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| <b>EXXON</b><br>EXXON<br>ENGINEERING | <b>FIRED HEATERS</b><br><b>INCINERATORS</b><br><br><b>PROPRIETARY INFORMATION</b> - For Authorized Company Use Only | <b>DESIGN PRACTICES</b> |                 |
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#### Revision Memo

|              |                                      |                                                                                                                                                                                                                                                                                                                                               |
|--------------|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>12/99</b> | The highlights of this revision are: |                                                                                                                                                                                                                                                                                                                                               |
|              | Page 3                               | Added references to <b>IP 3-4-1</b> , <b>IP 7-4-1</b> , <b>IP 15-7-2</b> , <b>IP 19-3-3</b> , <b>EE.13E.87</b> and <b>EE.89E.93</b> . Deleted reference to <b>IP 4-5-1</b> , <b>IP 10-13-1</b> and <b>IP 16-1-1</b> . Added that information in this Design Practice Section applies to design specifications as well as duty specifications. |
|              | Page 4                               | Added information on VPS overhead waste streams.                                                                                                                                                                                                                                                                                              |
|              | Pages 4 to 7                         | Expanded / clarified descriptive information provided for each type incinerators.                                                                                                                                                                                                                                                             |
|              | Page 4                               | Eliminated outdated discussion of problem areas for direct fired incinerators.                                                                                                                                                                                                                                                                |
|              | Pages 4 to 7                         | Updated advantages / disadvantages listed for each type of incinerator.                                                                                                                                                                                                                                                                       |
|              | Page 8                               | Added sentence pointing out that trace fouling or corrosive components in waste streams also need to be identified. Added sentence indicating the destruction efficiencies as high as 99.99% required in some cases.                                                                                                                          |
|              | Page 10                              | Corrected destruction efficiency equations by adding brackets at appropriate places. Clarified that substituting $X = 1$ in the complex destruction efficiency equation does not directly lead to the simple expression given later. Added in Excess Air Requirements that 2% oxygen is on a wet basis.                                       |
|              | Page 11                              | Added Item g covering corrosive or fouling compounds.                                                                                                                                                                                                                                                                                         |
|              | Page 12                              | Added that waste streams containing oxygen may require detonation arrestors. Deleted sentence calling for use of oil burner as a pilot since this is not normal practice.                                                                                                                                                                     |
|              | Page 13                              | Eliminated sentence calling for pressure relief on the incinerator combustion chamber as this is not done. Corrected metric units for volumetric heat release. Added that standard vendor controls packages are not preferred.                                                                                                                |
|              | Page 14                              | Added recommendation to do economic evaluation of heat recovery option on each incinerator application. Changed duty specification to duty / design specification.                                                                                                                                                                            |
|              | Page 15                              | Provided additional considerations on use of flame scanners.                                                                                                                                                                                                                                                                                  |
|              | Page 16                              | Added emission testing requirements.                                                                                                                                                                                                                                                                                                          |
|              | Page 17                              | Corrected equations by adding brackets at appropriate places.                                                                                                                                                                                                                                                                                 |



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## SCOPE

This section describes the various types of incinerators available and presents guidelines for preparing duty / design specifications covering incinerators for refinery and chemical plant wastes. It is concerned primarily with the combustion phase of incineration and does not consider in detail either the upstream feed handling or the downstream flue gas or water effluent treatment facilities. Since these items are usually included in any incinerator system, the project design engineer should treat the entire unit as a system in preparation of the complete duty specification. The basic upstream and downstream interface problems and operating considerations are discussed in this section, but details for duty / design specification preparation should be obtained from the appropriate Environmental Technology Consultants.

## REFERENCES

### INTERNATIONAL PRACTICES

|            |                                   |
|------------|-----------------------------------|
| IP 2-1-1,  | Plant Noise Design Criteria       |
| IP 3-4-1,  | Piping for Fired Equipment        |
| IP 7-1-1,  | Fired Heaters                     |
| IP 7-4-1,  | Burners for Fired Heaters         |
| IP 15-1-1, | Instrumentation for Fired Heaters |
| IP 15-7-2, | Protective Systems                |
| IP 19-3-3, | Linings for Fired Heaters         |

### OTHER COMPANY LITERATURE

*Guidelines for Selection and Operation of Gaseous Waste Incinerator*, ER&E Report No. EE.74E.84.  
*Economics of Onsite Incineration for Refinery / Petrochemical Sludges*, ER&E Report No. EE.13E.87.  
*Safety Considerations for Marine Vapor Recovery Systems*, EE.89E.93.  
Exxon Refractory User's Manual. EEEEE10

## BACKGROUND

### INCINERATOR PROCUREMENT

The primary criteria required to specify any incinerator are a precise definition of the waste stream to be oxidized and the required effluent gas quality. Items normally covered in such duty specifications are included in this section.

Incinerators are not easily classified, since each unit must usually handle a different type of waste stream. Each requires the integration of several sub-systems: a feed system, a combustion system, a control system, and possibly a heat recovery and effluent or flue gas emission control system. Both available technology and vendor capability and experience differ widely among these system areas. For example, combustion-oriented vendors usually know little about sophisticated scrubbing systems and would need assistance in that area for any waste stream incinerator requiring state-of-the-art flue gas emission control.

Because of these complexities, vendors often refuse to guarantee incinerator systems except when they have experience with similar waste streams. There is even some reluctance to design incinerators for new, difficult, waste streams because of the development costs involved. With the present rapidly-evolving technology, the only sure way of purchasing an incinerator for industrial application is to find a vendor who has operational experience with similar units. Demonstration tests are a common practice in the industry whenever experience cannot be cited. If no experienced vendors can be found for a given disposal problem, one alternative is to develop a design using in-house technology and testing, preferably in cooperation with the most experienced vendor available.

### POLLUTION CONTROL

In all cases, local pollution control legislation should be carefully examined, to assess the impact of present and proposed laws during the early years of incinerator operation. Using this information, the pollution emission requirements for the incinerator can be determined and specified.

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## BACKGROUND (Cont)

### COMBINING STREAMS IN EXISTING UNITS

#### 1. Incinerators

With proper incinerator design, more than one waste stream can be incinerated in a single unit. Examples are:

- Combustion of a stream with a high heat of combustion to replace auxiliary fuel which would otherwise be needed to help burn a stream with a heat of combustion so low that it has poor burning characteristics.
- Incineration of a stream with a low heating value to replace cooling water or air in an incinerator burning a high heating value waste.
- Small streams that would add less than 10 or 20% to the feed rate to an existing unit can sometimes be added without upsetting operation of the existing unit.

#### 2. Process Heaters

In some cases, small easily handled waste streams (less than about 10% of the heat fired) can be efficiently and economically disposed of in a process heater. If the waste is generated from the same unit, e.g. vacuum pipestill overhead gas routed to the vacuum pipestill heater, rates equivalent to about 30% of the process heater firing rate have been accommodated. To ensure adequate destruction of the waste, it should be injected in the throat of the burners or immediately adjacent to the burners via a pipe angled to inject the waste into the burner flame envelope. However, control, safety, and waste distribution systems can raise the costs.

## TYPES OF INCINERATOR HARDWARE

### 1. DIRECT-FIRED INCINERATORS

These are the most common of all types of incinerators, found at almost every refinery and chemical plant. They are typically used in refineries for Claus plant tail gas and general waste gas cleanup. One or more auxiliary fuel burners are provided to heat the waste up to 1200 to 1800°F (650 to 980°C) and provide excess oxygen needed to oxidize the waste. The waste injection and auxiliary burners are arranged in a manner to promote rapid mixing of the waste and the combustion products from the burners. Sufficient residence time is provided in an adiabatic chamber as required to ensure complete mixing and fully oxidize all combustibles in the waste stream.

The units vary largely in size, and can be either vertically or horizontally fired. They generally consist of a cylindrical refractory lined steel shell with the burner(s) located at the end (or side) wall. Quench air is sometimes introduced at the outlet of the incinerator to cool the flue gases and permit a lower design temperature for the stack or ducting. This can result in afterburning or stack sulfur fires on Sulfur Recovery Unit incinerators and is generally not recommended on new installations of these type incinerators. A list of applications, advantages and disadvantages is given below. Applications

- Claus Plant tail gas cleanup.
- Incineration of gaseous streams.

#### • Advantages

- A large amount of operating experience has been gained. The design criteria are well known to Exxon designers.
- No size restriction, large or small units can be installed.
- Proven technology.
- Simple construction.
- Relatively low installation cost.

#### • Disadvantages

- High operating temperatures increases cost of waste heat recovery, if used.
- High operating temperatures increase auxiliary fuel requirements.
- Cannot incinerate solids effectively.
- Cold end corrosion concerns may limit the use of waste heat recovery in sulfur service.

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## TYPES OF INCINERATOR HARDWARE (Cont)

### ▶ CATALYTIC INCINERATORS

As the name implies, these units rely on the action of a working catalyst to achieve high destruction efficiencies. Gaseous waste streams are first mixed with air and then preheated to 600 – 900°F (315 – 480°C). In many cases hot, oxygen containing flue gas generated by an auxiliary fuel fired burner is used for this purpose. The hot mixed gases are then passed over a bed of catalyst in which the pollutants are oxidized. Heat recovery is possible from the flue gas up to a maximum level of 70% [dependent upon the concentration of VOC (Volatile Organic Components) in the waste stream]. Heat recovery is often used to preheat the combustion air or waste stream. Steam generation is normally uneconomic.

The incinerators can only be used to incinerate waste gaseous streams. Any liquid streams would first need to be flashed before entering the unit. Waste streams in the region of 40 – 50,000 cfm (85,000 m<sup>3</sup>/h) are the upper limit for volumetric flowrate, and a turndown of 6:1 from maximum design conditions is achievable. Concentrations of VOC are limited to 25% of the lower flammability limit before dilution air is required. If dilution air is needed, a large increase in size of the unit will be necessary. These criteria eliminate catalytic incinerators for use at product loading terminals, as the flowrates and concentrations are too high to be economic. Also the destruction efficiency of some side reactions may not be thermodynamically favored at the lower operating temperatures of catalytic incinerators. All reactions should be considered before selecting this technology.

- **Applications**
  - Gaseous VOC streams.
  - H<sub>2</sub>S oxidation.
- **Advantages**
  - Lower operating temperature results in low fuel consumption.
  - High destruction efficiency (up to 99%).
  - Lower cost heat Recovery possible due to lower operating temperatures.
  - Turndown ratios of 6:1 are achievable.
- **Disadvantages**
  - Potential problems with catalyst disposal.
  - Liquid streams must be vaporized.
  - No solids incineration possible.
  - Limited Exxon experience.
  - Catalyst contamination reduces destruction efficiency.

### ▶ FLUID-BED INCINERATORS

These units are used for the incineration of solid and liquid waste. The waste solid stream is conveyed to the bed of the incinerator. The conveying system can be either pneumatic or mechanical, depending on the liquid content of the solid containing waste stream. A liquid waste would typically be pumped to and atomized into the fluid bed. A supplemental burner located at the base of the unit supplies hot air for the incineration of the waste and fluidization of the inert bed material, e.g. sand. Alternatively, flue gas to air exchangers are used to preheat the air. Depending upon the combustibles content of the waste, the heat generated by the combustion of the waste stream may be sufficient to eliminate firing the auxiliary burner. In these cases the auxiliary burner is only needed for startup, thus saving on fuel costs. Thermal destruction efficiencies are typically 99% or higher.

|                                                           |                 |                               |                                                                                    |
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### TYPES OF INCINERATOR HARDWARE (Cont)

Acid gas emissions from the unit can be controlled. For example, NO<sub>x</sub> levels can be controlled by varying the bed temperature, while limestone can be added to the feed to reduce SO<sub>x</sub> levels. Thus the degree of downstream flue gas scrubbing can be reduced. However, by the nature of the wastes being incinerated, particulate cleanup, either by bag filter or electrostatic precipitator, will be required.

- **Applications**
  - Incineration of solids, sludges, etc.
  - Waste water treatment plant sludges
- **Advantages**
  - Acid gas concentrations can be controlled in the incinerator itself.
  - Reduced fuel consumption since intense mixing promotes use of lower operating temperatures.
- **Disadvantages**
  - High capital cost.
  - Complex waste handling system.
  - Size limitation at lower end.
  - Particulate cleanup usually required.
  - Limited Exxon experience.

### ▶ **REGENERATIVE INCINERATORS**

Regenerative incinerators employ integrated packed, ceramic bed heat recovery modules to transfer heat from the hot flue gas products to the cooler, incoming the waste stream. A valving arrangement is provided which allows the ceramic beds to be cycled between heating the incoming waste stream or being heated by the hot flue gas from the incineration chamber. These units are best suited for handling a dilute waste stream that is mostly air with a small amount of VOC. The units must first be brought up to temperature by burning an auxiliary fuel through supplemental burners. Once the temperature in the unit is above the auto ignition temperature, the VOC stream can be introduced. Once stable combustion is achieved, the auxiliary fuel can be reduced to very low levels or in some cases turned off. Typically the waste stream must contain VOC's equivalent to 16 % or more of the lower flammability limit before auxiliary fuel can be completely turn off. At higher VOC concentrations, it may prove necessary to add dilution air to control the incinerator temperature, as the temperature rise may be too great.

The VOC concentration in the waste is limited to 25% of the lower flammability limit as higher concentrations lead to large quantities of dilution air. There is no upper limit on total volumetric flow.

- **Applications**
  - Incineration of VOC bearing gaseous waste streams.
  - Plant with high fuel cost / marginal fuel availability.
  - Potential for marine vapor recovery units (see later).
- **Advantages**
  - Low specific fuel consumption.
- **Disadvantages**
  - High capital cost.
  - Only VOC streams can be incinerated.
  - Gaseous streams only.
  - Limited Exxon experience.

### ▶ **ROTARY KILNS**

Rotary kilns have been used for many years for calcining aggregates. Their use in the petrochemical industry has been limited to the manufacture of petroleum coke and incineration. Their use as incinerators is limited and only a few plants use them.