Instrumentation of an Incinerator  
Two Case Studies

J. D. STICKLEY  
Honeywell  
Philadelphia, Pennsylvania

H. B. ORTHS  
Honeywell  
New York, New York

Abstract

This paper consists of a study of the instrumentation system of two incinerators, to determine what progress is being made in the utilization of instrumentation in incinerators, and to determine what deficiencies, if any, exist in incinerator instrumentation as furnished on incinerators being constructed today.

Introduction

The intent of this paper is to make and present analysis of two instrumentation systems; one, as applied to an incinerator which has been in operation for approximately two years; and the other, as applied to an incinerator on which construction is not yet complete. The older incinerator selected is owned and operated by the Town of Islip, Long Island, New York. The newer incinerator is presently being constructed in the northeastern part of the United States. The object is to determine what instrumentation was selected for each plant, why the particular instrumentation systems were selected; the adequacy or inadequacy of the instrumentation from an operating viewpoint, and whether the trend in incinerator instrumentation is in the direction of more effective incinerator operation.

The purpose of an incinerator instrumentation system is to assist the operators to accomplish the following:

1) To effect complete combustion of the refuse, thereby reducing it to materials that are non-offensive and easily disposable. In order to effect complete combustion, a temperature of 1600-2000 F must be maintained in the furnace. This temperature can be maintained by controlling the total amount of air delivered by the forced draft system. This control may be either manual or automatic. As a guide to the overall operation of the furnace, the operator must know at all times the pressure gradient throughout the incinerator. This knowledge, together with the knowledge of the temperature of the gases leaving the furnace, serves as a guide to the operator as to the effective operation of the furnace. Furnace draft is controlled either manually or automatically by controlling the speed of the induced draft fan.

2) To protect all sections of the incinerator from damage due to excess temperature. The furnace operating temperature of approximately 2000 F must be reduced to approximately 600 F before the gases enter the equipment downstream from the furnaces. This is accomplished by passing the gases through an expansion chamber, through a waste heat boiler, through a spray chamber, or through any combination thereof. Water sprays are commonly used to reduce gas temperature. Suitable interlocks and high temperature alarm points are desirable to inform the operator of an emergency condition and to shutdown the plant before the equipment is damaged.

3) To prevent the release to atmosphere of offensive gases and smoke. The three most prevalent causes of problems in this area are:
   a) Incomplete combustion of odor causing gases.
   b) Insufficient oxygen to convert the carbon in the gases to CO₂.
c) Inefficient operation of dust removal facilities.

If the furnace is operated at a temperature sufficiently high to destroy odor causing gases and with sufficient excess oxygen to prevent the release of carbon to the atmosphere and if the dust removal equipment is maintained to operate at top efficiency, most of the public relations problems of incinerator operation magically disappear.

Incinerator "A"

The Islip Incinerator has two rectangular furnaces, each with a capacity of 150 tons in 24 hours. Each furnace contains a single Combustion Engineering grate driven by a 7-1/2 hp motor through a Reeves drive. Grate speed can be varied from 9 to 54 feet per hour.

Each furnace has its own forced draft fan and induced draft fan. The forced draft fan delivers to the furnace, through underfire and overfire ports, 17600 cfm of air at 100°F with 3-1/2 in. static loss. The induced draft fan has a capacity of 65000 cfm of 700°F air with 8 in. static loss.

The hot gases discharged from the furnaces are cooled in spray chambers mounted outside of the building. Each spray chamber is designed to reduce the temperature of 95,000 cfm of flue gas from 2000°F to 650°F. Gases leaving the spray chamber are discharged to atmosphere through a John Wood dust collector, the induced draft fan, and a 5-1/2 foot diameter stack. For operator convenience, all operating instrumentation is mounted on a central control panel.

It was felt desirable to record on a single chart those variables which would indicate the effectiveness of plant operation. Therefore, the temperature of the gases leaving each furnace and the smoke density of the gases leaving each stack are recorded on a single 12 in. strip chart Honeywell Electronik 15 Multipoint Recorder. Because there are times when the operator must be away from the control panel, an auxiliary Honeywell Millivoltmeter Indicator with a 4 point selector switch was mounted on the stoker floor.

Ellison draft gauges, mounted on the main panel, indicate primary air pressure, overfire air pressure, secondary air pressure, furnace draft pressure, and induced draft suction pressure. No automatic control is furnished for draft or temperature. Forced draft fan capacity is controlled by a manually operated damper. A manometer, indicating differential pressure across the FD fan, is mounted at the fan as a guide to assist the operator in setting this damper. The capacity of the induced draft fan is controlled by manually positioning the speed control drum which is mounted on the operating floor. Stoker speed is manually set at each drive unit.

Spray chamber temperature is recorded and controlled by a single record 6 in. strip chart Honeywell Electronik 17. This instrument maintains the flue gas exit temperature at approximately 650°F by controlling the number of sprays in operation. Auxiliary switches incorporated in the recorder actuate an alarm in the event the temperature of the gases leaving the spray chamber reaches 800°F. In addition, a pressure switch in the water supply line to the spray nozzles sounds an alarm in the event of low water pressure. Fenwal temperature switches warn the operator of excessively high temperature in the stacks, the dust collector inlets, and the charging chute. Alarm switches in the furnace temperature recorder actuate an alarm in the event of high temperatures in either furnace, and alarm switches in the smoke detectors warn the operator of excess smoke.

The instrumentation which was installed when this incinerator was constructed is adequate for manual control. However, it is felt that additional instrumentation for automatic control of some of the variables in the plant operation could improve the overall performance of this incinerator.

The character of wastes, in regard to moisture content, Btu content, volatile matter, etc., varies considerably. These variations can cause wide swings in furnace temperature which in turn, can lead to incomplete combustion or brickwork damage. No operator, with all of his associated duties can be expected to maintain a constant furnace temperature with a manual control system. A furnace temperature controller could do an effective job of controlling this temperature to provide good combustion and maximum safety by adjusting the total air being delivered to the furnace.

With the above temperature control system continually changing the amount of tempering air to meet varying fuel conditions, a furnace pressure control system is mandatory. A furnace pressure controller, measuring draft pressure in the sidewall of the furnace outlet could effectively control the furnace pressure by automatically varying the speed of the induced draft fan.

Underfire air flow is a critical variable. Too little underfire air leads to incomplete combustion while too much leads to fly ash problems. It is felt that a remote control system so designed that the operator could conveniently adjust the quantity of underfire air delivered to the furnace should result in better overall operation.

Incinerator "B"

Incinerator "B" has a single rectangular furnace, the size and mechanical details of which are proprietary at this time. The furnace has one induced draft fan, one underfire air fan, and one overfire air fan. The hot gases are discharged from the furnace into a settling or expansion chamber and then partially cooled in a spray chamber, with provisions for final cooling by
introduction of outside air into the gas stream. Gases leaving the spray chamber are discharged to atmosphere through cyclone dust collectors, the induced draft fan, and a stack.

The instrumentation is divided into two general categories. All instrumentation involved directly with furnace operation is mounted on a local furnace control panel. All instrumentation involved with air pollution control is mounted on a central instrument panel in the plant superintendent's office.

Draft gauges were furnished on the local furnace control panel for indicating main underfire air duct pressure, main overfire air duct pressure, underfire air pressure of compartments one, two and three, primary settling chamber outlet pressure, spray chamber outlet pressure, dust collector inlet pressure, dust collector outlet pressure, dust collector differential pressure, and ID fan outlet pressure. A flow indicator and selector switch mounted on the panel enables the operator to read airflow of the underfire air main duct, overfire air main duct, underfire air of compartments one, two and three, and underfire air to the bulk burning chamber. A temperature indicator and selector switch enables the operator to read combustion chamber temperature, inlet and outlet temperatures of the primary settling chamber, spray chamber outlet temperatures, and dust collector inlet and outlet temperatures.

A smoke density indicator serves as a guide to the condition of the stack gases. A manual-automatic control station enables the operator to assume manual control of overfire air during startup. A similar station permits manual or automatic control of the induced draft fan speed. The underfire air volume can be set by a manual control station mounted on the panel. A manual-automatic control station permits manual or automatic control of the dust collector dampers. Also included on the panel are an induced draft fan speed indicator and an annunciator system for alarm identification.

On the central control panel, located in the superintendent's office are located two pen miniature strip chart recorders for recording dust collector inlet temperatures, underfire and overfire air flow, smoke density, cooling water flow, and collector differential pressure. Miniature recorder controllers record furnace temperature, furnace pressure, dust collector inlet temperature, and cooling air flow. A manual by-pass control is provided to enable by-passing the dust collectors and ID fan in the event of power failure or failure of the cooling system. Manual-automatic control stations permit either manual or automatic control of the spray valves. Indication of spray valve position is also provided.

The major control systems in Incinerator "B" are Furnace Temperature Control, Furnace Draft Control, Dust Collector Inlet Temperature Control, and Dust Collector Capacity Control. Furnace temperature is controlled by controlling the overfire air damper. Desirable furnace exit temperatures between 700 F and 1900 F may be achieved utilizing the complete flexibility in the overfire air system, while presetting the underfire air to produce a minimum of fly ash with a maximum of good combustion. Presetting the underfire air requires that the overfire air system be called on to control furnace exit temperature. Published test results on municipal incinerators indicate that from one third to one half the total combustion air (theoretical plus excess) should be introduced under the grates and from one half to two thirds of the total air over the grates. Fans are oversized to allow for more air either over or under the fire. Therefore, when dry refuse is fed to the furnace, a maximum of air will be allowed into the furnace to obtain desired exit temperature. If wet refuse is fed into the furnace the temperature drops due to the heat required to evaporate additional moisture and the lesser amount of combustible matter. The control loop then acts to automatically reduce the quantity of overfire air. The combustible gases are not cooled by the excess air to the extent that the gases were cooled before, and the resultant temperature is restored to 1700-1900 F. Draft control is accomplished by controlling the speed of the induced draft fan. Two control loops control collector inlet temperature. The temperature of the furnace gases is first reduced in the spray chamber and is controlled by sequenced control of the spray valves. The temperature of the hot gases is further reduced in the main flue by admitting cooling air. The temperature controller modulates the cooling air dampers to maintain the desired temperature.

The use of independent control loops for water cooling and air cooling permits complete flexibility in maintaining adequate cooling with the minimum use of water. The dust collectors are sequenced to maintain the desired flow through the collector for maximum efficiency. Induced draft fan speed, which is proportional to total gas flow through the collectors, is used to sequence the collector dampers.

Conclusions

Both incinerators studied were equipped with instrumentation systems which were considered up-to-date at the time the incinerators were designed. Two marked differences are evident. The operator of Incinerator "B" has at his fingertips much more operating information than has the operator of Incinerator "A". Incinerator "B" has incorporated automatic control in place of some of the manual control systems used in Incinerator "A". There is a trend toward more and better instrumentation in order to: 1) keep the operator better informed as to over-all operation; and 2) to relieve the operator of the tasks of manually controlling variables which can be automatically controlled with greater accuracy.
Instrumentation, as it is being furnished today must not be considered the ultimate. The science of instrumentation is advancing rapidly. New techniques and products are appearing daily. The Instrumentation Subcommittee of the ASME Incinerator Committee is making, at this time, an exhaustive study of incinerator instrumentation problems, searching for new methods and ideas which will improve overall operation, reduce operating costs, and reduce maintenance.