Products for Indoor Air Quality and Control

Constant Volume Fan Powered Units
AC_J Series

ECM Motor Technical Guide

Table of Contents

ECM General Information

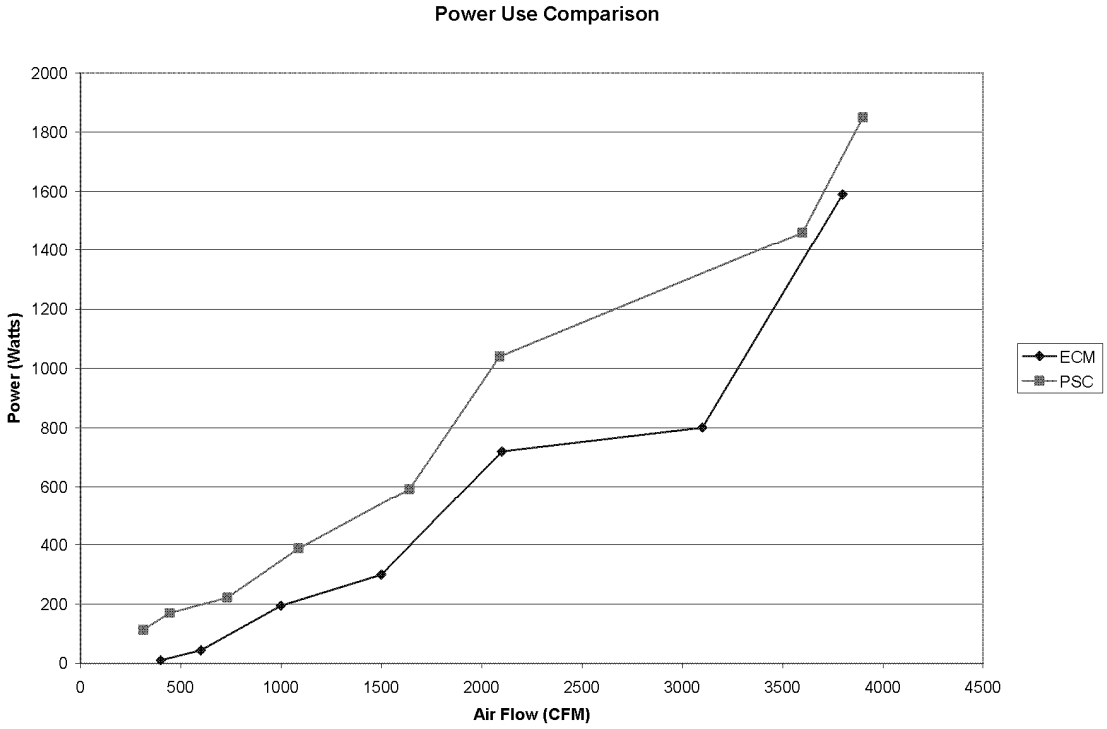
Fan powered constant volume terminal units are designed to deliver a constant volume of air to a given space. Currently a PSC motor with an SCR is used to turn a blower wheel at a constant rate. As primary air from the air handler is increased the amount of air induced from the conditioned space is decreased. Because there are multiple variable air volume units in a system, the duct static pressure may increase or decrease depending on the total load. As the static pressure in the duct system changes the typical PSC motor blower combination can not adjust itself and therefore the CFM delivered to an area will vary. This makes initial balancing difficult and provides a less than ideal flow of air to the conditioned space.

The ideal speed at which an induction motor can turn is fixed by the frequency of the voltage applied and the number of poles it contains. The motor's speed can be reduced by altering the voltage applied across its windings. This can be done with resistors, inductors, transformers or solid state speed controls. Decreasing the voltage reduces the starting and full- load torque, increases the rotors slip and decreases the motors efficiency. The further the motor operates from its ideal speed, the greater the energy loss and running temperature of the motor. The lack of torque control prevents precise airflow control and the low frequency noise may increase.

In response to the need for a high efficiency motor in which speed can be set and maintained, GE developed an Electronically Commutated Motor or ECM. It is an ultra high efficiency brushless DC motor with a built in inverter. The electronics package, included with the GE ECM motor serves two purposes. One, it switches the DC magnetic fields which allow the motor to operate. Two, it controls torque and speed so that the airflow is maintained despite the pressure seen by the fan. The ECM can be programmed in the factory to set maximum and minimum values which can then be adjusted in the field to the desired CFM. Once set, the motor will maintain constant airflow within + or – 5%.

In 1974 the first fan powered variable air volume boxes were introduced to the market. They provided significant energy savings compared to standard system at that time because of their ability to recapture plenum heat. With increasing energy costs, the demand for higher efficiency motors has increased. Through testing, the Carnes Company has shown that the ECM has proven true to its reputation for using less energy. The following chart shows the wattage used at various air flows over the range of units provided by Carnes.

Energy Savings



The energy savings for the ECM motor can be quite significant. Depending on energy cost for a given area, the payback for the ECM motor can be seen in as little as two years.

One of the unique features of the ECM motor is that it can be controlled by a 0-10V dc signal from the building automation system. The fan speed can now be increased in cooling mode and decreased for heating mode. This allows the design engineer to further optimize performance.

ECM Motor Control

ECM Motor Taps

The ECM motor was originally designed for the residential HVAC market. Because of the need to provide a different air flow rate for heating versus cooling, two different tap positions were provided. In addition two more tap wires are provided. One is to adjust the flow rate, for example in an application where humidity control was a concern. The other provided a way to delay the start of the fan according to a desired delay profile. The ECM motor tap connections are provided via the ECM control connection pictured below. Additional taps are provided as a way for the thermostat to send a control signal to the ECM motor. All of these tap positions are available when the ECM motor is programmed for the TSTAT mode. (See figure 1, table 1)

Variable Speed Control
When applying the ECM to use with a Variable air volume box it is more desirable to be able to provide a variable speed control. This allows the ECM to operate over a range of CFM values. The maximum and minimum air flow rates are programmed into the motor at the factory. The speed of the motor is then set by Pulse width modulated (PWM) signal sent to the ECM motor via a special controller provided by Carnes. The ECM tap positions are all given below. The positions used by Carnes for the Variable air volume application are out lined in blue.

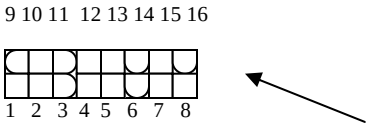


Figure 1

PIN	DESCRIPTION
1	C1
2	W/W1
3	C2 (GREEN WIRE) COMMON
4	DELAY
5	COOL
6	Y1
7	ADJUST
8	OUT – (GREEN WIRE)
9	O
10	PK/PWM (RED) CONTROLS SPEED OF MOTOR
11	HEAT
12	R
13	EM/W2
14	Y/Y2
15	G (WHITE WIRE) MOTOR ON/OFF – GROUND
16	OUT+(BLACK) - TACHOMETER

Table 1

The GE ECM motor is unique in that it is turned off and on via a 24 V control signal. Power should not be disrupted to the motor as a means to control the motor. In fact doing so will reduce the life span of the motor.

Carnes Control Options
Carnes is working together with Evolution Controls to provide three control options with the ECM motor. The standard electronic control is the VCU. It has a digital number readout, which allows the user to see the RPM output of the motor as well as the flow

index. The flow index is a range of flow from 0-100. A flow index of zero marks the minimum flow of the VAV box. A flow index of 100 is the maximum air flow of the VAV box. Refer to table 2 which is a listing of the expected CFM (within + or – 10%) for the various size units. Once a flow rate is set on the VAV unit, the ECM will maintain the airflow with in + or – 5% of the set value.

	AC J06	AC J07	AC J08	AC J10	AC J12	AC J14	AC J16
Min. CFM	200	450	700	1100	1800	2200	3100
Max. CFM	550	800	1200	1800	2500	3200	4200
Flow Index	Fan CFM	Fan CFM	Fan CFM	Fan CFM	Fan CFM	Fan CFM	Fan CFM
1	200	450	700	1100	1800	2200	3100
2	204	454	705	1107	1807	2210	3111
3	207	457	710	114	1814	2220	3122
4	211	461	715	1121	1821	2230	3133
5	214	464	720	1128	1828	2240	3144
6	218	468	725	1135	1835	2251	3156
7	221	471	730	1142	1842	2261	3167
8	225	475	735	1149	1849	2271	3178
9	228	478	740	1157	1857	2281	3189
10	232	482	745	1164	1864	2291	3200
11	235	485	751	1171	1871	2301	3211
12	239	489	756	1178	1878	2311	3222
13	242	492	761	1185	1885	2321	3233
14	246	496	766	1192	1892	2331	3244
15	249	499	771	1199	1899	2341	3256
16	253	503	776	1206	1906	2352	3267
17	257	507	781	1213	1913	2362	3278
18	260	510	786	1220	1920	2372	3289
19	264	514	791	1227	1927	2382	3300
20	267	517	796	1234	1934	2392	3311
21	271	521	801	1241	1941	2402	3322
22	274	524	806	1248	1948	2412	3333
23	278	528	811	1256	1956	2422	3344
24	281	531	816	1263	1963	2432	3356
25	285	535	821	1270	1970	2442	3367
26	288	538	826	1277	1977	2453	3378
27	292	542	831	1284	1984	2463	3389
28	295	545	836	1291	1991	2473	3400
29	299	549	841	1298	1998	2483	3411
30	303	553	846	1305	2005	2493	3422
31	306	556	852	1312	2012	2503	3433
32	310	560	857	1319	2019	2513	3444
33	313	563	862	1326	2026	2523	3456
34	317	567	867	1333	2033	2533	3467
35	320	570	872	1340	2040	2543	3478
36	324	574	877	1347	2047	2554	3489
37	327	577	882	1355	2055	2564	3500
38	331	581	887	1362	2062	2574	3511
39	334	584	892	1369	2069	2584	3522
40	338	588	897	1376	2076	2594	3533
41	341	591	902	1383	2083	2604	3544
42	345	595	907	1390	2090	2614	3556
43	348	598	912	1397	2097	2624	3567
44	352	602	917	1404	2104	2634	3578
45	356	606	922	1411	2111	2644	3589
46	359	609	927	1418	2118	2655	3600
47	363	613	932	1425	2125	2665	3611
48	366	616	937	1432	2132	2675	3622

49	370	620	942	1439	2139	2685	3633
50	373	623	947	1446	2146	2695	3644
51	377	627	953	1454	2154	2705	3656
52	380	630	958	1461	2161	2715	3667
53	384	634	963	1468	2168	2725	3678
54	387	637	968	1475	2175	2735	3689
55	391	641	973	1482	2182	2745	3700
56	394	644	978	1489	2189	2756	3711
57	398	648	983	1496	2196	2766	3722
58	402	652	988	1503	2203	2776	3733
59	405	655	993	1510	2210	2786	3744
60	409	659	998	1517	2217	2796	3756
61	412	662	1003	1524	2224	2806	3767
62	416	666	1008	1531	2231	2816	3778
63	419	669	1013	1538	2238	2826	3789
64	423	673	1018	1545	2245	2836	3800
65	426	676	1023	1553	2253	2846	3811
66	430	680	1028	1560	2260	2857	3822
67	433	683	1033	1567	2267	2867	3833
68	437	687	1038	1574	2274	2877	3844
69	440	690	1043	1581	2281	2887	3856
70	444	694	1048	1588	2288	2897	3867
71	447	697	1054	1595	2295	2907	3878
72	451	701	1059	1602	2302	2917	3889
73	455	705	1064	1609	2309	2927	3900
74	458	708	1069	1616	2316	2937	3911
75	462	712	1074	1623	2323	2947	3922
76	465	715	1079	1630	2330	2958	3933
77	469	719	1084	1637	2337	2968	3944
78	472	722	1089	1644	2344	2978	3956
79	476	726	1094	1652	2352	2988	3967
80	479	729	1099	1659	2359	2998	3978
81	483	733	1104	1666	2366	3008	3989
82	486	736	1109	1673	2373	3018	4000
83	490	740	1114	1680	2380	3028	4011
84	493	743	1119	1687	2387	3038	4022
85	497	747	1124	1694	2394	3048	4033
86	501	751	1129	1701	2401	3059	4044
87	504	754	1134	1708	2408	3069	4056
88	508	758	1139	1715	2415	3079	4067
89	511	761	1144	1722	2422	3089	4078
90	515	765	1149	1729	2429	3099	4089
91	518	768	1155	1736	2436	3109	4100
92	522	772	1160	1743	2443	3119	4111
93	525	775	1165	1751	2451	3129	4122
94	529	779	1170	1758	2458	3139	4133
95	532	782	1175	1765	2465	3149	4144
96	536	786	1180	1772	2472	3160	4156
97	539	789	1185	1779	2479	3170	4167
98	543	793	1190	1786	2486	3180	4178
99	546	796	1195	1793	2493	3190	4189
100	550	800	1200	1800	2500	3200	4200

Table 2

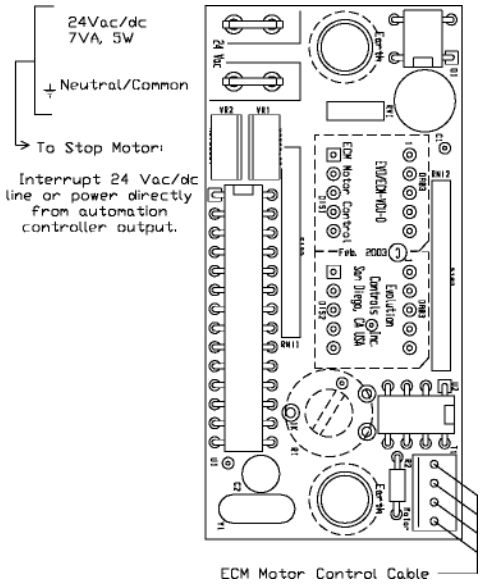
Visual Control Unit (VCU)

The EVO/ECM-VCU control allows accurate manual adjustment and monitor of fans using General Electric's ECM Motor. (See figure 2)

The EVO/ECM-VCU features a 4 digit LED numerical display to allow easy reading in dark spaces. Watch the display and set the flow index with a screwdriver adjust. Twenty seconds later, the display shows the motor RPM. Then, the display periodically alternates between the flow index and motor RPM.

The EVO/ECM-VCU may also be used where automation systems only turn the fan on or off.

Front of VCU



Back of VCU control unit.

Figure 2

Specifications

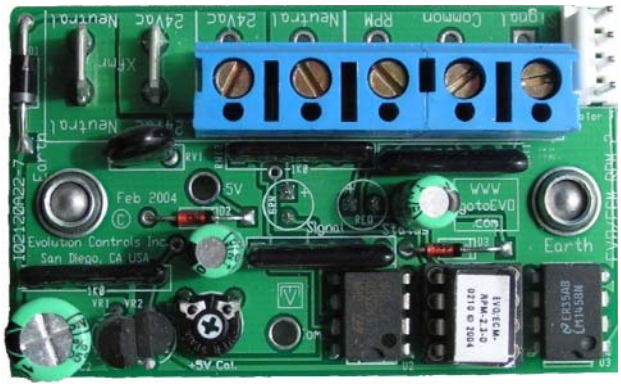
Power	NEC Class II Only 24 Vac ± 20% 50/60 Hz 4 W, 6 VA
Flow Index Adjustment	270° rotation F Off-0-100
RPM	0-2000 RPM ± 2%
Outputs	
Go & Vspd	24 Vdc @ 20 mA
ECM 2.3	Set for Vspd Operation Set Status Flag (7) to RPM Thermal
Stability	>0.01 %/^{o}F
Operating	0^{o}F to 130^{o}F (-18^{o}C to 55^{o}C) Environment 10-80% Rh
Connections	1/4 Tabs

Automatic Control Unit (ACU+)

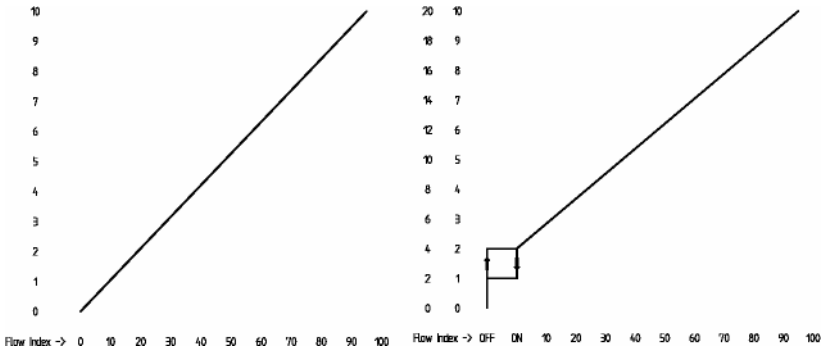
If digital controls are being used on the project it is possible to control the speed of the ECM motor with a 0-10V control signal using the EVO ACU+ unit. (See figure 3) The on/off signal is provided at a 24V input. Another option is to turn the motor on/off with a 0-1V signal and to use the 2-10V for speed control.

The EVO/ECM-ACU+ allows remote adjustment of the output from 0% to 100% of the programmed control range. A LED on the control continuously flashes out the flow index (percent of the programmed control range), so instruments are not required to read the value.

The "P" version provides ON/OFF control by switching the motor's "GO" control when the input signal drops below the 2 volt (4 mA) operating point.



The green LED continuously indicates the flow index. After a pause, the LED flashes out the tens digit, then the units digit of a number (percent) between 1 and 99. Two extra long flashes indicate a flow index of 0%. Long flashes represent the tens digit, and short flashes represent the units digit. A flow index of 23%, flashes two longs and three shorts.



Control Test Procedure

Warning: These tests are to be performed by qualified personnel who are familiar with the CARNES VAV box, where the EVO/ECM, series control and connected motor is installed. All mechanical, electrical and other applicable safety practices must be observed when performing these tests. While the EVO/ECM series controls are low voltage devices, they are often installed

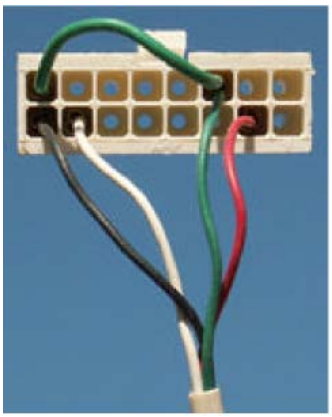
in or near high voltage cabinets and wiring. And they are connected to electrically isolated connections on the ECM motor. Wiring and device faults can occur. Always test for high voltage before starting these tests!

High Voltage Fault Test- Perform this test in addition to all tests and practices prescribed by the equipment manufacturer and your professional training.

1. Remove the VAV box control cover to gain access to the component side of the EVO/ECM series control. Leave everything connected.
2. If you removed power to gain access, re-power the equipment as necessary to troubleshoot the equipment.
3. Set the multi-meter to measure AC Volts.
4. Connect the BLACK lead to electrical earth.
5. Touch the RED lead to the EVO/ECM series connection marked 24VAC. The meter should read about 30 volts AC. If the meter reads a voltage above 48 volts AC immediately disconnect the VAV box. There is a high voltage fault somewhere in the system.
6. Touch the RED lead to the other connectors on the board. If the meter reads a voltage above 48 Volts AC, immediately disconnect the VAV box. There is a high voltage fault somewhere in the system.
7. Touch the RED lead to the metal wire grippers (top of connectors) for each of the 4 motor wires. (See Figure 2) If the meter reads a voltage above 48 Volts AC, immediately disconnect the machine. There is a high voltage fault somewhere in the system.

Motor Connection

Figure 2



White – Motor On/Off 0-24V
Black – Tachometer
Green – Common
Red – Speed 0 – min speed, 22 VDC max. speed

Figure 3

A quick test:

If the motor is not running and you want to determine if the EVO/ECM series control is calling for the motor to run, just measure the DC voltage between the Green and White wires on the motor control cable. If this voltage is greater than 10VDC, the motor should be running.

If you have an instance where the motor stops intermittently, and it restarts when power is removed then restored, perform this test before removing power. It will tell you if the intermittent part is the EVO/ECM series control.

Trouble Shooting Guide

Problem: The ECM motor will not run.

1. Check to make sure the power and control cables are securely fastened to both the ECM motor. Check the control connection to make sure it is secure.
2. Verify there is power to the unit.
3. Set the multi-meter to read 24VDC.
4. Touch the black lead to the motor 0n/Off (White) wire on the 4 pin motor connector.
5. Touch the red lead to the Motor On/Off (White) wire on the 4 pin motor connector.
6. If the DC voltage is 22VDC, the motor should run.
7. If the motor does not run, the cable may be defective.
8. Go to the control connector on the motor.
9. Insert the black meter lead into the connector shell hole containing the single green wire (See figure 3).
10. Insert the red meter lead into the connector shell hole containing the white wire. The DC voltage should be 22VDC. If it is not, the cable is defective. If the voltage is greater than 10VDC and motor does not run, contact CARNES CO. for further instructions.

Problem: The motor runs but the speed does not change.

1. Start the motor running.
2. Set the multi-meter to read 24 VDC.
3. Touch the black lead to the common (Green) wire on the 4 pin motor connector.
4. Touch the red lead to the speed (RED) wire on the 4 pin motor connector.
5. Set the EVO/ECM series controller to full speed.
6. The DC voltage should be equal to the voltage on the white wire (24VDC). The motor should run at full speed.
7. If the motor does not run at full speed, the cable may be defective.
8. Go to the control connector on the motor.
9. Insert the black meter lead into the connector shell hole containing the single green wire.
10. Insert the red meter lead into the connector shell hole containing the RED wire. The DC voltage should equal the voltage on the white wire (22VDC). If it is not the control cable is defective. If the voltage is 22VDC and the motor does not run at full speed, contact CARNES CO.

Problem: The VAV box does not run with in the expected speed range.

1. Verify the variable speed control is working correctly.
2. Verify the correct unit is installed in the space.
3. Contact CARNES CO.

Problem: The Automation System can not turn the motor off.

1. Turn the ECM motor off using the Automation System.
2. Touch the black lead to the common (Green) wire on the 4 pin motor connector.
3. Touch the red lead to the Tachometer (Black) wire on the 4 pin motor connector.
4. The DC voltage should be less than 3Vdc.
5. If the voltage is too high, the Automation Control is leaking current through its On/Off switching device.

Problem: The speed control does not provide the RPM.

Set the multi-meter to read 5Vdc.

1. Touch the black lead to the common (Green) wire on the 4 pin motor connector.
2. Touch the red lead to the Tachometer (Black) wire on the 4 pin motor connector.
3. You should read about 5Vdc.
4. Go to the control connector on the motor.
5. Insert the black meter lead into the connector shell hole containing the single green wire.
6. Insert the red meter lead into the connector shell hole containing the Black wire. The DC voltage should about 5Vdc. If it is not, the control cable is defective. Swap the EVO/ECM series control with a known good control to determine if the problem is with the EVO/ECM series control. If the problem persists, contact CARNES CO. for further details.

READ AND SAVE THESE INSTRUCTIONS

CARNES®

INSTALLATION and OPERATION MANUAL FOR FAN POWERED TERMINAL UNITS

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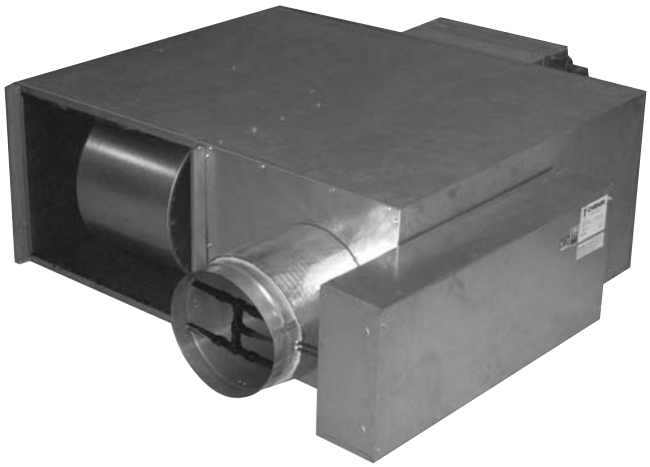
CONSTANT VOLUME *(Series)*

MODEL AC



INTERMITTENT VOLUME *(Parallel)*

MODEL AS

CAUTION: *Completely Read All Instructions Prior To Attempting To Assemble, Install, Operate, Or Repair This Product!*

INSPECT UNIT

UNPACKING AND INSPECTION

1. Open shipping carton or crate and check for concealed shipping damage. Report damage immediately to the carrier that delivered the shipment.
2. Inspect the unit for loose or missing components.
3. Optional accessories may be packed within the unit or in the same shipping carton or crate.

INSTALLATION

CAUTION: *This Product Includes Vibration Producing Components. When Supporting Or Suspending Units, Use Good Industry Practice and Materials Suitable For Vibration Producing Equipment.*

GENERAL

1. Units are to be supported in a horizontal and level position. For convenience, it is suggested that units be installed prior to installation of the ceiling tile grid system.
2. Sufficient working space must be provided as per paragraph 110-16 of N. E. C.
3. Allow sufficient space for the removal of air filters and for the efficient flow of air into the secondary air inlet.
4. Avoid abrupt transitions or duct turns at the inlet of the unit that would alter the inlet cross-sectional area.
5. It is preferred that the installer attempt to obtain a minimum of three (3) inlet diameters of straight duct ahead of the terminal unit inlet to achieve optimum control accuracy.

DUCT CONNECTIONS

1. Units are provided with either slip and drive or flanged discharge duct connections depending upon model type.
2. It is suggested that discharge ductwork be lined with a minimum of 1/2” thick, 1-1/2 lb. density fiberglass insulation with an erosion resistant surface in accordance with NFPA 90A (non-residential type air conditioning and ventilating systems) to provide both thermal and acoustical insulation.
3. Sealing of ductwork to preclude air leaks should be done according to the job specifications.
4. It is recommended that units be **supported from underneath** using trapeze hangers and vibration isolators. Flexible connections are recommended for all connecting ductwork and electrical conduit to preclude the transmission of vibration noise.
5. It is recommended that flexible ductwork connected to the primary air inlet be secured using a compression band. Rigid duct should be slipped over the unit inlet, secured in place with sheet metal screws, and sealed according to the job specifications.

ELECTRICAL INSTALLATION

CAUTION: *All Sources Of Supply Power Must Be Disconnected Before Working On This Equipment. More Than One Disconnect May Be Required To De-Energize Equipment.*

1. Follow the wiring/piping diagram found on the inside of the fan unit control enclosure cover.
2. Supply connections must be made using wires rated for 75°C minimum. **DO NO USE ALUMINUM CONDUCTORS.**
3. If supply connections are for 250 volts or greater, all wiring must be insulated for 600V.

4. Size supply conductors for 125% of rated combined load (fan motor FLA + heater current).

For electric heater use:

$$\text{Single phase Line Current} = \frac{\text{KW} \times 1000}{\text{Voltage}}$$

$$\text{Three phase Line Current} = \frac{\text{KW} \times 1000}{1.73 \times \text{Voltage}}$$

5. The following table shows the maximum current for 75°C Copper wire in conduit. Values are based on the 1984 N.E.C. Table 310-16 including note 8.

COMBINED LOAD MAXIMUM UNIT AMPERAGE		MINIMUM WIRE SIZES AWG/MCM
1 — 3 conductors	4 — 6 conductors	
12.0	9.6	14
16.0	12.8	12
24.0	19.2	10
40.0	32.0	8
48.0	38.4	6
- -	48.0	4

6. If not supplied as part of this unit, install a line disconnect and fusing or a circuit breaker in accordance with N. E. C.
7. The following table shows the maximum over current rating for wire servicing unit.

MAXIMUM SUPPLY UNIT AMPERAGE	MAXIMUM OVERCURRENT RATING
12	15
16	20
20	25
24	30
28	35
32	40
36	45
40	50
48	60

8. All field and factory made connections should be checked for tightness before operation.
9. The unit must be wired so as to provide a fan relay interlock to preclude heater operation unless air is flowing over the heater. An interlock is factory wired if heaters are factory attached.

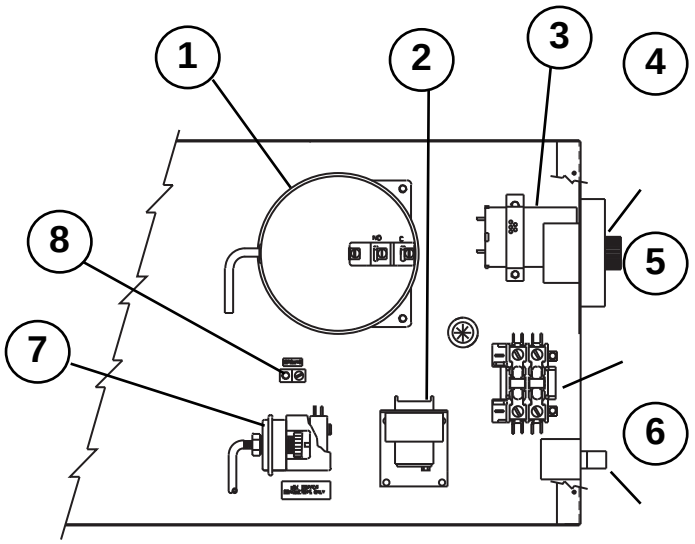
FAN UNIT CONTROLS *(See Figure 1)*

The following is a list of components located in the fan unit control panel. The figure at the right is to aid in component identification. Not all components are required for every control option and unit type.

1. Air Flow Switch. (Constant Volume Units)
2. Control Transformer. (Electronic/DDC Units)
3. Fan Motor Capacitor(s).
4. SCR Fan Speed Control.
5. Fan Motor Relay.
6. Fan Motor Disconnect Switch.
7. Pressure/Electric Switch. (Pneumatic Units)
8. Ground Lug.

Contact your local Carnes Representative for replacement parts.

CAUTION: *Severe Electrical Shock May Occur. Disconnect All Sources Of Supply Power Before Working On This Equipment. More Than One Disconnect May Be Required To De-Energize Equipment For Servicing.*



FAN UNIT CONTROL PANEL
Figure 1

BALANCING AND MAINTENANCE

DANGER:	*Severe Electrical Shock May Occur. Disconnect All Sources Of Supply Power Before Working On This Equipment. More Than One Disconnect May Be Required To De-Energize Equipment For Servicing.*

SETTING SECONDARY (HEATING) AIR FLOW

CONSTANT VOLUME (AC UNITS)

1. Adjust room thermostat to call for full cool. (Damper should open to the maximum CFM setting of the controller).
2. Remove secondary air filter if provided.
3. Tape a piece of cardboard onto the secondary air inlet. Size the cardboard 1/2" less than the height and 1/2" less than the width of the secondary inlet opening allow it to swing freely when taped in place. *(Figure 2)*
4. Adjust fan speed control (SCR) until the cardboard taped onto the secondary inlet hangs vertically indicating a balance between primary inlet air and discharge air CFM.
5. Remove the cardboard from secondary inlet. Replace filter if provided.
6. Fan CFM **MUST NOT BE LESS** than the maximum cooling CFM. Overloading the fan could cause motor damage and primary air to be forced out of the secondary inlet.

INTERMITTENT VOLUME (AS UNITS)

1. Adjust room thermostat to call for full heat. (Damper should close to minimum CFM setting on the controller).
2. Adjust fan speed control (SCR) to design CFM as measured at the diffusers.

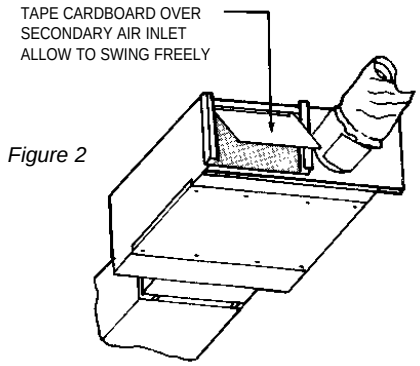


Figure 2

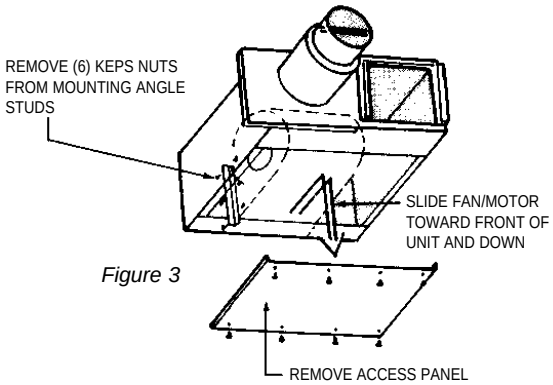


Figure 3

ROUTINE MAINTENANCE *(To be done at least once a year)*

1. Check all field and factory made electrical and pneumatic connections for tightness.
2. Clean all air filters. Throw-away air filters may be ordered through your local Carnes Representative. Aluminum mesh air filters may be washed in warm soapy water.
3. Check compressed air supply for clean, dry and oil free compressed air.
4. Fan motors are permanently lubricated not requiring annual service. If a fan wheel becomes out of balance due to dust or debris or if the fan motor should need replacing, follow the procedure outlined below.

FAN/MOTOR REMOVAL

1. Remove screws holding access panel in place.
2. Remove keps nuts from the mounting angle studs located on either side of the fan housing. *(See Figure 3)*
3. Disconnect fan motor wires from inside of the fan unit control panel.
4. Slide the fan/motor sub-assembly out through the access opening.
5. Reverse procedure for re-installation.

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