INCINERATOR DESIGN WITH OPERATOR IN MIND

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ABSTRACT

Ease, simplicity, and economy of operation and maintenance are important considerations in incinerator plant design, but the average designing engineer cannot acquire sufficient operating experience to become familiar with all the day to day problems faced by plant personnel. As the result, details considered minor by the designer may, if not properly treated, become major problems or inconveniences in plant operation or maintenance.

Suggestions by leading municipal incinerator plant operators, based on many years’ experience, are presented for consideration by designers.

INTRODUCTION

A municipal-type incinerator is one of the most difficult of process plants to operate and maintain satisfactorily. The varying composition, combustibility, and moisture content of refuse present problems in combustion control which are not met in plants burning coal, oil, and other relatively uniform fuels. The tendency to wide temperature fluctuation with the varying fuel, and the physical nature of refuse, residue, fly ash, combustion gases, and process water are such as to exact a heavy toll in wear and tear on incinerator components and plant auxiliaries. The dirty, dusty nature of refuse and residue, and the concern over possible production of smoke, odors, or other nuisances, present continuing problems in plant housekeeping and maintenance, and in maintaining a plant’s satisfactory public image.

Problems in operation and maintenance vary from incinerator to incinerator, including plants of similar design, and it is impossible to predict all the problems which may present themselves in a new plant. Still, ease, simplicity, and economy of operation and maintenance are and must be accepted as important considerations in incinerator plant design.

Unfortunately, the average designing engineer’s contract does not call for his full-time supervision of plant operation beyond, perhaps, the initial start-up and shake-down period and any performance test which may be specified. His visits may be at stated periods or as required during the guarantee period, and after that they are likely to be on an irregular basis as his available time permits.

During the guarantee period and for a time thereafter, the designer will usually be called in on major problems of operation and maintenance, but often he will neither see nor be advised of lesser day to day headaches or routine housekeeping procedures with which plant personnel must cope. Even when he is able to spend considerable time at plants of his own design, the engineer is likely to learn of only the major problems of other plants. As the result, questions or details which seem minor during the design period can become continuing problems or inconveniences
in operation or maintenance if not properly treated on the basis of past experience.

No one is more familiar with the capabilities and shortcomings of an incinerator plant than its operator. After a period of experimenting with various techniques, a competent operator can usually be expected to operate and maintain his plant at the maximum efficiency the design permits. Still, the perfect plant has not yet been designed or built, and whenever incinerator people meet, operators can be found in groups exchanging experiences and discussing their problems. Frequently, one operator’s experience will provide the solution to another’s problem, but all too frequently, the problems are inherent in the design and are not susceptible to easy solution after the plant has been built.

Inasmuch as it is impossible for a designer to become familiar with all incinerator plant problems and routine procedures, the suggestions of experienced operators should be valuable as guides and “red flags” for the practical aspects of future designs.

The request for such suggestions resulted in an enthusiastic response from leading incinerator superintendents and other municipal officials directly responsible for plant operation and maintenance. Several responded in writing, others served as panel members for discussion of the subject at subcommittee and open meetings of the ASME Incinerator Committee, and still others offered comments from the floor at the meetings. One superintendent wrote, “The little things are most irritating,” and it is interesting to note that many of the suggestions refer to what designers might consider “the little things.”

BASIC DESIGN CONSIDERATIONS

Operators generally feel plants should be designed with firm capacity (largest unit out of service) adequate to handle the daily refuse load. This means a spare furnace for a plant operating 24 hours a day. In plants operating less than 24 hours, number and capacity of furnaces should be such that with one out of service, the remaining units can handle the load by overtime or additional shift operation. In any event, plant capacity should be adequate to serve the municipality for a reasonable futurity, usually ten to twenty years, with both population increase and possible higher per capita rate of refuse production considered.

Plant structures and facilities should be designed and sized for 24-hour operation even though planned operation may be only one or two shifts. Refuse receiving, storage, and handling facilities should receive particular attention.

In his presentation to the owner, the designer should be realistic in listing personnel required for plant operation. The effect of vacations, sick leave, absenteeism, routine housekeeping, major maintenance, and the like must all be considered.

Operators feel that plant design should be such that its operation is within the ability of locally available manpower. Complicated controls and equipment which are difficult to operate and maintain should be avoided wherever possible. Conversely, operators feel it is the designer’s responsibility to make the owner aware of the necessity for establishing pay scales which will attract and retain personnel capable of operating and maintaining today’s more sophisticated plants.

Specifications should call for only the best and most rugged materials and equipment, and nothing less should be accepted. Cutting corners in the design as a matter of economy should be avoided, as it almost invariably leads to increased operating and maintenance problems and cost.

Do not tailor the design to a preconceived limit of cost, as this can lead to corner-cutting and false economy. The design should be the best the engineer can produce, consistent with local requirements, air pollution codes, etc., and should be accompanied by a realistic cost estimate.

In cases of plant additions or expansion, suggestions of the plant operator and owner should be sought in those areas of design in which they are qualified to advise. Their suggestions, based on experience, can also be helpful in design of a new plant for a city which already has one or more.

Operators feel that designers should look more to the future, particularly in indicated changes in refuse composition and air pollution control requirements. They also feel designers should maintain contact with their plants over the years, preferably through contract or retainer arrangements with the owners.

CONSTRUCTION AND START-UP

Operators feel strongly that the designer or his qualified representative should be on the job throughout the construction and start-up period to supervise construction, initial operation, and tests. They also feel the plant superintendent should be assigned to the job from the start of construction, or at least from the start of the mechanical work, so as to be thoroughly familiar with all construction details and the installation of all material and equipment.

Specifications should be crystal clear in placing responsibility for adjusting, testing, and initial operation of all equipment and the entire plant. This should be the responsibility of an experienced representative of the manufacturer.
of all but the simplest equipment. Specifications should require manufacturers' representatives to instruct plant personnel in operation and maintenance of equipment during the tune-up period, with a liberal number of days clearly stipulated for each piece of equipment. For major equipment, specifications should require periodic visits by manufacturers' representatives during the guarantee period to make necessary adjustments and give further instruction as required.

General supervision of initial operation, including establishment of overall operating procedures, should be the sole responsibility of the designer, but the contractor should be responsible for the details, including actual instruction of operating personnel.

**BUILDINGS AND GROUNDS**

Architectural treatment should be carefully considered to assure that the plant structure harmonizes with the surrounding area. Adequately sized grounds, with well-kept lawns and attractive landscaping, are important for good public relations. Shield dirty, dusty, noisy, and other unavoidably unattractive areas with evergreen trees or shrubs.

Orientation of the building should be carefully considered, with the receiving area facing the best weather whenever possible.

Operators feel attractive surroundings and adequate comfortable facilities are important in attracting and holding competent personnel. Designers should give more attention to providing comfortable, adequately sized and equipped, well-lighted, and well-ventilated facilities for plant personnel, including shower, locker, toilet, lunch, and wash rooms. Administrative areas, including offices, conference room, scale room, and record storage area should be carefully planned and adequately sized and furnished. All the foregoing areas should be in a separate wing or section of the building, separated from the dirt, dust, and noise of plant operation. All necessary facilities, including furniture, window blinds, file cabinets, etc., should be included in the original contract.

Toilet and wash rooms should be provided adjacent to operating areas, and a separate toilet and wash room, with entrance only from outside, should be provided for collection crews.

Finishing equipment in various colors, instead of a solid color throughout, can make a plant more attractive. Circular furnaces have been painted with bands of different colors. There is no reason adjacent casing panels cannot be finished in different colors, and it is good practice to color code and label all piping.

Provide a large, well-equipped shop and a large storage area for spare parts and materials. Both should be readily accessible from operating areas, and should have a large outside door with floor or platform at truck bed level. Avoid locating shop or storage area so that it is accessible only by stairway or elevator.

Provide garage space for vehicles as well as for lawn mowers, snow removal equipment and heavy tools, with adequate space and facilities for servicing.

For general housekeeping, hold dust catchers such as window sills, ledges, shelves, exposed piping and ducts, etc., to a minimum. Some operators recommend that the number of windows be held to a minimum, especially in operating areas because of the difficulty in keeping them clean. In any event, be sure all windows are accessible for washing, both inside and outside.

Walls and ceilings in dusty areas should be painted as a minimum; a sprayed-on, porcelain-type finish or glazed tile is far preferable. A cove base makes for more effective floor sweeping along walls. On charging floors, provide sweep holes through parapet walls for sweeping spillage back into the storage pit.

Provide sufficient access and headroom for repairs and maintenance of all equipment, with properly located platforms, hatches, etc. Stairs are preferred over ladders. Provide railings and other safety features for platforms and stairs.

Provide a liberal number of large floor drains, properly located. Plans should show drain and floor elevations to assure drainage: the note "slope to drain" is seldom sufficient.

Provide sufficient bracing to prevent building sway from crane operation.

Make adequate provision for thermal expansion and contraction near furnaces and other hot areas.

An elevator is desirable, particularly in larger plants. An elevator is desirable, particularly in larger plants. Access roads should preferably be laid out for one-way traffic.

**TRUCK SCALE**

Operators are unanimous in wanting a truck scale at all plants, with the scale room preferably inside the building. Electronic or semi-electronic load cell type are preferred; among other advantages, they permit far greater flexibility in location of scale platform relative to the scale room.
Suggested scale features include:
- Total capacity not less than 65,000 pounds
- Printed weight record, with time and date included
- 20 pound weight increments
- 34 x 10 foot minimum size platform. If trailers or semi-trailers are to be weighed, 50 feet is the recommended minimum.
- Adequate drainage for scale pit
- Stop and go signal lights, visible to truck drivers and controlled by the scale operator.

Some operators prefer that the platform be under cover, and one suggested that an intercom for communication between truck drivers and scale operator would be desirable. Pit depth should be sufficient to permit a mechanic to work comfortably without removing the platform.

**TIPPING AREA**

Well-lighted and ventilated enclosed tipping areas are preferred, especially in residential areas. Where not enclosed, provide canopies for weather protection over trucks in dumping position, and fences, hedges, etc., to catch blowing papers.

Size tipping areas for maneuvering of trucks with a minimum of jockeying. Provide for one-way traffic through tipping area, and lay out approaches and scale so trucks are not required to back to the drivers' blind side to dump.

Provide rough floor surface for maximum traction.
- Provide hold-down chains for trucks while dumping.
- Provide armor or other protection against wear of floor for a distance of approximately twenty feet from edge of pit.

**REFUSE STORAGE PIT**

Operators strongly emphasize the need for an adequately sized storage pit with sprays for fire protection and dust control. Pits should have capacity of not less than 24 hours burning, and designers are cautioned against overestimating the density of refuse in the pit.

Spray nozzles should be provided on both sides of the pit for complete coverage, should be recessed in walls for protection against damage by bucket or grapple, and should be arranged so as not to spray onto tipping floor or trucks in dumping position.

Provide a carefully selected fire detection system, arranged to energize an alarm and turn on pit sprays automatically. Some operators feel smoke detectors may be preferable to heat sensors.

Other suggestions include:
- Power exhausters with capacity to remove heavy smoke from a pit fire.
- Exhauster and spray manual controls located so as not to be isolated by smoke during a pit fire.
- Fire hose stations adjacent to the pit, with adequately sized hose. Some operators recommend at least one hose 1½ to 2½ inches in size.
- Good pit drainage, with screens to exclude material which may stop up drain pipes or clog pumps.
- Adequate armoring of pit walls and floor for protection against damage by the bucket or grapple is recommended by most operators.
- Design and arrangement of pit and crane to permit complete cleaning of the pit with a bucket or grapple with clean-up scoops.
- Forced ventilation for protection of personnel working in the pit.
- Pit access at lower level rather than by ladder from tipping or charging floor.
- Means of disposing of pit contents other than through the furnaces—as in the case of saturated refuse after a pit fire.

**CRANE**

The necessity for providing rugged cranes for severe service was emphasized. Do not overlook even relatively minor items such as contacts and limit switches. Particular attention was called to correct sizing of cables, drums, and sheaves to avoid excessive cable wear.

Locate and arrange crane cabs to permit operators to observe pit, charging hoppers, trucks in dumping position, and other cranes. Provide cabs with standard make, adequately sized and easily maintained heaters and air conditioners, shatterproof glass, and means of emergency exit in addition to normal safe access. Operators also urge development of a good intercom system for crane use.

Care should be taken to specify adequate crane speeds.

Grapples are generally preferred over clamshell buckets.

Provide removable scoops for pit cleanup.

Provide crane parking space away from pit for servicing and for protection in case of pit fire. Provide an armored-floor area to rest the bucket or grapple.

If more than one crane is provided, be sure operating cranes can reach all charging hoppers when any one crane is out of service.
Provide a hoist or other facilities over the crane for removing motors and other components. Be sure the building design and layout provides for removal of crane wheels, shafts, axles, etc.

An Auxiliary hoist on the crane trolley is desirable for plant maintenance service, particularly if hatches or openings are provided in all floors to permit the hook to reach the lowest level of the building, and if a truck entrance is provided to permit use of the hoist for loading and unloading heavy equipment.

**INCINERATORS**

Most comments related to operation and maintenance rather than to basic design, however, operators generally expressed a desire for designs providing better control of air pollution. They would also like greater volume in the various chambers for maximum burnout as well as to assist in air pollution control. Several indicated a need for simple facilities for shredding, grinding, or otherwise reducing telephone books, newspaper bundles, etc., which are normally found in mixed refuse, to more readily burnable size prior to charging.

Based on experience in existing plants, designers should give careful consideration to the following:

- Charging hopper top dimensions should be larger than the open bucket or grapple to avoid spillage.
- Charging hopper sides should have sufficient slope to be self-cleaning.
- Design charging hoppers and throats to deflect refuse away from refractory around opening to minimize physical damage.
- Install charging or cut-off gates above rather than below the charging floor for better access, and to minimize spillage.
- Provide sufficient test and observation ports but eliminate unnecessary doors, particularly in furnaces.
- Provide a sufficient number of undergrate observation ports and access doors.
- Require door handles to be a type that stays cool.
- Require tight settings throughout to minimize air leakage.
- Specify walls and arches that are capable of unit replacement and be sure they have adequate support and ventilation.
- Be sure there are enough refractory expansion joints, properly designed and located.
- Omit auxiliary burners unless they are needed for a particular purpose.
- Provide hydraulic operation for charging and ash gates and dump gates. Operators generally seem to dislike pneumatic operation.

- Improve the design and construction of stoker drives to minimize maintenance requirements.
- Be sure stoker drives provide sufficient adjustment to compensate for normal wear.
- Provide alarms and automatic shut-offs for stoker drives in case of jamming or other difficulty.
- For travelling grates, provide electrical interlocks to assure starting at low speed.
- Provide hydraulic, mechanical, or other non-manual means of removing undergrate siftings. Manual removal should not be considered except for very small furnaces.
- Install ash gates with travel parallel to trucks to minimize spillage.
- Provide manually controlled foam or water spray system for quenching siftings with other than hydraulic removal.
- Provide readily accessible cremation hearths for small animals. Some operators like facilities for log burning.
- Design flues to be self-cleaning so far as possible.
- Eliminate pockets, shelves, ledges, etc., on which fly ash may accumulate.

- Provide openings and gates in floors where chambers must be cleaned manually.
- Develop improved spray chamber designs with better resistance to the effects of moisture. Keep the amount of exposed metal in spray chambers to a minimum.
- Spray chamber flushing systems must be carefully designed for complete cleaning of the floor. Avoid designs requiring manual cleaning.
- Specify abrasion resistant materials for ash hoppers, conveyor troughs and chains, pipes and conduits for water containing fly ash, and the like. Keep such pipes and conduits accessible for maintenance; do not bury them under floor slabs. Wherever possible, provide troughs with removable covers instead of pipes. Jet nozzles are desirable at bends in sluice troughs or pipes.

- Provide by-passes around waste heat boilers so furnaces can continue in operation when boilers are down.
- Provide protection for air pollution control equipment and induced draft fans in case of water or power failure. Suggestions include an emergency water supply and provision for dumping hot gas to atmosphere in case of fan or power failure. Both should be activated automatically in emergency.

**CHIMNEYS**

Many operators prefer plants designed for natural draft
operation with tall chimneys rather than induced draft fans; however, they caution designers to be sure natural draft chimneys are tall enough. Insufficient draft is a problem in many plants.

Do not use one chimney to serve more than two furnaces. With two furnaces, provide proper dampering for draft control.

Chimney lining must be carefully selected in view of the low temperature and high moisture content of the exit gas from most of the more modern plants.

Provide safety belts, cages, or other protection for personnel on chimney ladders.

Where aircraft warning lights are required, provide dependable lowering devices to permit maintenance and service at ground level.

Be sure the original plans and specifications include all necessary ports, sleeves, platforms, and other facilities for sampling, testing, and permanent instrument sensing devices.

**FORCED DRAFT**

Forced draft problems, particularly inadequate air supply, are sources of frequent complaints by operators, who suggest that designers pay particular attention to the following:

- Be sure all ducts and plenums are adequately sized.
- Avoid square elbows or bends wherever possible; provide sweeps and turning vanes, particularly in larger ducts. Cylindrical ducts may be preferable to square or rectangular.
- Be careful not to underestimate draft losses in the duct system.
- Specify fans with adequate discharge and pressure ratings; when in doubt, be on the high side.
- Most operators dislike common air ducts for two or more furnaces.
- Provide positive control of air supply to each undergrate plenum. In this connection, many operators feel one of today's greatest needs is for development of a simple, dependable air flow meter for incinerator service.
- A pet peeve of many operators is light weight dampers which soon become inoperative. Stovepipe type dampers in smaller ducts are particularly troublesome. All dampers should be of rugged construction for heavy duty, with suitable bearings located outside the gas streams wherever possible. All dampers should be capable of fine adjustment, with provision for locking in position.
- Ducts should be arranged to draw air from either inside or outside the building, or both. Care must be taken not to create a negative pressure in the furnace area when drawing air from inside the building.

Consideration should be given to drawing warm air from over the furnaces when burning wet refuse. This can be effective in some instances.

Overfire air control should be automatic for furnace temperature control. Many operators like the so-called "cascading" control of overfire and underfire air. Automatic control of overfire air by smoke detectors can also be effective for smoke control, although it may be difficult to combine the two automatic functions.

**INSTRUMENTATION AND CONTROLS**

Nowhere is the operators' desire for simplicity combined with ruggedness more evident than in their comments on instrumentation. At the same time they recognize that modern plants require more sophisticated instrumentation, but they ask generally that it be limited to essentials, which will vary from plant to plant. Many operators feel best operation is still achieved by direct observation of the fire and basically manual control, with such assistance as essential instruments and automatic controls may give.

Good intercom and PA systems are considered "musts," and be sure to call for an intercom jack at the chimney for use while adjusting the smoke detector. A PA system which is "on" continuously is preferred to a system that turns on only when a microphone is used. One operator suggests that suitable background music be played over the PA during operating hours.

In larger plants particularly, it is desirable to provide indication of key functions (temperature, smoke, etc.) in the superintendent's office as well as in the operating area. Many operators prefer to have all recorders in the office, with only indicators and basic controls in the operating area.

Consider installing duplicate thermocouples at key locations to assure an accurate reading in case one fails.

When one chimney serves two furnaces, be sure the chimney thermocouple is located so as to detect the temperature of the combined gases.

Provide indicator lights or a large dial type temperature indicator near the charging hopper for each furnace to guide the crane operator in feeding wet or dry refuse.

Some operators would like closed circuit TV for each furnace, with monitors located in the superintendent's office.

Require smoke detector sleeves large enough to permit adjustment of the light source and sensor in case of misalignment.
WATER SUPPLY AND DRAINAGE

Be sure potable and process water piping systems are clearly differentiated, particularly at outlets.

Provide plenty of unions, couplings, and valves to permit isolating and disconnecting or taking down small sections of piping without the necessity of shutting down the entire system.

Be sure all water and drain piping, including ash gates and drains, is adequately protected from freezing. Pipe insulation alone frequently is not enough.

Some operators prefer to use process water only once, without recirculation.

Many operators prefer rubber or dacron hose to canvas. Hoses should be sized for handling by one man.

Take particular care in specifying pumps and piping, particularly those handling spray chamber and conveyor overflow, to assure selection of type and material which will offer maximum resistance to corrosive and erosive action. One operator suggested consideration of pneumatic ejectors instead of pumps at certain locations.

Pumps should be installed in such manner that greasing and normal service are performed from outside the pump pit. Provide positive, forced ventilation of pump pits which must be entered by plant personnel.

In general, operators prefer gravity flow of incinerator waste water wherever possible, with pumping held to a minimum.

HEATING AND VENTILATING

Among the more frequent complaints are those about inadequate building heat and ventilation. Operators are very emphatic in urging designers to consider these suggestions:

Provide plenty of heat and fresh air ventilation throughout the building.

Keep heat sources low, particularly in high ceiling areas such as charging and operating floors.

Do not specify small unit heaters, which are seldom effective.

Carefully consider all aspects of building ventilation, forced draft fan intakes, and furnace draft to avoid possible interference. Building air pressure adjacent to furnaces must be higher than pressure inside the units.

Provide sufficient ventilation over furnaces to avoid overheating arch supports and building structural members. In some instances, excessive heat in this area has resulted in melting of roofing. Consider using this hot air for forced draft with wet refuse or for building heat.

Specify ventilators, louvers, etc., which positively exclude rain water.

Air condition offices, scale rooms, lunch rooms, etc., using standard make, easily installed and maintained units.

Many operators like radiant heat over operating positions in large or open areas.

When hot water heating systems are installed, some operators prefer a few large pumps to several small circulators.

Provide controls that are simple, rugged, and tamper-proof.

ELECTRICAL EQUIPMENT

Be sure all equipment is rugged and suitable for incinerator plant service. In general, specify totally enclosed motors, dust- or moisture-proof enclosures for controls, etc.

Where possible, avoid installing electrical equipment in excessively dirty, dusty, or wet areas.

Be sure all controls are suitable for the equipment. One operator made particular reference to the requirement that transformers be compatible with allowable motor voltage ranges.

In addition to controls in panels and motor control centers, provide start-stop and stop-lockout stations adjacent to all motors. One operator recommends emergency-stop buttons on all platforms adjacent to conveyors.

Install breakers for essential 120-volt circuits (pumps, alarms, signals, etc.) in separate, clearly identified, locked cabinets to prevent their being shut off in error by someone trying to turn off the lights.

Provide standby Diesel or gasoline-engine-driven generators. They need not have capacity for full plant operation, but should be adequate for lighting and to permit gradual, orderly plant shut-down.

Install fuel tank on approximately the same level as the engine to help overcome difficulties which may arise with infrequently operated fuel pumps.

FACILITIES FOR OPERATION, MAINTENANCE, AND REPAIR

Operators are unanimous in asking that all facilities, materials, equipment, tools, and parts required for normal plant operation and maintenance be included in the original contract. They also feel that most—perhaps ninety percent—of the repair and major maintenance work should be done with in-plant personnel and facilities, with only the most major repairs and reconstruction being
done by others. Requests for purchase of the necessary materials and equipment after a plant has been completed frequently involve time-consuming, piecemeal procedures, and may not be granted until emergencies arise.

As noted previously, all plants should have generously-sized, fully-equipped machine shops and storage areas. Shops should have a full complement of power and hand tools, benches, storage cabinets, and the like. Provide locked cabinets or areas for tool storage.

Storage areas should be liberally furnished with bins and shelves, and should have sufficient area for storing spare motors and drives, large castings, pallets of firebrick, and similar materials.

Other facilities requested by operators include welding equipment with a liberal number of outlets in key locations throughout the building; a compressed air system; a central vacuum cleaning system for building cleaning; a steam jenny; and plenty of waterproof electrical outlets, hose bibbs, slop sinks, water coolers, and lights.

Any necessary trucks and residue containers should be included in the original contract unless there are definite arrangements to furnish them from other sources or funds. And don’t forget seemingly minor items such as brooms, mops, buckets, detergents, hoses and nozzles, lubricants, trouble lights, extension cords, paper towels, bathroom tissue, and lunch room equipment including tables, chairs, sink, stove, refrigerator, storage cabinet, and unbreakable tableware and utensils. Combination kitchen units frequently are used.

All safety equipment including clothing, face shields, fire extinguishers, first aid supplies, emergency lights, and the like should be specified. Many operators favor wire gauze type face shields instead of the plastic type which tend to retain heat.

For key mechanical equipment, provide one spare for each motor, reducer, drive, and other important component; where duplicate equipment is installed, one spare of each type will usually suffice. In general, specify only equipment for which there is reasonable assurance that repair parts will continue to be available as stock items for at least five to ten years.

The original contract should include service agreements for truck scales, instruments, cranes, elevators, and the like. Agreements should provide for complete maintenance service for at least a year after the guarantee period.

Operators unanimously agree that a good set of as-built drawings is one of their most important tools. The drawings should be prepared by the designer in cooperation with the contractor and plant superintendent.

Equally important is a set of instruction manuals for all equipment. Each manual should be prepared by the manufacturer, and should include drawings, cuts, parts lists, wiring and piping diagrams, and instructions for operation, maintenance, and repair. For convenient reference, require that all data not pertinent to the particular installation be deleted from any catalogs or brochures which are included in the manuals.

WASTE HEAT UTILIZATION

It was not intended that this subject be ignored; however, operators’ comments did not indicate any areas of agreement either on whether to reclaim waste heat or on the extent of its utilization.

CONCLUSION

Based on first-hand knowledge and experience, incinerator plant operators are in an excellent position to advise on practical aspects of design as they affect plant operation and maintenance.

Operators do not agree in all areas, as noted above for waste heat utilization; however, the foregoing suggestions are those in which agreement is indicated by a number of leading operators.

Not all suggestions will apply to all designs, particularly smaller plants, but it is hoped that consideration of the foregoing by engineers will contribute to the design of more effectively, efficiently, and economically operated incinerator plants.