The Flow Characteristics of the VORTRAN E-Vent Case Manifold System

Introduction

During the national statewide disaster drills, many health care facilities realized the finite limit of ventilators determines the number of patients that can be managed in any mass casualty incident (MCI). Under the Hospital Preparedness program, the bureau awards grant money to states who allocate, to as many hospitals as possible within the designated regions, to strengthen the ability of hospitals and other health care facilities to respond to bio-terror attacks, infectious disease outbreaks and natural disasters that may cause MCI.*

It is recognized, that the VORTRAN Automatic Resuscitator (VAR), a pneumatically driven automatic resuscitator, provides the best clinical options as to location (not all triage sites have A/C power), portability, relative ease of use and the most cost effective way of providing basic mechanical ventilation to a large number of patients.

Packaging the VARs in the VORTRAN E-Vent Case (Figure A), with all your emergency procedures and supplies, allows for rapid emergency ventilator deployment in any MCI.

The E-Vent Case gas distribution manifold system is engineered specifically for operating multiple VARs from a single gas source (oxygen, compressed air or oxygen enriched air). For added robustness while operating in the field, the manifold is mounted on a sturdy stand. The manifold inlet is connected to the gas source via a twenty foot (20') heavy duty oxygen hose. The supplied gas pressure is adjustable using the manifold mounted pressure regulator and pressure gauge. Each of the seven (7) outlets is fitted with male thread oxygen DISS fitting with auto shut off. The manifold system can support up to seven VARs operating from the single gas source. The VAR is a completely pneumatic driven resuscitator that runs on a continuous flow of compressed gas. Typically, hospital supplied gas is regulated to 50 PSIG and the system is capable of providing sufficient flow to meet the demand of medical equipment.

However, in the emergency situation, with limited resources, preparing for an emergency means knowing the capacity and

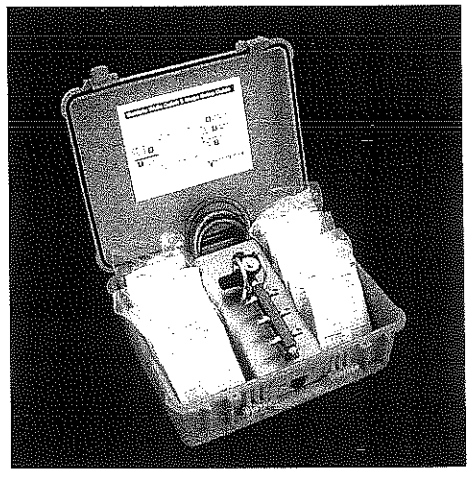

Figure A - E-Vent Case packages with the VARs

limits of your facility. Understanding your gas supply is essential in determining the numbers of surge capacity ventilator patients the facility can manage. The VARs and E-Vent Case offer tools to help you meet your needs but it is not the complete solution. You also need trained clinicians and sufficient gas resources. This report details the flow requirements and operational characteristics of the VARs using the E-Vent Case manifold system. Using the flow requirement information provided herein, there are many alternative gas distribution systems that the hospital's biomedical department can develop to achieve the same result. To safely and effectively operate multiple VARs from a single gas source, make sure your gas distribution can provide the flow (liters per minutes) to meet the demand.

Setting up the manifold

Setting up the E-Vent Case manifold distribution system for multiple VARs is easy. Follow the five quick steps [1] – [5]:

1 Connect to a gas source. Connect the other end of tubing to manifold inlet (Figure B).
2 Set patient flow to 25 LPM with pressure gauge at 25 PSIG (Figure C).
3 Connect patient (Figure D).

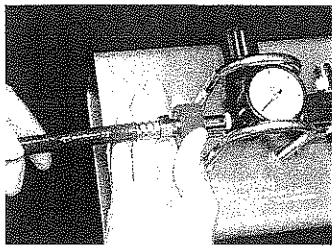

Figure B - Manifold is connected to source gas via a 20' tubing

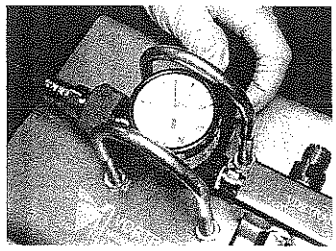

Figure C - Set manifold pressure using the regulator and pressure gauge

Figure D - Connect patients

Figure E - Adjust PIP and rate

Table *A1* – VAR is operated in the 100% FiO_2 mode with green colored connector when manifold pressure is set to 50 PSIG

No. of VARs connected to manifold		*1*	*2*	*3*	*4*	*5*	*6*	*7*
Supplied source pressure	(PSIG)	51	52.5	55	58	62	67	73
Total flow requirement	(LPM)	42	83	125	166	208	249	291
Averaged flow to each VAR	(LPM)	42	41.5	41.6	41.5	41.6	41.5	41.6

Table *B1* – VAR is operated in the 50% FiO_2 mode with grey colored connector when manifold pressure is set to 50 PSIG

No. of VARs connected to manifold		*1*	*2*	*3*	*4*	*5*	*6*	*7*
Supplied source pressure	(PSIG)	50	50	51	51	52	53	54
Total flow requirement	(LPM)	16	31	47	62	78	93	109
Averaged flow to each VAR	(LPM)	16	15.5	15.6	15.5	15.6	15.5	15.6

Table *A2* – VAR is operated in the 100% FiO_2 mode with green colored connector when supplied source pressure is set to 50 PSIG

Nos of VARs connected to manifold		*1*	*2*	*3*	*4*	*5*	*6*	*7*
Manifold pressure	(PSIG)	49	47	45	43	40	37	34
Total flow requirement	(LPM)	41	79	114	147	173	196	214
Averaged flow to each VAR	(LPM)	41	39.5	38	37	34.5	33	30.5

Table *B2* – VAR is operated in the 50% FiO_2 mode with grey colored connector when manifold pressure is set to 50 PSIG

Nos of VARs connected to manifold		*1*	*2*	*3*	*4*	*5*	*6*	*7*
Manifold pressure	(PSIG)	50	50	49	49	48	47	46
Total flow requirement	(LPM)	16	31	46	61	75	89	102
Averaged flow to each VAR	(LPM)	16	15.5	15.3	15.3	15	15	14.5
Delivered flow w/entrainment	(LPM)	~40	~40	~40	~40	~40	~40	~40

Table 3 - Estimate delivered flow rate (LPM) for each patient

Delivered flow	Set manifold pressure	
	100% FiO_2	50% FiO_2
20 LPM	25 PSIG	10 PSIG
25	30	20
30	40	30
35	45	40
40	50	50

4 Adjust PIP and rate for patient's needs (Figure E).
5 Verify PIP with a manometer.

Methods of Evaluation

The E-Vent Case manifold system is connected to a compressed air source using the twenty foot (20') oxygen hose supplied. This bench top evaluation was conducted using the following two (2) scenarios:

- When the gas source supplied is capable of maintaining a constant 50 PSIG pressure to the manifold
- When the gas pressure supplied is limited to maximum of 50 PSIG

In each scenario, *i* and *ii*, the VAR is operated in both the [*A*] 100% FiO_2 mode and in the [*B*] 50% entraining mode to simulate oxygen consumption. In both cases, compressed air (21% FiO_2) is used and flow rate is measured. The density of the oxygen compared to the density of room air makes an insignificant difference in the flow measurements herein. At each pressure setting, flow from each individual VAR is recorded and summarized in Tables *A1*, *B1*, *A2* and *B2*.

Table *A*1 indicated the maximum flow of 291 LPM when operating 7 VARs in 100% mode. This requires the source pressure to be at 73 PSIG in order to maintain a 50 PSIG manifold pressure. Although this is not common, due to regulated hospital source gas pressure, it demonstrated that the manifold can deliver maximum flow to 7 VARs. Table *B*1 indicated the flow demand is significantly less when operating in entrainment mode.

When the supplied source pressure is regulated to 50 PSIG, adding or removing VARs to the manifold will result in a pressure drop as indicated in Table *A*2. When operating all 7 VARs from a 50 PSIG gas source, the maximum flow available to each VAR will be 30 LPM. The pressure drop in the entrainment mode as shown in Table *B*2 is significantly less with a lower flow demand and maximum flow can be delivered for up to 7 VARs.

Conclusions

The E-Vent Case manifold system demonstrated that it can sustain up to 7 VARs operating simultaneously. The key is to understand the supply pressure capability of the gas source (compressed air or oxygen). It is critical for each facility to evaluate the gas supply system in order to prepare for any surge capacity incidents.[1,2,3]

When connected, all patients on the same manifold system will receive the same amount of flow (LPM) regardless of their individual clinical situation. Any adjustment made on supply pressure will affect all patients connected to the manifold and flow is estimated to be within ±15% (see Table 3).

*Health Resources and Services Administration (HRSA). HRSA works to fill in the health care gaps for people who live outside the economic and medical mainstream. The agency uses its $7.4 billion annual budget (FY 2005) to expand access to quality health care for all Americans through an array of grants to state and local governments, health care providers and health professions training programs. HRSA'S Special Programs Bureau provides $660 million in programs and services.

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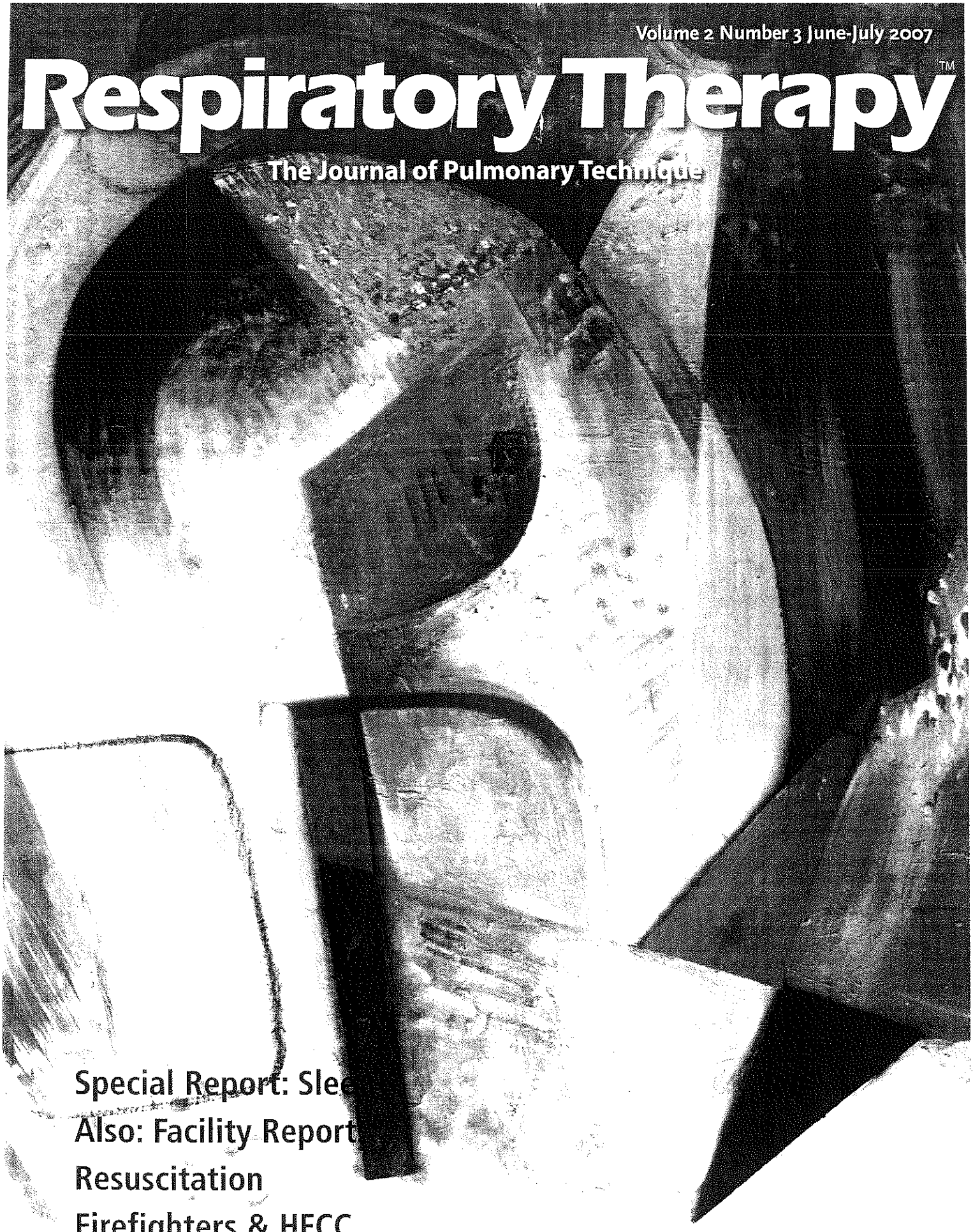

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