Abstract

As a result of the growing demand for nuisance-free refuse disposal and the increasing complexity of modern refuse incinerator plants, performance-type plans and specifications for incinerators are no longer acceptable. Public health considerations also require greater control of refuse disposal by public agencies.

In this paper, the author presents his views of the relative responsibility of state health departments, designing engineers, and contractors for proper design and operation of municipal incinerators. He also cites examples of performance-type specification requirements still in use which are not consistent with the best engineering practice.

Introduction

Prior to World War II, and for a few years thereafter, most knowledge of refuse incineration was concentrated in the hands of a few pioneer incinerator builders who designed and erected the plants, trained operating personnel, and put the plants into operation. To all intents and purposes, public officials and agencies exercised no authority over design or operation. Accordingly, it was only logical, and the accepted practice, that plans and specifications for municipal plants, as prepared by consulting or municipal engineers, be of the performance type. All that was necessary for contract drawings was a few sheets showing general building arrangement and architectural treatment, approximate location of furnaces, chambers and equipment, minimum clearances, and perhaps some approximate overall dimensions. Specifications covered capacity requirements, materials of construction in general, occasionally some minimum areas and volumes, and sometimes a general description of the type of incinerator required. Detailed design of incinerator and building, construction, and initial operation were then left to the successful bidder, who was required to demonstrate compliance of the completed project with capacity requirements by means of a so-called official performance test. In some instances, the builder was also required to evaluate and interpret the test results.

To the extent that the science of incineration had been developed, this procedure usually produced an adequate plant; however, due to the press of competition and an innate desire to stay in business, the builders were required to keep their costs to a minimum. It reflects no discredit on these builders, many of whom continue preeminent in the field today, to note that in order to accomplish this purpose, they were forced to hold areas and volumes of incinerator units as low as possible. In the official performance test, with its artificially ideal operating conditions, the units could usually be shown to meet the specified performance requirements. In the days, weeks and months following the test, with operating personnel working at a more normal rate under more normal conditions, and without the builder’s expert supervision, incinerators
frequently burned under capacity and often became sources of considerable nuisance. It was during this period that the picture of a refuse incinerator as a monstrosity discharging smoke, sparks, odors, and an offensive, incompletely burned residue, became fixed in the public mind. Even today it is not unusual for public officials and engineers to have to overcome strong objections based on this image before a needed incinerator plant can be built.

Design and Operating Responsibility

In the past fifteen or twenty years, public demand for nuisance-free refuse disposal, the increasing difficulty in securing land for sanitary fills, and the absence of other suitable means of disposal has resulted in tremendous advancement in the art of refuse incineration. The increasing complexity of the plants and the rapid development of more sophisticated mechanical equipment have forced recognition of the fact that detailed incinerator design can no longer be left to the low bidder whose plant layout and equipment selection must of necessity be influenced by economic considerations. As a result, the roles of the consulting engineer, the contractor, and the equipment manufacturer have radically been changed.

Now that refuse disposal has become universally recognized as a matter of public health concern, there is a definite need for control over incinerator design and operation by public agencies. State health departments exercise close control over design and operation of water and sewage treatment plants; to protect the public, this same type of control must be exercised over municipal incinerators, as well as all other refuse disposal facilities. Minimum design criteria should be established and published, as well as minimum standards for operation. Review of plans and specifications based on these criteria would assure conservative designs which would, in turn, make the desired operating results more readily attainable. As in water and sewage treatment, however, establishment of such criteria should not preclude plant designs based on new developments, provided there is reason to believe the operating standards can be met.

A report in 1960 [1] indicated that Connecticut was the only state at that time with established criteria on which state health department review of municipal incinerator designs was based. Nine other states indicated that health department approval of designs was required, but that the review was founded on current practice or on another equally indefinite basis. Ten states indicated that they controlled incinerator operation; three based control on air pollution standards, while the remaining seven essentially required only that the operation be nuisance-free, but did not define a nuisance. Today, Connecticut remains the only state with established design criteria for municipal incinerators.

Many states and local governments have established stringent air pollution control regulations which they attempt to apply to incinerators; however, in too many instances these regulations have been written for boiler plants or other uniformly fired industrial installations. They are difficult to apply to incinerators and frequently serve only to make the designers' and operators' jobs more difficult. Likewise, to the author's knowledge, there are no established standards for quality of residue. It is important, therefore, that state health departments establish not only conservative design criteria, but also standards for quality of residue and stack effluent which are written specifically for refuse incinerators. In sewage plants, the degree of treatment and quality of effluent required are based on the use classification of the receiving waters. Similar flexibility should be allowed for incinerators in that the degree of ash removal for each plant should be based on its location and the minimum quality of residue should depend on its ultimate use or disposal.

Designers Responsibility

Despite the fact that this control is needed, ultimate responsibility for design of an incinerator plant and its ability to burn refuse at the required capacity and in the desired manner must rest with the designing engineer. This is not to suggest that the designer ignore incinerator builders and equipment manufacturers. Many of the old-line builders can offer invaluable suggestions and advice, and no experienced engineer would or should attempt to include major equipment in his design without the advice of the manufacturer on its proper application. This advice must, however, be tempered by the designer's knowledge and experience, and final decisions in all aspects of the design must be those of the engineer. Likewise, a substantial portion of an incinerator plant specification must be written with the advice of builders and equipment manufacturers. Again, however, the finished specification must be the designer's work. In the interest of fair competition and securing the best possible bid for his client, the designer must avoid verbatim insertion of specifications or drawings prepared for him by builders, equipment manufacturers, or material suppliers.

Performance Type Specifications

In recognition of the fact that straight performance-type plans and specifications are no longer sufficient, design of most incinerator plants is now handled by independent consulting engineers who apply basic design factors to determine areas and volumes of the various
incinerator components. As a rule, contract drawings prepared for bidding purposes today are complete in every respect. Buildings, furnaces, chambers, and flues are carefully detailed and dimensioned to the fraction of an inch; the location, arrangement, and important features of mechanical equipment are shown in minute detail. In short, contract drawings for incinerator plants are now usually as complete as engineering and drafting skill can make them. Specifications also are vastly improved, in that type and construction of plant, equipment, and facilities are usually spelled out in complete detail. A review of current specifications shows, however, that in almost every case various performance-type requirements from the past continue to be included. Most of these requirements, which place varying degrees of responsibility for plant design and operation on the contractor, are not consistent with the high degree of engineering skill and responsibility required for the modern refuse incinerator.

The great majority of today's incinerator specifications require, in one form or another, that the contractors check or certify the adequacy of the design. Some go on to require, if any inadequacies are found, that the contractor make the necessary changes — including enlargement of chambers, increased capacity of mechanical equipment, etc. — and include the cost in his bid price.

As noted above, most competent incinerator designers of years past were to be found among the few experienced builders. Such is not the case today as there are many more contractors in the field. Relatively few of today's contractors claim to be designers and, as a result, the likelihood of a satisfactory review of the design by a bidder is low. A more practical consideration is the fact that we can be certain that, even if a contractor feels a design is inadequate, any bid he submits will be based on the design as specified or shown. No contractor who wants a job will bid on anything more than he knows his competition is bidding on. If there is time, he may attempt to have the deficiency corrected by addendum. If not, he may decide not to bid, or he may attempt to qualify his bid by attaching a statement calling attention to the deficiencies, or he may just go ahead and bid on the original plans and hope for the best in straightening out any problems later on. Of one thing we can rest assured: No contractor will voluntarily add any appreciable amount to his cost unless he is sure of being paid accordingly.

Many incinerator designers are consulting sanitary engineers who also design water and sewage plants. Specifications for such plants do not require that the contractor check and, if necessary enlarge upon the design of settling basins, aeration tanks, digesters, conduits, pumps, and the like. The plant is expected to be built as specified and detailed. Based on the Engineer's knowledge and experience, it is expected that, after a shakedown period, the plant will operate as intended, and it is on this basis that engineers are selected and paid by their clients. Fees for incinerator design are determined on the same basis as those for design of water and sewage plants. The client retains a professional engineer to do a professional job, and has every right to expect the engineer to be responsible for his design without transferring the responsibility to a third party.

Attention should be called to the present tendency of both municipalities and the courts to hold consulting engineers professionally responsible for the adequate performance of plants designed and built to their plans and specifications.

Performance guarantees in most incinerator plant specifications fall into the same category as requiring the contractor to review the design. Operating conditions which the contractor is frequently required to guarantee, in addition to capacity include: maximum, minimum, and average temperature; maximum smoke density; nuisance free operation, with particular reference to odors and to smoke and dust in operating areas; and quality of residue as determined by quantity of organic matter, combustible matter, or unburned material remaining. More than one violent argument has arisen over interpretation of the requirement that all refuse, except metals and other noncombustibles, be burned to a clean (or inoffensive) mineral ash, "practically free of combustible (or organic) matter". Another potential source of trouble is any requirement that a plant operate without smoke, odor, or other nuisance in excess of that specified or implied.

To return to the sewage plant analogy, once a plant is completed in accordance with plans and specifications, the contractor is not required to prove its capacity or its effectiveness in B.O.D. or suspended solids removal; this is the designing engineer's responsibility. Why, then, should a contractor be required to prove out an incinerator design? If the plant has been designed correctly and the proper equipment specified, and if the plant has been built according to the plans and specifications, it will operate satisfactorily. If the design is inadequate, specification wording will not increase capacity, improve the quality of residue, or reduce odors.

The same principle applies to performance requirements for individual pieces of equipment. Most engineers do a good job in specifying equipment such as cranes and buckets, pumps, fans, conveyors, charging and ash gates, and refractories, but the most important mechanical equipment in an incinerator — the stoker — is frequently handled somewhat less satisfactorily. It is not uncommon to find a specification which permits or requires a bidder to submit alternate prices based on two, three, or even four different types of stokers. The experienced incinerator designer should be thor-
 thoroughly familiar with the capabilities of the various types. Each has advantages and disadvantages which, together with installation and operating costs, type of refuse, and degree of burnout required, must be carefully weighed for each installation. After considering all factors, the designer should select and specify the one or perhaps, in some instances, two types of stoker best suited for the particular installation. Permitting or requiring bids on three or four different types gives the impression that selection is to be made on the basis of low bid—hardly a sound engineering approach.

Specifications should and usually do go into considerable detail on size, arrangement, and construction of stokers, including dimensions and configuration of individual grate bars or keys, proportion of air openings in the grate surface, type and speed of stoker motion, and type and power requirements for the drive mechanism. In too many instances the same specifications go on to require the contractor or even the equipment manufacturer to demonstrate that this stoker, which has been built to the engineer’s detailed requirements, will burn refuse at a stated rate. The contractor must, of course, be held responsible for the mechanical performance and design of the equipment he furnishes; however, the fact that furnace configuration and myriad other features of design radially affect the burning performance make it unjust to hold the contractor or manufacturer responsible for the burning rate. During the design period, the designer should consult with the manufacturers and consider their recommendations for design factors, but final decision must be made by the designer on the basis of his own knowledge and experience.

The one area in which a performance type specification may presently be desirable as well as permissible is in fly ash removal facilities. Actually, most incinerator designers have little choice, considering the fact that the field of air pollution control is in its infancy, knowledge of the art is relatively limited, and so much of the available equipment is of a proprietary nature; however, the designing engineer should select and specify the basic type of equipment he wants, together with materials of construction and performance requirements and guarantees.

**Experience Requirements**

Suitable experience clauses should be included in the specifications for all major incinerator installations, and should apply to both the contractor and important items of equipment. We frequently hear concern expressed over the possibility that the low bidder may wish to install stokers or other major equipment furnished by a manufacturer with little or no experience in the incinerator field. This problem has been overcome in water and sewage treatment plants, for example, and there is no reason it can not be overcome by a carefully written experience clause for incinerator equipment.

**Penalties**

The imposition of penalties on the contractor in case of failure of a plant to meet the specified performance guarantees and requirements is another unhappy holdover from the days of straight performance-type plans and specifications. The following is taken from a recent specification.

"If in the performance test, the installation should fail in any respect to meet any one or more of the specified guarantees, the Contractor will be allowed six weeks in which to make alterations, correct failures and deficiencies, and conduct such tests as he may deem necessary. Upon completion of this work the test shall be repeated.

In case of failure to meet any one or more of the guarantees in the repeat test, the Contractor hereby agrees that such failure may be cause for rejection of the equipment by the Town. The Contractor further agrees that, upon formal notice of rejection by the Town, he will, within three months, remove all equipment furnished and installed by him and will also, within three months of receipt of notice of rejection, reimburse the Town for all payments made to him."

While this is extreme, it is not an unusual specification provision. Obviously, any attempt to enforce such a provision when a plant has been built in accordance with the plans and specifications would lead to endless legal entanglements. For the reasons cited previously, it is questionable whether such a provision is enforceable in court.

Some specifications include a blanket statement requiring the contractor to make modifications and correct all deficiencies as required to meet performance guarantees if the installation fails to do so in the initial test. All other considerations aside, the original layout of incinerators and buildings may well be such that major changes after the plant has been built are impractical or impossible. With competent design they should not be necessary.

A practical but hardly justifiable approach to the problem of failure to meet capacity requirements is found in specifications which provide for reduction of contract price by a stated amount for each ton per day deficiency in plant capacity. A municipality retains an engineer to design an incinerator to meet its refuse disposal needs, and has every right to expect that the plant as built will provide the necessary capacity. Money will not burn refuse, and inclusion of such a provision in the specifications accomplishes nothing except to force the owner to accept something less than he needs and has contracted for.

**Performance Test**

From the foregoing, it is evident that the so-called "official performance test" as we know it should be a
thing of the past. The owner has every right to know that the plant performs at the required capacity and in a satisfactory, nuisance-free manner in accordance with applicable laws, ordinances, and regulations; however, this should be demonstrated over a period of time with the plant operating under normal conditions. It cannot be properly demonstrated in a short officially designated test period under unavoidably artificial conditions which invariably produce unrealistic results.

A performance demonstration period should extend over several weeks, during which time the designing engineer should supervise the operation, make the necessary tests and observations, and see that the necessary records are kept as required for a full report to the owner. If possible, every engineering contract for design and supervision of construction of an incinerator should include provision for the engineer to supervise plant operation for six months to a year. This would give the engineer the opportunity to see that the plant is operated in the manner he intended and to demonstrate its ability to operate in the desired manner over an extended period. We all know how far operating habits carried over from many years' experience in an old plant can go toward cancelling out the advantages and improvements built into a new modern plant. Supervision of operation of a new plant by the designer for an extended period should permit him to train operating personnel so that the modern operating procedures become habit, and old habits are forgotten.

The above is not intended to relieve the contractor of certain responsibilities which must remain his alone, including materials, workmanship, and proper operation of all equipment and facilities. These should be observed during construction, tune up, and initial operation as well as during the guarantee period, and the contractor required to correct any deficiencies.

The contractor should also be required to furnish the services of manufacturers' representatives and other trained personnel as necessary to supervise installation, adjustment, and initial operation of major equipment, to train plant personnel in operation and maintenance of the equipment, and, under the engineer's direction, to supervise start-up and initial operation of the plant. The contractor should also demonstrate that the equipment furnished, individually and as an integrated installation, operates as specified. Any equipment which does not operate properly should be made good or replaced by the contractor.

Summary

The modern incinerator plant is a complex installation requiring the highest degree of engineering skill in its design and operation. Accordingly, the practice of receiving bids on performance-type plans and specifications is no longer acceptable. Today's incinerator must be designed by a qualified, experienced engineer who, in justice to his client and the engineering profession, is willing to accept full responsibility for his design. Design and operation must be subject to review and approval by appropriate public agencies, based on published minimum criteria. Layout of the plant, incinerator details and the selection of equipment and materials must be determined by the engineer on the basis of a careful weighing of all factors involved for each installation. Plans and specifications must be complete and detailed, leaving as little as possible to the discretion of the contractor.

Responsibility for furnishing materials, workmanship, and equipment in accordance with the specifications remains with the contractor; he must be required to demonstrate their compliance or to make good any deficiency. In addition to basic design, the engineer must be responsible for demonstrating that the plant operates at the required capacity in a nuisance-free manner and without hazard to health or property. We are still fighting in many areas to prove that an incinerator is an acceptable means of refuse disposal. Any other approach to design, construction, and operation will weaken the battle for universal acceptance of incineration.

Reference