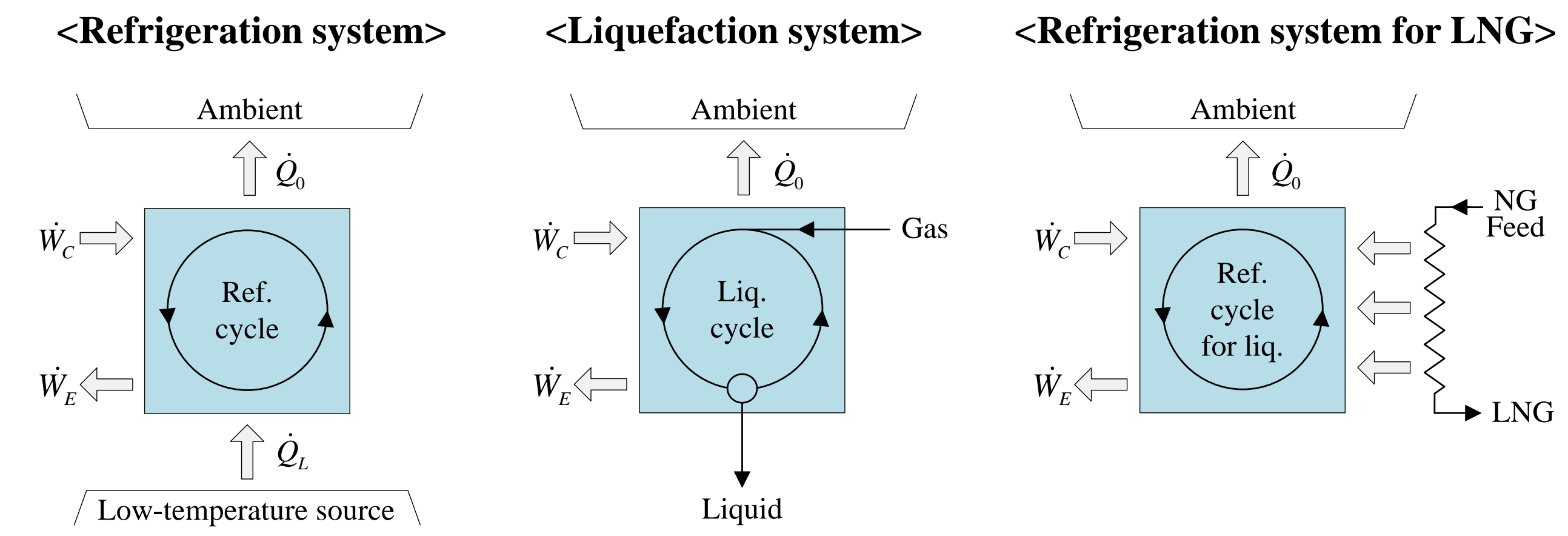


Proposed Thermodynamic Nomenclature of Cryogenic Refrigeration Cycles for Liquefaction of Natural Gas

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Refrigeration Cycle for Natural Gas Liquefaction



Classification of Refrigeration Cycles

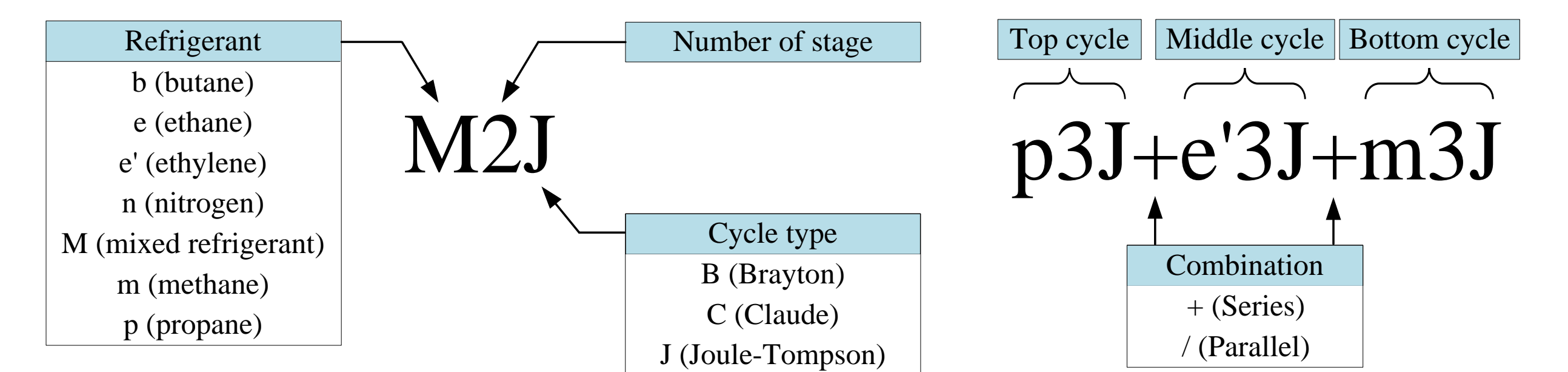
Existing classification (Conventional)

Refrigerant /Components	Technical terms	Proper nouns	Company
C3-MR Nitrogen-Expander	SMR DMR(I, II) Optimized Cascade MFC	PRICO AP-X LIQUEFIN TEALARC	Conoco Phillips APCI Linde MUSTANG Axens

Proposed classification (Academic)

Refrigerant Cycle type	Pure Refrigerants (PR)	Mixed Refrigerants (MR)	Pure and Mixed Refrigerants
JT Cycles	Cascade	SMR SMR with PS PRICO DMR(I, II)	C3-MR
Brayton Cycles	N Turbine Dual N Turbine		
Combined or Claude Cycles	C3-C2-N2	NG Claude	AP-X

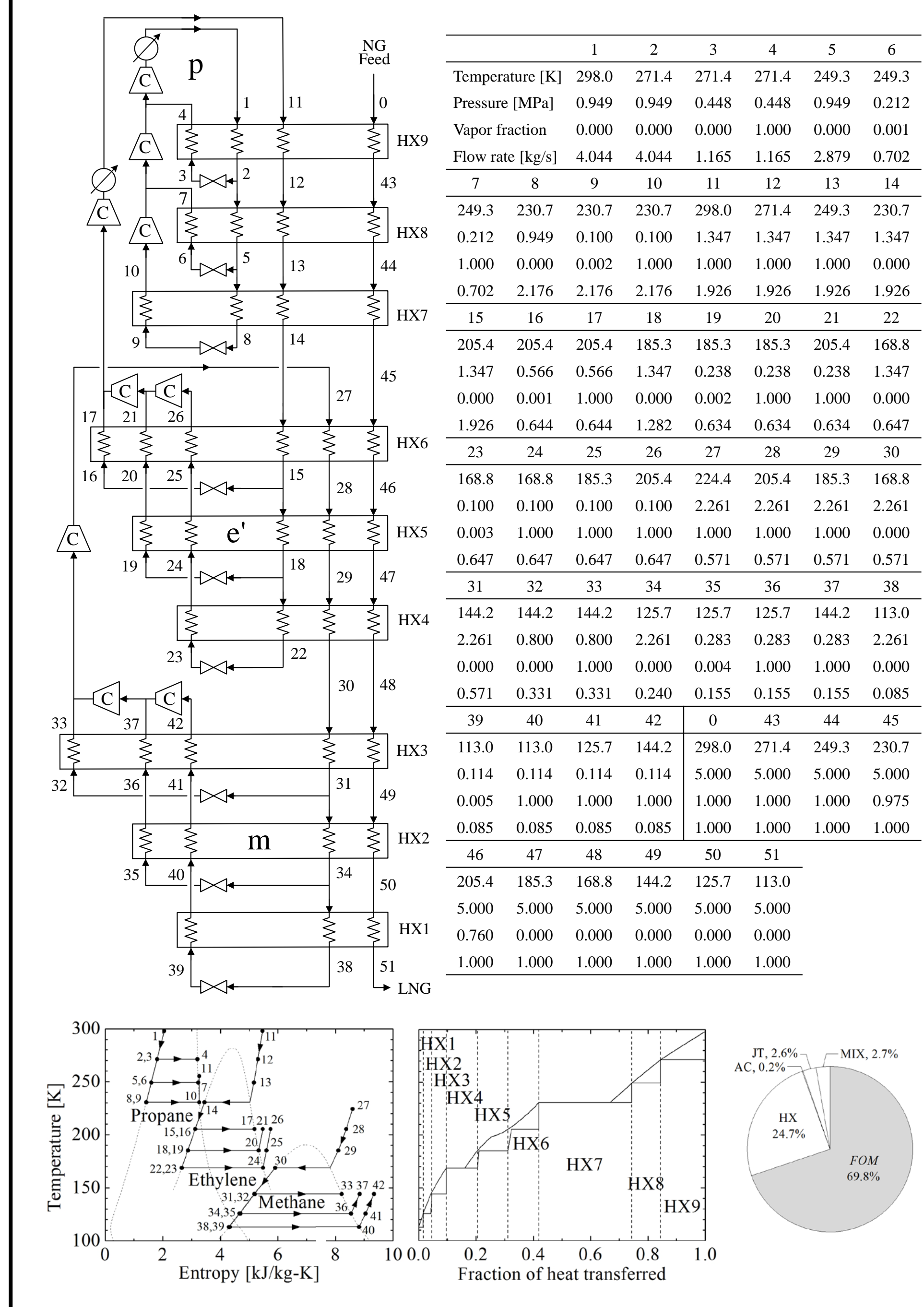
Nomenclature of Cycles



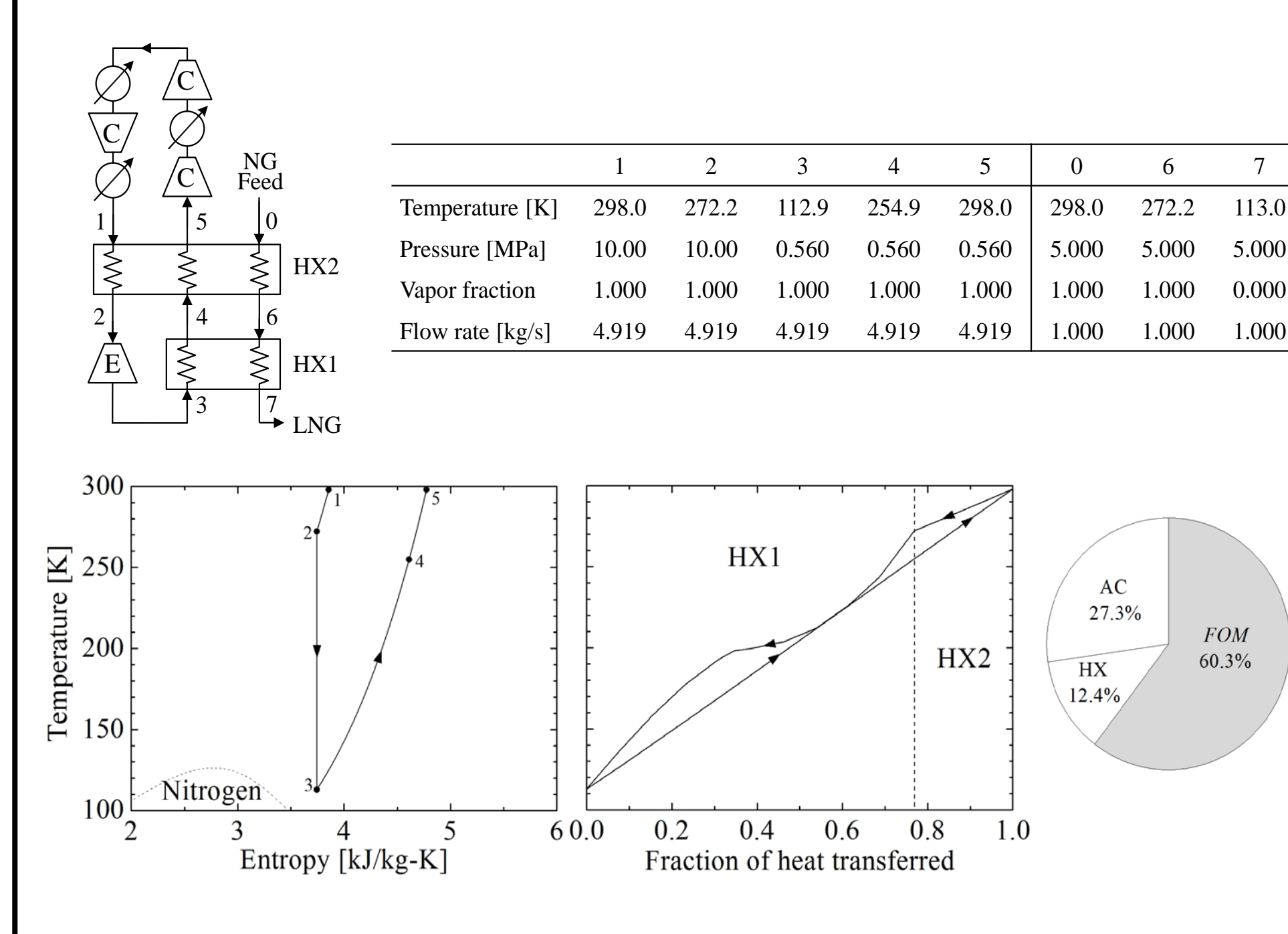
p3J+e'3J+m3J	3-stage propane, 3-stage ethylene, 3-stage methane JT cycles	Cascade
M1J, M2J	1-stage MR JT cycle, 2-stage MR JT cycle	SMR, SMR with PS
M1J+M1J	Dual 1-stage MR JT cycles	PRICO
M1J+M2J	1-stage MR, 2-stage MR JT cycles	DMR-I
M2J+M2J	Dual 2-stage MR JT cycles	DMR-II
p4J+M2J	4-stage propane, 2-stage MR JT cycles	C3-MR
b1J/e1J+M2J	Parallel 1-stage butane/1-stage ethane, 2-stage MR JT cycles	
n1B, n2B	1-stage nitrogen Brayton cycle, 2-stage nitrogen Brayton cycle	N Turbine
m1B+n1B	1-stage methane, 1-stage nitrogen Brayton cycles	Dual Turbine
p3J+e3J+n1B	3-stage propane, 3-stage ethane JT, 1-stage nitrogen Brayton cycles	C3-C2-N2
M1C	1-stage MR Claude cycle	NG Claude
p4J+M1J+n1B	4-stage propane, 1-stage MR JT, 1-stage nitrogen Brayton cycles	AP-X

Examples

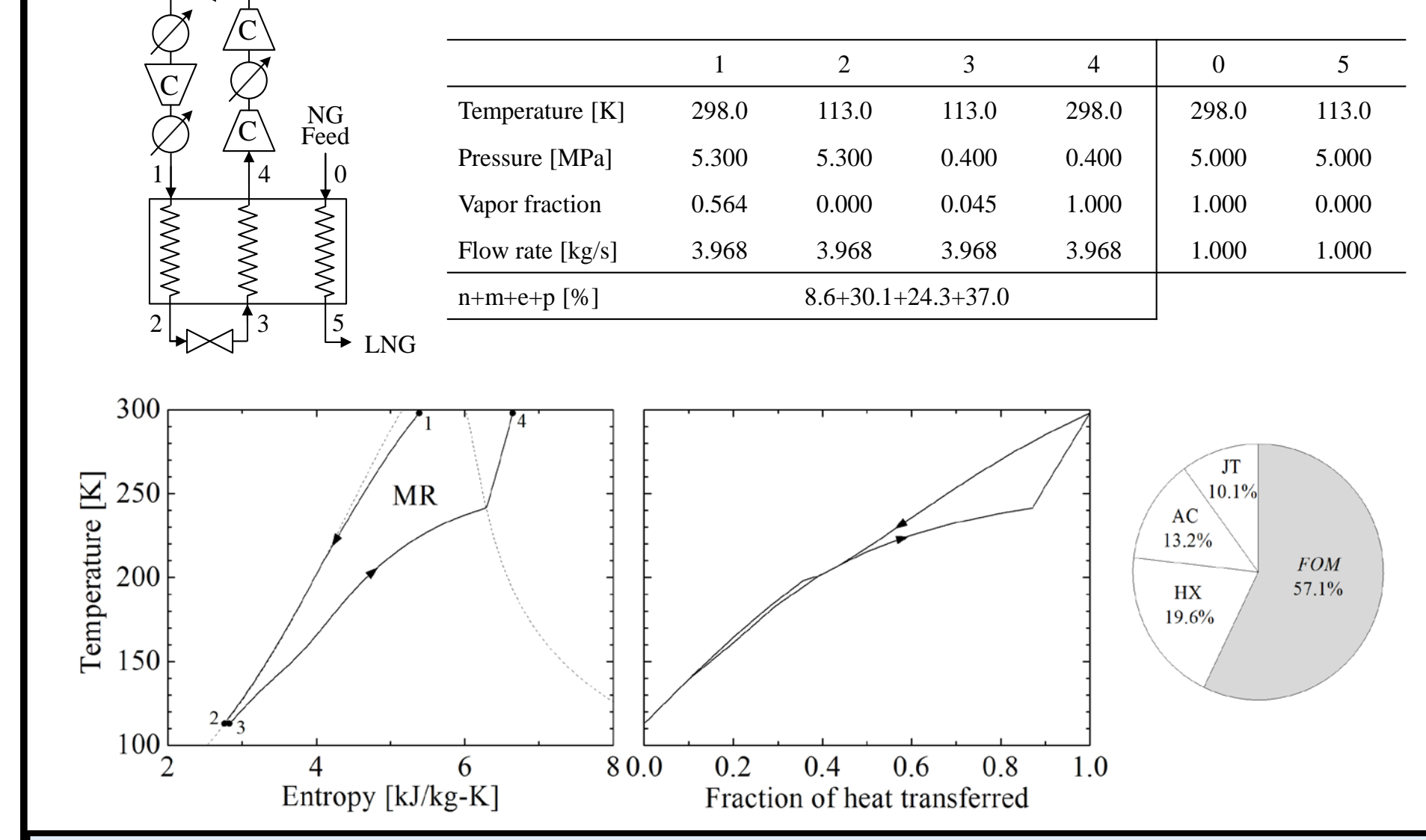
p3J+e'3J+m3J (Cascade)



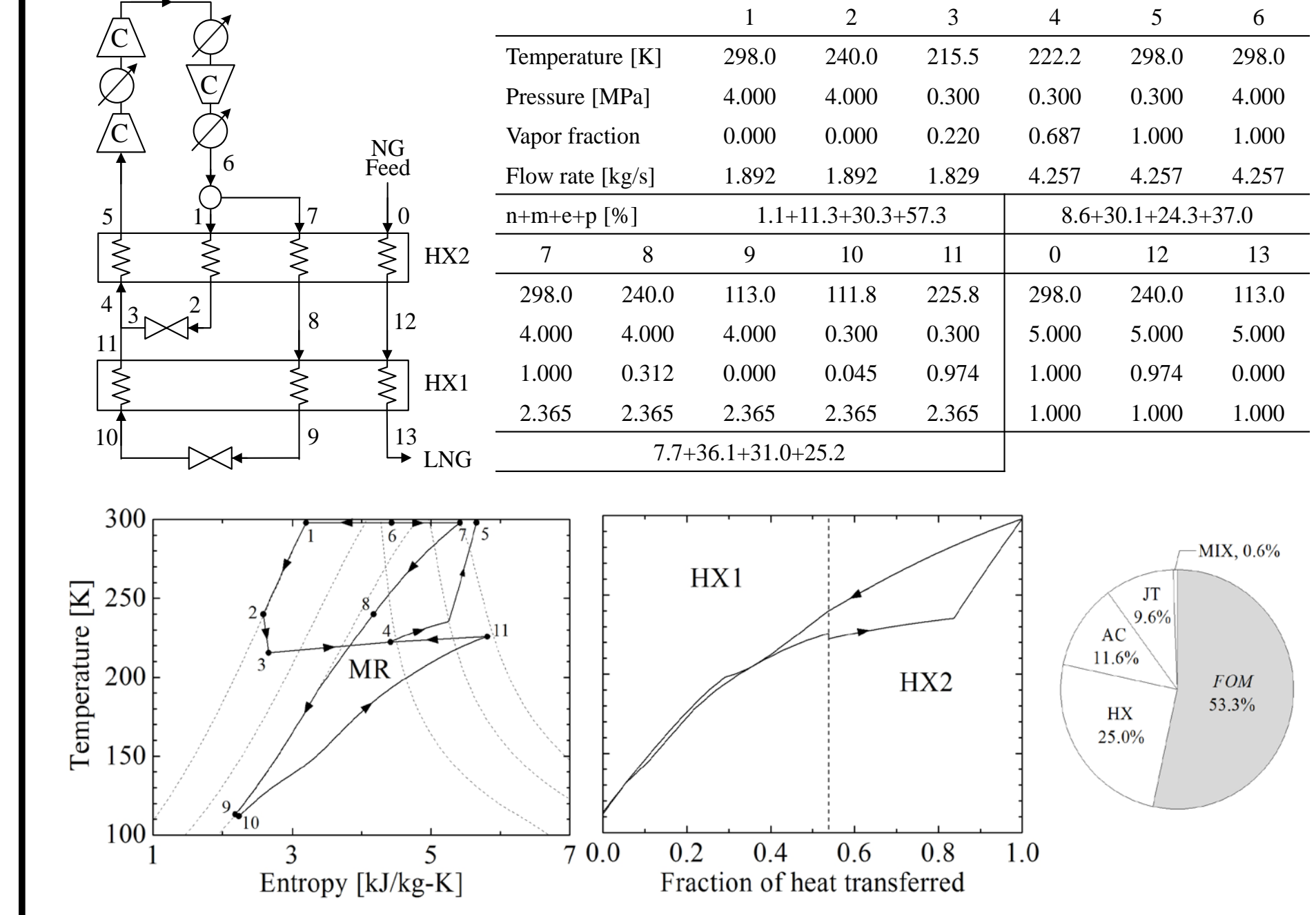
n1B (Nitrogen-Expander)



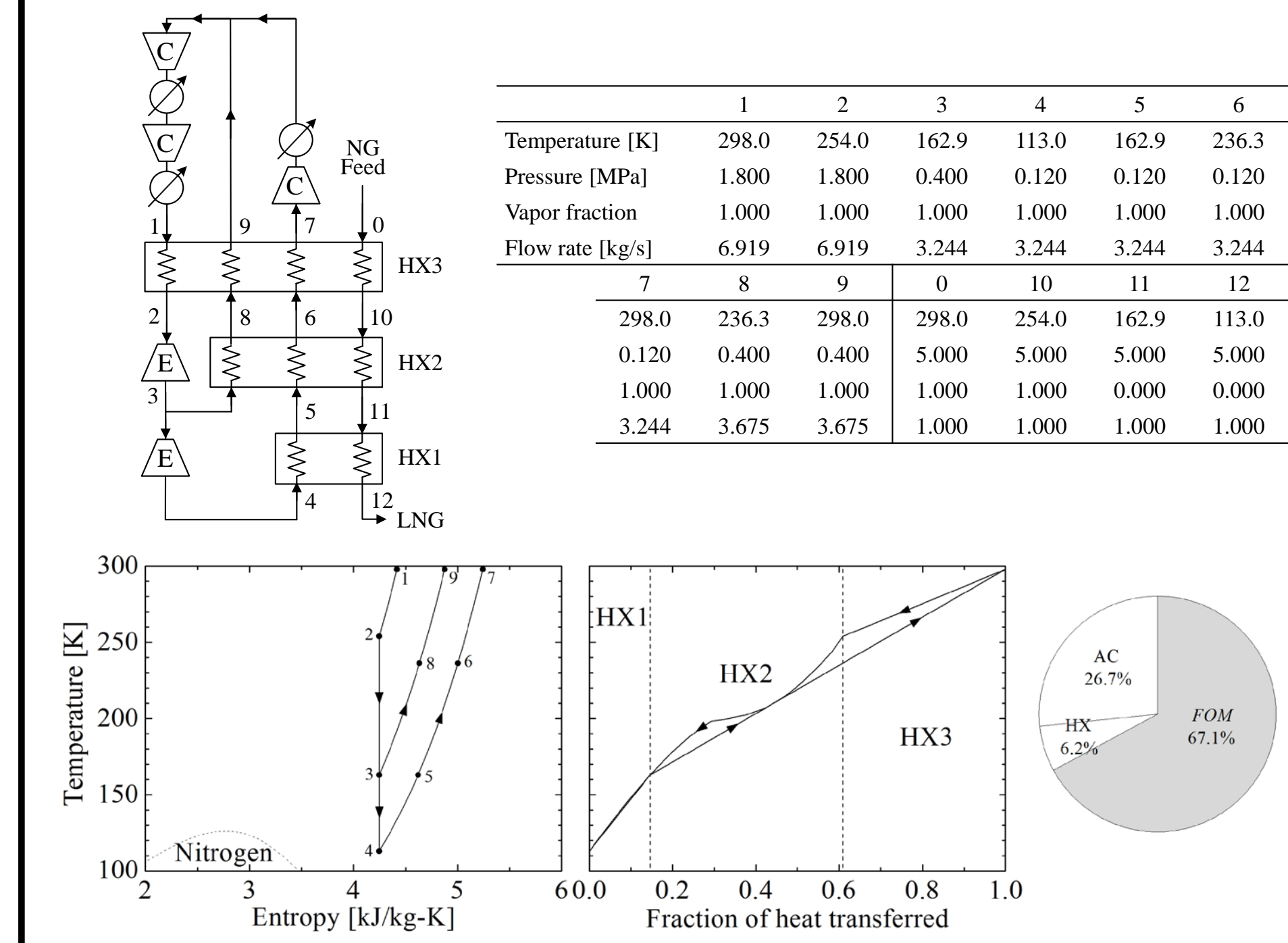
M1J (SMR)



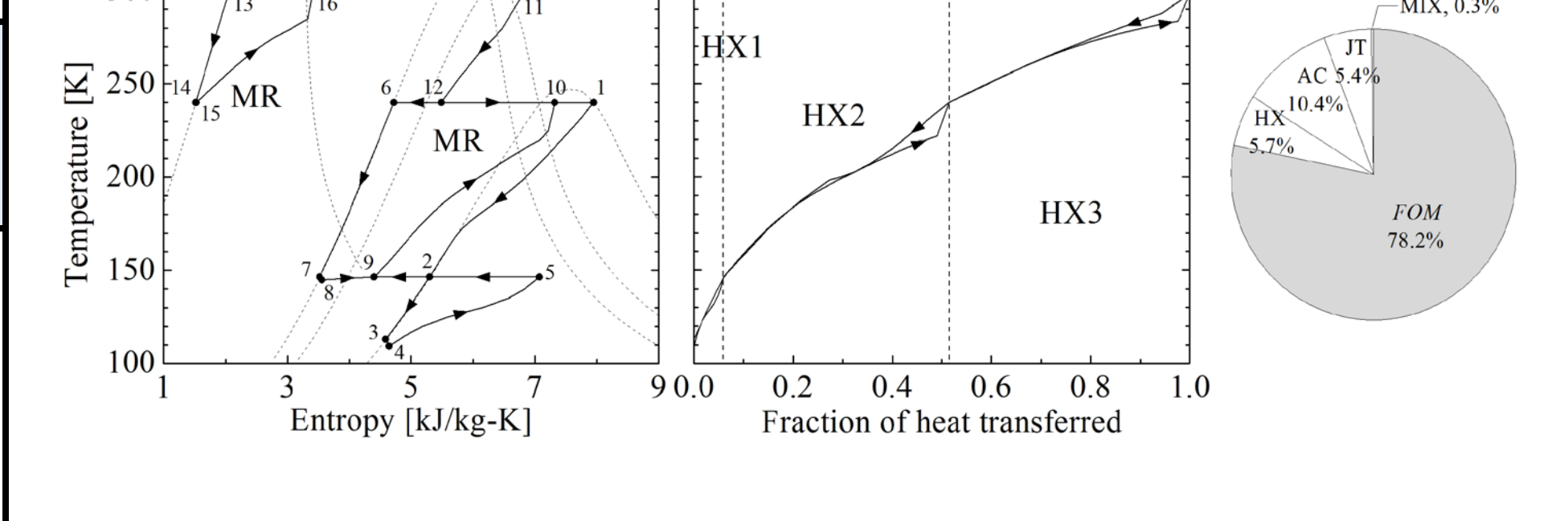
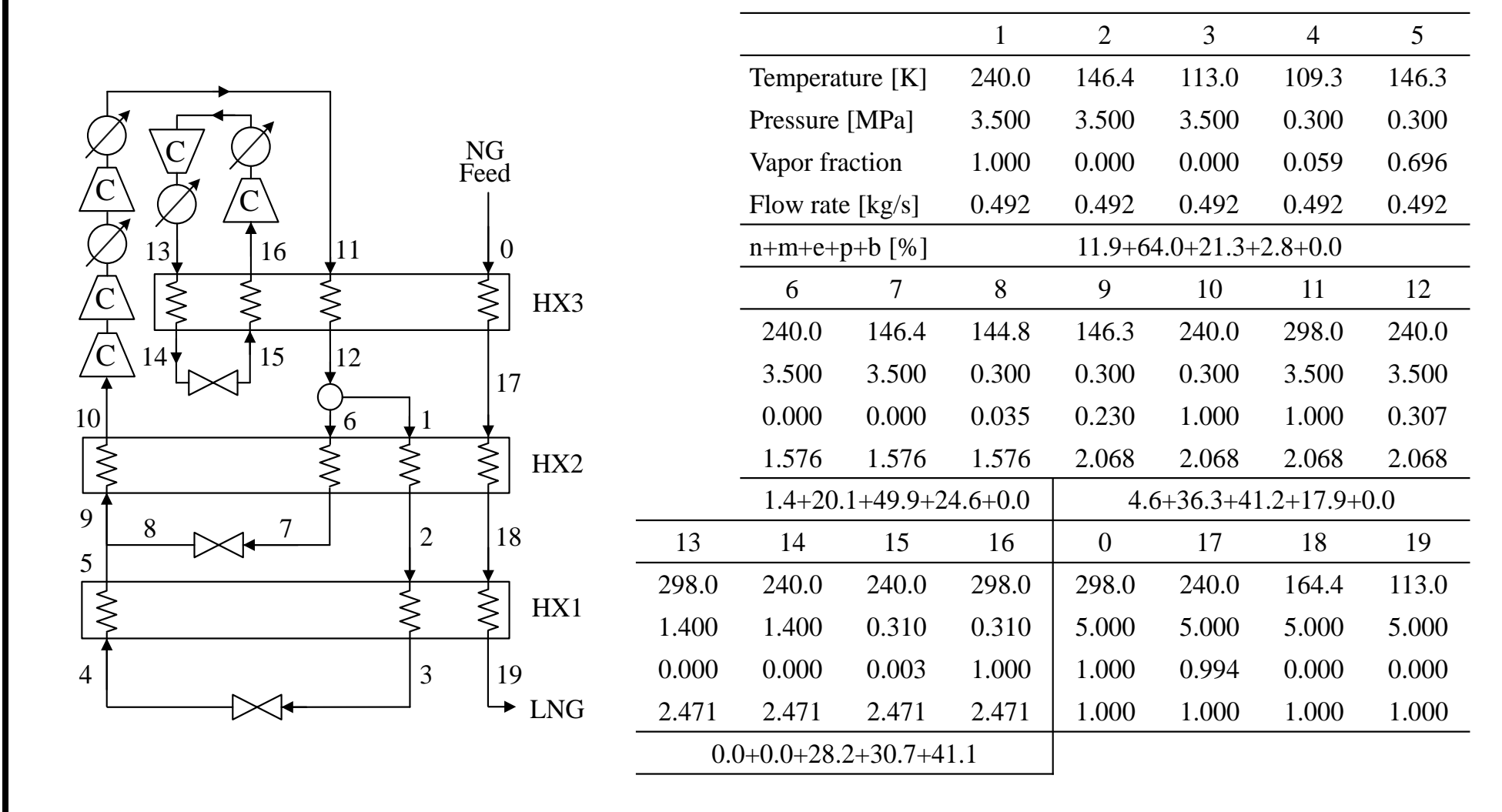
M2J



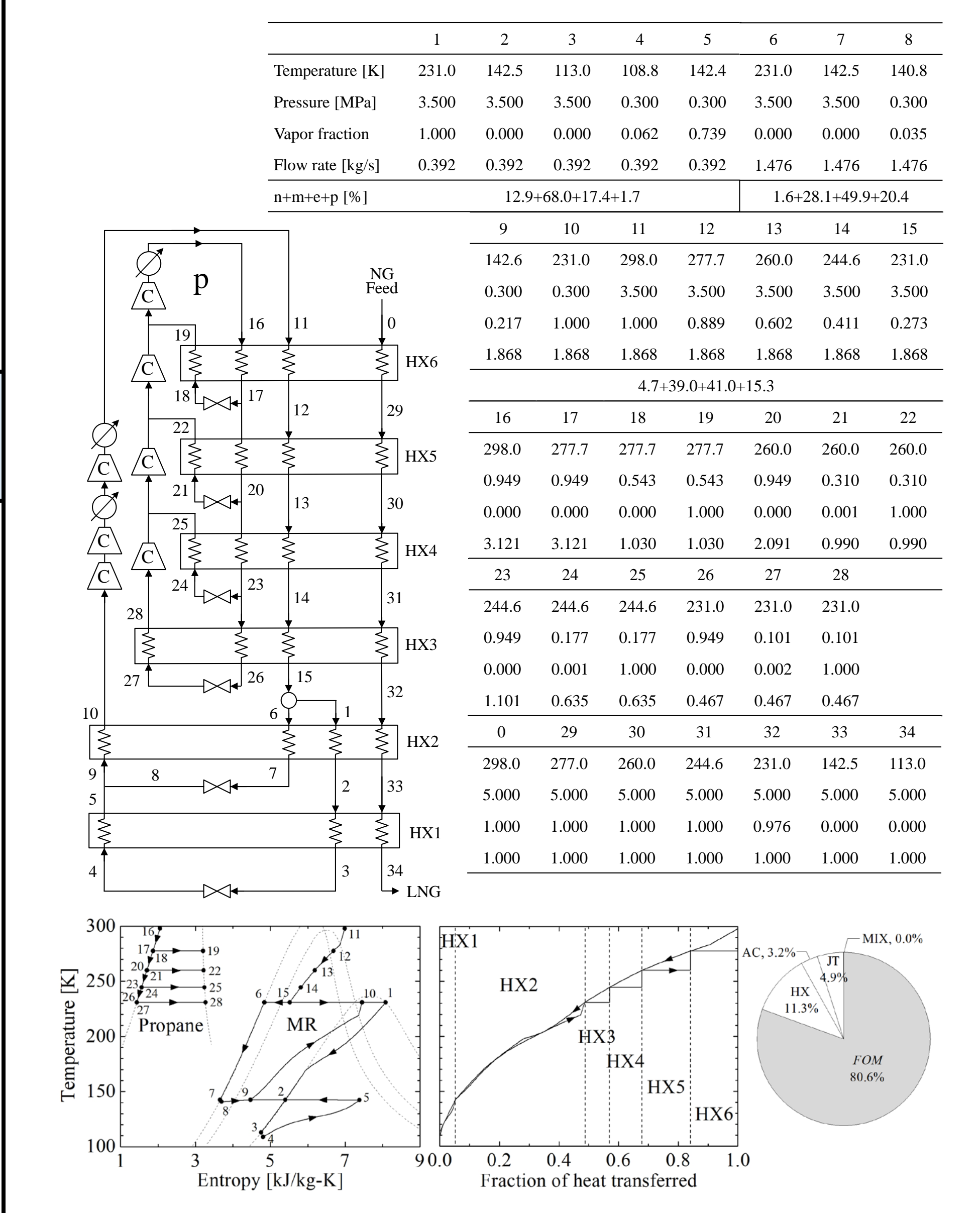
n2B



M1J+M2J (DMR-I)



p4J+M2J (C3-MR)



Summary

- The refrigeration cycles - Classified in a systematic way
 - By the type of expansion processes : JT / Brayton / Combined cycles
 - By the type of refrigerants : Pure / Mixed refrigerants
- A newly proposed nomenclature - Effectively used to identify the thermodynamic structure of refrigeration cycles

Acknowledgments

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