Proceedings of the 2003 International Radon Symposium – Volume II
American Association of Radon Scientists and Technologists, Inc.
October 5 – 8, 2003

# TECHNICAL CONSIDERATIONS IN RADON FAN APPLICATION

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## ABSTRACT

There is currently a proliferation of radon fans available to the radon mitigation market. Many mitigators carry only one or two fan models to cover all requirements. Current fan development efforts are being directed to fan models which extend specific capabilities beyond what is currently available. The presentation will provide technical information on effective fan selection.

## FAN TYPES

A fan is a machine which moves a constant flow of air or gas against a pressure created by the system in which the fan is installed. The choice of fan type depends on both the application and the fan performance

There are two main types of fans, axial or centrifugal. In general, axial fans are more suited to handling relatively large volumes of clean air or gas against low pressures, whilst centrifugal fans are used to develop higher pressures.

By definition the direction of air flow through an axial fan is parallel to the fan axis whereas the airflow turns through 90 degrees when passing through a centrifugal impeller. The higher pressure development of a centrifugal impeller is largely due to the effect of the centrifugal force exerted by the blades as the air leaves the impeller.

Centrifugal fans differ in terms of blade geometry being either forward, radial or backward bladed.

Forward bladed fans
The impeller blades are curved forward in the direction of rotation.
Efficiencies are relatively low at 65%.
The absorbed power increases towards free air delivery.

Radial bladed fans
The impeller blades are radial in the direction of rotation.
Efficiencies are relatively low at 60%.
The absorbed power increases towards free air delivery.

Backward bladed fans
The impeller blades are backward inclined or backward curved in the direction of rotation.
Efficiencies are relatively high at 85% for the backward curved.
The absorbed power has a non-overloading power characteristic.
The backward bladed fan is the type of impeller normally used for radon gas extraction.
The maximum efficiency occurs at maximum absorbed power.

## FAN PERFORMANCE

It is important to match the fan performance with the system requirement, especially the communication characteristics of the sub-slab material. There are two fundamental facts regarding fan selection and operation:

1.) A fan can only operate on its pressure versus volume curve.
2.) The system resistance is proportional to the square of the volume flow rate.

Fan Performance Curve
The catalogued performance data is based on laboratory testing under ideal conditions to the fan performance testing standard AMCA 210. For a typical range of radon extract fan performance curves refer to Fig 1.

The most common cause of a fan not achieving the catalogued design duty is the result of poor installation conditions. Abrupt changes in duct diameter, an obstruction, or a sharp bend either side of the fan will disrupt the airflow and have a detrimental effect on the fan performance.

System Resistance Curve
The system resistance curve is the graphical representation of the system resistance as a pressure versus volume curve. The system resistance is proportional to the square of the volume flow rate and for every time the volume flow rate doubles, the system resistance increases fourfold. The system resistance curve is a fixed relationship for any air movement system, unless the system is altered for some reason. An example would be seasonal weather fluctuations affecting the porosity of the earth.

Operating Point

The operating point of the fan is the intersection of the fan performance curve and the system resistance curve. Refer to Fig 2. Provided that the actual system resistance is as calculated, the fan will operate at the design duty point which will be close to the fans peak efficiency for the ideal selection.

If the actual system resistance is lower than the design resistance, the intersection of the system resistance line and the fan curve will move towards the right and there will be an increase in the volume flow delivered. Conversely if the actual system resistance exceeds the design resistance, the intersection of the system resistance line and the fan curve will move towards the left and there will be a shortfall in the volume flow delivered. Both the power and efficiency will vary dependant on the operating point on the fan curve and the fan will very often not be operating at the highest wattage point which is the value normally stated on the fan rating plate.

For some fans the performance curve reaches a peak before dropping off as it approaches the shut off or minimum volume position. Provided that the intersection of the system resistance line and the fan performance curve remains on the rising pressure portion of the fan curve, the fan operation will remain stable. However, if this point falls towards the left of the peak of the fan performance curve, the fan could be operating in an area of unstable operation. Under these conditions the fan will tend to hunt and will deliver fluctuating performance.

## SERIES AND PARALLEL OPERATION

In certain instances it may become necessary to use more than one fan to achieve either the required volume flow rate or pressure.

Series Operation

For two identical fans in series, the combined pressure delivered by the two fans at any volume will be the sum of the individual pressures at that volume.

Parallel Operation

For two identical fans in parallel, at any pressure the combined volume delivered by the two fans will be the sum of the volumes delivered by each of the two fans. This occurs when both fans are operating on a common system against the same resistance.

## FAN CONSTRUCTION

The most commonly used fan for radon mitigation is the in-line centrifugal fan, which offers high performance in a cost effective package.

Motors

All electric motors use the principle of a rotor being driven by a copper wound stator. The greatest revolution in fan technology in recent years has been the innovation of the external rotor motor with the rotor rotating externally about the central stator. This has resulted in a motorized impeller providing a very compact fan unit.

The integrated impeller and rotor allows for precision balancing of the combined impeller and motor assembly resulting in quiet operation and greatly reduced bearing stress. This arrangement provides optimum cooling to the motor with the impeller and motor being positioned directly in the air stream and both combining to dissipate the heat generated by the motor. This results in low motor operating temperatures with the benefit of lower winding insulation stress and greatly reduced degradation of the bearing lubricant. A normally closed thermal contact imbedded in the motor windings will provide protection in the eventuality of the motor over heating. The thermal contact can be either of the auto-reset or mains-disconnect type. The advantage of fitting a mains-disconnect thermal contact is that it will require someone to reset the unit and to investigate the cause of tripping.

For radon extraction the air stream is often saturated and the motor windings can be further protected by additional moisture protection varnish and the rotor provided with drain holes to get rid of condensation. Maintenance free sealed for life ball bearings will provide a minimum L10 life of 40000 hours.

These factors all combine in a high quality external rotor motor to provide significant benefits in terms of life expectancy.

Housings

The impeller and motor assembly is mounted in a moulded plastic casing which is sealed to prevent gas leakage. Modern plastics are available to provide a weatherproof, flame retardant, corrosion resistant casing suitable for mounting internally or externally.

For external applications it is important to ensure that the casing material includes UV inhibitors to provide resistance to ultra violet radiation. This will prevent unsightly discolouration and embrittlement of the plastic material. The two main types of plastic in use are thermoplastic and dough moulding compound. Advantages of DMC include high structural stability especially at higher temperatures plus greater rigidity and thicker wall sections resulting in reduced transmission of sound from the fan.

Spigot dimensions should be compatible with available pipe diameters and rubber couplings. Rubber couplings allow for ease of fit and reduce noise and vibration transmission from the ducting by isolating the fan from the ducting.

## CERTIFICATION

In order to provide peace of mind to the installer and end user, it is becoming increasingly common practice to specify independently certified fans. The relevant certification bodies and their purposes are as follows:

Underwriters Laboratories
Underwriters Laboratories Inc. (UL) is an independent, not-for-profit product safety testing and certification organisation. The UL Listing Mark on a product is the manufacturers representation that samples of that complete product have been tested by UL to nationally recognized Safety Standards and found to be free from reasonably foreseeable risk of fire, electric shock and related hazards and that the product was manufactured under UL's Follow-Up Services program. (Source: www.ul.com UL Listing vs. Recognition. Whats the difference.)
In the case of radon extract fans the UL Listing confirms that the product has been evaluated to confirm compliance to UL 507 Standard for Safety Electric Fans.

Air Movement and Control Association Inc.
The purpose of the AMCA Certified Ratings Program – Air Performance is:
To provide the buyer, user and specifier assurance that the manufacturer's published performance ratings of air moving equipment are reliable and accurate, and further, to provide these parties with information on how the product was tested, what appurtenances were included, and other pertinent information so that they may be able to select a fan that will provide the performance required.

To provide a procedure for verification of the manufacturer's performance ratings on a regular schedule by check-testing of the certified product line in the AMCA Laboratory.

To provide assurance that competitors' ratings are based on standard test methods and ratings procedures. (Source: AMCA Publication 211 Certified Ratings Program-Air Performance)

Home Ventilating Institute
The purpose of the HVI Product Performance Certification Procedure is:
To provide uniform and impartial testing, rating and certified labelling for home ventilating equipment and to provide dependable certified performance ratings for comparing models for builders, specifiers, designers, contractors, code officials and consumers.

To assure manufacturers that standard tests and procedures are administered for determining the ratings which are published. ( Source: HVI 920 Product Certification Procedure)

## NEW DEVELOPMENTS

A large amount of effort has been expended to develop and expand fan technology to improve radon mitigation for both pre-piped systems that require low suction/high flow fans and for large footprint basement houses with very poor sub-slab communication which require high suction/low flow technology._

Low suction/High flow
Additional models are constantly under development to supply the required volume flow at usable pressures.

High suction/Low flow
There has been a need for higher performance fans to permit satisfactory radon extraction from highly compacted very impermeable soil. In these circumstances it has become common practice to stack fans. There are now a number of alternative options available.

Fan pressure development is proportional to the square of the impeller rotational speed and also proportional to the square of the impeller diameter. The required pressure can thus be obtained by using a fan with a higher impeller tip speed. This can be achieved through driving a larger diameter impeller at the same rotational speed or by driving the same diameter impeller at a higher rotational speed. The second option can be achieved through using a direct current (DC) motor operating at a speed above the synchronous speed limitations of a standard alternating current (AC) motor.

An alternate option is to use a two-stage fan. This comprises of two motorised impellers mounted in one housing with the airflow being directed from the first to the second stage by means of an inter-stage guide vane arrangement.

Positive Pressurisation
By positively pressurising the basement or living area radon can be prevented from entering the house. Positive pressurisation requires sealing of the floor slab and is not effective in all cases.

Heat Recovery Ventilation
A heat recovery system gently ventilates the home drawing warm moist air and unpleasant smells from the kitchen, bathrooms and toilets, extracting to the outside. Fresh air is drawn into the living spaces providing constant ventilation even when the house is sealed up for the day. At the heart of the system is a typically 90% efficient counter flow heat recovery cube which eliminates the need for additional heating of the incoming air during winter months. This free heat is circulated to the living spaces via a network of insulated ducting to provide quiet and unobtrusive fresh tempered air. By keeping humidity levels low and introducing fresh air to replace the contaminated air, the quality of the internal environment is significantly improved.

## CONCLUSION

There is great variation in system resistances due to both variations in the soil permeability and the ducting system used. It is not possible for one fan to provide the desired extract rate for all conditions. The fan industry is constantly striving to make available ranges of radon fans to provide mitigators with a fan to suit the performance requirements of their specific application.

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**Fig 1**
**Fan Performance Curve**

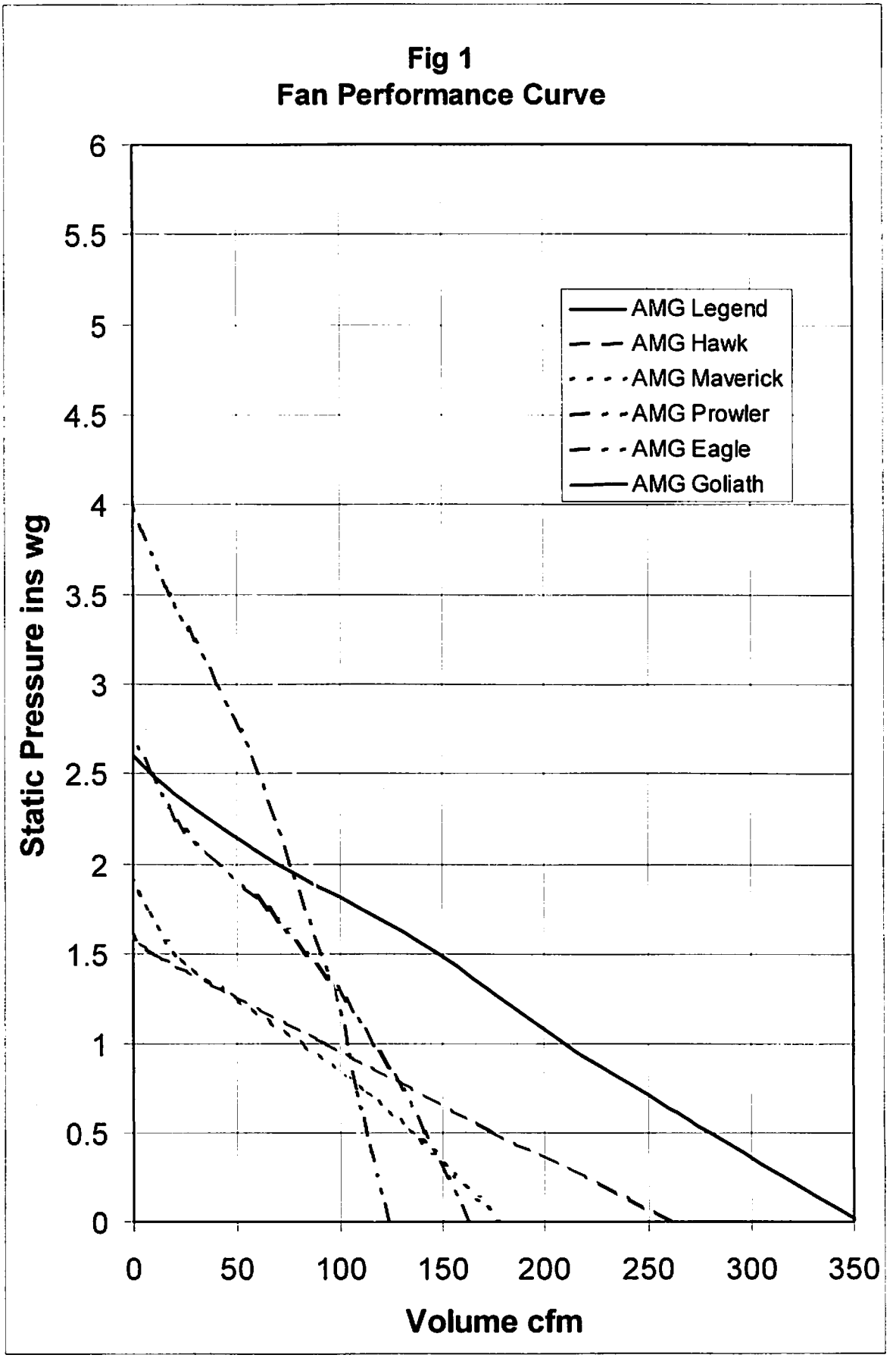

**Fig 2**
**Fan Operating Point**