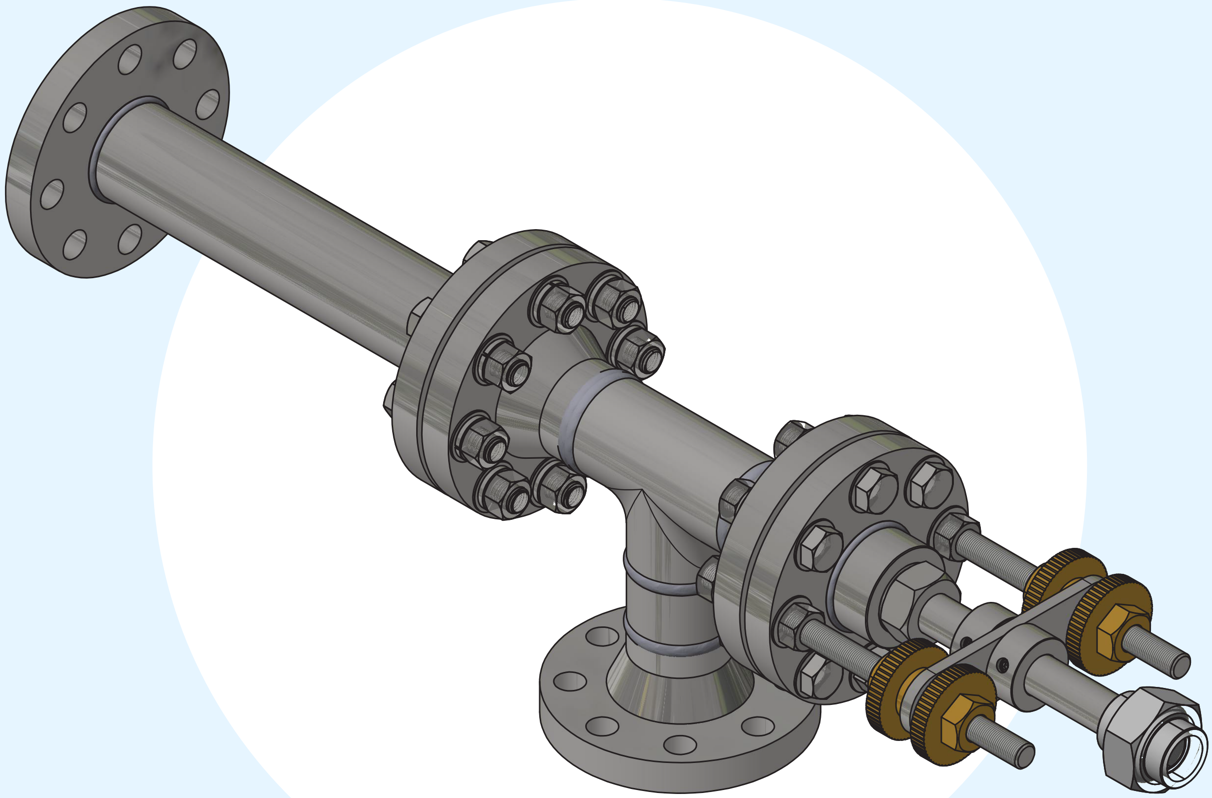
CANEJEX
EJECTOR CALCULATION TOOL

USER MANUAL



Natural Resources Canada
Ressources naturelles Canada

Canada

Table Of Contents

01 INTRODUCTION

CanEJEX is a user-friendly calculation tool specifically designed to support professionals with technical backgrounds in evaluating the potential of gas/gas ejectors in industrial process applications where fluid compression or entrainment is desired. The software also provides analysis capabilities for two-phase CO_2 ejectors operating in refrigeration and heat pumping conditions. Information on the basic operating principles of ejectors and a list of references are provided in the annex.

1.1 SOFTWARE CAPABILITIES

CanEJEX offers two calculation modules, each designed to meet specific engineering requirements:

1. **Preliminary Design:** Evaluates the feasibility of designing an ejector to meet specific operational requirements. It provides initial estimates of key geometric dimensions (nozzle throat diameter, nozzle exit diameter, and mixing chamber diameter). These estimates facilitate the optimization and final design stages, which require advanced methods such as Computational Fluid Dynamics (CFD) simulations and experimental validation.
2. **Performance Prediction:** Predicts the performance of a specific ejector under various operating conditions. By inputting three key geometric parameters (nozzle throat diameter, nozzle exit diameter, and mixing chamber diameter), it calculates values for the two key performance criteria: entrainment ratio and compression ratio.

1.2 WORKING FLUID

CanEJEX supports the analysis of ejectors with multiple working fluids: CH_4 ,CO_2 , air, water, natural gas mixture, and others.

02 USER INTERFACE

CanEJEX employs a two-tier tab structure. The primary level consists of four main menus, each providing access to corresponding submenus and functionalities.

2.1 INTERFACE OVERVIEW

The main interface is organized into four sections:

1. ‘’File” Menu: File management and application control
2. Calculation Menu: Data entry relative to the ejector application and results
3. Options Menu: Language and measurement unit configuration
4. Help Menu: Documentation and support information

2.2 FILE MENU

The File menu provides essential file management and functions:

Table 1: File Menu Functions

Function	Description
New	Create a new project with default parameters
Open	Load an existing project file
Close	Close the current project
Save	Save the current project
Save As	Save the project with a new name
Home	Return to the main interface
Quit	Exit the application

2.3 CALCULATION MENU

The Calculation menu is the heart of CanEJEX and contains all analytical functionality:

Table 2: Calculation Menu Structure

Submenu	Functionality
Ejector	Parameter input relevant to ejector application and selection of calculation function or module
Calculate	Execute the calculation process
Results	Display calculation results
Export	Export data in various formats
Logs	Session calculation history

2.3.1 Ejector Tab

The Ejector tab is where all parameters relevant to the ejector application are entered. It contains two main sections:

Global Parameters: This section requires entering project the analysis settings as defined in table 3.

Table 3: Global Parameters

Parameter	Type	Description
Project Name	Text	Identifier for the analysis project
Flow Condition	Selection	Single-phase (gas-gas) or two-phase CO_2
Working Fluid	Dropdown	CH_4, CO_2 , water, air, and others
Model Type	Selection	Preliminary design or performance prediction

Inputs: This section requires to enter operating conditions specific to the ejector application, as well as key ejector geometric parameters when the "Performance prediction" model is selected. Inputs vary according to the ejector type (single-phase or two-phase CO_2). Further details are provided in section 3 of this manual.

2.3.2 Calculate Tab

The Calculate tab triggers the calculation process.

2.3.3 Results Tab

The Results tab displays calculation results with performance metrics and operating conditions. Results vary based on the selected model type and flow condition. Further details are provided in section 3 of this manual.

2.3.4 Export Tab

The Export tab provides data export functionality:

- Excel Export: Complete input and results in Excel format
- CSV Export: Data export in comma-separated values format

2.3.5 Logs Tab

The Logs tab exports all calculations performed during a working session in a single Excel file, providing:

- Calculation History: Complete record of all the analyses
- Parameter Tracking: Input parameter changes over time
- Results Comparison: Performance comparison across calculations

2.4 OPTIONS MENU

The Options menu provides configuration settings for language and units:

Table 4: Options Menu Configuration

Setting	Options	Description
Language	English/French	Interface language selection
Units	SI/Imperial	Default unit system (individual units can be se- lected per parameter)

2.5 HELP MENU

The Help menu provides support and documentation:

- Software Information: Version details and licensing information
- Contact Us: Contact information and support channels
- License Agreement and License Request: Licensing details and terms of use

03 EJECTOR ANALYSIS

3.1 SINGLE-PHASE EJECTOR ANALYSIS

3.1.1 Input Operating Parameters

For single-phase (gas-gas) ejector analysis, the required user inputs for operating conditions include: pressure and temperature for both the motive fluid (primary flow) and the suction fluid (secondary flow) to be entrained or compressed, as well as the primary mass flow rate and the desired ejector outlet pressure.

Table 5: Single-Phase Ejector Input Parameters

Parameter	Unit	Default	Description
Primary Pressure	kPa	-	Motive fluid pressure
Primary Temperature	°C	-	Motive fluid temperature
Secondary Pressure	kPa	-	Suction fluid pressure
Secondary Temperature	°C	-	Suction fluid temperature
Primary Mass Flow Rate	kg/s	-	Motive fluid flow rate
Ejector Outlet Pressure	kPa	-	Desired outlet pressure
Isentropic Efficiency	-	0,98	Primary nozzle isentropic efficiency (default provided)
Loss Coefficient	-	0,98	Mixing chamber loss coefficient (default provided)

Parameter Range Limitations

Parameter ranges are determined by fluid properties and engineering constraints. The software automatically validates inputs against:

- Fluid thermodynamic property limits (temperature and pressure boundaries)
- Physical constraints (positive values for geometric parameters)
- Engineering feasibility (realistic operating conditions)

Default Value Modification

Default values are provided for the isentropic efficiency of the ejector's primary nozzle and the loss coefficient of the mixing chamber. These defaults can be replaced with user-defined values by selecting the "Allow value modification" option.

3.1.2 Input Geometric Parameters (Performance Prediction)

When the "Performance prediction" model is selected, three key geometric parameters of the ejector are required:

Table 6: Geometric Parameters for Performance Prediction

Parameter	Unit	Description
Nozzle Throat Diameter	mm/in	Throat diameter at narrowest point
Nozzle Exit Diameter	mm/in	Exit diameter of primary nozzle
Mixing Chamber Diameter	mm/in	Constant area section diameter

3.1.3 Single-Phase Ejector Results

Preliminary Design: The table below shows the results generated with the "Preliminary Design" module

Table 7: Results for Single-Phase ejector Preliminary Design

Parameter	Unit	Description
Entrainment Ratio	-	Entrainment ratio at critical conditions
Outlet Temperature	°C	Calculated discharge temperature
Secondary Mass Flow	kg/s	Calculated suction fluid flow rate
Nozzle Throat Diameter	mm	Calculated throat diameter
Nozzle Exit Diameter	mm	Calculated exit diameter
Mixing Chamber Diameter	mm	Calculated constant area section diameter

Note: Units shown are indicative; actual units may vary depending on user selection or design setup.

The three calculated ejector key geometric parameters are displayed on the ejector schematic for visual reference and validation.

Performance Prediction : The table below shows the results generated with the "Performance Prediction" module.

Table 8: Results for Single-Phase ejector Performance Prediction

Parameter	Unit	Description
Primary Mass Flow Rate	kg/s	Calculated motive fluid flow rate
Secondary Mass Flow Rate	kg/s	Calculated suction fluid flow rate
Entrainment Ratio	-	Maximum achievable entrainment ratio
Critical Outlet Pressure	kPa	Maximum achievable outlet pressure
Outlet Temperature	°C	Calculated discharge temperature

Note: Units shown are indicative; actual units may vary depending on user selection or design setup.

3.2 TWO-PHASE CO_2 EJECTOR ANALYSIS

3.2.1 Input Operating Parameters

For the analysis of two-phase ejectors using CO_2 as working fluid, required inputs on operating conditions include pressure and temperature for both the motive fluid (primary flow) and the suction fluid (secondary flow), the primary mass flow rate, and either the desired outlet pressure or the secondary mass flow rate.

Table 9: Two-Phase CO_2 Ejector Input Parameters

Parameter	Unit	Default	Description
Primary Pressure	kPa	-	Motive fluid pressure
Primary Temperature	°C	-	Motive fluid temperature
Secondary Pressure	kPa	-	Suction fluid pressure
Secondary Temperature	°C	-	Suction fluid temperature
Primary Mass Flow Rate	kg/s	-	Motive fluid flow rate
Outlet Pressure	kPa	-	Desired outlet pressure
Secondary Mass Flow Rate	kg/s	-	Suction fluid flow rate (alternative to outlet pressure)
Loss Coefficient	-	0,78	Mixing chamber loss coefficient (default provided)

CO_2 Two-Phase Limitations

Two-phase CO_2 ejector analysis is subject to additional constraints:

- Operating conditions must be within CO_2 thermodynamic boundaries
- Phase change considerations affect calculation convergence
- Critical point proximity requires careful parameter selection

The software automatically handles phase equilibrium calculations using CoolProp.

Default Value Modification

A default value is provided for the loss coefficient of the ejector's mixing chamber. This default value can be replaced with a user-defined value by checking the "Allow value modification" box.

3.2.2 Input Geometric Parameters (Performance Prediction)

Three key geometric parameters of the ejector are also required when the "Performance prediction" model is selected:

Table 10: Geometric Parameters for Two-Phase CO_2

Parameter	Unit	Default	Description
Nozzle Throat Diameter	mm/in	-	Throat diameter at narrowest point
Nozzle Exit Diameter	mm/in	-	Exit diameter of primary nozzle
Mixing Chamber Diameter	mm/in	-	Constant area section diameter

3.2.3 Two-Phase CO_2 Ejector Results

Preliminary Design : The table below shows the results generated with the "Preliminary Design" module.

Table 11: Results for Two-Phase CO_2 Ejector Preliminary Design

Parameter	Unit	Description
Entrainment Ratio	-	Maximum achievable entrainment ratio
Outlet Quality	%	Vapor quality at discharge
Outlet Temperature	°C	Calculated discharge temperature
Critical Outlet Pressure	kPa	Maximum achievable outlet pressure
Primary Flow State	-	State of primary flow (subcritical/supercritical)
Secondary Flow State	-	State of secondary flow (subcritical/supercritical)
Nozzle Throat Diameter	mm	Calculated throat diameter
Nozzle Exit Diameter	mm	Calculated nozzle exit diameter
Mixing Chamber Diameter	mm	Calculated constant area section diameter

Note: Units shown are indicative; actual units may vary depending on user selection or design setup.

The three calculated key geometric parameters are displayed on the ejector schematic for visual reference and validation.

Performance Prediction : The table below shows the results generated with the "Performance Prediction module".

Table 12: Results for Two-Phase CO_2 Ejector Performance Prediction

Parameter	Unit	Description
Primary Mass Flow Rate	kg/s	Calculated motive fluid flow rate
Secondary Mass Flow Rate	kg/s	Calculated suction fluid flow rate
Entrainment Ratio	-	Maximum achievable entrainment ratio
Critical Outlet Pressure	kPa	Maximum achievable outlet pressure
Outlet Quality	%	Vapor quality at discharge
Outlet Temperature	°C	Calculated discharge temperature
Primary Flow State	-	State of primary flow
Secondary Flow Phase	-	State of secondary flow phase

Note: Units shown are indicative; actual units may vary depending on user selection or design setup.

04 TROUBLESHOOTING

4.1 COMMON ISSUES AND SOLUTIONS

4.1.1 Input Parameter Issues

Parameter Validation Errors

Symptoms:

- Calculation fails after starting
- Error messages about invalid parameters
- Inconsistent results

Solutions :

1. Verify all input fields contain valid numeric values
2. Check parameter ranges are within acceptable limits
3. Ensure geometric parameters are positive values
4. Validate temperature and pressure combinations

4.1.2 Calculation Convergence Issues

Convergence Problems

Symptoms:

- Long calculation times
- Inconsistent results between similar cases
- Calculation termination without results

Solutions :

1. Adjust initial pressure estimates
2. Modify operating conditions within fluid limits
3. Try different efficiency values
4. Use more conservative parameter estimates

4.1.3 Fluid Property Issues

Fluid Property Errors

Symptoms:

- Error messages about fluid properties
- Unrealistic operating conditions
- Phase boundary violations

Solutions :

5. Check temperature and pressure within fluid limits
6. Verify fluid selection matches application
7. Adjust operating conditions away from critical points
8. Ensure appropriate phase conditions for selected model

4.2 TIPS

Calculation Best Practices

1. **Input Parameters Validation:**
   Always verify input parameters before calculation
2. **Fluid Limits:**
   Check temperature and pressure within fluid property boundaries
3. **Conservative Estimates:**
   Start with realistic operating conditions
4. **Module Selection:**
   Choose the appropriate module for the desired objective
5. **Result Verification:**
   Cross-check results with expected ranges
6. **Documentation:**
   Save successful configurations for future reference

05 ANNEX

5.1 BASIC CONCEPTS

5.1.1 Ejector Operating Principle

An ejector is a device used to move and compress fluids or gases by utilizing the Venturi effect. It operates based on the principle of fluid dynamics, which states that as the velocity of a fluid increases, its pressure decreases.

The operating principle of the ejector is quite similar to that of the conventional compressor. In a conventional compressor, electrical power ($W_{electric}$) is used to compress a given mass flow rate of fluid (m_{fluid}) at a given compression ratio. The compression ratio is the ratio of the discharge pressure to the suction pressure ($P_{discharge}/P_{suction}$).

In the case of the ejector, the power input comes from the motive fluid (W_{motive}); it is a function of its pressure and mass flow rate. Using the motive fluid, the ejector allows compressing a given mass flow rate of a suction fluid ($m_{suction}$) at a given compression ratio.

5.1.2 Performance Characteristics

In both the conventional compressor and the ejector, for a given power input, the suction mass flow rate is inversely proportional to the compression ratio. This relationship is of vital importance for applications requiring pressure buildup, steam compression, or fluid circulation.

5.2 EJECTOR PARAMETERS AND KEY PERFORMANCE METRICS

5.2.1 Geometric Parameters

The ejector's design and performance depend on several critical parameters, including three main geometric dimensions (calculated with the tool):

1. **Diameter of the Mixing Chamber (D_{mix}):**
   The diameter of the section of the ejector between the convergent and the diffuser sections
2. **Diameter of the Primary Nozzle Throat (D_{throat}):**
   The diameter at the narrowest point of the primary nozzle that controls the motive fluid mass flow rate
3. **Diameter of the Primary Nozzle Exit (D_{exit}):**
   The diameter where the motive fluid exits the nozzle

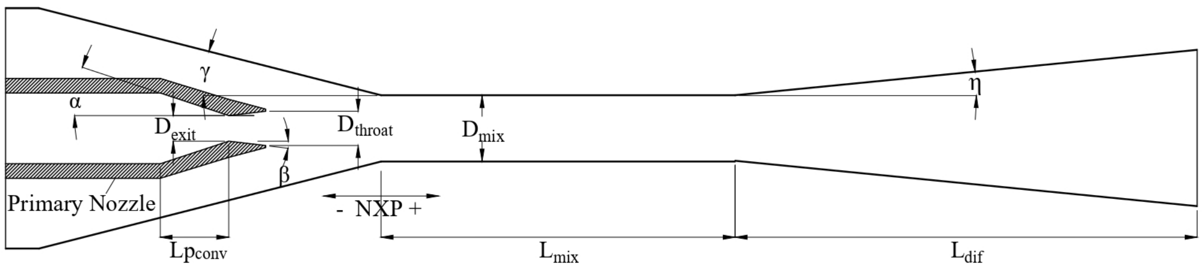


Figure 1: Schematic of an ejector with main geometrical parameters

5.2.2 Operating Pressures

Three key operating pressures determine ejector performance:

1. Primary Pressure (P1): The motive fluid's pressure
2. Secondary Pressure (P2): The suction fluid's pressure
3. Outlet Pressure (Pout): The pressure at the ejector's outlet

5.2.3 Key Performance Metrics

There are two main performance metrics for an ejector: the entrainment ratio and the compression ratio.

Entrainment Ratio (ω): The entrainment ratio (ω) measures the ejector's ability to draw and mix the secondary fluid into the primary fluid stream. It is calculated as the ratio of the suction fluid (m2) mass flow rate to the motive fluid (m1) mass flow rate:

$$\omega = \frac{m_2}{m_1} \quad (1)$$

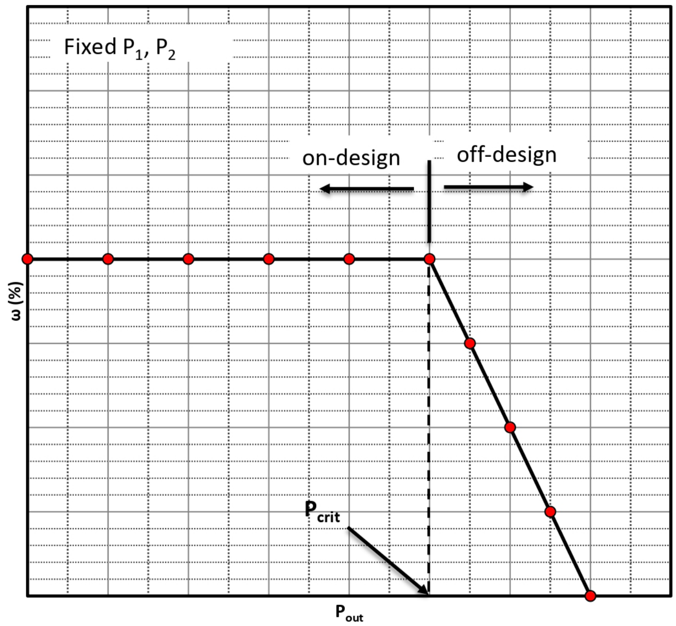


Figure 2: Typical performance curve of a gas-gas ejector

At low outlet pressures (P_{out}), the ejector is operating "on-design", and the entrainment ratio remains constant up to the critical outlet pressure ($P_{out-crit}$). In this state, both motive and suction flow are choked. Beyond the $P_{out-crit}$, the ejector operates "off-design" with a decreasing entrainment ratio.

The behavior can be summarized as:

- m_2 remains constant when $P_{out} < P_{out-crit}$
- m_2 decreases when $P_{out} > P_{out-crit}$

Compression Ratio: The compression ratio represents the pressure increase of the suc-tion flow achieved by the ejector:

$$\text{Compression Ratio} = \frac{P_{out}}{P_2} \quad (2)$$

For optimal performance, the ejector should operate close to its critical outlet pressure, where the compression ratio ($P_{out\text{-}crit}/P_2$) is maximized for $\omega = \omega_{crit}$. Depending on the application, either the entrainment ratio or the compression ratio may be prioritized as the key performance parameter.

5.3 THE SCIENCE BEHIND THE CALCULATION TOOL

CanEJEX software calculation tool incorporates two one-dimensional thermodynamic models: the "Preliminary Design Model" and the "Performance Prediction Model" deve-loped for both single-phase (gas/gas) and two-phase CO_2 ejectors. The models utilize:

1. **Isentropic Flow Relations:**
   For nozzle calculations and throat analysis
2. **Momentum Conservation:**
   For mixing chamber analysis
3. **Energy Conservation:**
   For thermodynamic property calculations
4. **Mass Conservation:**
   For flow rate determinations
5. **Homogeneous Equilibrium Model:**
   For two-phase flow analysis

References at the end of the user manual are provided on ejector applications and modeling approaches.

5.4 FLUID PROPERTIES

Users can select from a predefined set of fluids, with the flexibility to expand options to include other fluids. The thermodynamic properties of these fluids come from the free CoolProp package, and more information on each fluid can be found in the CoolProp documentation.
For "Natural gas mixture", a coded equation of state is used; when this option is selected, the exact mixture composition has to be specified.

Fluid Property Limitations

The software automatically determines fluid property limits using CoolProp:

- **Temperature Limits:**
  Minimum and maximum temperatures for each fluid
- **Pressure Limits:**
  Maximum pressure boundaries for thermodynamic calculations

These limits vary significantly between fluids and are automatically enforced during calculations.

Table 13: Corrected Fluid Property Limits (from CoolProp 7.x)

Fluid	Tmin (K)	Tmax (K)	Pmax (kPa)
CO_2	216.6	2 000,0	800,000
R134a	169.9	455,0	70,000
CH_4	90.7	625,0	1,000,000
Air	59.8	2 000,0	2,000,000
H_2	14.0	1 000,0	2,000,000

Term	Definition
A_{CA}	Cross section area of the ejector’s constant area section
A_{throat}	Cross section area of the nozzle throat
D_{exit}	Diameter of the nozzle exit
D_{throat}	Diameter of the nozzle throat
m_1, m_{motive}	Mass flow rate of the primary/motive fluid
m_2, $m_{suction}$	Mass flow rate of the secondary/entrained fluid
m_{fluid}	Mass flow rate of the fluid
P_1	Primary pressure (pressure of the motive fluid)
P_2	Secondary pressure (pressure of the suction fluid)
P_{out}	Outlet pressure of the ejector (discharge pressure)
$P_{out-crit}$	Critical outlet pressure of the ejector (critical discharge pressure)
ω	Entrainment ratio
$W_{electric}$	Electric power
W_{motive}	Kinetic power provided by the motive fluid
CFD	Computational Fluid Dynamics
CoolProp	Thermodynamic property library

06 REFERENCES

1. *Aidoun, Z., Ameur, K., Falsafioon, M. et Badache, M. (2019).* Current advances in ejector modelling, experimentation and applications for refrigeration and heat pumps. Part 1: single-phase ejectors. Inventions, vol. 4, no 1, p. 15.

2. *Aidoun, Z., Ameur, K., Falsafioon, M. et Badache, M. (2019).* Current advances in ejector modelling, experimentation and applications for refrigeration and heat pumps. Part 2: two-phase ejectors. Inventions, vol. 4, no 1, p. 16.

3. *Falsafioon, M., Ameur, K. et Poppe, I. (2025).* A thorough and efficient design process for transcritical CO_2 ejectors. International Journal of Heat and Mass Transfer, vol. 239, article no 126511.

4. *Ameur, K. et Aidoun, Z. (2023).* A simple design approach of two-phase ejectors for CO_2 transcritical heat pumps. Journal of Applied Fluid Mechanics, vol. 16, no 10, p. 1887-1900.

07 CONTACT INFORMATION AND TECHNICAL SUPPORT

For technical support, licensing information, or to learn more about the CanEJEX software, please contact the development team through the following channel:

Technical Support Channel

User Support: For assistance or questions,
please contact: CanEJEX@nrcan-rncan.gc.ca.

SOFTWARE INFORMATION

CanEJEX - Ejector Calculation Tool
Version 1.0
By downloading the software, the user accepts the terms and conditions set forth in the end-user license agreement.

ISBN : 978-0-660-99757-5
Catalog No.: M154-218/2026E-PDF