

fuel beds on the grate increase the effective combustion space in the furnace, supply more air for combustion, and are sometimes effective in reducing the smoke emitted, but care should be taken that holes are not formed in the fire. A *lower volatile coal* or a higher gravity oil always produces less smoke than a high volatile coal or low gravity oil used in the same furnace and fired in the same manner.

The installation of more modern or better designed fuel burning equipment, or a change in the construction of the furnace, will often reduce

TABLE 1. TOXICITY OF GASES AND FUMES IN PARTS PER 10,000 PARTS OF AIR^a

VAPOR OR GAS	RAPIDLY FATAL	MAXIMUM CONCENTRATION FOR FROM ½ TO 1 HOUR	MAXIMUM CONCENTRATION FOR 1 HOUR	MAXIMUM ALLOWABLE FOR PROLONGED EXPOSURE
Carbon monoxide.....	40	15-20	10	1
Carbon dioxide.....	800-1000	-----	-----	-----
Hydrocyanic acid.....	30	1½	½	⅓
Ammonia.....	50-100	25	3	1
Hydrochloric acid gas.....	10-20	½	-----	⅓
Chlorine.....	10	½	-----	⅓
Hydrofluoric acid gas.....	2	1/10	-----	1/100
Sulphur dioxide.....	4-5	½-1	-----	1/10
Hydrogen sulphide.....	10-30	5-7	2-3	1
Carbon bisulphide.....	-----	11	5	½
Phosphene.....	20	4-6	1-2	-----
Arsine.....	2½	½	½	-----
Phosgene.....	Over ¼	¼	-----	1/100
Nitrous fumes.....	2½-7½	1-1½	-----	1/3
Benzene.....	190	-----	31-47	1½-3
Toluene and xylene.....	190	-----	31-47	-----
Aniline.....	-----	-----	1-1½	1/10
Nitrobenzene.....	-----	-----	1/100	1/500
Petrol.....	243	100-220	-----	-----
Carbon tetrachloride.....	480	240	40	16
Chloroform.....	250	140	50	2
Tetrachlorethane.....	73	-----	-----	1½
Trichlorethylene.....	370	-----	-----	-----
Methyl chloride.....	1500-3000	200-400	70	5-10
Methyl bromide.....	200-400	20-40	10	2
Lead vapor.....	-----	-----	-----	5-6

^aOriginal data compiled by Y. Henderson and H. Haggard. (See *Noxious Gases*, 1927). Data revised by T. M. Legge. (See *Lessons Learned from Industrial Gases and Fumes*, Institute of Chemistry of Great Britain and Ireland, London, 1930).

smoke. The installation of a Dutch oven which will increase the furnace volume and raise the furnace temperature, often produces satisfactory results.

In the case of new installations, the problem of smoke abatement can be solved by the selection of the proper fuel-burning equipment and furnace design for the particular fuel to be burned and by the proper operation of that equipment. Constant vigilance is necessary to make certain that the equipment is properly operated. In old installations the solution of the problem presents many difficulties, and a considerable investment in special apparatus is necessary.

Legislative measures at the present time are largely concerned with the

smoke discharged from the chimneys of boiler plants. Practically all of the ordinances limit the number of minutes in any one hour that smoke of a specified density, as measured by comparison with a Ringelmann Chart (Chapter 40), may be discharged.

These ordinances do not cover the smoke discharged at low levels by automobiles, and, although they have been instrumental in reducing the smoke emitted by boiler plants, they have, in many instances, increased the output of chimney dust and cinders due to the use of more excess air and to greater turbulence in the furnaces.

Legislative measures in general have not as yet covered the noxious gases, such as sulphur dioxide and sulphuric acid mist, which are discharged with the gases of combustion. Where high sulphur coals are burned, these sulphur gases present a serious problem.

DUST AND CINDER ABATEMENT

The impurities in the air other than smoke come from so many sources that they are difficult to control. Only those which are produced in large quantities at a comparatively few points, such as the dust, cinders and fly-ash discharged to the atmosphere along with the gases of combustion from burning solid fuel, can be readily controlled.

Dusts and cinders in flue gas may be caught by various devices on the market, such as fabric filters, dust traps, settling chambers, centrifugal separators, electrical precipitators, and gas scrubbers, described in the following paragraphs.

The cinder particles are usually larger in size than the dust particles; they are gray or black in color, and are abrasive. Being of a larger size, the range within which they may annoy is limited.

The dust particles are usually extremely fine; they are light gray or yellow in color, and are not as abrasive as cinder particles. Being extremely fine, they are readily distributed over a large area by air currents.

The nuisance created by the solid particles in the air is dependent on the size and physical characteristics of the individual particles. The difficulty of catching the dust and cinder particles is principally a function of the size and specific gravity of the particles.

Lower rates of combustion per square foot of grate area will reduce the quantity of solid matter discharged from the chimney with the gases of combustion. The burning of coke, coking coal, and sized coal from which the extremely fine coal has been removed will not as a general rule produce as much dust and cinders as will result from the burning of non-coking coals and slack coal when they are burned on a grate.

Modern boiler installations are usually designed for high capacity per square foot of ground area because such designs give the lowest cost of construction per unit of capacity. Designs of this type discharge a large quantity of dust and cinders with the gases of combustion, and if pollution of the atmosphere is to be prevented, some type of catcher must be installed.