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.

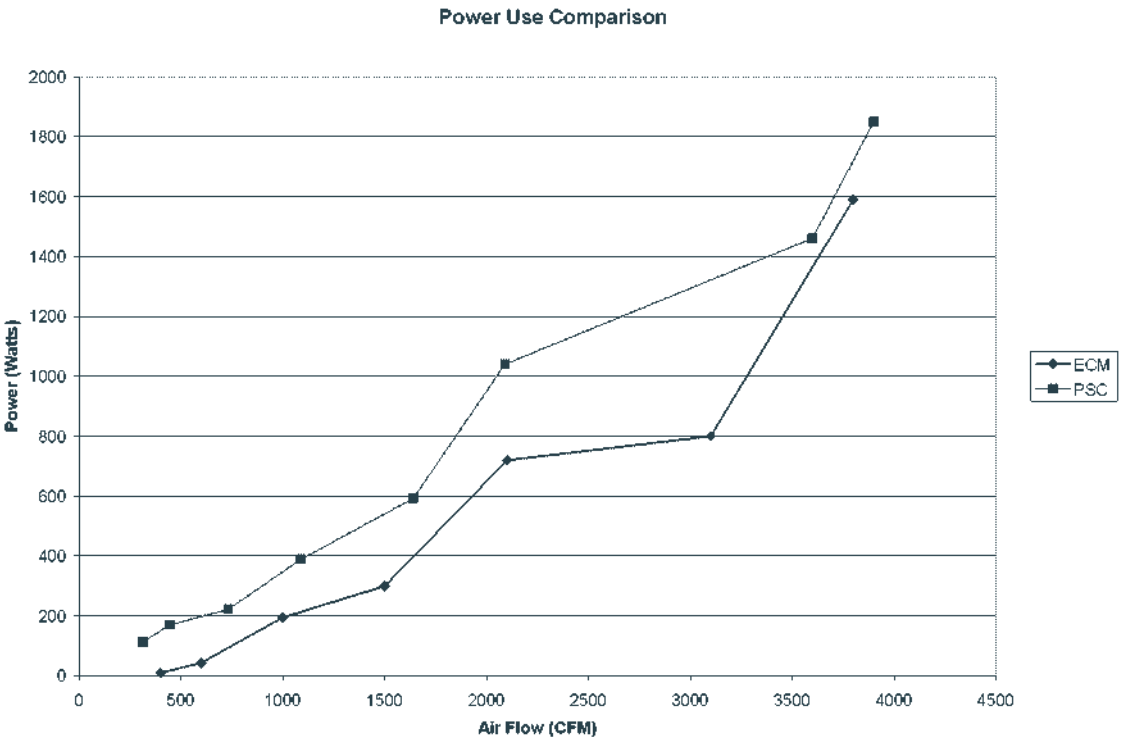
In response to the need for a high efficiency motor in which speed can be set and maintained, GE developed an Electronically Commutated Motor or ECM. It is an ultra high efficiency brushless DC motor with a built in inverter. The electronics package, included with the GE ECM motor serves two purposes. 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 systems 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.

ECM

Front of VCU

Energy Savings



The energy savings for the ECM motor can be quite significant. Depending on energy cost for a given area, the pay-back 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. 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.

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

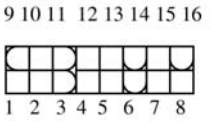


Figure 1

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 within + or – 5% of the set value.

ECM Flow Index

	AC_H06B	AC_H07C	AC_H08D	AC_H10E	AC_H12F	AC_H14G	AC_H16G
Max CFM	400	600	1000	1500	2100	3100	3800
Min CFM	150	350	550	900	1400	2000	2700
Flow Index	Fan CFM	Fan CFM	Fan CFM	Fan CFM	Fan CFM	Fan CFM	Fan CFM
0	150	350	550	900	1400	2000	2700
1	153	353	555	906	1407	2011	2711
2	155	355	559	912	1414	2022	2722
3	158	358	564	918	1421	2033	2733
4	160	360	568	924	1428	2044	2744
5	163	363	573	930	1435	2055	2755
6	165	365	577	936	1442	2066	2766
7	168	368	582	942	1449	2077	2777
8	170	370	586	948	1456	2088	2788
9	173	373	591	954	1463	2099	2799
10	175	375	595	960	1470	2110	2810
11	178	378	600	966	1477	2121	2821
12	180	380	604	972	1484	2132	2832
13	183	383	609	978	1491	2143	2843
14	185	385	613	984	1498	2154	2854
15	188	388	618	990	1505	2165	2865
16	190	390	622	996	1512	2176	2876
17	193	393	627	1002	1519	2187	2887
18	195	395	631	1008	1526	2198	2898
19	198	398	636	1014	1533	2209	2909
20	200	400	640	1020	1540	2220	2920
21	203	403	645	1026	1547	2231	2931
22	205	405	649	1032	1554	2242	2942
23	208	408	654	1038	1561	2253	2953
24	210	410	658	1044	1568	2264	2964
25	213	413	663	1050	1575	2275	2975
26	215	415	667	1056	1582	2286	2986
27	218	418	672	1062	1589	2297	2997
28	220	420	676	1068	1596	2308	3008
29	223	423	681	1074	1603	2319	3019
30	225	425	685	1080	1610	2330	3030
31	228	428	690	1086	1617	2341	3041
32	230	430	694	1092	1624	2352	3052
33	233	433	699	1098	1631	2363	3063
34	235	435	703	1104	1638	2374	3074
35	238	438	708	1110	1645	2385	3085
36	240	440	712	1116	1652	2396	3096
37	243	443	717	1122	1659	2407	3107
38	245	445	721	1128	1666	2418	3118
39	248	448	726	1134	1673	2429	3129
40	250	450	730	1140	1680	2440	3140
41	253	453	735	1146	1687	2451	3151
42	255	455	739	1152	1694	2462	3162
43	258	458	744	1158	1701	2473	3173
44	260	460	748	1164	1708	2484	3184
45	263	463	753	1170	1715	2495	3195
46	265	465	757	1176	1722	2506	3206
47	268	468	762	1182	1729	2517	3217
48	270	470	766	1188	1736	2528	3228

ECM Flow Index

	AC_H06B	AC_H07C	AC_H08D	AC_H10E	AC_H12F	AC_H14G	AC_H16G
Max CFM	400	600	1000	1500	2100	3100	3800
Min CFM	150	350	550	900	1400	2000	2700
Flow Index	Fan CFM	Fan CFM	Fan CFM	Fan CFM	Fan CFM	Fan CFM	Fan CFM
49	273	473	771	1194	1743	2539	3239
50	275	475	775	1200	1750	2550	3250
51	278	478	780	1206	1757	2561	3261
52	280	480	784	1212	1764	2572	3272
53	283	483	789	1218	1771	2583	3283
54	285	485	793	1224	1778	2594	3294
55	288	488	798	1230	1785	2605	3305
56	290	490	802	1236	1792	2616	3316
57	293	493	807	1242	1799	2627	3327
58	295	495	811	1248	1806	2638	3338
59	298	498	816	1254	1813	2649	3349
60	300	500	820	1260	1820	2660	3360
61	303	503	825	1266	1827	2671	3371
62	305	505	829	1272	1834	2682	3382
63	308	508	834	1278	1841	2693	3393
64	310	510	838	1284	1848	2704	3404
65	313	513	843	1290	1855	2715	3415
66	315	515	847	1296	1862	2726	3426
67	318	518	852	1302	1869	2737	3437
68	320	520	856	1308	1876	2748	3448
69	323	523	861	1314	1883	2759	3459
70	325	525	865	1320	1890	2770	3470
71	328	528	870	1326	1897	2781	3481
72	330	530	874	1332	1904	2792	3492
73	333	533	879	1338	1911	2803	3503
74	335	535	883	1344	1918	2814	3514
75	338	538	888	1350	1925	2825	3525
76	340	540	892	1356	1932	2836	3536
77	343	543	897	1362	1939	2847	3547
78	345	545	901	1368	1946	2858	3558
79	348	548	906	1374	1953	2869	3569
80	350	550	910	1380	1960	2880	3580
81	353	553	915	1386	1967	2891	3591
82	355	555	919	1392	1974	2902	3602
83	358	558	924	1398	1981	2913	3613
84	360	560	928	1404	1988	2924	3624
85	363	563	933	1410	1995	2935	3635
86	365	565	937	1416	2002	2946	3646
87	368	568	942	1422	2009	2957	3657
88	370	570	946	1428	2016	2968	3668
89	373	573	951	1434	2023	2979	3679
90	375	575	955	1440	2030	2990	3690
91	378	578	960	1446	2037	3001	3701
92	380	580	964	1452	2044	3012	3712
93	383	583	969	1458	2051	3023	3723
94	385	585	973	1464	2058	3034	3734
95	388	588	978	1470	2065	3045	3745
96	390	590	982	1476	2072	3056	3756
97	393	593	987	1482	2079	3067	3767
98	395	595	991	1488	2086	3078	3778
99	398	598	996	1494	2093	3089	3789
100	400	600	1000	1500	2100	3100	3800

Table 2

Visual Control Unit (VCU)

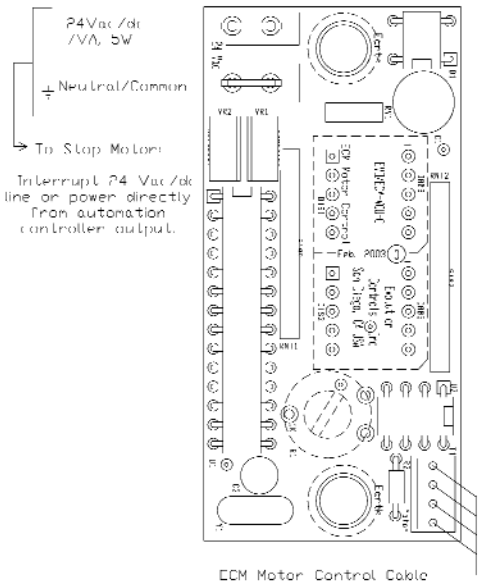
The EVO/ECM-VCU control allows accurate manual adjustment and monitor of fans using General Electric's ECM Motor. (See Figure 2)

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 to 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.

Figure 2

Front of VCU



Back of VCU control unit

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 ECM 2.3	24 Vdc @ 20 mA Set for Vspd Operation Set Status Flag (7) to RPM Thermal
Stability	>0.01 %/°F
Operating	0°F to 130°F (-18°C to 55°C) Environment 10-80% rh
Connections	1/4 Tabs

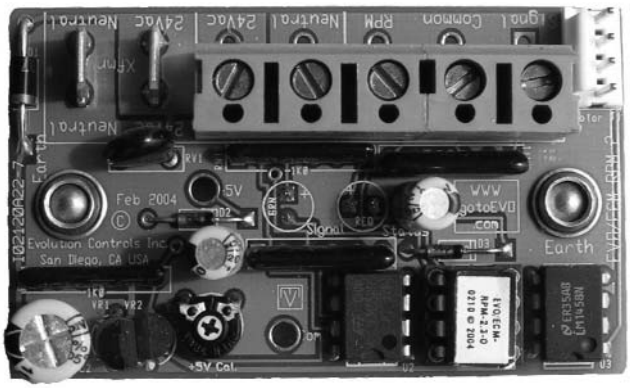
Automatic Control Unit (ACU+)

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.

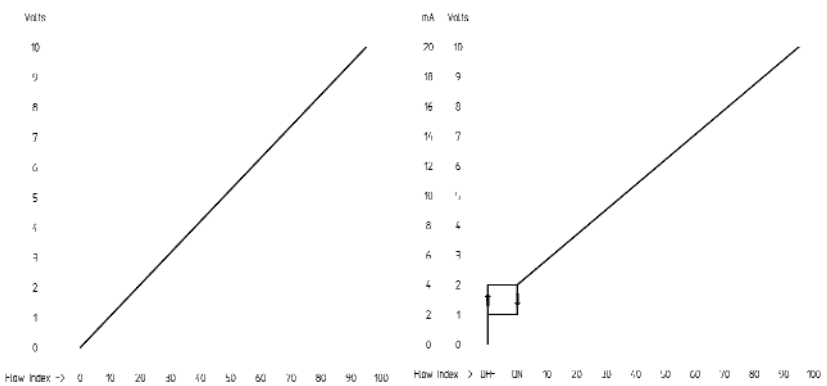
The EVO/ECM-ACU+ allows remote adjustment of the output from 0% to 100% of the programmed control range. A LED on the control continuously flashes out the flow index (percent of the programmed control range), so instruments are not required to read the value.

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.

Figure 3



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.



General
Furnish and install Carnes Constant Volume Fan Terminal Units of the size, capacity, and performance as shown on the plans.

Performance
The air pressure drop through the terminal units shall not exceed values tabulated on the job schedule. Sound levels of the terminal unit shall be **ARI Certified** and rated in accordance with **Standard 880-98**. An ARI Label shall be attached to each unit prior to shipment.

Construction
The valve assembly is to be constructed from galvanized steel with the damper mechanically fastened to a 3/8" shaft and isolated from the casing to eliminate the possibility of damper binding due to shipping or handling damage. The damper shaft is to rotate in oil impregnated sintered bronze bearings at three points for support and long life. Shaft shall be clearly marked on the end to indicate damper position. The terminal unit casing is to be 22 gauge galvanized steel.

Control Valve
The valve shall be sealed for minimum leakage. The throttling damper is to be of a sandwich design incorporating a solid sheet of Volara®, type A gasket material sandwiched between two halves of reinforced galvanized steel [18 gauge]. The average valve leakage of all unit sizes combined shall not exceed 1% at 3" inlet static pressure. Control valves shall be (Normally open) (Normally closed) as required.

Insulation
Insulation for fan terminal units ACF, ACW and ACE shall be 1" thick. All insulation shall be 1.5 lb./cu. ft. dual density fiberglass liner. The surface of the insulation shall conform to **UL Test 181** for erosion resistance. The insulation must be **UL** listed and meet **NFPA 90A** requirements for 250°F continuous temperature.

Foil Coated Insulation
The foil faced insulation shall be 1" thick dual density fiberglass with a .001", fiber reinforced aluminum foil on the matted face. The insulation must be **UL** listed conforming to **UL Test 181** for erosion resistance and must meet **NFPA 90A** requirements for 250°F continuous temperature.

Pneumatic control
Pneumatic actuators shall be furnished and mounted by the terminal unit manufacturer. The actuators shall be pivoted to protect against side forces throughout the full stroke. Provide **pressure independent pneumatic** volume control to maintain constant air volume regardless of duct pressure changes at air flows from minimum to maximum required by the zone. This action is to be instantaneous rather than having to wait for the thermostat to respond. External controls permit field adjustment of air volume. As a standard, the Carnes reset volume controller is offered for use with reverse or direct acting thermostat and a normally open or a normally closed damper.

Compressed consumption of the control shall not exceed 30 SCIM (0.017 SCFM) at 20 P. S. I.

Electronic Control (Analog)
Provide **pressure independent analog electronic** control to maintain constant air volume regardless of duct static pressure changes at all air flows from minimum to maximum required by the zone thermostat. Air flows shall be factory set and be field adjustable. Controls shall be provided with optional morning warm-up, dual minimum setpoints, and fan/reheat staging. Thermostat with integral maximum and minimum air flow setpoints shall be provided by the terminal unit manufacturer. A line voltage to 24 volt transformer shall be provided by the terminal unit manufacturer or by others [field mounted].

DDC Electronic Controller
The DDC control supplier must coordinate with the VAV manufacturer and will send the control devices to the VAV manufacturer to be factory mounted and wired. Calibration of DDC controls by control supplier.

Controls Enclosure
Provide a galvanized steel enclosure with a removable cover for protection of control components.

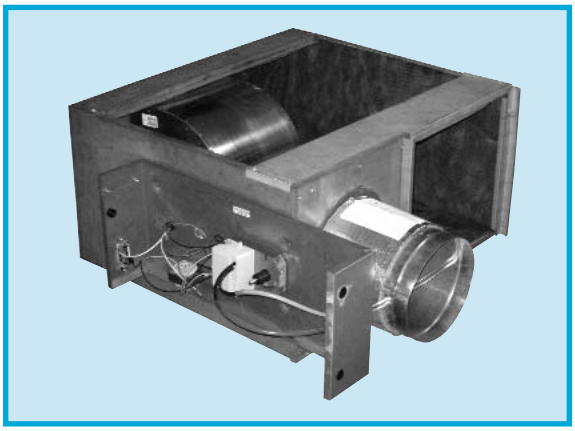
Balancing
Terminal units shall have flow taps and calibration chart for the purpose of measuring air flow.

Hot Water Coil
Hot water coil shall be Slip and Drive connected as an integral part of the terminal unit. If insulation is required, it must be field supplied and installed. One and two row coils shall be constructed using 1/2" O. D. copper tubes, 1-1/4" x 1.08" (per row) rippled aluminum fins 0.005" thick. Fin spacing shall be 10 F. P. I. Coil connections shall be either right or left hand. All hot water coils to be pre-tested under water at 350 P. S. I.

Electric Heaters
Each electric heater will have an integral air flow interlock, automatic reset primary thermal cutout, resetable secondary thermal cutout, door interlocking disconnect switch, 80/20 Ni-Ch element wire. P/E switches shall be included with pneumatic controls. De-energizing magnetic contactors and a 24 volt control transformer shall be included with electronic controls. The electric heater will be available with 1 or 2 stage heaters for the electronic controlled fan powered units and 1, 2 or 3 stage heaters for all pneumatic or DDC units.

Fan Terminal Unit Motors
Fan terminal unit motors shall be ECM in 120, 220, 240, or 277 volt, single phase.

Models ACF w/o Coil
ACW w/Hot Water Coil
ACE w/Electric Coil



The Carnes constant volume fan terminal unit provides constant air volume to the space while retaining the advantages of a variable air volume system.
The primary air control assembly operates in the same manner as a standard throttling control valve when cooling loads are high. As cooling loads diminish the integral blower(s) induces warm ceiling plenum air to maintain constant air volume.

Features Include:

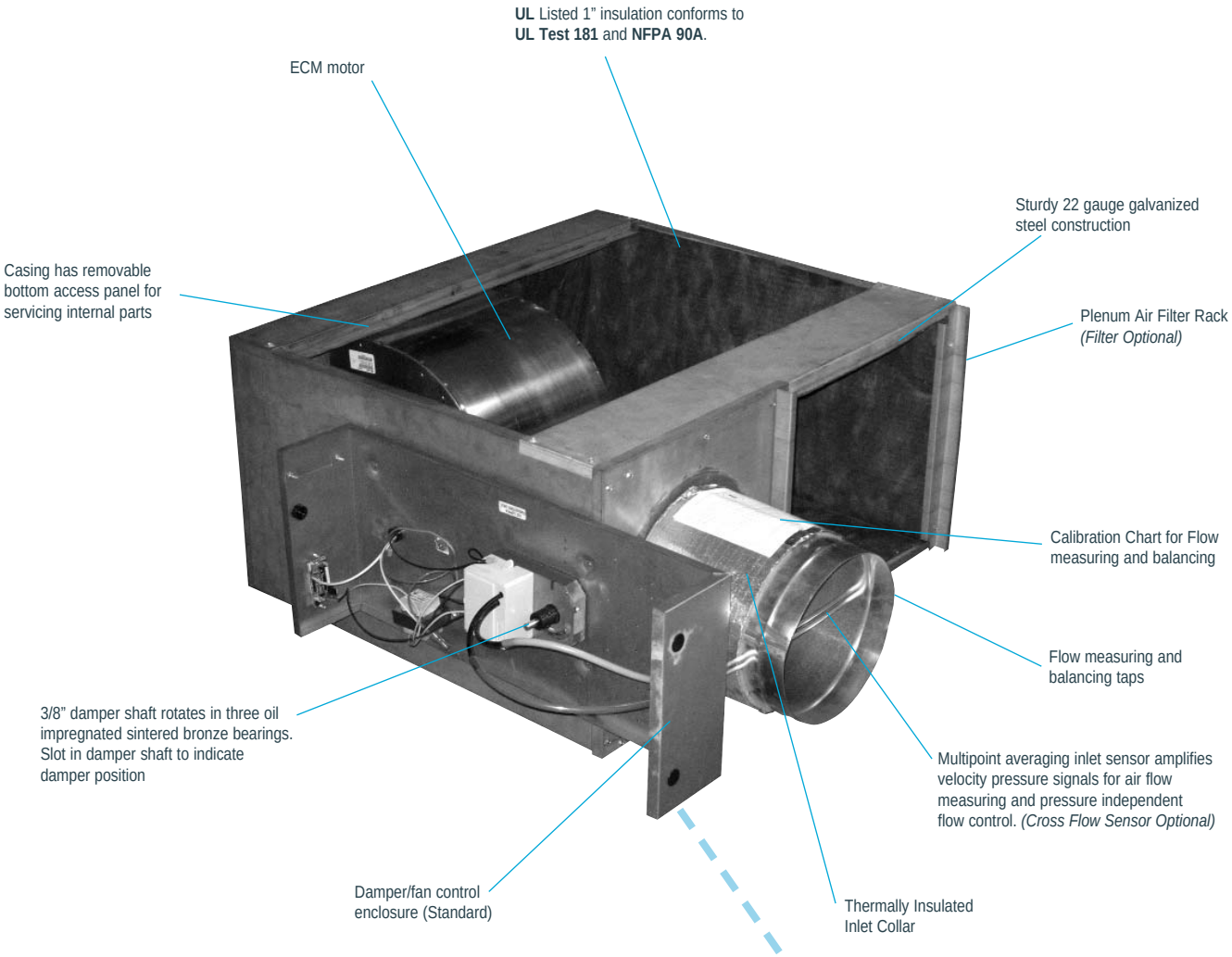
- Air flow capacities to 3800 CFM.
- Durable 22 gauge galvanized steel casing construction.
- Bottom access panel for internal components.
- Flange or slip and drive discharge connections.
- Forward curved centrifugal type fan assemblies with thermally protected, ECM 120, 220, 240, or 277 volt, single phase, motors.
- Adjustable fan speed control.
- Fan/motor assemblies are isolated from the casing using rubber isolators to minimize vibration transmission.
- Low leakage primary air damper design.
- Secondary air filter rack.
- Performance data based on tests conducted in accordance with ARI Standard 880-98.
- Field adjustable P/E switch with pneumatic controls.
- Averaging type velocity sensor and calibration chart for measuring air flow through the primary air damper.
- Insulation is 1” thick, 1-1/2 lb. dual density fiberglass with surface treated to prevent air erosion, UL listed and meets NFPA 90A requirements.
- Damper controls and fan controls are located in one enclosure.
- ARI listed.
- Optional ETL listing.
- Optional secondary air sound baffle. Sound baffle is factory attached to secondary air inlet. (Contact Carnes)
- Optional one or two row hot water coils (Model ACW). Coil is factory attached to the unit discharge.
- Optional one, two or three stage electric reheat coils (Model ACE). Coil is factory attached to unit discharge or shipped separately for field mounting.
- Optional secondary air filters, Class I (re-usable) or Class II (throw away).
- Optional non-fused or fused fan disconnect switch.
- Optional foil coated insulation (Hospital, Laboratory, etc. applications).

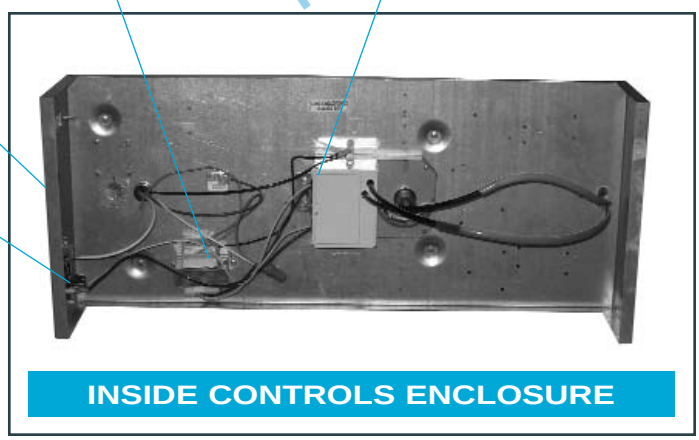
Available Modules:

- Basic control unit — **Model ACF**.
- Basic control unit with hot water coil — **Model ACW**.
- Basic control unit with electric coil — **Model ACE**.

IAQ

Foil Faced Insulation Available





INSIDE CONTROLS ENCLOSURE

ARI Standard 880

OPTIONAL ETL LISTING

QUICK SELECTION TABLE

Table A – Constant Volume Fan Terminals

Unit Type	Fan Size	Inlet Size (In.)	Motor HP	Full Load Amps 120 V	Full Load Amps 277V	Maximum Primary Air Flow	Min. Primary Air Flow (Pneumatic)	Min. Primary Air Flow (Electronic)	Maximum Fan CFM 0.25"wg
AC_H	B	6	1/3	1.7	0.8	400	0 or 110	0 or 65	400
	C	7	1/3	2.7	1.1	600	0 or 140	0 or 85	600
	D	8	1/3	5.0	2.2	1000	0 or 185	0 or 105	1000
	E	10	1	6.2	2.7	1500	0 or 300	0 or 155	1500
	F	12	1	9.3	4.0	2100	0 or 430	0 or 225	2100
	G	14	1 (2)	14.0	6.0	3100	0 or 600	0 or 335	3100
	H	16	1 (2)	18.0	9.0	3800	0 or 780	0 or 465	3800

Table B – Primary Air Inlet CFM Ratings

Inlet Diameter	Rated CFM	Pneumatic Minimum CFM Range	Electronic Minimum CFM Range	Maximum CFM Range
6"	500	ø or *110-200	ø or *65-200	300-500
7"	700	ø or *140-280	ø or *85-280	420-700
8"	1000	ø or *185-400	ø or *105-400	600-1000
10"	1500	ø or *300-600	ø or *155-600	900-1500
12"	2300	ø or *430-920	ø or *225-920	1380-2300
14"	3100	ø or *600-1240	ø or *335-1240	1860-3100
16"	4200	ø or *780-1680	ø or *465-1680	2520-4200

**See Note 2.*

NOTES:
1. *Rated CFM is based on a maximum inlet velocity of approximately 3000 FPM.*
2. *Minimum CFM selection below this value (except ø) with pressure independent control may provide less than optimum control characteristics. (Minimum CFM values for the ACE units will vary with a change in electric coil KW. See Electric Coil Section to calculate minimum air flow).*
3. *CFM selections out of the recommended maximum or minimum ranges shown may result in less than optimum control.*
4. *Minimum CFM selection is recommended to be 40% of maximum rated CFM or less.*
5. *Maximum CFM selection is recommended to be 60% of maximum rated CFM or more.*

Selection Procedure

- From the job specification or schedule, determine the Max and Min primary CFM requirement for each zone.
- Refer to the fan curves located under the Performance Data Section of this catalog.
- Select a fan size from these curves, making sure that the fan selected can deliver the maximum primary CFM at a given downstream external static pressure [ESP]. Downstream ESP consists of ductwork, flex, coils etc. NOTE: For proper operation, it is recommended that the downstream ESP be at least 0.20" WG.
- Units must be selected to operate within the minimum and maximum range of the fan curves. Fan speed controllers are provided as standard to allow airflow adjustments and balancing.
- Inlet size is predetermined according to the Fan Size selected for constant volume units [i.e.: Fan size B = 6" inlet, C = 7" etc.]. See Quick Selection Table A.
- After a Fan Size is selected, refer to the Primary Air Inlet Parameter chart Table B. Make sure that the Minimum primary CFM is within the ranges shown for Pneumatic or Electronic controls.
- Sound Level: Refer to the sound section of this catalog to determine if the unit selected meets the required NC or Db levels specified.
- Pressure Drop: Refer to the performance section of this catalog to determine the air differential pressure [DPs]. DPs is the static pressure difference from the inlet to discharge and doesn't include hot water or electric coils.
- Heating Coils: For units that require hot water or electric heat refer to the appropriate sections of the Carnes Mega Catalog for performance data.
- Controls: See Control Section of the Carnes Mega Catalog for Terminal Unit Controls and the sequence of operation as specified.