MMTO Conversion Technical Memorandum #97-1

6.5-m Ventilation System:
Exhaust Ejector Performance Test Results

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May 14, 1997

Abstract:

Testing was conducted by S. Callahan & P. Benjamin at the MMT summit to determine the performance characteristics of an MMT exhaust ejector at ambient pressure. This is a summary of the tests and results.

The exhaust ejectors operate on the same principle as the MMT jet ejectors. The throats of the exhaust ejectors have a ring of 24 small jets that serves the same purpose as the larger single jet of the jet ejectors. Drawing mmt0428 (attached) illustrates the design of the exhaust ejector.

Six exhaust ejectors are used to exhaust excess air that is brought into the telescope cell via the jet ejectors (hence the name "exhaust ejector").

Test Procedure:

The supply flow, Q_{supply}, and the discharge, Q_{out} , were measured for each setting of the supply pressure P_{supply}. The supply flow is the flow to the ring of 24 jets. The discharge flow is the sum of the supply flow and the entrained flow. Flow rates were determined by measuring the time required to fill a known volume. All tests were conducted at the MMT summit (altitude $2606m$ $(8550\ ft)$, pressure $73.8\,KPa$ $(10.7\,psia)$).

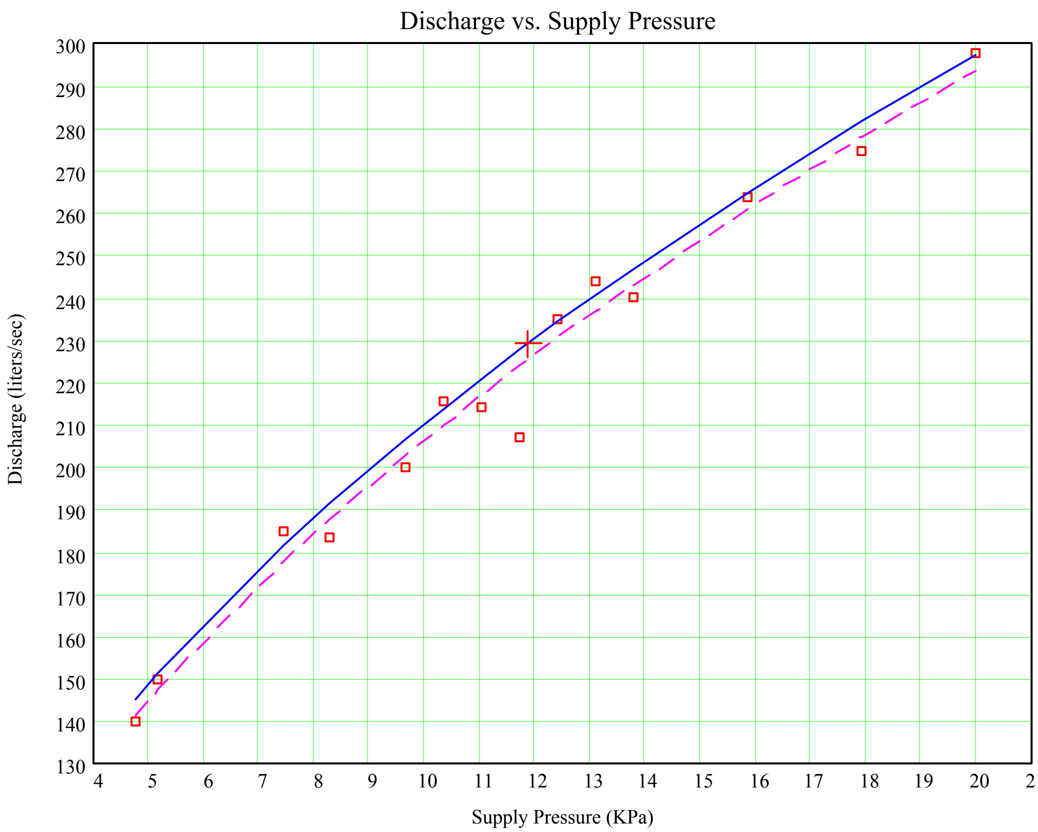
Analysis:

All indicated errors define a 95% (2σ) confidence interval about the stated results. All confidence intervals are based on Student's *t*-distribution. Results based on the analysis of the data taken have been adjusted for bias errors found in the discharge data. However, all data is presented without correction. In all graphs, a solid line is used to show fits after bias correction and a dashed line is used to show the true fits.

A "+" symbol is used on all graphs to indicate the operating point of the exhaust ejector. This point corresponds to the supply pressure at which the exhaust ejectors will be used.

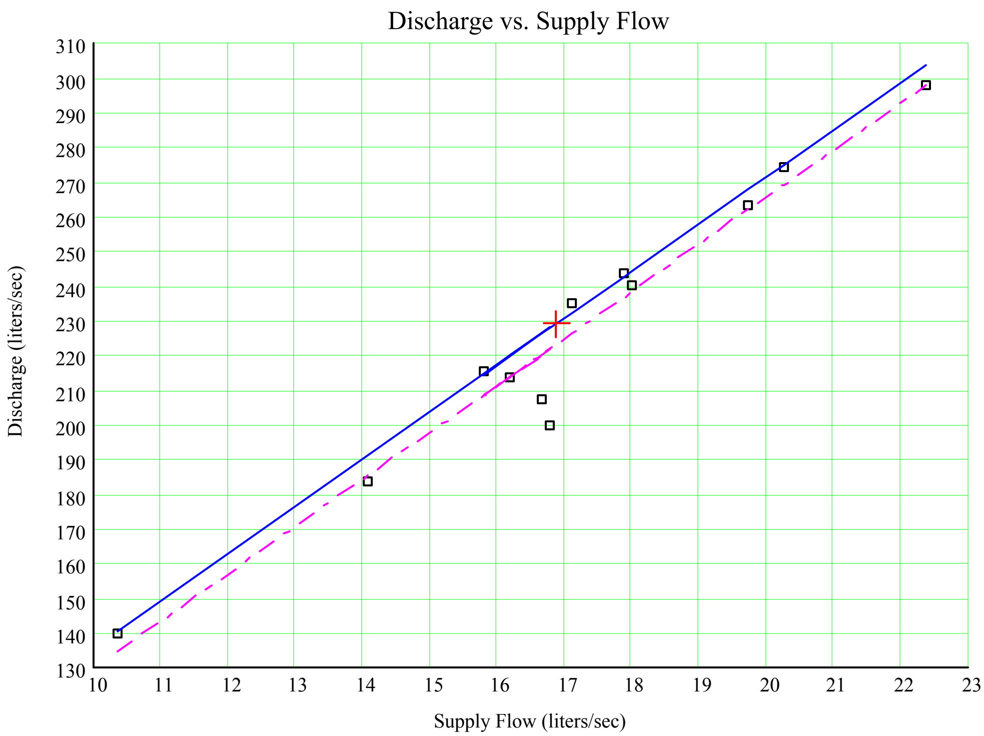
A least squares fit of the Bernoulli equation to the discharge and supply pressure data, $Q_{out}\left({}^{liters}\!/_{sec}\right)$ and $P_{supply}(KPa)$, is

$$Q_{out} = (66.5 \pm 5.8)\sqrt{P_{supply}}$$



A least squares fit of the discharge and supply flow data, $Q_{out}\left({}^{liters}\!/\!_{sec}\right)$ and $Q_{supply}\left({}^{liters}\!/\!_{sec}\right)$, yields the entrainment ratio,

$$\varepsilon = \frac{Q_{out}}{Q_{supply}} = 14 \pm 2$$



For calculation details, point to the Mathcad v6.0+ file:
ftp://muir/.as.arizona.edu/pub/archive/mathcad/mmt0002.mcd

Conclusions:

The discharge $Q_{out}\,(liters/_{sec})$ is related to the supply pressure $P_{supply}\,(KPa)$ by

$$Q_{out} = (66.5 \pm 5.8)\sqrt{P_{supply}}$$

The exhaust ejector entertainment ratio is $\varepsilon = \dfrac{Q_{out}}{Q_{supply}} = 14 \pm 2$.

At the specified supply pressure of $12\,KPa\,(1.7\,psi)$ the volumetric discharge flow rate (per exhaust ejector) is

$$(66.5 \pm 5.8)\sqrt{12KPa} = 2.3 \times 10^2 \pm 2.0 \times 10\ liters/_{sec} \qquad (4.9 \times 10^2 \pm 4.2 \times 10\, cfm)$$

and the volumetric supply flow rate is

$$Q_{supply} = \frac{Q_{out}}{\varepsilon} = \frac{230 \pm 20}{14 \pm 2} = 1.7 \times 10 \pm 3\ liters/_{sec} \qquad (3.6 \times 10 \pm 6\, cfm)$$

In terms of mass flow rate, at the specified supply pressure of $12\,KPa\,(1.7\,psi)$, the discharge is

$$2.2 \times 10^{-1} \pm 1.9 \times 10^{-2}\ Kg/_{sec} \qquad (4.0 \times 10^2 \pm 3.5 \times 10\ SCFM\ )$$

and the supply is

$$1.6\times10^{-2}\pm2.8\times10^{-3}\ {}^{Kg}\!/_{sec}\qquad(2.9\times10\pm5.1\ SCFM)$$

Combined, all six exhaust ejectors are capable of a volumetric flow rate of

$$6\cdot2.3\times10^{2}\ {}^{liters}\!/_{sec}=1.4\times10^{3}\pm1.2\times10^{2}\ {}^{liters}\!/_{sec}\qquad(2.9\times10^{3}\pm2.5\times10^{2}\ cfm)$$

at the specified supply pressure of $12\ KPa\,(1.7\ psi)$ or

$$1.3\pm1.1\times10^{-1}\ {}^{Kg}\!/_{sec}\qquad(2.4\times10^{3}\pm2.1\times10^{2}\ SCFM)$$

This exceeds the $1200\ {}^{liters}\!/_{sec}$ brought into the cell via the jet ejectors. Thus the six exhaust ejectors will exhaust the air that is brought into the telescope cell via the jet ejectors.

Data:

The following table lists, as a function of supply pressure P_{supply}:

- The time, t_{out}, required for the discharge to fill an evacuated $900\,l$ bag to atmospheric pressure
- The corresponding discharge $Q_{out} = {}^{900l}\!/_{t_{out}}$
- The time, t_{supply}, required for the exhaust ejector to fill an evacuated $900\,l$ bag to atmospheric pressure
- The corresponding supply flow $Q_{supply} = {}^{900l}\!/_{t_{supply}}$

P_{supply}	t_{out}	Q_{out}	t_{supply}	Q_{supply}
KPa	sec	${}^{liters}\!/_{sec}$	sec	${}^{liters}\!/_{sec}$
4.8	6.43	140	86.9	10.4
5.2	6.00	150		
7.4	4.87	185		
8.3	4.91	183	63.9	14.1
9.7	4.50	200	53.6	16.8
10	4.18	215	57.0	15.8
11	4.21	214	55.6	16.2
12	4.35	207	54.0	16.7
12	3.83	235	52.6	17.1
13	3.69	244	50.3	17.9
14	3.75	240	50.0	18.0
16	3.42	263	45.6	19.7
18	3.28	274	44.4	20.3
20	3.02	298	40.2	22.4

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