Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, “Vehicle emissions, air demand, environment, longitudinal ventilation”. Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example that uses Darcy friction factor, positive airflow and traffic slower than air.

Tunnel geometry input

Length	2000	m
Area	50	m²
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Traffic input

Traffic speed (+ve)	10	km/h
Car flowrate	500	cars/hr
LCV flowrate	50	LCVs/hr
HGV flowrate	100	HGVs/hr
Car area	2	m²
Car drag factor	0.4	—
LCV area	4	m²
LCV drag factor	0.8	—
HGV area	6	m²
HGV drag factor	0.9	—
Use blockage correction in calc?	N	(Y/N)

Wind input

P at left portal	0	Pa
P at right portal	20	Pa

Jet fan input

Count of fans	10	—
Static thrust	730	N at 1.2 kg/m³
Jet velocity	30	m/s
Installation efficiency	0.75	—

Calculation (vehicles slower than air)

Air velocity	3.152227	m/s
Volume flow	157.611	m³/s

Independent check calc of pressures

Wind pressure	20.00	Pa
Friction pressure	77.62	Pa
Traffic pressure	0.37	Pa
Jet fan pressure	-97.99	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, “Vehicle emissions, air demand, environment, longitudinal ventilation”. Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example that uses Darcy friction factor, positive airflow and traffic faster than air.

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Traffic input

Traffic speed (+ve)	10	km/h
Car flowrate	500	cars/hr
LCV flowrate	50	LCVs/hr
HGV flowrate	100	HGVs/hr
Car area	2	m^2
Car drag factor	0.4	—
LCV area	4	m^2
LCV drag factor	0.8	—
HGV area	6	m^2
HGV drag factor	0.9	—
Use blockage correction in calc?	N	(Y/N)

Wind input

P at left portal	0	Pa
P at right portal	20	Pa

Jet fan input

Count of fans	2	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	30	m/s
Installation efficiency	0.75	—

Calculation (vehicles faster than air)

Air velocity	1.065254	m/s
Volume flow	53.263	m^3/s

Independent check calc of pressures

Wind pressure	20.00	Pa
Friction pressure	8.86	Pa
Traffic pressure	-7.74	Pa
Jet fan pressure	-21.12	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, “Vehicle emissions, air demand, environment, longitudinal ventilation”. Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example that uses Darcy friction factor and negative airflow.

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Traffic input

Traffic speed (+ve)	10	km/h
Car flowrate	500	cars/hr
LCV flowrate	50	LCVs/hr
HGV flowrate	100	HGVs/hr
Car area	2	m^2
Car drag factor	0.4	—
LCV area	4	m^2
LCV drag factor	0.8	—
HGV area	6	m^2
HGV drag factor	0.9	—
Use blockage correction in calc?	N	(Y/N)

Wind input

P at left portal	0	Pa
P at right portal	100	Pa

Jet fan input

Count of fans	2	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	30	m/s
Installation efficiency	0.75	—

Calculation (reverse airflow)

Air velocity	-1.726343	m/s
Volume flow	-86.317	m^3/s

Independent check calc of pressures

Wind pressure	100.00	Pa
Friction pressure	-23.28	Pa
Traffic pressure	-53.56	Pa
Jet fan pressure	-23.16	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, “Vehicle emissions, air demand, environment, longitudinal ventilation”. Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example that uses Fanning friction factor, positive airflow and traffic slower than air.

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Fanning	(Darcy/Fanning)
Fanning fricfac c_f	0.009	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Wind input

P at left portal	0	Pa
P at right portal	20	Pa

Jet fan input

Count of fans	10	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	30	m/s
Installation efficiency	0.75	—

Traffic input

Traffic speed (+ve)	10	km/h
Car flowrate	500	cars/hr
LCV flowrate	50	LCVs/hr
HGV flowrate	100	HGVs/hr
Car area	2	m^2
Car drag factor	0.4	—
LCV area	4	m^2
LCV drag factor	0.8	—
HGV area	6	m^2
HGV drag factor	0.9	—

Use blockage correction in calc? N (Y/N)

Calculation (vehicles slower than air)

Air velocity	3.152227	m/s
Volume flow	157.611	m^3/s

Independent check calc of pressures

Wind pressure	20.00	Pa
Friction pressure	77.62	Pa
Traffic pressure	0.37	Pa
Jet fan pressure	-97.99	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, “Vehicle emissions, air demand, environment, longitudinal ventilation”. Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example with the traffic blockage correction term turned off.

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Wind input

P at left portal	20	Pa
P at right portal	0	Pa

Jet fan input

Count of fans	4	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	30	m/s
Installation efficiency	0.75	—

Traffic input

Traffic speed (+ve)	50	km/h
Car flowrate	1800	cars/hr
LCV flowrate	200	LCVs/hr
HGV flowrate	500	HGVs/hr
Car area	2	m^2
Car drag factor	0.4	—
LCV area	4	m^2
LCV drag factor	0.8	—
HGV area	6	m^2
HGV drag factor	0.9	—
Use blockage correction in calc?	N	(Y/N)

Calculation (vehicles faster than air)

Air velocity	5.347430	m/s
Volume flow	267.371	m^3/s

Independent check calc of pressures

Wind pressure	-20.00	Pa
Friction pressure	223.38	Pa
Traffic pressure	-167.39	Pa
Jet fan pressure	-35.99	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, “Vehicle emissions, air demand, environment, longitudinal ventilation”. Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

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Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example with the traffic blockage correction term turned on and the drag factors adjusted to cancel out the correction.

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Wind input

P at left portal	20	Pa
P at right portal	0	Pa

Jet fan input

Count of fans	4	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	30	m/s
Installation efficiency	0.75	—

Traffic input

Traffic speed (+ve)	50	km/h
Car flowrate	1800	cars/hr
LCV flowrate	200	LCVs/hr
HGV flowrate	500	HGVs/hr
Car area	2	m^2
Car drag factor	0.36864	—
LCV area	4	m^2
LCV drag factor	0.67712	—
HGV area	6	m^2
HGV drag factor	0.69696	—
Use blockage correction in calc?	Y	(Y/N)

Calculation (vehicles faster than air)

Air velocity	5.347430	m/s
Volume flow	267.371	m^3/s

Independent check calc of pressures

Wind pressure	-20.00	Pa
Friction pressure	223.38	Pa
Traffic pressure	-167.39	Pa
Jet fan pressure	-35.99	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, “Vehicle emissions, air demand, environment, longitudinal ventilation”. Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example with the traffic flow and drag data switched around.

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Wind input

P at left portal	20	Pa
P at right portal	0	Pa

Jet fan input

Count of fans	4	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	30	m/s
Installation efficiency	0.75	—

Traffic input

Traffic speed (+ve)	50	km/h
Car flowrate	500	cars/hr
LCV flowrate	1800	LCVs/hr
HGV flowrate	200	HGVs/hr
Car area	6	m^2
Car drag factor	0.9	—
LCV area	2	m^2
LCV drag factor	0.4	—
HGV area	4	m^2
HGV drag factor	0.8	—
Use blockage correction in calc?	N	(Y/N)

Calculation (vehicles faster than air)

Air velocity	5.347430	m/s
Volume flow	267.371	m^3/s

Independent check calc of pressures

Wind pressure	-20.00	Pa
Friction pressure	223.38	Pa
Traffic pressure	-167.39	Pa
Jet fan pressure	-35.99	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, "Vehicle emissions, air demand, environment, longitudinal ventilation". Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example with the traffic flow and drag data switched again and the pressures modified

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Traffic input

Traffic speed (+ve)	50	km/h
Car flowrate	200	cars/hr
LCV flowrate	500	LCVs/hr
HGV flowrate	1800	HGVs/hr
Car area	4	m^2
Car drag factor	0.8	—
LCV area	6	m^2
LCV drag factor	0.9	—
HGV area	2	m^2
HGV drag factor	0.4	—
Use blockage correction in calc?	N	(Y/N)

Wind input

P at left portal	0	Pa
P at right portal	-20	Pa

Jet fan input

Count of fans	4	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	30	m/s
Installation efficiency	0.75	—

Calculation (vehicles faster than air)

Air velocity	5.347430	m/s
Volume flow	267.371	m^3/s

Independent check calc of pressures

Wind pressure	-20.00	Pa
Friction pressure	223.38	Pa
Traffic pressure	-167.39	Pa
Jet fan pressure	-35.99	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, “Vehicle emissions, air demand, environment, longitudinal ventilation”. Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example with the traffic just slower than the airflow

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Traffic input

Traffic speed (+ve)	18	km/h
Car flowrate	1800	cars/hr
LCV flowrate	200	LCVs/hr
HGV flowrate	500	HGVs/hr
Car area	2	m^2
Car drag factor	0.4	—
LCV area	4	m^2
LCV drag factor	0.8	—
HGV area	6	m^2
HGV drag factor	0.9	—
Use blockage correction in calc?	N	(Y/N)

Wind input

P at left portal	94.92	Pa
P at right portal	0	Pa

Jet fan input

Count of fans	11	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	30	m/s
Installation efficiency	0.75	—

Calculation (vehicles faster than air)

Air velocity	4.999939	m/s
Volume flow	249.997	m^3/s

Independent check calc of pressures

Wind pressure	-94.92	Pa
Friction pressure	195.30	Pa
Traffic pressure	0.00	Pa
Jet fan pressure	-100.38	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, "Vehicle emissions, air demand, environment, longitudinal ventilation". Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

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Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example with the traffic just faster than the airflow

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Traffic input

Traffic speed (+ve)	18	km/h
Car flowrate	1800	cars/hr
LCV flowrate	200	LCVs/hr
HGV flowrate	500	HGVs/hr
Car area	2	m^2
Car drag factor	0.4	—
LCV area	4	m^2
LCV drag factor	0.8	—
HGV area	6	m^2
HGV drag factor	0.9	—
Use blockage correction in calc?	N	(Y/N)

Wind input

P at left portal	94.93	Pa
P at right portal	0	Pa

Jet fan input

Count of fans	11	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	30	m/s
Installation efficiency	0.75	—

Calculation (vehicles slower than air)

Air velocity	5.000061	m/s
Volume flow	250.003	m^3/s

Independent check calc of pressures

Wind pressure	-94.93	Pa
Friction pressure	195.30	Pa
Traffic pressure	0.00	Pa
Jet fan pressure	-100.37	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, “Vehicle emissions, air demand, environment, longitudinal ventilation”. Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example with the air velocity positive and just above zero.

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Traffic input

Traffic speed (+ve)	18	km/h
Car flowrate	200	cars/hr
LCV flowrate	500	LCVs/hr
HGV flowrate	1800	HGVs/hr
Car area	4	m^2
Car drag factor	0.8	—
LCV area	6	m^2
LCV drag factor	0.9	—
HGV area	2	m^2
HGV drag factor	0.4	—
Use blockage correction in calc?	N	(Y/N)

Wind input

P at left portal	0	Pa
P at right portal	192.18	Pa

Jet fan input

Count of fans	3	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	30	m/s
Installation efficiency	0.75	—

Calculation (vehicles faster than air)

Air velocity	0.000051	m/s
Volume flow	0.003	m^3/s

Independent check calc of pressures

Wind pressure	192.18	Pa
Friction pressure	0.00	Pa
Traffic pressure	-159.33	Pa
Jet fan pressure	-32.85	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, “Vehicle emissions, air demand, environment, longitudinal ventilation”. Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example with the air velocity negative and just below zero.

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Wind input

P at left portal	0	Pa
P at right portal	192.19	Pa

Jet fan input

Count of fans	3	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	30	m/s
Installation efficiency	0.75	—

Traffic input

Traffic speed (+ve)	18	km/h
Car flowrate	1800	cars/hr
LCV flowrate	200	LCVs/hr
HGV flowrate	500	HGVs/hr
Car area	2	m^2
Car drag factor	0.4	—
LCV area	4	m^2
LCV drag factor	0.8	—
HGV area	6	m^2
HGV drag factor	0.9	—

Use blockage correction in calc? N (Y/N)

Calculation (reverse airflow)

Air velocity	-0.000103	m/s
Volume flow	-0.005	m^3/s

Independent check calc of pressures

Wind pressure	192.19	Pa
Friction pressure	0.00	Pa
Traffic pressure	-159.34	Pa
Jet fan pressure	-32.85	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, “Vehicle emissions, air demand, environment, longitudinal ventilation”. Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

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Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.
Example in which the jet fan thrust exactly balances the wind pressure difference.

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Traffic input

Traffic speed (+ve)	50	km/h
Car flowrate	0	cars/hr
LCV flowrate	0	LCVs/hr
HGV flowrate	0	HGVs/hr
Car area	2	m^2
Car drag factor	0.4	—
LCV area	4	m^2
LCV drag factor	0.8	—
HGV area	6	m^2
HGV drag factor	0.9	—
Use blockage correction in calc?	N	(Y/N)

Wind input

P at left portal	0	Pa
P at right portal	43.8	Pa

Jet fan input

Count of fans	4	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	30	m/s
Installation efficiency	0.75	—

Calculation (vehicles faster than air)

Air velocity	0.000000	m/s
Volume flow	0.000	m^3/s

Independent check calc of pressures

Wind pressure	43.80	Pa
Friction pressure	0.00	Pa
Traffic pressure	0.00	Pa
Jet fan pressure	-43.80	Pa
Is the sum zero?	TRUE	

Slug flow in a simple road tunnel by quadratic equations. Solution of the equations in section IV of PIARC report 05.02.B, “Vehicle emissions, air demand, environment, longitudinal ventilation”. Handles stationary traffic, moving traffic (vehicle speed must not be negative) jet fans and wind. Selects the solution from a range of different quadratics, depending on the inputs. The check calculation uses the source formula.

Single tunnel of constant area with losses, friction, jet fans, traffic drag and portal pressures.

Example in which the traffic drag exactly balances the jet fan thrust.

This case also verifies that jet fans blowing backwards are handled correctly.

Tunnel geometry input

Length	2000	m
Area	50	m^2
Perimeter	32	m
Friction type	Darcy	(Darcy/Fanning)
Darcy fricfac λ	0.036	—
Left portal loss	0.5	—
Right portal loss	1	—
D_h (info only, not used)	6.25	m

Wind input

P at left portal	0	Pa
P at right portal	0	Pa

Jet fan input

Count of fans	4	—
Static thrust	730	N at 1.2 kg/m^3
Jet velocity	-30	m/s
Installation efficiency	0.75	—

Traffic input

Traffic speed (+ve)	36	km/h
Car flowrate	821.25	cars/hr
LCV flowrate	0	LCVs/hr
HGV flowrate	0	HGVs/hr
Car area	2	m^2
Car drag factor	0.4	—
LCV area	4	m^2
LCV drag factor	0.8	—
HGV area	6	m^2
HGV drag factor	0.9	—
Use blockage correction in calc?	N	(Y/N)

Calculation (vehicles faster than air)

Air velocity	0.000000	m/s
Volume flow	0.000	m^3/s

Independent check calc of pressures

Wind pressure	0.00	Pa
Friction pressure	0.00	Pa
Traffic pressure	-43.80	Pa
Jet fan pressure	43.80	Pa
Is the sum zero?	TRUE	