TECHNICAL DATA BULLETIN #221

CONDUCTING AIRFLOW CHECK ON THE 3M™ VERSAFLO™ PAPR TR-600

Consult the TR-600 *User Instructions* for general system operation.

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Rev 1: Replaces all previously published Bulletins on this topic until superseded.

The following Technical Data Bulletin is for reference purposes only. **Before using the TR-600 PAPR, all users must read and understand the respected product's *User Instructions*.** If you have questions, consult your supervisor or call 3M Technical Service at 1-800-243-4630 (USA) or 1-800-267-4414 (Canada).

Overview:

This Technical Data Bulletin provides directions and examples of conducting airflow checks on the 3M™ Versaflo™ Powered Air Purifying Respirator TR-600. It expands on the directions in the *User Instructions*. It also provides insight on the behavior of the 3M™ Airflow Indicator TR-971 in more extreme environments. The TR-600 PAPR assemblies are part of the 3M™ Versaflo™ Family of respiratory protection products. The motor/blower unit draws ambient air through its filter/cartridge and supplies filtered air to the headgear via a breathing tube. The blower provides three user selectable airflow settings. It is equipped with automatic flow control; the motor airflow is regulated during operation to help compensate for the charge state of the battery, the increasing level of airflow resistance caused by particle filter loading, and changes in air density due to changes in elevation and air temperature. Should the airflow fall below the minimum design flow rate, an audible alarm and vibratory alarm will activate and the filter loading LED on the blower unit will turn red to warn the user to immediately leave the contaminated environment.

The TR-600 motor/blower unit is airflow controlled based on air volume. Even as the air density changes, the volume of air delivered by the PAPR is designed to remain consistent at the given user-selected airflow setting. This is similar to how your own lungs work. In other words, you should therefore be able to breathe roughly the same volume of air at sea level as you do atop a mountain, even though at higher elevations that given volume of air weighs less because it is less dense. This same principle holds true for air temperature. A one cubic-foot volume of air at 100°Farenheit (37.8°Celcius) weighs less (because it has a lower density) than a one cubic-foot volume of air at 32°Farenheit (0°Celcius).

While the TR-600 is pre-calibrated to help ensure required airflow, the 3M™ Airflow Indicator TR-971 should be used to verify that the minimum required airflow is attained prior to each day's use.

Since the TR-971 airflow indicator is based on a ball rotameter-style flow meter, the height of the ball in the airflow indicator tube is subject to changes in the air density pushing on it. At a given volume of airflow, air at a higher density will push up on the ball with greater amount of force than air at a lower density. The greater amount of force results in the ball being pushed higher in the airflow indicator tube.

Because of this difference in force, the airflow indicator is graduated into different 'Zones' based on air density, which is based on altitude and ambient temperature.

Use Chart 1 below or the reference card supplied with your TR-971 airflow indicator to determine your 'Zone'. Follow the steps below for conducting an airflow check.

Determining your 'Zone'

- The airflow indicator is graduated into different 'zones' based on air density, which is based on elevation and ambient temperature.
- In order to determine your zone, you must know the elevation and temperature for the environment where you are conducting the airflow check (not for where the system will be used). See your supervisor if you are not certain of these values. During use, the system will automatically compensate for changes in air temperature and pressure.
- Example: you are conducting an airflow check where the elevation is 2700 feet (823 meters) and the temperature is 72°Farenheit (22°Celcius).
    - 2700 feet falls between 2000 and 3000, rounding to the nearest value, round up to 3000 feet
    - 72°Farenheit falls between 68°F and 86°F, rounding to the nearest value, round down to 68°F
    - Locate the zone where 3000 feet intersects with 68°F
    - Your "Zone" is H
- Note: The recommended operating altitude range is -328 feet (-100 meters) to 16404 feet (5000 meters). For use in elevations outside this range contact 3M Technical Service.
- Additional examples of determining your zone may be found at the end of this bulletin.
- Additional guidance on determining you zone at different humilities and based on measured air pressure is provided below.

Airflow check:

- Must be conducted before each day's use.
- Ensure the filter you are planning to use is properly installed.
- If the breathing tube is attached, remove it.
- Insert the TR-971 air flow indicator into the outlet on the TR-600 blower unit (Fig. 2). Make sure the float ball moves freely in the tube and the gasket at the bottom end of the tube is in place.
- Turn the TR-600 blower unit on (Fig. 1, #1) and run for 1 minute to allow the air flow to stabilize.
- Ensure the airflow setting is set to standard / lowest (Fig. 1, #3). The unit will start-up in standard mode. To get back to standard mode, press and hold the Flow Control Button (Figure 1, #2) to cycle through the flow settings. When in Standard Flow Setting, one (1) flow LED will be illuminated on the Flow Setting Indicator (Figure 1, #3).
- Tilt the blower unit so that the airflow indicator is vertical (Fig. 3).
- The bottom of the floating ball must rest at, or above, the minimum flow mark for the 'letter' representing your 'Zone' as indicated on the reference card supplied with your TR-971 airflow indicator, in the *User Instructions*, and on chart 1 below.
- If the airflow indicator ball fails to rise above your 'zone' of the minimum flow level, do not use the unit.
- Repeat the test with a fully charged battery and/or a new filter and cartridge (and pre-filter if used).
- If issues persist, refer to the TR-600 troubleshooting guidance or contact 3M technical service at 800-243-4630 in the United States or 800-267-4414 in Canada.

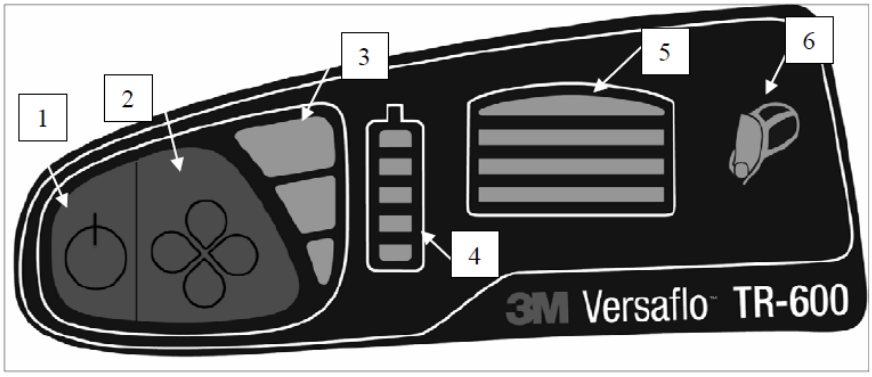
If the airflow indicator ball fails to rise at or above the minimum flow level

- Double check you selected the correct zone based on current environmental conditions.
- Do not use the unit.
- Refer to the guidance in this document, the TR-600 troubleshooting guidance document, or contact 3M technical service.

Conducting a low flow alarm check:
Check the low airflow alarm by simulating a low airflow condition.
With the motor/blower on:

- Remove the airflow indicator and tightly cover the outlet of the motor/blower with the palm of your hand. The motor should automatically speed up, attempting to compensate for the low airflow condition. Continue to press your palm tightly against the end of the outlet, making a tight seal. In less than approx. 30 seconds, the unit will sound an audible and vibratory alarm, and the bottom bar on the filter loading/low flow indicator will flash red. (Fig 1, #5).
- Remove your hand from the end of the breathing tube. In less than approx. 30 seconds, the audible alarm and the flashing red LED should both stop when the motor returns to the selected speed.

Figure 1: TR-600 Motor/Blower User Interface



1. On/Off button
2. Flow control button
3. Flow level/alarm indicator
4. Battery charge status level/alarm indicator
5. Filter loading/alarm indicator
6. Tight-fitting mode indicator (future option; not currently available)

Fig. 2 - Attaching airflow indicator

Fig. 3- Checking airflow

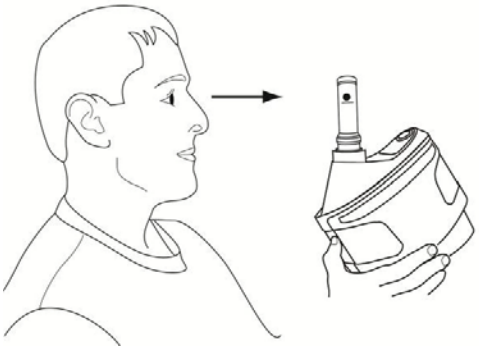
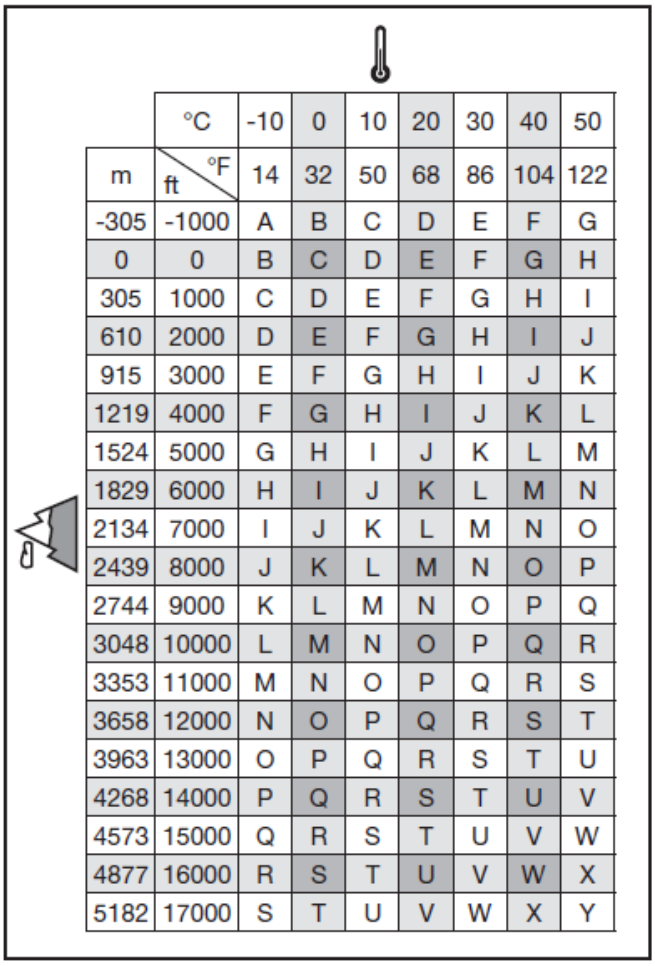


Chart 1 – Determining airflow indicator Zone based on elevation and temperature. This chart mirrors the one provided with the 3M™ Airflow Indicator TR-971.



	°C	-10	0	10	20	30	40	50
m	ft \ °F	14	32	50	68	86	104	122
-305	-1000	A	B	C	D	E	F	G
0	0	B	C	D	E	F	G	H
305	1000	C	D	E	F	G	H	I
610	2000	D	E	F	G	H	I	J
915	3000	E	F	G	H	I	J	K
1219	4000	F	G	H	I	J	K	L
1524	5000	G	H	I	J	K	L	M
1829	6000	H	I	J	K	L	M	N
2134	7000	I	J	K	L	M	N	O
2439	8000	J	K	L	M	N	O	P
2744	9000	K	L	M	N	O	P	Q
3048	10000	L	M	N	O	P	Q	R
3353	11000	M	N	O	P	Q	R	S
3658	12000	N	O	P	Q	R	S	T
3963	13000	O	P	Q	R	S	T	U
4268	14000	P	Q	R	S	T	U	V
4573	15000	Q	R	S	T	U	V	W
4877	16000	R	S	T	U	V	W	X
5182	17000	S	T	U	V	W	X	Y

Background:

- While the TR-600 is pre-calibrated to help ensure required airflow, the 3M™ Airflow Indicator TR-971 should be used to verify that the minimum required airflow is attained prior to each day's use.
- The TR-600 is designed to compensate automatically for changes in air density, which is affected by elevation and air temperature while the system is running. Thus, the air density at the location you check your airflow can be different than the location of use. For example, you can check your airflow in an indoor conditioned space, such as where you charge your batteries, and then use it outside (where it may be warmer or colder). The TR-600 will automatically compensate for the temperature change to help ensure the correct airflow is delivered.
- If you suspect the TR-600 is not delivering a minimum of 6 cfm (170 lpm), do not enter the contaminated area, see your supervisor, and check the airflow with the 3M™ Airflow Indicator TR-971.
- While wearing a separate means of appropriate respiratory protection, the TR-971 airflow indicator may be used to check the airflow of the TR-600 while in the environment of concern. Do not check airflow with the TR-971 airflow indicator in contaminated area without separate respiratory protection. Note: If the breathing tube is disconnected from the TR-600 in a contaminated environment, the inside of the breathing tube and TR-600 unit may be exposed to contaminants, and when resealed, the contaminant may become trapped. Clean and inspect prior to use.

Additional Examples:

Temperature: 99°Farenheit (37°Celcius); Elevation: 5 feet (1.5 meters)

- 5 feet, rounding to the nearest value, rounds down to 0 feet
- 99°Farenheit falls between 86°F and 104°F, rounding to the nearest value, round up to 104°F
- Locate the zone where 0 feet intersects with 104°F
- Your "Zone" is G

Temperature: 45°Farenheit (7°Celcius); Elevation: 5280 feet (1609 meters)

- 5280 feet, rounding to the nearest value, rounds down to 5000 feet
- 45°Farenheit falls between 32°F and 50°F, rounding to the nearest value, round up to 50°F
- Locate the zone where 5000 feet intersects with 50°F
- Your "Zone" is I

Advanced Guidance:

As discussed above, the height of the ball in the 3M™ Airflow Indictor TR-971 at a given airflow volume is based on the density of the air in the environment. Air density is mainly affect by air pressure and temperature, with minor effects based on relative humidity. Air pressure is primarily dependent on elevation. However, at a given elevation the air pressure can be affected by other variables, such as weather conditions, building ventilation, and artificially pressured environments (such as caissons, air locks, and positive or negative pressure rooms.)

Since for most users it is easier to determine their elevation than ambient pressure, the table on the airflow indicator card uses elevation to determine the 'zone' (see Chart 1). It is also possible to determine the appropriate airflow indicator zone by knowing the ambient pressure in kilopascals (KPa). Cart 2 is similar to Chart 1, but with pressure values added in line with elevation.

Chart 2 – Determining airflow indicator Zone based on pressure and temperature. This chart is similar to Chart 1, but with pressure values added in line with elevation. This chart is based on 10% relative humidity.

		°C	-10	0	10	20	30	40	50
kPa	m	ft \ °F	14	32	50	68	86	104	122
107.5	-305	-1000	A	B	C	D	E	F	G
101.3	0	0	B	C	D	E	F	G	H
97.7	305	1000	C	D	E	F	G	H	I
94.2	610	2000	D	E	F	G	H	I	J
90.8	915	3000	E	F	G	H	I	J	K
87.5	1219	4000	F	G	H	I	J	K	L
84.3	1524	5000	G	H	I	J	K	L	M
81.2	1829	6000	H	I	J	K	L	M	N
78.2	2134	7000	I	J	K	L	M	N	O
75.3	2439	8000	J	K	L	M	N	O	P
72.4	2744	9000	K	L	M	N	O	P	Q
69.7	3048	10000	L	M	N	O	P	Q	R
67.0	3353	11000	M	N	O	P	Q	R	S
64.4	3658	12000	N	O	P	Q	R	S	T
61.9	3963	13000	O	P	Q	R	S	T	U
59.5	4268	14000	P	Q	R	S	T	U	V
57.2	4573	15000	Q	R	S	T	U	V	W
54.9	4877	16000	R	S	T	U	V	W	X
52.7	5182	17000	S	T	U	V	W	X	Y

Relative humidity (RH) can also affect the density of air, and thus the height of the ball in the airflow indicator. Dry air has a higher density than humid air. As such, at a given temperature, pressure, and airflow dry air will push a ball higher in the airflow indicator tube than will humid air. The chart provided

with the 3M™ Airflow Indicator TR-971 is based on dry air (~10% RH), which is a conservative approach. Charts 3 & 4 show airflow zones based on 50% RH and 90% RH respectively. Note: If the airflow check passes using the standard chart supplied with the 3M™ Airflow Indicator (TR-971) – based on 10% RH - it will also pass using on Charts 3 & 4 – based on higher RH values.

Chart 3 – Determining airflow indicator Zone based on pressure/elevation and temperature. This chart is based on 50% relative humidity.

~ 50% RH		°C	-10	0	10	20	30	40	50
kPa	m	ft °F	14	32	50	68	86	104	122
105.0	-305	-1000	B	C	D	E	F	G	H
101.3	0	0	C	D	E	F	G	H	I
97.7	305	1000	D	E	F	G	H	I	J
94.2	610	2000	E	F	G	H	I	J	K
90.8	915	3000	F	G	H	I	J	K	L
87.5	1219	4000	G	H	I	J	K	L	M
84.3	1524	5000	H	I	J	K	L	M	N
81.2	1829	6000	I	J	K	L	M	N	O
78.2	2134	7000	J	K	L	M	N	O	P
75.3	2439	8000	K	L	M	N	O	P	Q
72.4	2744	9000	L	M	N	O	P	Q	R
69.7	3048	10000	M	N	O	P	Q	R	S
67.0	3353	11000	N	O	P	Q	R	S	T
64.4	3658	12000	O	P	Q	R	S	T	U
61.9	3963	13000	P	Q	R	S	T	U	V
59.5	4268	14000	Q	R	S	T	U	V	W
57.2	4573	15000	R	S	T	U	V	W	X
54.9	4877	16000	S	T	U	V	W	X	Y
52.7	5182	17000	T	U	V	W	X	Y	-

Chart 4 – Determining airflow indicator Zone based on pressure/elevation and temperature. This chart is based on 90% relative humidity.

~ 90% RH		°C	-10	0	10	20	30	40	50
kPa	m	ft °F	14	32	50	68	86	104	122
105.0	-305	-1000	C	D	E	F	G	H	I
101.3	0	0	D	E	F	G	H	I	J
97.7	305	1000	E	F	G	H	I	J	K
94.2	610	2000	F	G	H	I	J	K	L
90.8	915	3000	G	H	I	J	K	L	M
87.5	1219	4000	H	I	J	K	L	M	N
84.3	1524	5000	I	J	K	L	M	N	O
81.2	1829	6000	J	K	L	M	N	O	P
78.2	2134	7000	K	L	M	N	O	P	Q
75.3	2439	8000	L	M	N	O	P	Q	R
72.4	2744	9000	M	N	O	P	Q	R	S
69.7	3048	10000	N	O	P	Q	R	S	T
67.0	3353	11000	O	P	Q	R	S	T	U
64.4	3658	12000	P	Q	R	S	T	U	V
61.9	3963	13000	Q	R	S	T	U	V	W
59.5	4268	14000	R	S	T	U	V	W	X
57.2	4573	15000	S	T	U	V	W	X	Y
54.9	4877	16000	T	U	V	W	X	Y	-
52.7	5182	17000	U	V	W	X	Y	-	-

Chart Index:

Chart 1	Mirrors chart supplied with 3M™ Airflow Indicator TR-371. Based on 10% RH
Chart 2	Similar to chart 1, but with an additional column in line with elevation showing ambient air pressure. Based on 10% RH
Chart 3	Chart based on 50% RH. Showing elevation/pressure and temperature.
Chart 4	Chart based on 90% RH. Showing elevation/pressure and temperature.

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