A panel discussion was held on Tuesday afternoon, June 5, to discuss various aspects of thermal testing and performance monitoring of municipal solid waste fired resource recovery facilities. The panelists were:


Steven A. Scavuzzo — Babcock & Wilcox Co. Barberton, Ohio

James E. Boucher — HDR Engineering, Inc. Omaha, Nebraska

Alfred W. Joensen — Iowa State University Ames, Iowa

Before opening the session for discussion, each of the panelists presented information drawing on his experience. Mr. Hecklinger, who is Chairman of PTC-34 Waste Combustors with Energy Recovery, outlined the activities of PTC-34 up to the time of the conference. His comments are included herein. Mr. Grillo presented his thoughts regarding the relative importance of heat outputs, losses and credits in boiler-as-a-calorimeter calculations. His comments are also included on pages 123–126. Mr. Scavuzzo described the challenges of a 30-day performance test. Copies of his visual aids are included herein. Mr. Boucher described two programs, written in BASIC that had been developed to assist in on-site, on-line performance monitoring of municipal solid waste fired boilers. Copies of the two programs were available at the session. Professor Joensen, who is Chairman of PTC-45 Emission Testing of Municipal Waste Combustors, described the activities and plans of PTC-45 at the time of the conference. A meeting of PTC-45 was held on Thursday and Friday of the conference week in Long Beach.

Following the panelists’ presentations, a spirited discussion was held.

STATUS REPORT
COMMITTEE PTC-34
WASTE COMBUSTORS WITH ENERGY RECOVERY

INTRODUCTION
The activity of developing performance test codes (PTC) was initiated by the American Society of Mechanical Engineers in 1884 for the purpose of providing uniform rules and procedures for testing and result reporting for mechanical equipment, processes and systems. The codes provide explicit test procedures for determining the capability of the equipment or process to meet performance criteria or compliance requirements. After more than 100 years, the work goes on.

At the Thirteenth Biennial National Waste Processing Conference and Exhibit at Philadelphia in 1988, an organizational meeting was held for a new performance
test code committee to develop procedures for using the boiler-as-a-calorimeter. The Committee is now designated PTC-34 Waste Combustors With Energy Recovery. The first working meeting of PTC-34 was held in March 1989. Since then, five more meetings have been held. The next meeting is scheduled for June 1990.

MEMBERSHIP

PTC-34 has sixteen members at present, balanced between users, manufacturers and general interest as follows:

Users: (system suppliers are considered to be users)
Franklin A. Hamlyn — Wheelabrator Technologies
Thomas J. Morello — American Ref-Fuel
Zenon Semanyshyn — Ogden Martin Systems
Jill Weldon — Westinghouse
John M. Yanok — WTE

Manufacturers: (boiler and incinerator manufacturers)
R. John Briggs — Foster-Wheeler
David B. Lesneski — Riley-Stoker
William E. McMillan — Synergy Systems
Steven A. Scavuzzo — Babcock & Wilcox
Eric Snyder — Zurn Industries
Jeffrey M. Welsh — ABB/Combustion Systems

General Interest:
Leonard M. Grillo — Grillo Engineering
Roger S. Hecklinger, Chairman
Herbert I. Hollander
Manuel T. Rai — CSI Resource Systems
Robert E. Sommerlad, Vice Chairman & PTC-34 Representative to the Board on Performance Test Codes

All members are experienced in performance testing of waste combustors with heat recovery using the boiler-as-a-calorimeter.

SECRETARY

Up to this time, the secretary for PTC-34 has been George Osolsobe of the ASME staff. Following the June meeting, Mr. Osolsobe will shift committee assignments with Jack Karian of the ASME staff so that Mr. Karian will then serve simultaneously as secretary of PTC-34, PTC-4 Steam Generating Apparatus and PTC-45 Emission Testing of Municipal Waste Combustors. This will afford a means for coordination of committee activities for these three related committees.

OBJECT

The object of the committee as defined at this time, is:

The object of this code is to establish procedures for conducting performance tests of waste combustors using the boiler-as-a-calorimeter to determine:

- The higher heating value of waste fuels
- The thermal capacity of systems combusting waste fuels
- The thermal efficiency of systems combusting waste fuels

THE REASON FOR BOILER AS A CALORIMETER

The reason for a new performance test code to test waste combustors with energy recovery is that PTC-4, developed to test fossil fuel fired steam generators, has proved to be unsuitable for testing steam generators fired with heterogenous waste materials. This is because the usual, heat loss method for measuring the thermal efficiency of a steam generator requires:

Measurement of:

- air wet and dry bulb temperatures
- gas temperature leaving the last heat trap
- percentage of oxygen, carbon dioxide and carbon monoxide in the flue gas by Orsat (inherently dry percentage by volume)
- quantity of fuel fired during the test
- quantity of residue generated during the test

Sampling of:

- fuel to be analyzed for calorific value and ultimate analysis
- residue to be analyzed for unburned combustibles

Calculation of boiler efficiency:

It is not necessary to measure steam flow, feedwater flow, air flow, flue gas flow or water vapor content of flue gas.

Those who test waste combustors have found that it is not possible to gather a sample of municipal solid waste or other heterogenous waste, with assurance that the sample is representative of the whole. Therefore the calorific or ultimate analysis of the fuel fired during the test can not be established with assurance of accuracy. (PTC-33 Large Incinerators has also been found to be
unsuitable because, in addition to excluding recovery of useful energy as a measure of performance, it, like PTC-4, is predicated on gathering a representative sample of the waste combusted.)

This impelled procedures for using the boiler-as-a-calorimeter; i.e., the input to the boiler is calculated as the sum the heat output in steam, stack losses (sensible and evaporative), heat loss due to unburned combustibles in the residue and appropriate allowances for minor losses. Use of the boiler-as-a-calorimeter is practical at present because virtually all waste combustors with heat recovery have means for measuring the steam and/or feedwater flow, temperature and pressure required to calculate heat absorbed by the steam; and in the course of emissions testing, flue gas flow is measured as well as the percentages of the major flue gas constituents including water vapor.

Work is underway to develop the specific procedures. At the meeting in June 1990, the fourth draft of PTC 34 will be reviewed.

**TEST UNCERTAINTY**

Test procedures in a performance test code must include an analysis of the expected level of test uncertainty for the procedures specified. At present, a major concern of PTC-34 is to establish the accuracy of measurement of gas quantity and constituents in order to establish a criterion for overall test uncertainty.

The inherent operating conditions that affect accuracy of gas measurements are:

- Flow rate unbalances induced by the geometry of the gas path on the plane of flow measurement.
- Temperature unbalances induced by upstream heat transfer surface on the plane of temperature measurement.
- Constituent stratification induced by the combustion process.
- Variation with time in flow, temperature, and constituents induced by the continuous variation in heating value, moisture content and ultimate analysis of waste fuel combusted during the course of the test run.

The difficulties confronting PTC-34 are apparent when one considers that other performance test codes require established, steady state operation that is to be repeated from test run to test run, whereas waste combustors are inherently subject to significant variations in waste fuel quality throughout a test run and significant variations in average quality from run to run.

**NEW MEMBERS**

Others with experience in performance testing of waste combustors with energy recovery and with the freedom to dedicate the necessary time to attend meetings and do the necessary “homework” between meetings will be welcomed by PTC-34.
FACILITY DESCRIPTION

• RDF PLANT
  MSW THROUGHPUT - NOMINAL RATING 2000 TPD
  - AVERAGE 1714 TPD

• BOILER PLANT
  NUMBER TWO
  BURN RATE 412 MILLION BTU PER HOUR
  • 900 TPD OF RDF
  • 1085 TPD OF MSW
  STEAM FLOW PER BOILER 310,000 LB/HR
  PRESSURE 750 PSIG
  TEMPERATURE 750 °F

• ELECTRIC PLANT
  61.3 MW TURBINE
  NET POWER OUTPUT - 563 KWH PER TON OF MSW

PURPOSE OF TESTS

• WASTE THROUGHPUT WAS GUARANTEED
  (TONS OF MSW PROCESSED)
  (RESULTING RDF INCINERATED)

• ELECTRIC OUTPUT WAS GUARANTEED
  (KWH PER TON)

• OBTAIN THE HHV OF THE RDF

TEST PROCEDURE
Heat Balance Method Using Measured Gas Weight and Flue Gas Moisture

INPUT
HEAT IN FUEL (CHEMICAL)

HEAT IN RDF (CHEMICAL)

HEAT IN AUX FUEL (CHEMICAL)

OUTPUT

Heat in entering dry air
Heat in moisture in entering air
Sensible heat in fuel
Heat from auxiliary equipment power

envelope
boundary

Heat in desuperheater water
Heat in feedwater

Heat in dry gas

Moisture from fuel
Moisture in air
Unburned carbon
Sensible heat in residue
Surface radiation and convection
CO in flue gas
Unburned hydrocarbons

INPUT FROM RDF = OUTPUT + LOSSES - CREDITS
- AUX FUEL INPUT
HHV = WEIGHT OF RDF

' - UNMEASURED LOSSES
UNBURNED HYDROCARBONS - ESTIMATED TO BE LESS THAN 0.1%.

FLUE GAS FLOW MEASUREMENT

• GAS FLOW WAS MEASURED CONTINUOUSLY

• AVERAGING FLOW GRID INSTALLED

• TEST GRID CALIBRATION USING ASME PTC 11 - FANS

METHODS TO VERIFY GAS FLOW

• THREE METHODS USED TO VERIFY GAS FLOW
  1 - ECONOMIZER HEAT BALANCE -- ±5% "
  2 - CONVENTIONAL STOICHIOMETRIC CALCULATIONS -- ±3%
  3 - EXPECTED THEORETICAL AIR -- 7.2 TO 7.8 LBS/10KBTU
     CALCULATED THEORETICAL AIR -- 7.43 LBS/10KBTU

" 5% ERROR IN GAS FLOW MEASUREMENT
≤ 0.85% ERROR IN CALCULATED BOILER INPUT EFFICIENCY
HHV

1 All of the following material on this page and the next is courtesy of Babcock & Wilcox, a McDermott company.
**FLUE GAS MOISTURE MEASUREMENT**

- 8 MANUAL TRAVERSSES EVERY 24 HOURS
- INTERMITTENT MEASUREMENT INITIALLY LED TO ERRORS
  
  SOLUTION - DETERMINE 'WATER FROM FUEL' DURING TRAVERSE PERIOD AND APPLY THE RESULTS TO THE ENTIRE TEST PERIOD.

**ADDITIONAL CONSIDERATIONS**

- DETERMINATION OF HHV FOR TEST LESS THAN 24 HOURS DIFFICULT
- DIRECT MEASURE OF BOILER RESIDUE AND UNBURNED CARBON DIFFICULT DUE TO SCRUBBER SOLIDS

**METHODS TO VERIFY MEASURE FLUE GAS MOISTURE**

- CALCULATE TOTAL H2O FROM FUEL USING MEASURED GAS FLOW
  AGREEMENT TO WITHIN ±0.5% ULTIMATE

- CALCULATE TOTAL H2O STOICHIOMETRICALLY FROM ULTIMATE
  AGREEMENT TO WITHIN ±0.5% MEASURED

  5% ERROR IN TOTAL H2O FROM FUEL
  => 0.50% ERROR IN CALCULATED BOILER INPUT EFFICIENCY HHV

**TEST RESULTS**

- 96.537 MILLION POUNDS (48,269 TONS) OF MSW PROCESSED.
- 80.424 MILLION POUNDS (40,212 TONS) OF RDF INCINERATED.
- 421,077 MILLION BTUs TOTAL HEAT INPUT TO BOTH BOILERS.
- HIGHER HEATING VALUE OF THE RDF USING THE BOILER AS A CALORIMETER WAS 5,236 BTU/LB.
- HIGHER HEATING VALUE OF DAILY RDF SAMPLES USING A BOMB CALORIMETER WAS 5,220 BTU/LB.