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Capital and O and M Cost Relationships for Hazardous Waste Incineration Addendum No. 1 - Ionizing Wet Scrubber Costs

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CAPITAL AND O&M COST RELATIONSHIPS FOR HAZARDOUS WASTE INCINERATION: ADDENDUM NO. 1 - IONIZING WET SCRUBBER COSTS

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16. ABSTRACT

This report addresses certain cost aspects of hazardous waste incineration; specifically capital and operating costs for ionizing wet scrubbers (IWS). It is an addendum to a more comprehensive report "Capital and O&M Cost Relationships for Hazardous Waste Incineration," which developed parametric methods for estimating capital and annual costs for incinerators as a function of waste characteristics and quantities, facility capacity, type and location.

The earlier study assumed that particulate/HCl emissions were controlled using a venturi scrubber/packed bed absorber systems. This study includes a IWS systems as a design alternative. It provides for IWS systems a methodology to estimate:

(1) Capital cost vs. capacity/particulate efficiency and
(2) Operating (primarily power and makeup water) requirements

These can be used with the earlier study to project overall capital and O&M costs for incineration facilities using IWS's.

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Hazardous Waste Engineering Research Laboratory (HWERL) assists in developing and demonstrating new and improved methodologies that will meet these needs efficiently and economically.

This report provides information on capital and operation costs for ionizing wet scrubber systems designed to achieve RCRA air emissions standards for hazardous waste incineration facilities. It is intended primarily for EPA utilization in assessing cost/benefit trade-offs, although it may also be useful to other individuals or organizations interested in hazardous waste incineration economics. The Thermal Destruction Branch, HWERL, may be contacted for additional information on this subject.

David G. Stephan, Director
Hazardous Waste Engineering Research Laboratory
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ABSTRACT

The U.S. Environmental Protection Agency, Office of Solid Waste, is currently conducting a Regulatory Impact Analysis (RIA) of performance standards for hazardous waste incinerators. This RIA is intended to determine both the costs and benefits of various regulatory standards. The study reported here addresses certain cost aspects of hazardous waste incineration; specifically capital and operating costs for ionizing wet scrubber (IWS) systems used to control air emissions in some incineration facilities.

This report serves as an addendum to a much more comprehensive report, entitled "Capital and O&M Cost Relationships for Hazardous Waste Incineration", (Reference 1). The referenced report was the result of a two-year study to develop parametric cost estimating methods for hazardous waste incineration. These parametric relationships allow capital and annual costs for incineration facilities to be estimated as a function of waste characteristics and quantities, facility capacity, generic incineration system design, energy recovery utilization, air pollution control requirements, operating schedule, and location within the U.S.

Due to the broad scope of the original study, a number of assumptions concerning facility design and operation were needed to limit the user input requirements and ensuing engineering/cost calculations. One of the major design assumptions was that particulate/HCl emissions are controlled using venturi scrubber/packed bed absorber systems. In recent years, however, IWS systems have increased in popularity relative to the more conventional venturi/packed bed scrubbing systems. This is particularly true for large incineration facilities which generate extremely fine particulate (<1 um) in the combustion process.

In order to include IWS systems as a design alternative in the capital and O&M cost estimation model for hazardous waste incineration, the study reported herein was performed. This study provides a methodology to estimate:

(1) Capital cost vs. capacity/particulate efficiency relationships removal for IWS systems, and,

(2) IWS operating requirements, primarily power consumption and makeup water.

These estimates can be used in conjunction with Reference 1 to project overall capital and O&M costs for incineration facilities incorporating IWS's for air emissions control.

This report is submitted in partial fulfillment of Contract No. 68-02-3176 by Acurex Corporation, Energy & Environmental Division, under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period December 1, 1983 to June 1, 1984 and work was completed as of August 15, 1984.

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FIGURES

CONVERSION FACTORS

To convert from	To	Multiply by
Btu	kcal	0.2520
°F	°C	(°F-32)/1.8
ft	m	0.3048
ft^2	m^2	0.09290
ft^3	m^3	0.02832
gal	lit	3.785
gr	mg	64.80
hp	kw	0.7457
in.	cm	2.540
in.W.C.	kPa	0.2487
lb	kg	0.4536
psi	kPa	6.895

SECTION 1

INTRODUCTION

The U.S. Environmental Protection Agency, Office of Solid Waste, is currently conducting a Regulatory Impact Analysis (RIA) of performance standards for hazardous waste incinerators. The RIA is intended to determine both the costs and benefits of various regulatory standards. The benefits of hazardous waste incinerator regulations are being evaluated through risk assessment studies conducted by other investigators. The work reported here addresses certain cost aspects of hazardous waste incineration; specifically, capital and operating costs for ionizing wet scrubber (IWS) systems used to control air emissions in some incineration facilities.

This report serves as an addendum to a much more comprehensive report, entitled "Capital and O&M Cost Relationships for Hazardous Waste Incineration", (Reference 1). The referenced report was the result of a two year study to develop parametric cost estimating methods for hazardous waste incineration, enabling the user to project potential economic impacts of regulation over various segments of the incineration industry. The parametric relationships developed in that study allow capital and annual operating costs for incineration facilities to be estimated as a function of waste characteristics and quantities, facility size or capacity, generic incinerator system design, energy recovery utilization, air pollution control requirements, facility operating schedule, and facility location in the U.S.

The capital cost relationships in the original study encompass all facets of hazardous waste incineration facilities, including waste storage and handling equipment, combustion equipment and instrumentation, air pollution controls, flue gas handling equipment, and auxilliary structures. Installation costs and indirect costs for design and construction, air discharge permitting, and startup are also addressed. The annual operating cost relationships encompass variable costs such as fuel, utilities, chemicals, and waste disposal; semi-variable costs such as labor and maintenance; and fixed charges to capital--depreciation, insurance, and taxes.

Due to the broad scope of the original study, a number of assumptions concerning facility design and operation were needed to limit the user input requirements and ensuing engineering/cost calculations. One of the major design assumptions was that particulate/HCl emissions are controlled using venturi scrubber/packed bed absorber systems such as that shown in Figure 1. With minor variations, this is the system of choice for the vast majority of hazardous waste incineration facilities, where efficient particulate/HCl removal from combustion gas is required.

In recent years, however, IWS systems have increased in popularity relative to the more conventional venturi scrubber/packed bed absorber systems. This is particularly true for large incineration faciltics which generate extremely fine particualte (<1um) in the combustion process. Highly efficient sub-micron particulate collection requirements --95%, or even 99+% in some cases -- demand extremely high venturi scrubber pressure drops, on the order of 100 inches of water column (in. WC). Multiple, high-head capacity ID fans and exorbitant power consumption are required for such applications. IWS systems, with pressure drops of less than 10 in. WC for the same particulate collection efficiencies, offer substantial reductions in power consumption and operating cost. The tradeoff is initial capital cost; IWS systems are several times more expensive than comparably sized venturi scrubber/packed bed absorber systems. This capital vs. operating cost tradeoff can be advantageous for many large incineration facilities and possibly for smaller facilities, depending on the specific application.[a]

In order to include IWS systems as a design alternative in the capital and O&M cost estimation model for new hazardous waste incineration facilities, the study reported herein has been performed to estimate the capital costs and operating requirements for IWS's. Capital cost vs. capacity relationships are presented in Section 3 for 1-stage and 2-stage IWS systems, each incorporating a crossflow prescrubber. Section 4 presents methods to estimate IWS system operating requirements, primarily power consumption and blowdown/makeup water rate. The required input for these calculations, all derived from Reference 1, are itemized in Section 2.

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[a] There are some incinerator facilities which are replacing their current pollution controls with an IWS or which are adding an IWS after existing controls. This report does not cover the retrofit costs to install an IWS on an existing incinerator, which is expected to be higher than the costs of installation when the incinerator is being built.

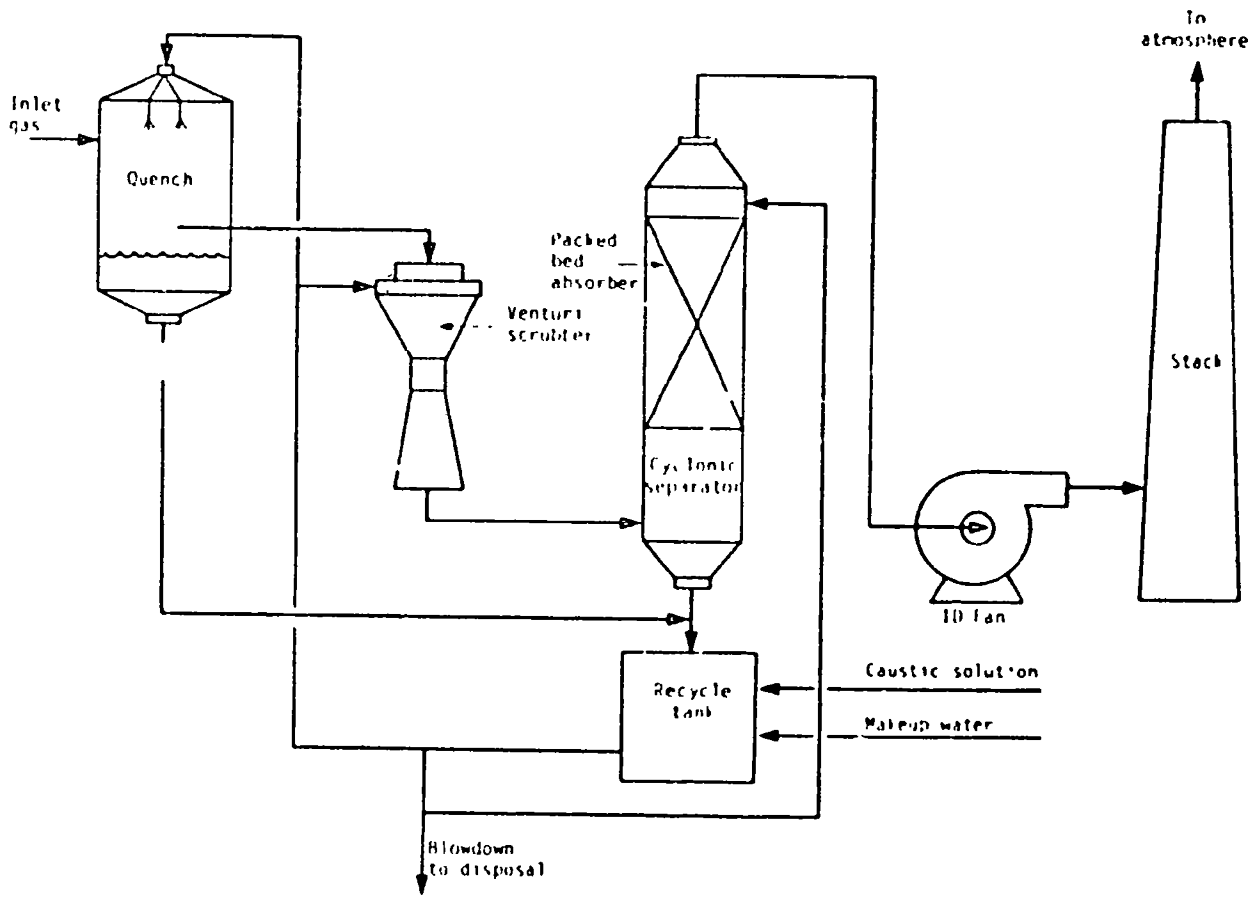

Figure 1. Generalized flow diagram for quench/scrubber system.

SECTION 2

INPUT DATA REQUIREMENTS

Because this report is an addendum to the basic cost estimation model for hazardous waste incineration, Reference 1 should be consulted for all preliminary user data specifications and material balance/design calculations. The engineering quantities needed for IWS cost estimation are listed below, along with the sections in Reference 1 in which these quantities are calculated.

- Dry gas flow rate (Section 3.4.7),

  q_{DG} = ________ scfm

- Particulate loading in combustion gas (Section 3.4.8),

  (C_{part}) I = ________ gr/dscf

- Saturation temperature (Section 3.5.3 or 3.6.1),

  T_{sat} = ________ F°

- Saturated gas flow rate (Section 3.5.5 or 3.6.3)

  $(q_{TG})_{sat}$ = ________ scfm

- Quench outlet pressure (Section 3.5.5 or 3.6.3

  P_Q = ________ psia

- Fractional particulate collection requirement (Section 3.7.1),

  n_{part} = ________

SECTION 3

CAPITAL COSTS

APPLICABILITY

IWS systems are technically feasible and potentially economical alternatives to venturi scrubber/packed bed absorber systems for particulate or combined particulate/HCl control. IWS's are primarily limited to large, $\geq$ 50 M Btu/hr incinerator applications, however, they may be economical for smaller facilities if high loadings of extremely fine, submicron particulate must be removed from the combustion gas.

BASIS FOR COST ESTIMATES

- Because the vast majority of IWS system applications are large incineration facilities handling a variety of wastes - chlorinated and non-chlorinated, combined particulate/HCl removal capability is assumed in all cases.

- Therefore, vendor price quotations reflect the inclusion of a crossflow prescrubber for quantitative HCl removal upstream from the basic IWS. Figure 2 depicts the IWS system configuration, along with the upstream quench and downstream fan and stack which are common to both IWS and venturi/packed bed absorber systems.

- For 90-95% particulate removal, a single stage IWS is considered adequate for most applications. The actual vendor quotations for single-stage IWS systems are based on 92% removal at an inlet particulate loading of 2.0 gr/dscf.

- For very high efficiency ($\geq$ 99%) particulate removal, a two-stage IWS is required (two IWS modules in series).

- The vendor price quotations are based on water scrubbing for HCl removal. To maintain consistency with Reference 1, however, caustic recycle scrubbing is also assumed in this study.

- Thus, the IWS system costs presented in Figure 3 reflect the incremental costs for addition of a caustic recycle system --

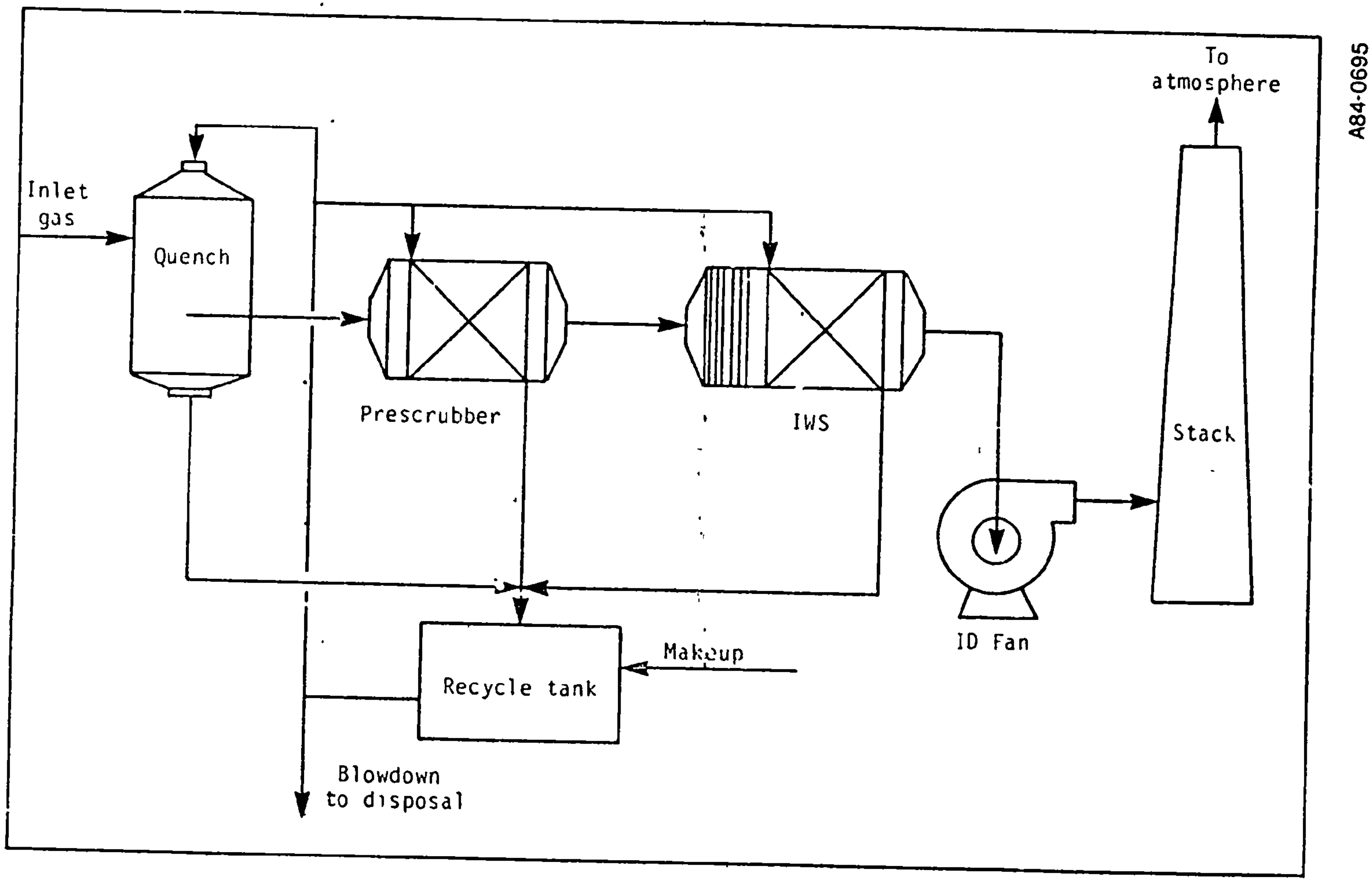

Figure 2. Generalized flow diagram for quench/IWS system.

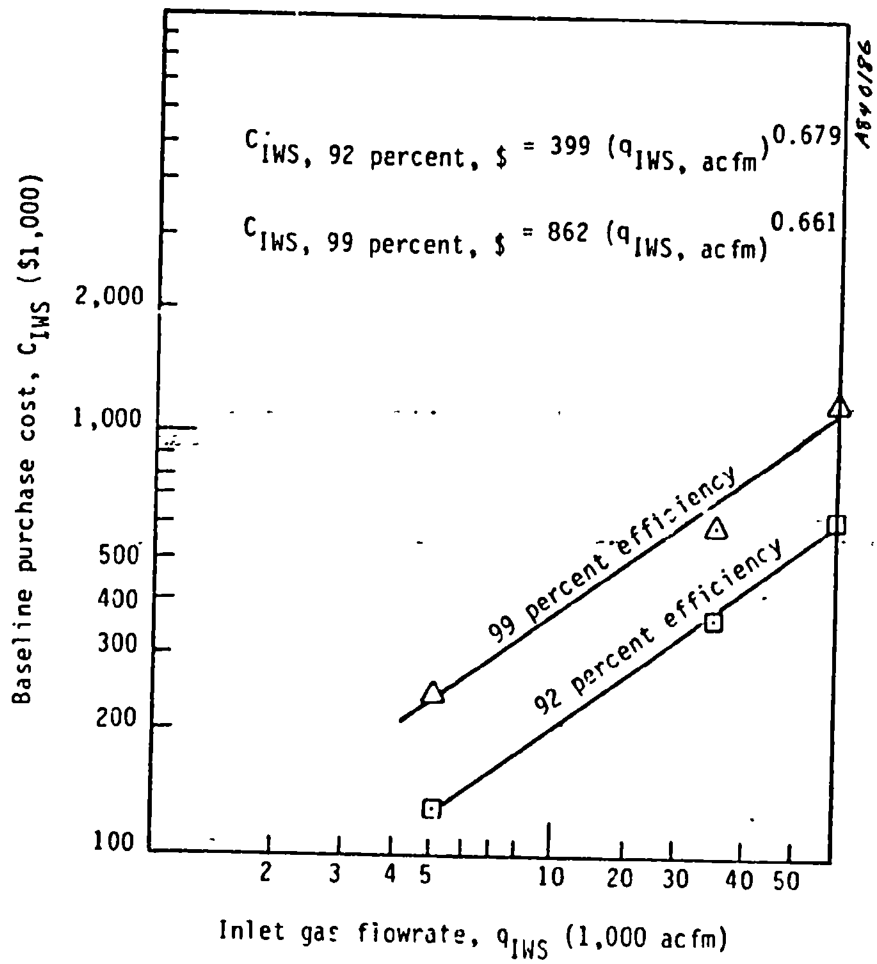

Figure 3. IWS system purchased costs.

pumps, piping, recycle tank, and ph controls. These incremental costs are based on the information provided in Section 4.2.3.3 of Reference 1.

- The costs for other flue gas treatment/handling system components -- quench, ID fan, and stack -- are not included in the Figure 3 estimates. Costs for these components should be estimated using the methods presented in Reference 1 or 2.

- The IWS/prescrubber system cost estimates are representative of first quarter, 1984 prices. These costs were provided by one vendor with a dominant (if not exclusive) market share in IWS technology.

COSTS

- Figure 3 presents graphical representations and regression equations for purchased cost versus inlet gas flow rate for two nominal particulate removal efficiencies. The lower curve (92% efficiency) represents a 1-stage IWS/crossflow prescrubber/caustic recycle system. The upper curve (99% efficiency) reflects the costs for two in-series IWS modules, plus prescrubber and caustic recycle system.

- The appropriate curve in Figure 3 is determined by the fractional collection efficiency requirement, calculated in Reference 1.

- Because an upstream quench is assumed, the inlet gas flow rate, q_{IWS}, is given by,

  $q_{IWS} = (q_{TG})_{sat} [(T_{sat} + 460)/520] (14.696/P_Q) =$ _____acfm

- Based on this information, the IWS system purchased cost from Figure 3 is,

  $C_{IWS} =$ $_____

- Installation costs for IWS systems are approximately 25-30% of the purchased costs, based on vendor estimates. For conservative cost estimating purposes, however, a 50% installation cost factor for the entire incineration and air pollution control system may still be assumed, particularly if the incinerator is a rotary kiln. For other incineration systems, a 40% overall installation cost factor may be more appropriate if IWS systems rather than venturi scrubber/packed bed absorber systems are utilized. The 5% overall factor for incineration system equipment delivery assumed in Reference 1 is still applicable.

SECTION 4

OPERATING REQUIREMENTS

Overall incineration facility operating requirements and costs include fuel, power, water, caustic for HCl scrubbing, residue disposal, labor, maintenance, and in-coming waste characterization. However, most of these operating requirements are not affected by IWS system versus venturi/packed bed system utilzation. In most cases, the only significant difference will be in the areas of:

(1) Scrubbing system power consumption

(2) ID fan power consumption, and

(3) Scrubbing system blowdown rate and makeup water requirement.

SCRUBBING SYSTEM POWER CONSUMPTION

- In venturi/packed bed scrubber operation, the major sources of power consumption are the two scrubbing fluid recycle pumps. In Reference 1, these two power demands are symbolized by $(P_{pump})_{VSW}$ and $(P_{pump})_{Abw}$, with units of horsepower. Power requirements for the quench system and ID fan are addressed separately.

- In IWS/crossflow prescrubber operation, power is needed for high voltage particle charging, heating purge air for the IWS insulator compartments, and operating the scrubber fluid recycle pumps.

- Based on vendor-specified estimate of power consumption, these requirements are related to the inlet gas flow rate by,

  $(P_{IWS})_1 = 13.8 + 7.8 \times 10^{-3}\ q_{IWS} =$ _____hp

  for single stage IWS systems, and,

  $(P_{IWS})_2 = 33.4 + 6.4 \times 10^{-3}\ q_{IWS} =$ _____hp

  for two stage IWS systems.

This quantity, P_{IWS}, is equivalent to the quantity $(P_{pump})_{VSW} + (P_{pump})_{Abw}$ for venturi/packed bed scrubber operation.

ID FAN POWER CONSUMPTION

- As discussed in Section 1 of this report, reduced ID fan power consumption is the major advantage of IWS versus venturi scrubber/packed bed absorber system utilization.
- Estimated pressure drops for the IWS systems addressed in Section 3 are 5 in. WC for the single-stage unit.
- Based on these values and the information presented in Reference 1, Section 3.8, total system pressure drops vs. equipment configuration are as follows:

  Quench/1-stage IWS, P_{sys} = 11 in WC

  Quench/2-stage IWS, P_{sys} = 14 in WC

  WHB/quench/1-stage IWS, P_{sys} = 15 in WC

  WHB/quench/2-stage, IWS, P_{sys} = 18 in WC

- Following selections of the appropriate system pressure drop estimate, the fan horsepower requirement, P_{fan}, can be calculated using the equation presented in Section 3.8 of Reference 1.

BLOWDOWN RATE AND MAKEUP WATER REQUIREMENT

- Based on vendor specifications, the IWS system recycle flow and blowdown streams are limited to suspended solids concentrations of 6000ppm.
- Particulate is the only major source of suspended solids in the recycle loop.
- Thus, based on simple material balance, the blowdown rate is given by,

$$q_{Bdw} = 0.003\ (C_{part})_I\ \ q_{DG}\ n_{part} = \underline{\qquad}\ gpm$$

- This blowdown rate, q_{Bdw}, can be used in Section 3.7.9 of Reference 1 to estimate the total quench/scrubbing system makeup water requirement.

REFERENCES

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