SPECIFICATIONS

1.0 BACKGROUND

The Combustion Modeling and Scaling Section of the Navy Technology Center for Safety and Survivability has a need for a system capable of measuring the characteristic combustion properties of materials used in ship construction. The data produced by this system is required for fire hazard analysis during the design phase for proposed new ship classes and will also be used to specify inputs to fire models for smoke and fire spread studies for existing ship classes.

The materials to be studied include deck and bulkhead coverings (such as polyimide acoustic and thermal insulation), bedding and upholstery, false deck panels (as used in electronic spaces) and composite materials that may be used in future ship designs. The primary properties of interest are heat release rate (HRR), effective heats of combustion in normal and vitiated atmospheres, and characteristic yields of the combustion byproducts (for example, carbon monoxide, carbon dioxide and soot) as a function of combustion conditions.

1.1 Cone Calorimeter Description

The oxygen consumption calorimeter (OCC) is commonly used for measurements of these parameters. Essentially, it consists of a system for collecting and analyzing combustion products and, typically, a system for monitoring the mass of the sample during the tests. Combustion products are entrained into an exhaust stream where, at a minimum, the concentration of oxygen is measured, and the HRR of the combustion process is calculated based on the difference in the oxygen concentrations in the inlet and exhaust streams (oxygen consumption). Additional data, including the mass the test sample, the obscuration due to soot, and the concentrations of other species, may also be collected to increase the accuracy of the HRR calculations and to permit determination of other properties, such as effective heat of combustion and the toxicity of the combustion products.

For bench-scale experiments, the most common form of the OCC apparatus is the cone calorimeter. In this instrument, a sample stage (usually including a load cell for mass loss measurements) is located below to a truncated, cone-shaped radiant heater. The heater provides sufficient energy to ignite the sample; the combustion products rise through the hole in the heater and are exhausted via an instrumented duct in which gas concentrations, flow rates and obscuration are measured. Combined with the mass loss and sample temperature data, this is sufficient to calculate most of the combustion properties of the sample material.

Note that the cone calorimeter sample holder is suited only for small-scale experiments due the size of the holder (typically on the order of 10 cm x 10 cm) and the capacity of the load cell (usually less than one kilogram). However, the gas analysis subsystem has no such limitation and, in principle, can be used for experiments on any scale.

2.0 SYSTEM SPECIFICATIONS (CLIN 0001)

This section describes the specifications needed to meet the current requirements for a research OCC system. The “Base System” specifications include the features and capabilities required to meet our immediate needs, “Expansion Options” discusses the “hooks” which must be built into the base system to enable capabilities to be added to the system in the future and “System Calibration and Maintenance” defines the requirements for calibrating and maintaining the base system.

2.1 Base System

The base system must include at least the capabilities specified in this section. Capabilities described in the next section, “Expansion Options,” may be incorporated into the base system at the manufacturer’s discretion.

2.1.1 Physical Requirements

The base system must meet the following physical specifications.

2.1.1.1 Dimensions

The height of the system, including the exhaust stack, must not be greater than 3.0 meters, depth (distance from the front panel to the opposite side of the instrument) must not be greater than 0.75 m and width (dimension in the horizontal plane perpendicular to the depth dimension) must not be greater than 2.0 meters.

2.1.1.2 Electrical Power Supply

The system electrical power requirement must not exceed 7.5 KVA at a voltage not to exceed 230 VAC. The apparatus must be compatible with standard 60 Hz power mains.

2.1.1.3 Water Supply

If cooling water is required for system operation, it must be compatible with standard city water taps. The required water pressure must not be greater than 50 psi, the maximum flow rate must not exceed 1 l/min. and the minimum required water temperature at the inlet to the apparatus must not be less than 25 °C.

2.1.1.4 Exhaust Ventilation

The maximum exhaust flow rate from the apparatus must not exceed 50 liters/s. All ventilation system components that come into contact with the effluent must be manufactured from stainless

steel to minimize corrosion. The exhaust blower must be of the variable speed type and the exhaust subsystem must incorporate an orifice plate flow measurement instrument.

2.1.1.5 Oxygen Depletion Analysis Unit

The oxygen depletion analysis unit must be housed in a separate module which may be detached from the cone calorimeter for use in larger scale oxygen consumption calorimetry experiments.

2.1.1.6 Sample Holder

The sample holder must be capable of holding samples up to at least 10.0 cm x 10.0 cm in area, and at least 5.0 cm thick, in a horizontal orientation. There must be a mechanical shutter to isolate the sample, after the sample has been installed in the sample holder, from the radiant heater during experiment setup and sample equilibration.

2.1.1.7 Adjustable Sample Platform

The load cell, sample holder and heater cone must be mounted on a platform that can be moved vertically to adjust for different test configurations and sample sizes.

2.1.1.8 Conical Heater

The truncated cone heater element must have an electrical rating of at least 5 kW at the apparatus operating voltage and must be capable of providing radiant fluxes up to at least 100 kW/m^2. It must be capable of operation in both the horizontal and vertical orientation and must be temperature controlled.

2.1.1.9 Gas Sampling

Gas sampling within the exhaust duct must be accomplished with a ring probe connected to a pump system capable of maintaining a controlled gas flow rate. The gas sampling subsystem must incorporate particulate filtration, gas cooling and drying and carbon dioxide scrubbing.

2.1.1.10 Safety Door

The apparatus must incorporate a safety door which can be used to enclose the burner area to protect the operator from hazardous materials that may be produced by combustion of the sample.

2.1.2 System Software

The system software must provide, at a minimum, the following capabilities.

2.1.2.1 User Interface

The software must provide a graphical user interface incorporating menus and windows typical of those used in Microsoft Windows and Apple Macintosh operating systems.

2.1.2.2 Status

The software must provide a real time display of the instrument status.

2.1.2.3 Instrument Calibration

The software must provide for calibration of the apparatus and storage of the calibration results for future use.

2.1.2.4 Data Acquisition

The software must provide for acquisition of data during a test and saving of that data to hard disks or other storage media.

2.1.2.5 Data Reduction

The software must provide for reduction of the raw data to, at least, the thermophysical parameters listed in Section 2.1.4.

2.1.2.6 Data Display

The software must provide for display of the data, including the reduced data.

2.1.2.7 Data Printout

The software must provide for printing the data, including the reduced data.

2.1.3 Measurement Requirements

The base system instrumentation must meet the following requirements.

2.1.3.1 Load Cell

The load cell must be capable of measuring sample masses of at least 500 g to an accuracy of 0.1 g or better. The load cell must incorporate an anti-vibration mounting (to improve the accuracy and reproducibility of the mass measurements), mechanical stops (to prevent damage if the mass limit is exceeded) and a digital mass readout.

2.1.3.2 Smoke Obscuration

Smoke obscuration must be measured using a laser system which must include both sample and reference beam measurements to correct for system drift.

2.1.3.3 Oxygen Analyzer

The oxygen analyzer must use a paramagnetic oxygen sensor and must incorporate temperature and gas flow rate control. The analyzer range must be at least 0 - 25 volume percent and it must provide an accuracy of at least ±50 ppm.

2.1.3.4 Carbon Monoxide Analyzer

The carbon monoxide analyzer must employ non-dispersive continuous infrared (NDIR) sensors with flow control. The analyzer range must be at least 0 - 1 volume percent and it must provide an accuracy of at least ±1% of the range.

2.1.3.5 Carbon Dioxide Analyzer

The carbon dioxide analyzer must employ non-dispersive continuous infrared (NDIR) sensors with flow control. The analyzer range must be at least 0 - 10 volume percent and it must provide an accuracy of at least ±1% of the range.

2.1.4 Parameters Measured

The base system must be capable of reporting, either through direct measurement or by calculation from the fundamental measurements, the following thermophysical parameters.

2.1.4.1 Heat Release

The apparatus must report the heat release rate (kW) and the total heat released (kJ).

2.1.4.2 Heat of Combustion

The apparatus must report the effective heat of combustion (MJ/kg).

2.1.4.3 Mass Loss Rate

The apparatus must report the sample mass loss rate (g/s).

2.1.4.4 Ignition Time

The apparatus must report the time from the start of the experiment to sample ignition (s).

2.1.4.5 Smoke Density

The apparatus must report the specific extinction area of the smoke (m^2/kg).

2.1.5 Standards Compatibility

The system must comply with the standards listed in this section.

2.1.5.1 Bench-Scale Cone Calorimeter Standards

The apparatus must comply with the cone calorimeter instrument requirements specified in the following standards:

a. ASTM E1354, "Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter."

b. ASTM E1474, "Standard Test Method for Determining the Heat Release Rate of Upholstered Furniture and Mattress Components or Composites Using a Bench Scale Oxygen Consumptions Calorimeter."

c. ASTM E1740, "Standard Test Method for Determining the Heat Release Rate and Other Fire-Test-Response Characteristics of Wallcovering Composites Using a Cone Calorimeter."

d. ASTM F1550, "Test Method for Determination of Fire-Test-Response Characteristics of Components or Composites of Mattresses or Furniture for Use in Correctional Facilities after Exposure to Vandalism, by Employing a Bench Scale Oxygen Consumption Calorimeter."

e. ASTM D6113, "Standard Test Method for Using a Cone Calorimeter to Determine Fire-Test-Response Characteristics of Insulating Materials Contained in Electrical or Optical Fiber Cables."

f. NFPA 271 Standard Method of Test for Hear and Visible Release Rates for Material and Products using an Oxygen Consumption Calorimeter

2.1.5.2 Large-Scale Cone Calorimeter Standards

The oxygen depletion analysis unit, when used in conjunction with a appropriate burner and gas collection hood, must comply with the calorimeter instrument requirements specified in the following standards:

a. NFPA 265, “Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile Coverings on Full Height Panels and Walls

b. NFPA 286, “Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Wall and Ceiling Interior Finish.”

c. ASTM E1537, “Standard Test Method for Fire Testing of Upholstered Furniture.”

d. ASTM E1590, “Standard Test Method for Fire Testing of Mattresses.”

2.2 Expansion Options

The following capabilities are not needed in the base system, but the base system must be designed and constructed in such a way that these capabilities can be added to the system in the future.

2.2.1 Vertical Sample Holder

The system must have the capability of accepting a sample holder that positions the sample in the vertical orientation.

2.2.2 Soot Mass Subsystem

The system must have the capability of accepting a subsystem for analysis of soot in the exhaust stream.

2.2.3 Non-Standard Ambient Oxygen Subsystem

The system must be compatible with an enclosure that permits control of the composition of the air supplied to the burning sample. With this optional enclosure, it must be possible to reduce the oxygen concentration below the normal value (to simulate effects of vitiated air) and to increase the oxygen concentration above the normal value (to simulate effects of oxygen-enriched air).

2.2.4 Combustion Gas Analyzer

The system must have the capability of connecting with a general purpose Fourier transform infrared (FTIR) for real time measurement of combustion products other than those measured by the base system.

2.2.5 Smoke Corrosivity Subsystem

The system must have the capability of accepting a subsystem for analysis of the corrosion characteristics of the smoke in the exhaust stream.

2.3 System Calibration and Maintenance

The base system must include the tools needed to perform at least the following system calibrations. The contractor is not required to include expendable calibration standards, such as certified calibration gases.

2.3.1 Heat Release Rate

The contractor shall include a methane burner assembly suitable for calibration of the heat release rate and total heat release measurements.

2.3.2 Radiant Flux

The contractor shall include a heat flux meter suitable for calibration of the cone heater radiant flux.

2.3.3 Optical Density

The contractor shall include one or more standard neutral density filters for calibration of the laser optical density subsystem.

2.3.4 Calibration Software

The provided software must include calibration routines for heat release rate and radiant flux measurements.

2.3.5 Documentation

The contractor shall provide operating and maintenance manuals for the hardware components of the apparatus and a user manual for the software components.

3.0 SPARE PARTS (Optional CLIN 0002)

The contractor shall provide a list of available spare parts and their current price list.