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METC Combustion Research Facility

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OBJECTIVES

The objective of the Morgantown Energy Technology Center (METC) high pressure combustion facility is to provide a mid-scale facility for combustion and cleanup research to support DOE's advanced gas turbine, pressurized, fluidized-bed combustion, and hot gas cleanup programs. The facility is intended to fill a gap between lab scale facilities typical of universities and large scale combustion/turbine test facilities typical of turbine manufacturers. The facility is now available to industry and university partners through cooperative programs with METC.

BACKGROUND

Consistent with the energy policy act, a major DOE program, the Advanced Turbine Systems (ATS) Program has been initiated to develop more efficient gas turbine systems for both utility and industrial electric power generation (U.S. Department of Energy 1992). The program targets base load power systems for commercial offering in the 2000 to 2002 time frame. The program will target a 15 percent improvement in efficiency, reductions in NO_x, CO_2, CO, and unburnt hydrocarbon, and provide for a 10 percent lower cost of electricity than current technology.

The basic strategy of the program is to fund teams led by U.S. turbine manufacturers to develop ATS while in parallel to develop a technology base to address key technical issues. A university/industry consortium administered by the South Carolina Energy Research and Development Center will provide cross-cutting technical support for the ATS program. Under this consortium, the two rounds of research proposals were selected through a competitive process. Other activities including projects in the METC combustion facility will contribute to this technology base development of the ATS program.

High pressure combustion research is also important to other DOE programs. Integrated gasification combined cycle (IGCC) systems and second-generation, pressurized, fluidized-bed combustion (PFBC) systems use gas turbines/ electric generators as primary power generators. The turbine combustors play an important role in achieving high efficiency and low emissions in these novel systems. These systems use a coal-derived fuel gas for the turbine combustor. The METC facility is designed to support coal-derived fuel gas fired combustors as well as the natural gas fired combustors.

PROJECT DESCRIPTION

In 1990, an existing METC building, Building 6, that had been used to dry and prepare coal for the METC gasifier and other projects was decommissioned. The need for a modern, high-pressure combustion facility was recognized and the decision was made to modernize and upgrade B-6 to meet this need.

The primary considerations that dictated the renovations included safety in the event of an accident, the ability to remotely operate the test rigs, availability of substantial volumes of high

pressure preheated combustion air, availability of high pressure methane and other fuels, and a modern high speed data acquisition system. The renovations required to meet these needs were extensive. These included addition of blast walls to create isolated test cells, a separate control room, installation of a large ventilation system capable of reducing the risks from accidental release of gaseous fuels and dissipating the heat released by the combustors, installation of the needed high pressure utilities to the test cells, addition of a modern data acquisition system, and numerous smaller changes to the building.

The renovations were completed in January of 1993. A pressurized pulsed combustor began operating in July and several others are expected to be in operation by the end of 1994.

BUILDING LAYOUT

Figure 1 shows the physical layout of the facility which consists of two primary test cells, areas 103 and 105, a staging area, fuel handling room, control room, and a clean area. The test cell 105 is a high bay area with a ceiling height of 30 feet. It is capable of holding at least two test units. Test cell 103 has a ceiling height of 20 feet on the north side and a height of 10 feet on the south half. The staging area is used to assemble combustors for tests and to do minor repair and fabrication tasks. It is also used as a test area for cold flow visualization models and other small ambient pressure and temperature rigs. The distributed control system in the control room will be used to remotely operate rigs that are in either the 103 or 105 test cells. The common computer system is readily configured to control the various rigs. The fuel handling room was originally intended for use with coal water slurries and liquid fuels but currently it houses a methane compressor and some auxiliary equipment.

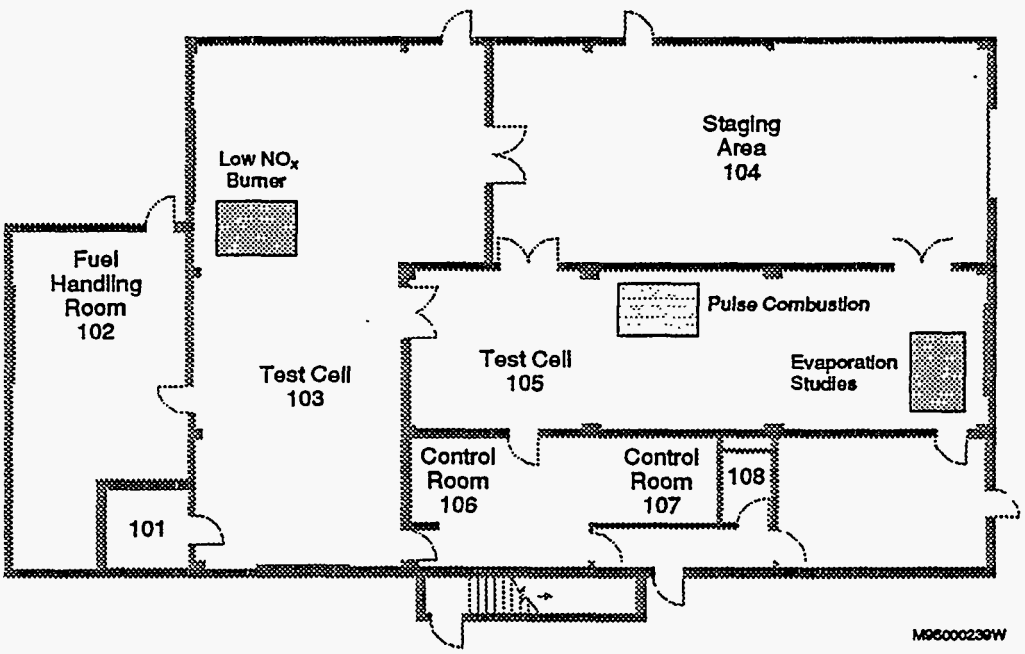

Figure 1. B-6 Combustion Facility

UTILITIES

Table 1 summarizes the utilities and services available in the main test cells in the facility. Basically the facility was sized to support a 10,000,000 Btu/h combustion process. One such process or a combination of smaller processes could be serviced at one time. Up to 160,000 scf/h of air is available for combustion, atomization and other needs. High pressure water is available as city, deionized or process cooling water.

High pressure air entering the building passes through a manifold where a portion or all of the air can be diverted to preheaters. The preheaters can deliver air at 700 psig at 1,050 °F. Preheated air is metered and then can be delivered to either of the two high pressure cells.

CURRENT PROJECTS

Currently two combustion rigs are operating in B-6 and one additional project is under construction for the facility. Space is available in the test cells for at least one additional test rig.

A pressurized pulsed combustor began operating in July of 1993 in the 105 test cell. The combustor will carry out pulsed combustion of natural gas at pressures up to 10 atmospheres. Figure 2 illustrates the components in this combustor. The objective of the test program is to test various pulsed combustor geometries to determine pressure gain performance, high pressure operating characteristics, evaluate formation of pollutants, and obtain information on scaling laws for this class of combustors. The information obtained will be used to evaluate the potential of pulsed combustors for achieving pressure gain in gas turbine systems.

A high pressure steady flow rig is currently completely fabrication. The objective of this rig is to test novel, steady-flow, pressurized combustors that produce very low NO_x and other emissions. Figure 3 is a schematic of the steady flow rig. The rig will be able to test burners in the range of 1 to 10 million Btu/h. It has a modular design that allows alternate burners to be installed in the rig.

An evaporation rig currently is in startup in area 105 of B-6. Figure 4 illustrates the basic components of this rig. This rig will test the concept of water injection in an externally fired cycle. The specific technical issue that the unit will address is evaporation rates of water droplets in high pressure flows.

FUTURE WORK

The METC B-6 combustion facility is a modern laboratory with sufficient ancillary equipment and utilities to simultaneously support multiple combustion projects. METC plans to work cooperatively with industrial and university partners on these projects.

REFERENCES

"Report to Congress, Program Plan, Advanced Turbine Systems," U.S. Department of Energy, 1992.

Table 1. Building B-6 Services

Air Supply -- Total of 160,000 scf/h	
• 700 psig combustion air @ up to 1,050 °F	156,000 scf/h
• 900 psig atomization air	5,700 scf/h
• 700 psig purge air	
• 125 psig plant air	
Water Systems	
• 500 psig city water	12 gal/min
• 500 psig deionized water	5 gal/min
• Process cooling water (closed loop)	250 gal/min
• Low pressure steam	1,000 lb/h
• 90 psig city water	
Fuels -- Up to 10,000,000 Btu/h	
• 600 psig natural gas	700 scf/h (10,000 scf/h available 3/95)
• 600 psig synthesis gas @ 1,500 °F	Planned
Gas Analyzers	
• Mass spectrometer	
• O_2/CO analyzers	
• Gas analyzer (CO_2, NO_x, HC, H_2)	
• N_2O analyzer	
• H_2O analyzer	
Control and Data Acquisition	
• Low speed: 100 channels @ 0.5 Hertz	
• High speed: 8 channels @ 100,000 Hertz	
Safety Features	
• Ventilated test cells	
• High pressure nitrogen	
• Low pressure nitrogen	
• Video monitoring systems in test cells	
• Remote control and operation of rigs	
• Blow out panels room 105	
• Toxic gas monitors and alarms	
• Combustible mixture monitor and alarm	

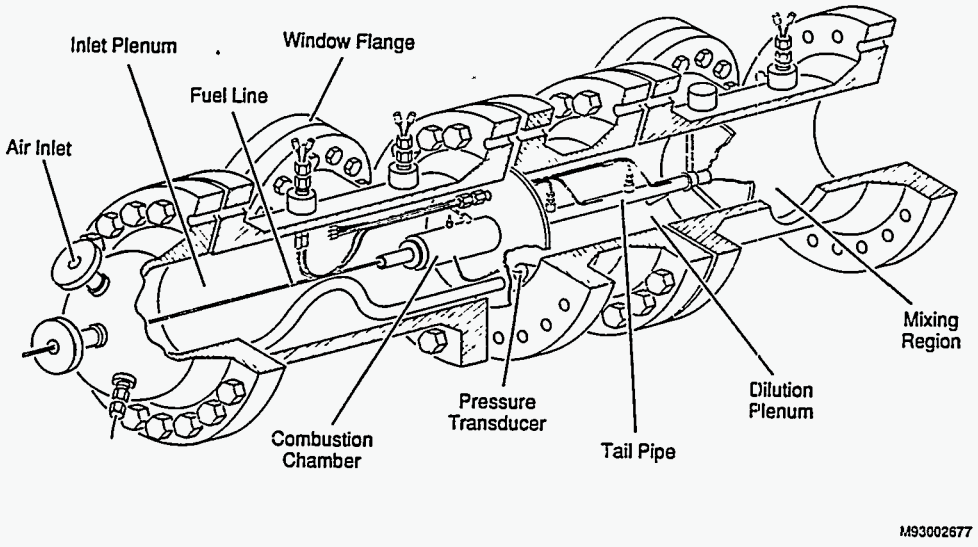

Figure 2. Pressurized Pulse Combustor

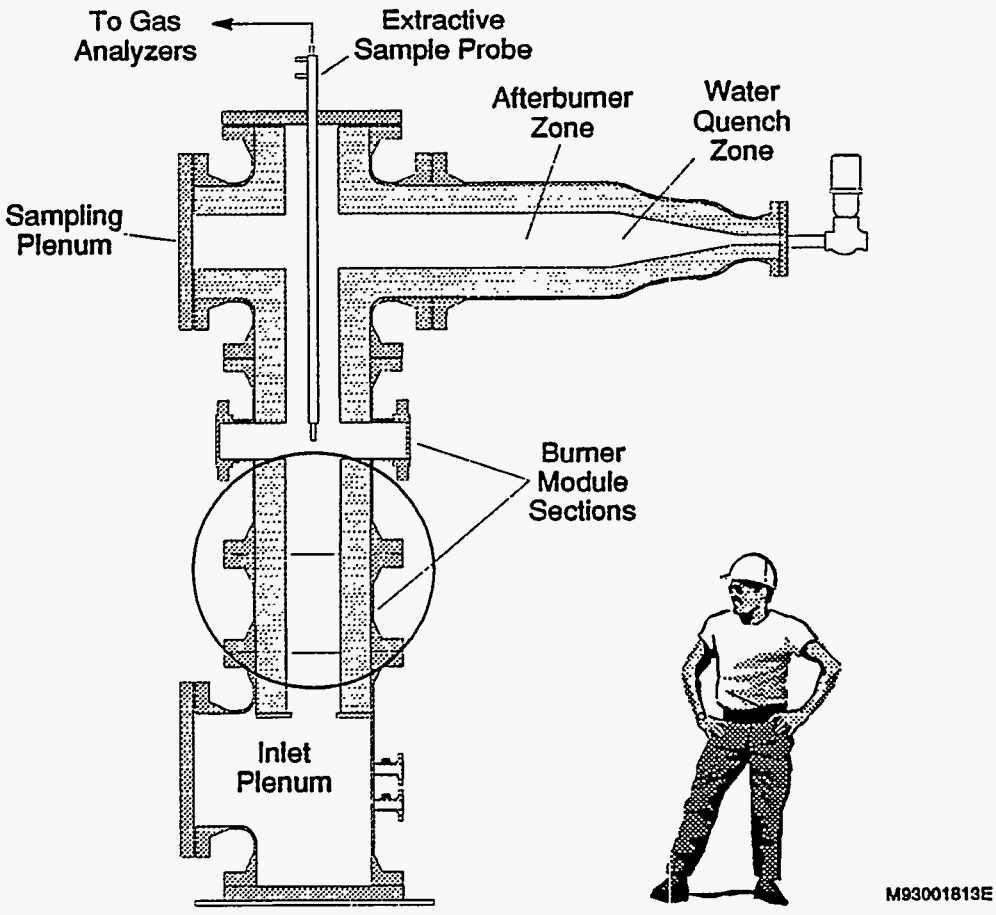

Figure 3. Pressurized Burner Test Facility

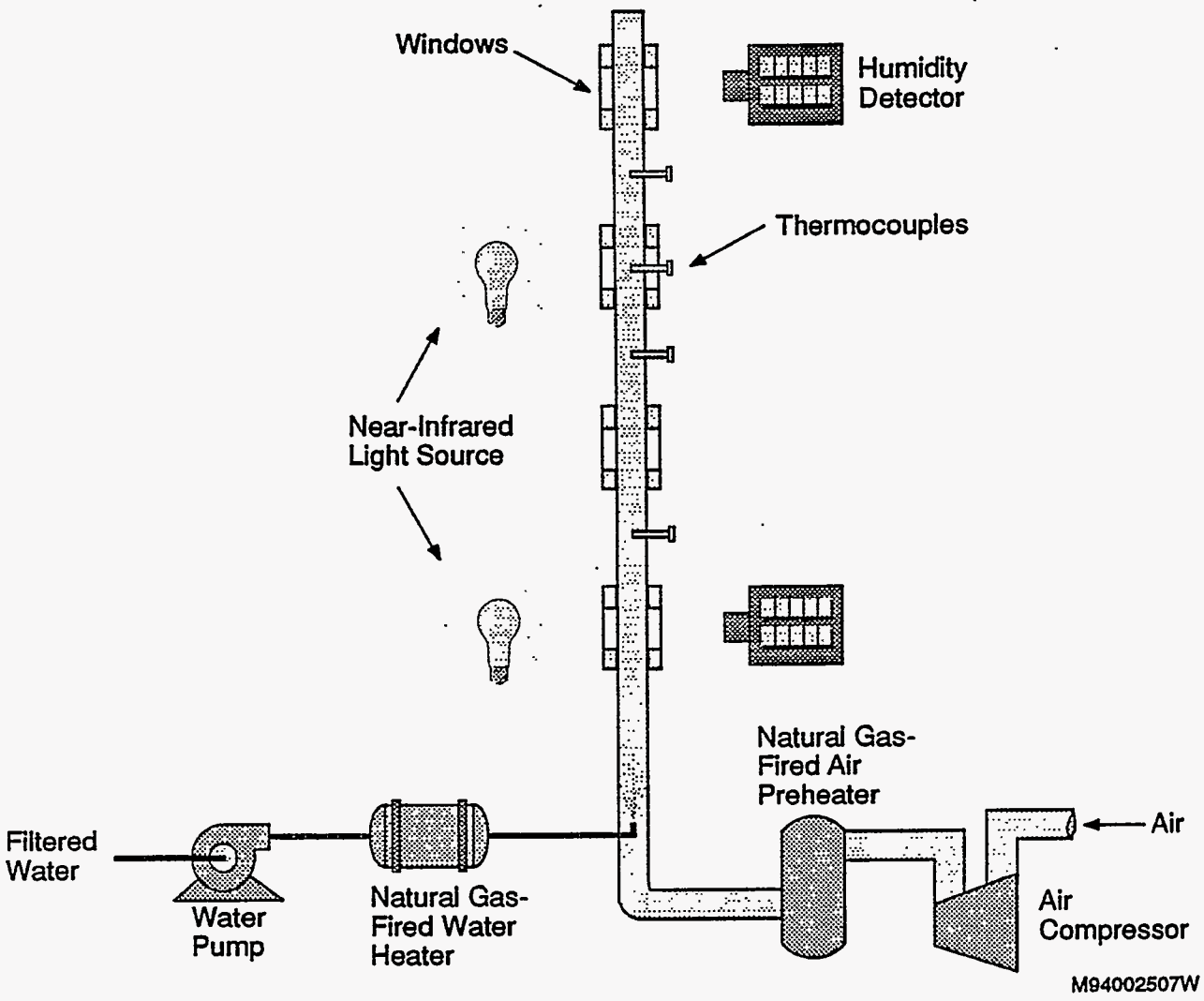

Figure 4. Evaporation Unit