

- B. Inventory of individual odor sources.
- C. Type of occupancy and volume to be purified.
- D. Purification test using a small adsorber.
- E. Survey based on smell.
- F. Rules-of-thumb and experience.

Method A—Knowledge or analytical determination of specific odor-causing compounds and their amounts. This method calls for knowledge of the operations within the area or an analysis of the contaminants in the air. If the odors come from a manufacturing process or similar operation, it may be possible to establish the types of vapors given off, their concentration, and the quantity which must be removed per year. In other cases this information can be obtained by analytical procedures. A method useful where the odor concentration is rather high involves freeing out the vapors at low temperature and subsequent chemical analysis.

Table 9 in Chapter 10 of the 1961 GUIDE AND DATA BOOK gives the relative capacity of 50-min activated coconut shell charcoal for most of the common air contaminants and many others that are found in specific applications. The values are based on the removal of the substance from dilute concentration in air encountered in air recovery and air purification projects.

If the odor under consideration is listed in classification 4 of the mentioned Table 9, it may be assumed that each pound of activated charcoal will take up $\frac{1}{4}$ lb odor. The weight of odor to be removed is multiplied by three to determine the weight of activated charcoal needed. If the compound is in Class 3, the weight of odor is multiplied by six.

Method B—Inventory of individual odor sources. An odor inventory (directly in terms of activated charcoal required) can be prepared using Table 10 in Chapter 10 of the 1961 GUIDE AND DATA BOOK.

Method C—Type of occupancy and volume to be purified. Table 1 shows the volume of space (cubic feet) of some selected types which can be purified by one pound of activated charcoal per year.

In connection with many chemical processes, coating operations, and other locations where large amounts of volatile compounds are given off, it is possible to regenerate the activated charcoal in-place by steaming or other suitable treatment. In a typical situation, the activated charcoal if regenerated in-place might be desorbed and reused 5000 times in one year. In the usual type of air-conditioning applications, it is not feasible or necessary to use in-place regeneration.

The relative odor levels in the various types of locations where activated charcoal air purification can be used are listed in Table 11 of Chapter 10, 1961 GUIDE AND DATA BOOK. Since many of the classifications are rather general, it was necessary to pick a typical average condition. The odor index for a specific situation could vary somewhat from that given if there are special circumstances.

For certain specific types of applications, experience may indicate the amount of activated charcoal to use and the best method of applying it. For example in cold storage rooms for apples, it has been shown that 6 lb of activated charcoal and 100 cfm of recirculated air should be used during each storage period for each 1000 bushels of apples.

Method D—Purification test using a small adsorber. A test can be made with a small activated charcoal purification unit to duplicate with a portion of the air or part of the space the type of treatment that can be expected with commercial activated charcoal filters. This test requires only a small

Table 1 Cubic Feet of Space That Can Be Purified by 1 lb of Activated Charcoal Per Year*

Application	Space Volume Cu Ft/ Year By 1 lb
Chemical processes	1/10 to 100
Chemical plants	50 to 500
Laboratories	50 to 500
Printing plants	10 to 500
Toilets	100 to 1000
Cold storage	100 to 1000
Offices	100 to 5000
Public buildings	200 to 1000
Homes	1000 to 5000

* This table is for general guidance only and gives the range in which the stated applications ordinarily fall. Although there is a variation of about 50 to 1 in typical air-conditioning situations, it is less than the difference between threshold and strong odor levels.

amount of equipment and is the simplest approach to complicated odor control problems.

For most industrial and commercial applications, it is suggested that the test be run with a test unit that has an air capacity of 50 to 65 cfm and contains $\frac{1}{4}$ to 3 lb of activated charcoal. This is a ratio of about 45 lb per 1000 cfm which is that contained in commercial activated charcoal cells. The test unit should be mounted in the area under consideration and operated so that the air being treated by it will represent that to be handled in the commercial installation. By smelling the air discharged from the test unit, it can be determined whether the odors are being satisfactorily removed. Where an unusual situation exists, or where a very detailed analysis must be made, the charcoal in the canister can be desorbed to permit examination of the recovered impurities.

Method E—Survey based on smell. Table 2 is a rough correlation between odor intensity, vapor concentration, and space that can be purified by one pound of activated charcoal per year. With approximately 500,000 min in a year and a 5-min air change, there would be 100,000 air changes per year. Assume the odor to be at the stated level one-third of the time, or 8 hr per day. Assume that 1 lb of activated charcoal takes up $\frac{1}{4}$ lb of odor. The odor level required to give a certain physiological reaction is a sort of typical average figure. Odor perception varies from person to person and also depends on temperature, humidity, and air velocity. Some odors are stronger than others so that the amount required might be greater or less by a factor of 10 or more.

A 1000 cubic foot space at the threshold level will require the treatment of 100 million cu ft of air per year with a 5-min change. If there is 1/100 lb of odor per one million cubic feet, this means that 1 lb of odor will be removed per year from this space, providing the stated level persists 100 percent of the time. Since it was assumed, however, that it will persist one-third of the time, this gives $\frac{1}{3}$ lb of odor. Also, since it was assumed that the activated charcoal will take up $\frac{1}{4}$ lb of odor per lb, 1 lb of activated charcoal will be sufficient. This manner of calculating is approximate but illustrates the principles involved in odor control.

Method F—Rules-of-thumb and experience. A person with experience in odor control problems and use of activated charcoal can ordinarily make a reasonable selection of equipment based on rather meager information. The better the information that is available, the more accurate can be the selection.

It is possible to make a rough determination of odor concentration by smell. An expert in odor control may be able to recommend the type of purification equipment to use based on an examination of the situation using his sense of smell.

Odor Control

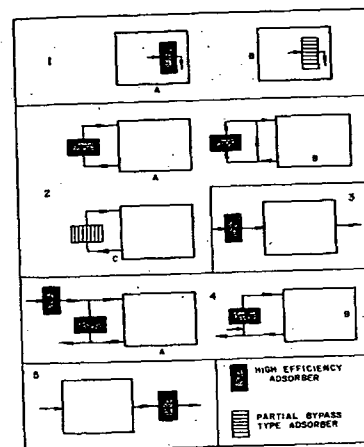
Table 2 Correlation Between Odor Intensity, Vapor Concentration, and Space That Can Be Purified by 1 lb of Activated Charcoal Per Year

Degree of Odor	Cu Ft per Year By 1 lb of Charcoal	Lb of Odor per Million Cu Ft	Odor Index
Too little to smell	10,000	0.001	0
Threshold (just perceptible)	1,000	0.01	1
Definite	100	0.1	2
Strong	10	1.0	3
Overpowering	1	10	4
Toxic (process only)	1/10	100	5

Whenever possible, this should be checked by one of the other methods.

Types of Charcoal Systems

The type of activated charcoal filters to use and the amount of air circulation depend on the amount of charcoal required, the method of odor release in the room, the type of occupancy, the arrangement of the ventilation system, and similar factors.



1. Self-contained unit
 - (a) complete purification in each passage
 - (b) partial purification in each passage
2. Recirculation system
 - (a) complete purification per pass handling all the air
 - (b) complete purification per pass handling part of the air
 - (c) partial air bypass filters handling all the air
3. All outdoor air (through activated charcoal)
4. Combination outdoor and recirculated air
 - (a) through separate banks of charcoal filters
 - (b) through one bank of activated charcoal filters
5. Exhaust system (alone or combined with one of the others)

Fig. 1 Systems of Applying Activated Charcoal

tors. The higher the rate of odor release, the faster should be the air turnover and the more activated charcoal would be required per year.

To be effective in any given situation, the odors from the ventilated area must reach the charcoal by means of circulated air so that they can be adsorbed. This is a function of the rate of odor release, size and shape of the room, type of ventilating system, placement of the activated charcoal filters or circulating units, eddy currents caused by open doors, partition walls, and moving machinery, and other related factors. The physiological reaction to odor depends on its concentration, the air velocity, temperature and humidity of the air, and the individual occupants.

Fig. 1 shows diagrammatically the important types of activated charcoal purification methods using self-contained circulating units or ducted systems.*

System 3 of Fig. 1 should not be used unless outdoor air is desirable for temperature, humidity, oxygen, or carbon dioxide control. Where there is some doubt about the oxygen sufficiency, a small amount of purified outdoor air may be introduced. The oxygen content in the building under consideration or in a similar building can readily be determined by use of available standard equipment.

System 4, Fig. 1 provides another approach where regulations or personal opinions have dictated a certain amount of outdoor air. In this case ventilating air can be brought in from the outdoors if desired or shut off so that complete recirculation is employed. After the system is in operation, a few tests will demonstrate where complete circulation can be used to advantage. Type 4b accomplishes this with the use of only one charcoal filter.

As indicated in System 5 of Fig. 1, activated charcoal can be used to advantage to purify air exhausted from kitchens, toilets, process operations, or other areas having high concentrations of contaminants. The air, after purification, can be discharged to the atmosphere without fear of pollution or can, in many cases, be reused in the ventilation of the building. Where the concentrations are high, thicker beds of activated charcoal should be used or in some cases the cells can be regenerated in-place. It is sometimes possible to recover useable and valuable material from exhaust air.

Purification of all of the recirculated air by activated charcoal is the most certain procedure in many cases. There is little that can go wrong with such a system and it will operate effectively even though there are periodic overloads of odor. This may, however, be more expensive in the initial installation than a smaller but adequate system. An oversized system does not increase the cost of operation. If extra activated charcoal is put in initially, the cells will not need reactivation so often.

If there is doubt about the amount of odor to be removed or the rate of air change to be employed, it is feasible to install a minimum bank of adsorbers and provide in the building plan for the addition of more adsorbers if they should be needed.

In cases of high odor concentration, it may be feasible to lighten the load on the activated charcoal adsorbers by using some type of pretreatment. The adsorbers should be protected with dust filters to prevent them from becoming mechanically loaded with particulate matter which interferes with the air flow. In the case of ammonia (for which activated charcoal has limited capacity), scrubbing with water either before or after passage through the activated charcoal cells may be desirable. In the case of kitchen exhaust, adequate grease filters should be used ahead of the adsorbers.