Invitation for Bid

For

High Fidelity Simulator for the Circulating Fluidized Bed Boiler Unit Located at Northside Generating Station

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1 Introduction

JEA is issuing this specification for the procurement of a circulating fluidized bed (CFB) boiler plant training simulator based on its Northside Generating Station (NGS) Unit 1, common equipment required to run the unit, and associated control room configuration. This specification contains the detailed requirements for the hardware, software and services necessary to supply a high fidelity, computer-based training simulator. The requirements in this specification include, but are not limited to, the design, development, fabrication, performance, testing, training, documentation, preparation for shipment, shipment, installation and long term technical support for the simulator.

1.1 Purpose

The simulator will be used by JEA to train unit operators in the startup and operation of JEA's Northside Generating Station CFB. The Simulator shall be high fidelity and be capable of verifying operating procedures in addition to tuning and verifying engineering design changes made to the actual unit. The successful bidder shall supply the best available technology that will functionally meet the specification and, at the same time, is cost advantageous to JEA. The simulator shall be capable of simulating

- Complete cold, warm, and hot startups
- Complete shutdown
- Load Changes
- Normal operating conditions
- Abnormal operating conditions
- Emergency operating conditions including runbacks and trips

1.2 Project Scope

The successful bidder shall meet the following general requirements of this specification. The equipment and the services furnished by the successful bidder in response to this solicitation will be complete in all respects for a computer-based simulator installation. The successful bidder shall:

- Provide simulator hardware, and software for an operator workstation, instructor workstation, ABB Symphony Plus (ABB S+) simulator and plant simulator
- Provide model development using data and information provided by JEA and reviewed by the successful bidder for accuracy and compatibility with their work
- Ensure that the simulator is capable of performing all tasks as defined by this specification
- Ensure that the simulator meets all performance criteria as defined by this specification
- Provide simulator documentation as defined by this specification
- Perform Inspection and Testing as defined by this specification
- Provide simulator training to JEA personnel as described by this specification

2 Plant Information for Simulator Basis

JEA's Northside Generating Station CFB Boiler unit consists of a General Electric (GE) D-6 model reheat steam turbine which is supplied with steam from a petcoke and coal fired CFB boiler. The boiler can co-fire up to ten percent natural gas as well. Natural gas is also used for startup.

2.1 BOP

The BOP primarily consists of the steam turbine generator, condensate, Feedwater systems, and auxiliary systems. The generator is controlled by a GE EX2100 exciter. The condensers utilized for the condensate system are two pass, shell and tube heat exchangers. The feedwater system consists of two boiler feed pumps (BFP). BFP A is driven by an electric motor and BFP B driven by the main turbine shaft. The Feedwater and condensate systems also consist of three low pressure heat exchangers, a deaerator, and two high pressure heat exchangers.

2.2 CFB Boilers

The CFB Boilers supply superheated steam and reheat steam to the steam turbine generator.. The CFB boiler is composed of the Furnace, three duct burners, three above bed burners, Cyclones, Integrated Recycle Heat Exchangers (INTREX), Stripper Coolers, a Heat Recovery Area (HRA), a primary superheater, intermediate superheaters in two of the INTREX's, a finishing superheater in the last INTREX, a reheater, and an economizer. The CFB boiler also includes a dry bed ash removal system.

2.3 AQCS

The Air Quality Control System (AQCS) is a multistage process to reduce stack emissions. First, limestone is injected using blowers to furnace to consume sulfur dioxide (SO_2). Then ammonia is injected into the flue gas and controls nitrous oxide (NO_X) through the Selective Non-Catalytic Reduction (SNCR) System. In the flue gas path leaving the boiler and air heaters, recycle fly ash slurry is added through a Spray Dryer Absorber (SDA or scrubber) to the flue gas to remove more (SO_2). The SDA was manufactured by Wheelabrator. Lastly, flue gas is passed through fabric filters in the baghouse to remove any particulates from the flue gas before it reaches the stack. The AQCS also includes a fly ash removal system, which removes particulates from hoppers located under the primary and secondary air heaters, the economizer and the baghouse.

2.4 Additional Plant Information

Additional nominal plant parameters and equipment information are provided in table 2-1.

Table 2-1 JEA's Northside Generating Station Equipment and Plant Parameters

Configuration Item	Plant Configuration
Net MWe at 100% power (base load)	310 MWs
Steam Turbine Model / Generator	GE D-6 Turbine / GE Generator
Steam Turbine Generator Excitation	EX2100

Configuration Item	Plant Configuration
Steam Turbine Controls	ABB Composer V6.0
Steam Turbine HMI	ABB Symphony Plus V2.0.4
BOP Distributed Control System (DCS)	ABB Symphony Plus V2.0.4
Number of Displays per Operator Station	16 Displays: 6 consoles each having 2 monitors and 4 of the consoles having an additional large overview monitor
Duct and Above Bed Burners	Yes, 3 above bed burners and 3 duct burners
Main Steam Pressure (psi)	2500
Main Steam Temperature (°F)	1000
Total Main Steam Flow (Kpph) to turbine	2200
Number of Feedwater Pumps	2
Feedwater Pump Configuration	A pump is driven by an electric motor B pump is driven by the main turbine shaft
Number of Condensate Pumps	2
Number of Circulating Water Pumps	2
Are PLCs Used? If so, for which systems	Yes: Allen Bradley (AB) PLC’s are used on Fly Ash, Bed Ash, Soot Blower, and Demineralization

3 Codes and Standards

All work shall be, at a minimum, in accordance with the standard ANSI/ISA 77.20.01-2012, Fossil Fuel Power Plant Simulators: Functional Requirements. Any performance criteria specified in this specification that exceeds those in ANSI/ISA 77.20.01-2012 shall take precedence. Exceptions to the codes and standards shall be clearly stated by the successful bidder. Any additional standards governing the work performed within the scope of this document shall be listed as well. It is the responsibility of the successful bidder to report any conflict within this specification with the codes and standards. The successful bidder shall also propose means of resolving any such conflicts.

3.1 Quality Assurance

The successful bidder, suppliers, and subcontractors will have in effect in their shops at all times an inspection, testing, and documentation program that will ensure that the equipment furnished under this specification meets, in all respects, the requirements of this specification. No formal submittal of this program is required.

JEA or their authorized representatives will be allowed access to the offices, shops, and working areas of the successful bidder and subcontractors at all reasonable times for the purpose of audit and/or surveillance of quality assurance/quality control procedures and programs as applicable to the work described in this Specification

4 Simulator Hardware Requirements

The simulator shall consist of windows based computers and shall include:

- Operator Workstation Hardware
- Instructor/Engineering Workstation Hardware
- All other hardware required for installation and operation of the ABB S+ Virtual controller software, plant modeling software and any other software required to make the simulator function as required by this specification.
- Any other equipment required for other simulator features shall also be included.

4.1 General Computer Requirements

Computer systems provided by the successful bidder shall be complete with all peripherals and associated support equipment. The speed, memory, graphic cards, and LED displays of the simulator computers shall be adequate to ensure a screen refresh rate equal to the cycle time of the proposed process model.

All computer system equipment, unless otherwise approved, will be supplied by a computer vendor who offers domestically available sales, parts, and technical support services.

All provided equipment shall be capable of being easily field upgradable.

Specifications for proposed computer equipment shall be submitted in the bid proposal. The successful bidder shall list the manufacturer, types, and models of each computer. The list shall have sufficient information to allow determination of:

- The number of CPUs proposed
- Memory size
- Spare memory available for each proposed CPU
- Peripheral devices for each CPU

All computers shall have at least two hard drives in a RAID 1 configuration for the purpose of mirroring data. The hard drive capacities shall be determined by the successful bidder based on software system requirements. It is the responsibility of the bidder to determine that the storage devices selected have access times that adequately meet the response time requirements for the entire system.

The successful bidder shall include a drawing showing the proposed configuration utilizing the existing simulator space and an equipment list. The drawing shall detail how the operator station, instructor station, and all other simulator hardware will interface.

Any deviations from these requirements shall be submitted for review and acceptance prior to incorporation into the system design.

4.2 Operator Workstation hardware

The operator hardware shall include operator workstations that shall be identical in appearance, response, and functionality to the equipment installed in the NGS control room. The workstation furniture is provided from the previous simulator and will be reused for the new simulator. The operator workstation will consist of one 42” 16:9 overview LCD monitor and eight 24” 1920 x 1200 LED monitors in a similar layout as those in the control room. The 24” monitors in use in the control room are Dell U2413 and the 42” monitors are NEC V423. If these models are unavailable, replace with a comparable monitor of the same size. Panels containing drum level indication, trip buttons and any other indication or control function that exist at the NGS operator workstation, but is not controlled from the S+ console, shall be included in the simulator operator workstation. This will be performed by utilizing the breaker panel from the existing simulator or utilizing a soft panel to control manual breakers not in S+.

4.3 Instructor/Engineering Workstation Hardware

The simulator hardware shall include an instructor workstation that shall include a computer with two 24" 1920 x 1200 LED monitors or more depending on the needs of the instructor station. The instructor workstation shall provide access to the plant model software. The instructor workstation shall be able to display any screen that the operator workstation can display. The instructor workstation shall also be connected to a printer for printing training reports and other reports as required. JEA already has a printer that was used on the previous simulator. The printer is an HP Color Laser Jet 3800dn. Utilize this printer for the new simulator, if possible.

4.4 Other Simulator Hardware

The simulator hardware shall include all hardware required to house and run the simulated plant models and the ABB virtual S+ controllers as well as all hardware required to establish and maintain communications between the simulator hardware components. Utilize existing desk and monitor mounting system. A minimum of 50% spare hard drive and 50% spare memory capacity shall be provided for all machines used for plant modeling. Programs operating in the background shall not affect programs operating in real time. Speakers will be needed to allow for audible alarms.

4.5 Hardware performance

The successful bidder shall be responsible for demonstrating that the computer system offered will perform adequately to meet all requirements of this specification. If at the completion of acceptance testing the successful bidder's computer does not meet all of the specifications, the successful bidder shall install additional hardware to meet the specifications at no additional cost to JEA. JEA will have the right to review and approve any modification or addition to the proposed simulator computer hardware.

The simulator will be designed to operate for extended periods of time. The design will provide 95% system availability. The design objective of all equipment will be based on continuous use with a minimum need for scheduled maintenance.

4.6 Hardware Electrical Requirements

The successful bidder shall provide all equipment with three prong molded plugs that have been UL approved.

Terminal barrier strips and terminals used for distribution of AC and DC voltages will be covered to avoid accidental contact and labeled as to voltages concerned. All exposed metal surfaces will be at earth ground potential. Where design considerations require plugs and receptacles of similar configuration in close proximity, the mating plugs and receptacles will be suitably coded or marked to clearly indicate the mating connections. Ground fault interrupter circuit breakers will be provided on any 120V AC circuits within the panels and consoles as required for safety. The simulator room has access to four 120V AC receptacles for the simulator and hardware. There are additional receptacles available for the instructor's station. Ground fault interrupter circuit breakers are in service for these receptacles.

5 Simulator Software Requirements

The simulator software shall be able to perform the necessary functions required for simulator operation and meet the requirements of this specification completely. Any alternatives or deviations from the specification shall be clearly identified and thoroughly explained in the successful bidder's proposal. The successful bidder shall clearly state in their proposal all licensing and copyright restrictions for all software installed in the simulator. The successful bidder's license should include the ability for JEA to modify the simulator software as plant modifications occur. JEA shall not be limited in any way from modifying the simulator and modeling software. The simulator software shall be designed to allow installation and operation on any standard PC that meets the minimum hardware requirements. Simulator software shall be included for

- Operator Workstation
- Instructor Control station
- ABB S+ virtual controller
- Plant modeling software and any other software required to make the simulator function as required by this specification.
- Any software required for additional simulator features

The successful bidder will furnish complete source code (program level language) for all system programs and other software developed for this contract on a machine-readable media. The source code shall be annotated with comments so that JEA personnel can maintain and modify the Simulator.

5.1 Operator Workstation Software

The simulator operator workstation shall be designed so that the operator cannot discern any difference between the operation of the simulator and that of the live unit. The operator workstation human machine interface (HMI) shall contain the same revisions of ABB software that are contained on the NGS operator workstation HMI. The HMI operating system and all other programs required for plant operation shall also be the same revisions as what is installed on the NGS operator workstation HMI. The HMI graphics and ABB software configuration shall use the same files as those used by the live system. Any files changed in the live system shall be able to be changed on the simulator using any method that they can be used by the live system. Utilize existing breaker box to simulate breakers and switches not in S+. If it would be more effective, remove breaker box and use a soft panel for devices not in S+.

5.2 Instructor Control Station Software

The instructor's control station will be configured with a console that enables complete control of the simulation process. The console will be designed for ease and convenience of use and maintenance by the instructor.

The simulator instructor workstation software requirements shall include all of the software and software configuration requirements of the operator workstation. The instructor workstation shall also include all software to allow the instructor to access the S+ virtual controller and model computers and make any required changes. All software required for training reporting shall be included on the instructor workstation. The instructor shall also have the ability to print the reports to a .pdf file so they can be transferred electronically and opened from any standard PC that has Adobe reader installed.

The instructors control station shall be designed to allow the instructor to concentrate on the activities of the operator trainees and not the operation of the simulator. The instructor's console shall be designed using good ergonomics to promote ease of use and to reduce error.

For details on the functions available from the instructor control station and other instructor control station requirements, see section 7.2.

5.3 ABB S+ Virtual Controller Software

ABB S+ Virtual Controller Software shall be used for control system emulation. The virtual controller will be loaded with the same files that are loaded in the controllers in the live system. The software shall allow any changes that are made to the live system control logic to be replicated to the simulator using the same method that was used to change the live system. All control system features that are available to the operator in the live control room shall be available to the operator using the simulator HMI.

5.4 Plant Model Simulator Software

The simulator software shall be designed such that the simulator system response is the same as the response of the live plant. This requires that simulator fidelity be high enough and the rate of software processing be fast enough to ensure that meter and recorder response is smooth and control delays are not noticeable to the operator. The opening of all simulator graphics shall have sufficient speed so that new displays are called up no slower than in the live control room.

The plant system programs will be based on first principle mathematical models that are designed using physical equations in conjunction with numerical techniques or an acceptable simplification thereof for the simulated phenomena.

The design and configuration of the delivered simulator software system will be such that all the program modifications that require recompilation or reassembly can be accomplished on the simulator computer system using utility and program development.

The simulator software shall include a set of modeling tools allowing the user to update the models as plant changes occur. These modeling tools shall include at least a two phase fluid modeling network, an electrical distribution network and relay modeling. The modeling tools architecture shall allow for graphical modeling of systems allowing the user to view the extent of simulation and allow for changes to the models as necessary with minimal impact on initial conditions and initial conditions maintenance.

The simulator software shall include a means for protecting the loaded plant models being used for training so that programming can be performed on the simulator without risk of unintentionally changing the plant models.

5.5 Testing and Diagnostic Software

All diagnostic programs and documentation provided with the computer system by the computer vendor shall be supplied to JEA. Any diagnostic software associated with special peripheral devices shall be supplied to JEA.

Equipment troubleshooting diagnostic programs will be provided to assist in the detection and repair of hardware system problems and equipment failure. These programs will be executed from the instructor's console, will be written to allow on-line hardware checks and will be incorporated as part of the total simulator testing procedure.

6 Simulation Model and Plant Model Data

6.1 Sources of Plant Model Data

The plant model design data is the data that is to be used as the design baseline for the simulator. Plant operating data is the data that represents plant control and process response of the actual plant. The successful bidder shall use the most recent design data, operating data and information furnished by or on behalf of JEA for performing work. The successful bidder shall review all provided data and information for reasonable accuracy and compatibility with the work. The successful bidder shall review the specification and shall notify JEA of any obvious error, inconsistency, or omission in the specification.

JEA will provide as available the following to the successful bidder for the design and manufacture of the specified simulator:

- Drawings and data on S+ and Control room console layout
- S+ database of I/O points
- Plant startup and alarm response procedures
- Piping and instrumentation drawings
- S+ control logic drawings
- Electrical Schematics
- OEM S+ manuals
- Heat Balance Data
- Performance curves for all pumps to be modeled
- Piping system volume and masses
- Steam turbine performance kit
- Existing system descriptions
- Generator performance curves
- Unit Protection System Logic Diagrams
- Plant engineering data books and equipment manuals as requested
- Boiler, AQCS, and turbine physical parameters
- Auxiliary equipment physical parameters
- Electrical system design data including metering and relaying three line diagrams and protective relay settings
- Operating Logs
- Results of plant performance test
- Process Information (PI) Data

Responses such as instrument noise, shrink and swell for water level, electrical motor starting current surges, etc., may not be specifically identified in the data provided by JEA, but occur in all plants and shall be accurately simulated.

Any additional information required by the successful bidder shall be identified in the proposal.

Available design data will be furnished to the successful bidder in a timely manner after contract signing but no later than the data freeze date that shall be established jointly by JEA and the successful bidder after contract award. It shall be the responsibility of the successful bidder to identify any additional design data necessary for the development of the simulator prior to the data freeze date. The freeze date shall not limit data that supports the design of the simulator that was approved prior to the freeze date. As long as the data applies to the design approved prior to the data freeze, the successful bidder shall incorporate the data into the simulator at no additional cost to JEA or schedule change.

In the event that the successful bidder determines that a void or conflict in the design data exists after the data freeze date, the successful bidder shall identify such void or conflict and propose alternate data, methods of filling the void, or resolution of the conflict which may be incorporated at no cost to JEA and without schedule change. JEA shall have 14 days to review and accept the successful bidder's proposed solution or to determine its own solution and provide the necessary data required to implement that solution. The selected solution shall be incorporated at no additional cost to JEA or schedule change. If JEA has not accepted the successful bidder's proposed solution or determined an alternate solution within the 14 day period, the successful bidder may proceed with design using the successful bidder's solution.

If the successful bidder needs data that was not initially identified as design data and was not requested by the successful bidder, JEA shall have three weeks from the date of JEA's receipt of the successful bidder's written notice in which to provide such data at no additional cost to JEA or schedule change. If JEA does not have the requested data they will advise the successful bidder within 7 days and successful bidder will propose alternate data and both parties shall agree upon the data to be used within the 14 day period.

The successful bidder will prepare a list of data that had been made available indicating the latest revision of the data. This will constitute the design database report and will contain the data used in the simulator design. The design database report will be provided to JEA for review, comment and acceptance. JEA will review the design database report and within 30 days after receipt either accept the report or provide comments which will be incorporated at no additional cost to JEA or schedule change. Acceptance will constitute the basis for the design obligation of the successful bidder and serve as the basis for measuring the successful bidder's compliance with these specifications during the acceptance and warranty period.

6.2 Component Simulation

Simulation requirements for components common to many systems are described below.

6.2.1 Pumps, Fans, and Blowers

Pump, fan, and blower models will utilize the actual flow vs. head curves, if available, or design flow versus head curves. Pumps, fans, or blowers which discharge to a common header at some downstream location shall be modeled to reflect the existence of any discharge check valves. The effects provided shall reflect the number of pumps in operation.

Cavitations of pumps shall be simulated in a realistic manner. Where observable, the cavitations shall occur upon loss of pump suction head. The cavitations shall affect such observable parameters as flow and pressure in the affected system as well as amperes in the electrical system. Locked rotor resulting from prolonged cavitations may be handled by a malfunction initiated from the instructor station.

The calculations of current for larger pumps, fans, and blowers shall be simulated with consideration of pump, fan, and blower work. The pump currents shall be summed by the electrical distribution model to provide proper electrical effects. For larger pumps, fans, and blowers, the thermal input to the fluid shall also be simulated, including the effects of density changes, and included in the thermal hydraulics computation.

The associated interlock and switching logic of pumps and fans shall be simulated to provide proper operator control and protection operations. The simulation of breakers shall also account for loss of bus and control power and subsequent return of power.

Variable flow as well as reverse flow and natural circulation, where appropriate, shall be simulated. The operation of the pumps, including startup and coast-down transients, shall be accurately and realistically modeled.

6.2.2 Valves and Dampers

The valves and dampers interlock and switching logic shall be simulated to provide proper operator control and protection operations. The availability of the control power and/or motor power shall be included. In the case of air operated solenoid valves, the operating air pressure and supply header pressure shall be considered. Where appropriate, the nonlinear characteristics of the valve or damper shall be represented. Each valve and damper shall have separate ramp open rates and ramp close rates. Modulated valves will be simulated as well as appropriate isolation valves. Steam bypass valves such as those for startup and shutdown as well as any desuperheater valves on the unit shall be appropriately simulated to display the nonlinear characteristics of system dynamics with regards to flow, temperature and pressure.

Valve and damper positions shall be used by mathematical models to compute fluid flows. Any nonlinear characteristics due to position shall be included in model computation as required. Remotely operated manual valves and dampers shall have realistic effects on flows, temperatures, and pressures. There shall be no instantaneous opening or closing of valves or dampers. Failure modes (Fail Open, Fail Close, Fail in Place) shall be simulated.

6.2.3 Heat Exchangers

Heat exchanger simulation shall reflect the effects of changing flow and temperature in either the primary or secondary fluid as well as the thermal capacitance of fluids and metal.

Simulation of single phase heat exchangers, such as turbine lube oil coolers, shall utilize the log mean temperature difference and textbook "effectiveness" calculations. Also, the type of heat exchanger, i.e., parallel flow or counter flow, shall be reflected in the modeling.

Two-phase heat exchangers such as the feedwater heaters, condenser, reheaters, etc., shall employ mass and energy balances.

Where appropriate, regions of superheat, saturation, and sub cooling shall be incorporated into the model.

6.2.4 INTREX's, Cyclones, and Stripper Coolers

INTREX and Cyclone simulation shall be modeled the same as a heat exchanger. INTREX simulation shall reflect that the primary fluid is circulating solid and the secondary fluid is steam. Cyclone simulation shall employ mass and energy balances to model the flows of flue gas, solids in the Cyclone, and steam flow in the Cyclone tubes.

Stripper Cooler simulation shall model the separation of bed ash from the combustibles to be returned to the furnace. The simulation shall employ mass and energy balances to model flow of solids into the Stripper Cooler from the furnace and out of the Stripper Cooler to the bed ash removal system as well as the temperature pickup in the condensate system due to the flow of condensate water through the stripper cooler heat exchangers.

6.2.5 Controls, Interlocks, Trips, and Alarms

All models of plant systems and components shall include the associated controls, interlocks, trips, and alarms. This includes modulating controls such as PID controllers as well as permissives, overrides, and run backs.

The simulator should replicate the logic and control of the plant. This should include the logic and control that exists in S+ as well as other logic and control that remains in relay form and any other interlocks. The relay diagram modeling should allow the instructor or the student to graphically view the behavior of the logic as the simulator is being used. All of the ABB S+ control logic shall be the exact logic that exists in the live control system. The successful bidder shall clearly state in his proposal his experience and understanding of ABB S+ and Composer control logic functional blocks.

JEA shall supply the most current version of all of the ABB S+ binary files as well as the latest ABB Composer project files for the successful bidder to load the control logic into the S+ virtual controller. The successful bidder shall state in the proposal the date by which the information from JEA will be required.

6.3 Scope of System Simulation

The following lists the scope of simulation of the various plant operating systems that are to be incorporated in the simulator models. This list is provided for information and in no way should be construed to limit the scope of the simulator to carry out normal plant operations or malfunctions. Systems and functions that are remotely operated or provide some input into the simulation models and are necessary to perform the plant operations and malfunctions shall be simulated.

The development of the simulator models shall be based on the process and control systems incorporated in JEA's Northside Generating Station. Unless otherwise noted, the functions simulated by the models shall include all process systems controlled from the S+ and those items controlled from auxiliary panels installed in the control room. They shall also include all control and information display functions available on the S+ and control room auxiliary panels. The control functions shall include process controls of the modulating type and discrete control logic for on-off operation of all plant equipment.

Unless otherwise noted the models shall be designed based on first principles to simulate plant operation from cold startup to maximum load under steady-state and transient conditions, taking into account the effects of changing parameters such as pressure, temperature, flow, and level. The effects of these parameters due to starting and stopping of all plant auxiliary equipment shall also be taken into account. All models shall provide response of the same magnitude and in the same direction that the plant would give under an equivalent set of circumstances.

Unless otherwise noted the control system models shall be a complete duplication of the systems simulated including all controllers, mode selection, interlock, and alarm functions.

Unless otherwise noted, the simulator shall be capable of duplicating operation of all systems simulated at ambient temperatures anywhere from 20 degrees F to 105 degrees F.

Unless otherwise noted, control logic models for motors, solenoid valves, and similar devices simulated shall include all starting permissives, alarm outputs, interlocking and tripping functions.

A description of the scope of modeling proposed, including sample models used, shall be provided with the successful bidder's proposal.

6.3.1 Systems Simulations

In addition to the simulation requirements included in elsewhere in this specification, the simulator shall include, but not be limited to, the following plant systems and components:

1. Solid Fuel Control Systems
2. Natural Gas Burner Control Systems

3. CFB Boiler System
4. Steam Turbine and Bypass System
5. Condensate System
6. Feedwater System
7. Generator Systems
8. Station Electrical System
9. Circulating Water System
10. Closed Cooling Water System
11. Auxiliary Steam System
12. S+ DCS
13. Soot Blower System
14. Primary, Secondary, INTREX, and Seal Pot Air Systems
15. Furnace Draft System
16. Bed Ash System
17. Fly Ash System
18. Limestone Injection System
19. Recycle Slurry SDA System
20. Cyclone and INTREX Systems
21. Lube Oil Systems
22. Turbine Pre-warming

6.4 System Modeling Requirements

Specific modeling requirements are detailed below for each system.

6.4.1 CFB Boiler System

The simulation shall accurately model the CFB. The model will accurately compute the constituents, thermal and transport properties of the Hot Loop of the CFB Boiler. The temperatures of CFB Boiler and steam shall be computed at all points that are displayed in the plant control room.

Simulation modeling of the CFB model shall include complete and realistic heat generation and heat transfer to all major components including, but not limited to drums, reheaters, superheaters (both in HRA and INTREX), air heaters, economizers, and AQCS Systems. The effect of fouling on heat transfer surfaces and its impact on heat transfer coefficients shall be accurately modeled. The pressures, temperatures and flows displayed in the control room shall be computed and displayed.

<u>Drums</u>

Simulation modeling of the drums shall compute the drum pressure, level and temperature under all operating conditions. The inlets of water from the economizer, cold fill line and evaporator tubes, and the outlets to the steam lines shall be simulated. The various drains and vents, including the blow down lines, shall be simulated along with the energy content to compute the level and pressure. Each boiler feed pump shall be modeled. Steam properties shall be used for these computations. Swelling and shrinking effects of the drum level shall be simulated.

<u>Superheaters and Reheater</u>

Simulation modeling of the superheater shall include all superheater and reheater tube sections. Drain and vent valves shall be simulated. The de-superheating stations for the superheater and reheater shall be simulated. This model shall compute the outlet steam flow and temperatures from the superheaters and reheater. The superheater model shall include proper outlet temperature response from HP and reheat de-superheater system as well as from water induction caused by high drum level water carryover. Superheater and reheater flue gas material and energy balances shall include response to outlet damper position.

<u>AQCS</u>

The simulation of the AQCS system shall include realistic models of all major components of AQCS systems including, but limited to, limestone addition to furnace, ammonia injection, SDA, and baghouse (fly ash removal system). All AQCS parameters in the control room and of importance shall be included in the simulation.

<u>Cyclones and INTREX's</u>

Simulation of the Cyclones and INTREX's shall include realistic models of all major components.

Simulation shall adjust performance of Cyclones and INTREX's with varied furnace conditions and bed ash removal conditions. The failure of this system will be reflected in other systems.

6.4.2 CFB Air System

Simulation modeling of the air system shall include complete and realistic models of all major components including, but not limited to, dampers, fans, and blowers as well as all associated ducts. The various dampers in the air path shall be included in the computation of the flows and pressure. The various fans and blowers shall be included in the computation of flow and pressure as well.

Interlocks and trip logics shall be simulated for each piece of equipment. Alarms as generated in the actual plant shall be simulated. Variables that are displayed in the control room shall be simulated and displayed at the simulator operator station. Control actions possible from the control room shall be possible from the simulator operator station.

6.4.3 Fuel and Burner Control Systems

Simulation of varied fuel ratios shall be provided. Simulation shall take into account the material and energy balances associated with varied amounts of each fuel. This shall include, but not limited to, the fuel required to run the unit due to varied BTU content of fuel and the amount of bed and fly ash produced due to varied fuel ratio. The instructor shall have the ability to set the sulfur content and the BTU content for petcoke and coal. The table below shows the range which each fuel can be burned. Each fuel can be burned within this range to add up to 100% of fuel entering furnace. JEA will provide historical data of fuel ratios previously ran.

Table 6-1 <u>Range of Fuel Ratios for Each Individual Fuel</u>

Fuel	Range of Possible Contribution to Fuel Ratio
Coal	0%-100%
Petcoke	0%-100%
Natural Gas	0%-10%

Solid Fuel System

Simulation modeling of the coal and petcoke system shall include complete and realistic models of major components including, but not limited to conveyors, fuel feeders, control valves, and silos.

Interlock and trip logics shall be simulated for the. Alarms displayed in the control room shall be simulated. Variables displayed in the control room shall be included for simulation.

Gas Fuel System

Simulation modeling of the natural gas system shall include complete realistic models of major components including, but not limited to, the trip and control valves, elbow duct burners, above bed burners, and associated valves and pipes.

6.4.4 Steam Turbine and Bypass System

Steam Turbine

Simulation modeling of the turbine shall include all stages of the high-pressure, all stages of the intermediate-pressure and all stages of the low-pressure turbine sections. It should model all HP, IP and LP flow additions and steam bypass operations. The simulation shall compute the steam flow, pressure, temperatures and turbine speed under various loads, startup and shutdown conditions. Accurate response of turbine differential and casing temperatures, turbine metal and bearing temperatures, eccentricities, vibration, water induction control, and other critical parameters shall be included in the simulation. The steam turbine model shall provide accurate simulation response to water induction whether caused by erroneous steam temperature control, excessive superheat or reheat spray flows or high drum level induced water carryover.

Steam Bypass System

Simulation modeling of the steam bypass system shall include computation of all bypass steam flows. The system shall accurately model, but not limited to, the steam bypass system for startup, shutdown and bypass operation. The effect on the condenser and the overall cycle shall be included.

Turbine Oil System

Simulation modeling of the turbine oil system shall include, but not limited to, the main and emergency oil pumps, along with the relevant interlocks, tanks, valves and coolers.

Gland Steam System

Simulation modeling of the gland steam system shall include all the devices and conditions necessary to provide realistic training to the operator.

Turbine Turning Gear

Simulation modeling of the turning gear shall include the turning gear along with its associated interlocks and realistic responses for operator training.

Turbine Supervisory Monitoring System

Simulation modeling of the turbine supervisory monitoring system shall include replicating the displays and readings under different operating conditions so as to provide realistic training.

Turbine EHC System

Simulation modeling of the turbine EHC system shall include all the devices and conditions necessary to provide realistic training to the operator along with the relevant interlocks and system components

6.4.5 Condensate System

Condenser and Hotwell

Simulation modeling of the condenser system shall include complete and realistic models of major components including, but not limited to, vacuum pumps and vacuum breaker along with the associated valves, piping and controls.

The simulation shall model the condensation of steam entering the condenser, the condenser vacuum, and the hotwell level accurately. The atmospheric relief valve shall be accurately modeled.

Interlock and trip logics shall be simulated for the condensate system equipment. Alarms displayed in the control room shall be simulated. Control actions performed from the control room shall be possible from the simulator operator station. Variables displayed in the control room shall be simulated and displayed at the operator station.

Condensate Pumps & LP Heaters

Simulation modeling of the condensate system shall include complete and realistic models of major components including, but not limited to, condenser hotwell, condensate pumps, make-up water tank, deaerator and the hotwell level control unit along with the associated valves, piping and controls.

The simulation shall model the condensate flow, the makeup flow, the excess return flow, the recirculation flow and the hotwell level. The differences between startup flows and normal flows and their effects on operation shall be incorporated in the simulator. The characteristic curve for the condensate pumps shall be included for simulation. Interlock and trip logics shall be simulated for the condensate system equipment. Alarms displayed in the control room shall be included for simulation. Control actions performed from the control room shall be possible from the simulator operator station. Variables displayed in the control room shall be simulated and displayed at the simulator operator station.

6.4.6 Feedwater System

Simulation modeling of the feedwater system shall include complete and realistic models of major components including, but not limited to, deaerator, feed water heater sections of the boiler, and boiler feed pump, along with the associated valves, piping and controls.

Simulation modeling shall include the flow, pressure and temperatures of the feedwater along the flow path. The characteristic curve for the feedwater pump shall be included for simulation. The non-linearity of the modulating valves shall be modeled.

Interlock and trip logics shall be simulated for the feedwater system equipment. Alarms displayed in the control room shall be simulated. Control actions performed from the control room shall be possible from the simulator operator station. Variables displayed in the control room shall be simulated and displayed at the simulator operator station.

6.4.7 Generator Systems

The Simulation of the generator shall include accurately computing the generator load, voltage, frequency, reactive power (VARS) and current under different turbine loading and grid conditions. The grid shall be typically considered to be an infinite grid.

The instructor shall have the capability to change the system voltage and frequency, and major electrical items (e.g., motor-driven pumps and fans) will respond accordingly. The simulation shall include accurate and realistic model of major components including, but not limited to generator, voltage regulator, exciter, hydrogen cooling, seal oil system, generator breaker, and generator transformer.

Interlocks for the generator and associated equipment protections and trip logics shall be accurately modeled. Speed matching and synchronization of the generator shall be modeled.

6.4.8 Station Electrical System

Simulation modeling of the electrical system shall include the lining up and charging of the various buses. Loss of power to these buses shall trip the corresponding equipment. The current on the buses shall be computed. Also, for each of the 6900 V, 4160 V and 480 V electrical components, the current, including the starting current, shall be computed. Also starting currents, time-delayed over current breaker trips, voltage/frequency droop and the effect on system performance shall be simulated.

6.4.9 Circulating Water System

Simulation modeling of the circulating water system shall include complete and realistic models of major components including, but not limited to, intake, circulating water pumps, discharge valve, and associated valves, piping and controls.

The simulation shall compute the water flow through the condenser and the water outlet temperature. The inlet temperature of the water shall be an instructor controlled variable.

6.4.10 Cooling Water System

Simulation modeling of the cooling water system shall include complete and realistic models of major components.

The system shall have the capability to train the operators on the proper lining up procedures. Also, failure of the system shall be reflected on the other systems. The effect of temperature excursions related to the cooling water system shall be simulated.

6.4.11 Auxiliary Steam System

The simulation of the auxiliary steam system shall include the different headers and their interconnections, including the pressure reducing stations and turbine pre-warming. All parameters monitored in the control room and of importance shall be included in the simulation.

6.4.12 S+ DCS

The simulation of the S+ DCS shall accurately reflect control characteristics of analog controls and include all permissives, interlocks and trips included in the digital logic. The ABB S+ Virtual Controller Software will be used to emulate the S+ DCS and shall be loaded with the same files that are loaded on the live system.

The trending and alarming features of the DCS system should be identical to those in the control room to provide an operator with the same information as in the control room. The simulation system shall accurately replicate the alarm system and its interface with operators.

6.4.13 Bed Ash Removal

Simulation of the bed ash removal shall include realistic models of all major components.

Bed ash removal system simulation shall adjust performance based on INTREX and furnace conditions. The failure of this system will be reflected in other systems.

Simulation shall calculate bed ash removed by stripper coolers based on CFB Boiler conditions.

7 Simulator Capabilities and Performance Criteria

The response of the Simulator resulting from operator action, no operator action, improper operator action, automatic plant controls, and inherent operating characteristics with and without plant malfunctions will be realistic within the limits of the performance criteria and the functional design specifications.

7.1 Normal Plant Evolutions

The Simulator will be capable of simulating, in real time, plant operations similar to JEA's Northside Generating Station.

The minimum operations that the Simulator will be capable of performing, using only operator action normal to the reference plant, are as follows:

- Integrated plant start-up - cold to 100% load. The starting conditions will be ambient conditions for temperature and pressure for all systems, piping filled with air. The Simulator shall be capable of performing hotwell and drum fill scenarios. Ambient air temperature and river water temperature will be instructor selectable from 20 degrees F to 105 degrees F.
- Integrated plant start-up from warm plant to 100% load.
- Steam turbine trip and recovery of steam turbine back to on line and full load through use of the bypass system.
- Steam turbine generator start-up and generator synchronization.
- Unit start up in forward or reverse flow
- Unit trip followed by recovery to rated load.
- Integrated plant shutdown from 100% load to hot standby and cool-down to cold shutdown conditions.
- Plant maneuvers (equipment swaps, load changes, and/or control by the load dispatch [instructor]).
- Operations to reduce emissions.
- Operator conducted testing on equipment or systems as applicable, (e.g. turbine valves).

7.2 Instructor Station Requirements

The successful bidder shall include a detailed description of its simulator instructor's station console and a description of how each feature is implemented as part of its proposal. Instructor station software will be written such that minimal instructor training is required for performing the functions. See section 5 for additional software requirements for the instruction station.

The displays shall be either graphical or tabular with a graphical or index table overview display providing a list of system and other function displays/pages. Each page will display and continuously update exercise time and clock time, and will provide the capability to jump to any other page without going back to the index. The system pages will be organized in such a way that all malfunctions required by this specification are listed by system. For example, if System X had 3 malfunctions the table might read:

System X Malfunctions (Prefix X)

- System X Leakage (5-500 GPM)

- System X Flow Transmitter Fails High
- System X Motor Trips

The functions and features in the following sections will be implemented on the instructor's console in a manner that the instructor can activate these functions with a minimum amount of effort. These functions and features are the minimum required by JEA and the bidder's shall include the cost of those features.

7.2.1 Initial Conditions

JEA has defined the preliminary Initial Conditions which need to preprogrammed and available for initial use at all times. The simulator needs to be capable of a minimum of 100 initial conditions which can also be used as snap shots during training. Preliminary listing of the specified initial conditions is provided below:

1. Black plant. Electrical distribution needs to be aligned. Cold Start and support systems are at ambient temperature
2. Cold Start and support systems are at ambient temperature and ready to start.
3. Boiler Ready-to-Fire (Cold) Fans and blowers ready to start. Turbine pre-warming required. Turbine first stage metal is <300 degrees F. BOP Support systems are operating.
4. Ready to Roll Turbine (Cold) Steam turbine, HP metal temp > 300 degrees F and < 400 degrees F. Reheat bowl temp >/= 130 degrees F. Boiler "online" with 14" bed and 900 degrees F bed temp.
5. Ready to Roll Turbine (Warm) - Steam turbine , HP metal temp > 400 degrees F < 700 degrees F. Reheat bowl temp >/= 250 degrees F. Boiler "online" with 14" bed and 900 degrees F bed temp.
6. Ready to Roll Turbine (Hot) The turbine-generator has experienced a trip, turbine first stage temperature is > 700 degrees F and is ready for rolling a hot turbine. Boiler stayed "online" at 40% MCR, bypass system in service.
7. Ready to Roll Turbine (Hot) The turbine-generator has experienced a trip, turbine first stage temperature is > 700 degrees F and is ready for rolling a hot turbine. Boiler tripped, bypass system in service.
8. Turbine-Generator Ready to Synchronize - The turbine is rolling approximately 3600 RPM at its final heat soak, ready to synchronize.
9. Minimum Load - The turbine-generator has just been synchronized and is at minimum initial MW load (10% MCR).
10. 150MW - Unit is on line with temperatures and pressures stabilized.
11. 180MW - Unit is on line with temperatures and pressures stabilized.
12. 200MW - Unit is on line with temperatures and pressures stabilized.
13. 250MW - Unit is on line with temperatures and pressures stabilized.
14. 310mw - Unit is on line with temperatures and pressures stabilized.

7.2.2 Plant Malfunctions

The Simulator shall be capable of simulating abnormal and emergency events in real-time including malfunctions and equipment failures to demonstrate inherent plant response and automatic plant control functions.

Variable/Discrete Malfunctions

The malfunctions available will include both discrete and variable malfunctions, which may be applied to plant equipment, controls, and processes. Discrete failures include the failure of the plant equipment to specific states. Variable malfunctions include the failure of plant equipment, controls, or processes to a variable state.

On variable malfunctions, the severity can be set instantaneously or may be ramped over time. An artificially imposed variation in heat exchanger fouling or an imposed drift in the signal from the sensing element is a typical variable malfunction. Where operator actions are a function of the degree of severity of the malfunction (e.g., tube leaks, loss of vacuum, and condenser tube failure, etc.) the Simulator shall have adjustable rates for the malfunction to represent a selectable range of plant malfunction conditions. The instructor shall be able to make variable malfunctions become progressively larger or smaller from the instructor station without clearing the malfunction.

Adding Malfunctions

The introduction of a malfunction will not alert the operator to the impending malfunction, except through alarms that would normally occur in the control room.

The Simulator should have the capability of generic type malfunctions that can be applied to any component such transmitter, pump, valve, etc. In addition to the agreed upon list that will be tested in the acceptance testing and will require malfunction cause and effect documents, the successful bidder shall provide the instructor, through the malfunction feature, the ability to fail every pump, fan, motor operated or control valve, heat exchanger, transmitter, and control element on the Simulator.

The successful bidder shall provide the instructor with the capability to add or modify malfunctions. The malfunctions the instructor adds or modifies shall function in a manner identical to those provided by the successful bidder. The instructor shall be able to compose a set of malfunctions and save it for later use as a composite malfunction.

If the successful bidder includes an incremental price for redundant components, such as Feedwater Pump 4A/4B, the successful bidder shall propose a cost reduction if JEA limits the malfunctions to only one of the redundant components.

Initiation of Malfunctions

The instructor shall be capable of initiating event-triggered or condition-based malfunctions. Once activated, these malfunctions will initiate automatically based on either time or a variable passing through a pre-set limit (e.g. BFP trip at 100MW). It will be possible to insert a malfunction by setting a finite time delay from time of entry or by specifying a "clock time" for initiation. The time delay feature will be based on exercise or scenario time (time elapsed since initialization and start) periods during which the Simulator is in freeze, the time displayed on the operator console will freeze as well.

Malfunctions shall be expected to have the ability to occur simultaneously if they can occur by virtue of actual plant design or simulator configuration or if they have occurred in actual operational experience of the reference plant. The Simulator shall be capable of simulating a minimum of 10 non-conflicting simultaneous malfunctions. Multiple effects that result from a discrete malfunction are not considered as separate malfunctions.

Clearing Malfunctions

The instructor shall be able to determine which malfunctions are active using the instructor's station. The instructor shall be able to clear all malfunctions by use of a single instructor console control and also be able to clear individual malfunctions. The instructor shall be able to clear all malfunctions automatically at the end of each training exercise as indicated by selection of a new Initial Condition (except for malfunctions active within the new IC).

7.2.3 Partial Malfunction List

The Simulator will be initially programmed by the successful bidder with a minimum of 50 malfunctions. As part of the successful bidder's training, the JEA simulator instructor(s) will be trained on creating new and editing existing malfunctions.

A preliminary list of malfunctions that may be selected by JEA is included below. The successful bidder is encouraged to identify any malfunctions it believes will increase the planned scope of the Simulator models and will, therefore, result in an incremental increase in the cost of the Simulator. The cost deduction for removing such malfunctions shall be indicated.

Provided in this partial list are sample malfunctions. The malfunction list will be finalized upon mutual agreement between JEA and the successful bidder.

Condenser

1. Hotwell level (high and low)
2. High condenser hotwell temp
3. Bad water quality (High sodium in hotwell, high sodium CPD)
4. Low condensate pump suction pressure

Feedwater/Condensate

1. Low Boiler Feed Pump (BFP) suction pressure
2. BFP Recirculating Valve failure
3. BFP motor and pump high vibration
4. BFP lube oil pressure low
5. BFP high discharge pressure
6. BFP coupling failure
7. Fluid drive loss of oil
8. High oil temperature
9. BFP motor bearing failure
10. Feed Water Heater (FWH) high level
11. FWH low level
12. One of two BFP trip
13. Condensate booster pump low flow
14. Condensate booster pump trip
15. Heater drain pump trip
16. Bed ash cooling pump trips

Boiler water / Steam Generator

1. Low drum level
2. High drum level
3. High drum pressure
4. High steam outlet temperature on HRH and HP
5. High HRH outlet steam temperature
6. High HP steam outlet temperature
7. Water Chemistry excursion
8. Spray water valve failure (TCV and isolation valve)

Steam Turbine

1. Bearing Vibration
2. Bearing Temperature
3. High exhaust temp
4. Lube oil temp high
5. Exhaust pressure high (low vacuum)
6. Low lube oil pressure
7. over speed incident
8. Control valve failure (single CV, single MSSV, single CRV)
9. Low steam seal pressure
10. High steam seal temperature
11. Low HRH steam pressure
12. Low Main steam pressure
13. High eccentricity
14. Differential expansion (high and low)
15. Rotor expansion (high and low)
16. HP exhaust temperature
17. L1 stage steam temperature (high and high trip)
18. Exhaust vacuum trip
19. Lube oil low pressure
20. Lube oil level (low, low low and low trip)
21. Hydraulic fluid pressure low
22. Emergency over speed
23. Axial position trip
24. CV/SV LVDT failure
25. Combined reheat valve LVDT failure
26. Hydraulic pump failure
27. Reverse flow valve failure on startup
28. CRH stop check failure to open, close or do anything it’s supposed to do

Boiler / Solid Fuel

1. High NO_X
2. High SO_2
3. Fuel Feeder trip
4. Loss of limestone
5. Slumped bed
6. Fuel feeder belt slipping

7. High bed temperature
8. Low bed temperature
9. High cyclone inlet temperature
10. Superheater protection
11. Cyclone/INTREX plug
12. Bed ash blower high pressure trip
13. Stripper cooler high temperatures
14. Stripper cooler low temperatures

<u>Electrical</u>

1. Switchyard breaker trips
2. Medium voltage breaker trips
3. SU and SS transformer trips
4. 480 main breaker trips
5. Protective relay fail

<u>Cooling Water</u>

1. Circulator pump trip
2. Circulator pump motor overheat
3. Water box inlet or outlet valve failure to open on startup
4. Raw water booster pump fail
5. Closed cooling water pump trip
6. Closed cooling water heat exchanger temperature issues

<u>Generator</u>

1. Loss of Generator Field
2. High vibration
3. Bearing temp high
4. Lube oil failure
5. Generator breaker failure trip
6. Ground detector – trip
7. Excitation trouble
8. Sync lockout
9. EX2100 Trip
10. EX2100 field over excitation
11. Stator cooling water pressure/flow low

<u>Fans</u>

1. Loss of 1 PA fan
2. Loss of 1 SA fan
3. Loss of 1 ID Fan
4. Loss of 1 INTREX blower
5. Loss of 1 seal pot blower
6. Loss of a set of fans (e.g. all “B” fans trip)
7. High duct pressure PA or SA fan
8. Low duct pressure PA or SA fan
9. Low duct pressure Seal Pot and INTREX blowers

AQCS

1. SDA trip
2. High density
3. Low density
4. Low zone SDA temperature
5. Fly ash high vacuum
6. Baghouse high hopper level
7. Recycle bin high / low
8. Low air pressure

7.2.4 Remote Functions

The instructor will be capable of operating equipment included in the simulation for which no controls are included on the control panels. These remote functions, which include such items as remote manual valves and motors, will be implemented to realistically simulate field operation of the component. The remote functions shall be provided in a graphical or tabular form where the instructor simply selects from the list of available remote functions. As part of the simulator design process, the successful bidder will prepare a list of simulator remote functions required for effective training for JEA approval. Following is a list of the type of remote functions that may be required on the Simulator.

Typical Remote Functions List

Provided in this preliminary list are sample remote functions. The remote function list will be finalized upon mutual agreement between JEA and the successful bidder.

1. 4160 Volt Station Service Busses Reset Relays
2. Turning Gear On/Off
3. Condenser Vacuum Breaker Open/Closed
4. Sealing Steam to Main Turbine
5. Gland Seal Condenser Exhauster On/Off
6. Vacuum Pumps On/Off (4)
7. Condensate/Feedwater Cleanup (short cycle)
8. Cooling Water System In/Out of Service
9. Steam Turbine Trip Relays Reset
10. Main Oil Pumps On/Off/Auto
11. Turbine Oil Temperature Controller Off/Auto
12. Generator Lockout Relays Reset
13. Vacuum Trip Reset
14. Turbine Trip Reset
15. Turbine Lockout Relays Reset
16. Startup Valve Line-up Open/Close

17. Condensate Drain to Waste (Off/On)
18. Reheat Spray Isolation Valves Open/Close
19. Main Condenser CW Inlet/Outlet Valves Open/Close
20. ST on Turning Gear On/Off
21. Boiler fan start/stop
22. Damper positions
23. AQCS systems

7.2.5 External Parameters

The instructor shall be capable of manipulating external parameters that affect the simulated unit. These external parameters include such items as ambient temperature. The successful bidder shall provide a cost for up to 30 external parameters that may be required for training effectiveness, as determined during the design review. A preliminary list of external parameters is listed below.

<u>External Parameters</u>

1. Ambient Air Temperature
2. Ambient Air Humidity
3. Circulating Water Inlet Temperature
4. River Water Temperature
5. Generator Hydrogen Pressure
6. Auxiliary Steam Pressure
7. Demineralized Water Tank Level
8. Electrical System Grid Frequency
9. Electrical System Grid Voltage

7.2.6 Instructor Console Features

<u>Freeze/Run</u>

The instructor shall be able to control (freeze/run) all dynamic simulation.

<u>Snapshot</u>

The instructor shall be able to initiate a snapshot of the particular simulator conditions that may exist at any chosen point in time without interrupting any dynamic simulation that may be in progress. This snapshot capability shall also be functional while the Simulator is in the freeze condition. The date, time, and descriptive label of selected parameters shall be recorded with each snapshot.

<u>Master Annunciator Silence On/Off</u>

The instructor shall have the ability to silence the audible annunciators/alarms installed on the simulator.

<u>Backtrack</u>

A backtrack capability shall be provided which periodically records the condition of the Simulator during a training exercise, while not in freeze, such that the instructor may initialize the Simulator to a previous point in the simulation exercise. The instructor shall have the ability to enable or disable this feature.

The Simulator Backtrack Capability will meet the following requirements:

- There will be provision for storing the most recent 120 backtrack records on the disk. The interval between records will be instructor-variable from 1 - 5 minutes. Records will not be stored when the Simulator is in the Freeze state.
- As each backtrack record is saved, the exercise time and clock time will be made available and displayed on a backtrack index table.
- The instructor will be able to access any of the available records from the instructor's station, either by entering the time of the desired record or by manually or automatically stepping in either direction (forward or reverse).
- After retrieving the desired record, by any or all of the methods described above, the instructor will be able to initialize the Simulator to that condition by selecting the Reset function.

Time Scaling

The instructor shall have the capability to select from three distinct modes of operation: real time, fast time, and slow time as detailed below:

Real time is the time mode in which one second of simulation time corresponds to one second of actual plant operation.

Fast time is the time mode used to speed up some lengthy plant evolutions, which represent little or no training value, to move quickly to another point in the plant operation while retaining the continuity of the training exercise. The successful bidder shall provide fast time capabilities for the following parameters:

- Condensate Cleanup
- CFB Boiler Metal and Bed Temperature Heating
- Main Condenser Air Removal
- Steam Turbine Metal Temperature Heating (Pre-warming)

The Instructor shall be able to vary the fast time rate on line (without stopping the simulator session) from 1 to 5 times real time for the parameters listed above.

Slow time is the time mode used to slow down the entire simulation, thereby allowing the operator to observe the action of the simulation model and controls to specific conditions. In the slow time mode, the instructor shall be able to vary the rate of the simulator on line by a factor of 0.5 and 0.1 times real time.

Displays of Simulated Systems and Parameters

The instructor shall be capable of monitoring and trending all simulated plant parameters on the instructor station monitor. This includes thermal hydraulic parameters, logic and control including the DCS parameters. Any screen the operator can see shall be able to be displayed on the instructor's console, or the successful bidder will provide optional pricing for an additional operator console for the instructor area. The instructor shall have the ability to build a group of parameters in tabular form for monitoring trainee performance with the ability to plot trends of these parameters on the screen and/or a printer. Up to 20 parameters will be displayed simultaneously.

Trainee Performance Review

The successful bidder shall provide a Trainee Performance Review (TPR) program, which will simultaneously monitor a minimum of twelve plant parameters. Any parameter that the operator trainee can monitor will be selectable for the TPR. This function shall enable data to be recorded, stored, and recalled for up to ten sessions.

The TPR feature shall be activated, and parameters selected and displayed (including high and low limits for each parameter), at the instructor's station. After activation of the feature, the instructor shall have the capability to monitor selected parameter values, along with high and low limits. If a parameter exceeds its limits, this shall be so indicated on the instructor's display. At the end of each exercise, the TPR shall also record:

- The highest and lowest value of each monitored parameter.
- The greatest amount of time each parameter remained outside its limits.
- The number of times each parameter exceeded its limits.
- An integrated error indicating the percentage of time during the exercise that the operator trainee was outside the operating limits

During the TPR exercise, the simulator will maintain a log of operator actions that the instructor has the ability to print out.

Instrumentation Override

An override feature shall be provided so that all controls, indicators, and annunciators can be failed or otherwise operated by the instructor from the instructor's station. A database query mechanism shall allow override selection based on tag number, simulation variable, and device type. The same flexibility for time-delay and ramping that is provided for malfunctions shall be provided for overrides.

Computer-Aided Exercise

A computer-aided exercise function that allows the instructor to predefine and permanently store a series of drills or operational problems shall be included. Each scenario shall be represented as a time-sequenced list of expert commands. The instructor may define computer-aided exercises with a text editor or by simple menu selection.

Student Tracking

A student tracking feature shall be installed on the instructor station that allows tracking of student time and performance on the simulator. The instructor station shall be password protected and the student tracking feature will keep a record of the log on and off date and time of the students and initial conditions used during their use of the simulator. This feature will also automatically store the data for the Trainee Performance Review and Computer-Aided Exercises, under the student's name.

A list of achievements will be displayed on a screen viewable on the instructor’s and operator’s station. As an achievement is reached a red “X” indication will be replaced with green check or a graphic which clearly indicates to the student that they have met the requirements for this progression. A series of progressions will be established with specific achievement which must be accomplished in a set amount of time. The a snapshot of the check sheet shall be saved in the Trainee Performance Review with achievements and progressions reached and time required to reach each one. As part of the successful bidder’s training, the JEA simulator instructor(s) will be trained on creating new and editing existing achievements and progressions. A preliminary list of achievements and progressions is provided in the list below. Target range or value and time limit for each of these progressions will be provided by JEA.

Progression #1

A. Fans in service/Balanced/Correct air flows
    1. ID Fans
    2. Seal Pot Blowers

3. INTREX Blowers
4. SA Fan Air Flow
5. PA Fans
6. Total Air Flow
7. Purge Complete

B. Bed Ash System in Service
1. Bed Ash Blower in Service
2. Conveyors in Service

Progression #2

A. Fans Balanced
B. >10” Bed Level
C. Boiler Vents and Drains Set
D. Turbine Drains Set
E. Reheat Damper Closed
F. Total PA to Grid Flow
G. Burners in Service
    1. One AB Burner at Minimum Flow
    2. All Duct Burners in Service
H. Cyclone Inlet Average Temperature

Progression #3

A. All Burners in Service
B. Cyclone Inlet Average Temperature
C. Positive Boiler Pressure
D. BFP in Service
    1. In Manual
    2. Discharge Closed
    3. Feedwater Path
    4. Minimum Flow Established

Progression #4

A. Boiler Drains and Vents Closed
B. Boiler Steam Stop Valve Open
C. Cyclone Inlet Average Temperature
D. Rate of Pressure Change

Progression #5

A. Cyclone Inlet Average Temperature
B. Rate of Pressure Change
C. Vacuum Drawn
D. Feedwater Valve in Auto
E. Solid Fuel Established
F. ABB’s Out of Service
G. Maintaining Drum Level
H. Maintaining Bed Level
I. Bypass & SH Sprays in Auto
J. Turbine Rolling

Progression #6

A. Unit on Line
B. Reducing Gas Flow
C. Fuel Flow in Limits
D. Turbine Group A Drains Latch Closed
E. SDA Inlet Temp Within Limits
F. Maintaining Drum Level
G. Maintaining Bed Level
H. Feedwater Heaters in Service

Progression #7

A. Solid Fuel Latch
B. SDA in Service
C. All Duct Burners Out of Service
D. Limestone Blowers in Service
E. Maintaining Drum Level
F. Maintaining Bed Level
G. Turbine Drains Closed
H. All Drains Closed

Progression #8

A. All Controllers in Auto
B. Second BFP in Service
C. Cond Booster & HTR Drain Pump in Service
D. Stripper Coolers in Service
E. DCS Control
F. Ammonia Flow Established
G. Limestone Flow Established

Instrumentation Out-of-Bounds Alarm

A feature shall be provided on the instructor's station to alert the instructor that the simulator is being operated in a range outside of the modeled plant's design. This feature will minimize those times when the trainees can operate the simulator in an unrealistic manner, such as a boiler pressure above the steam drum burst point. The successful bidder shall provide a list of the parameters that will initiate the out-of-bounds alarm, along with the setpoint, as part of the initial design plan.

7.3 Simulator Performance Criteria

The Simulator will present to the operator trainees quantitative values of plant parameters within the tolerance specified for those conditions that the Simulator is designed to simulate.

The Simulator will be based on data that pertain to the performance, operation, physical properties, and other characteristics of the reference plant.

7.3.1 Steady State Operation

The Simulator accuracies will be related to full power values and interim power levels for which design plant data is available. Tests will be conducted at several points over the operating range including:

- 310 megawatt output
- 250 megawatt output

- 225 megawatt output
- 200 megawatt output
- 180 megawatt output

The following tolerances, accuracies, and limits will also apply:

- The simulator-computed values for the principal mass and energy balance will be satisfied and will not detract from training. Drift of principal energy and mass balances is considered to detract from training and, therefore, does not meet these performance criteria.
- The simulator-computed values of critical parameters for all configurations will agree with the reference plant parameter data provided by JEA within the tolerances detailed in the Table 7-1.
- The calculated values of non-critical parameters, pertinent to unit operation, that are included on the simulator display screens, will agree with JEA provided values within a tolerance of ± 5% of normal or full load values and will not detract from training.

Table 7-1 <u>Critical Parameters for Steady State Load</u>

Parameter No.	Critical Parameter	Steady State Variation
1.	Main Steam Pressure	+/- 1%
2.	Main Steam Temperature	+/- 1%
3.	Reheat Steam Pressure	+/- 1%
4.	Reheat Steam Temperature	+/- 1 %
5.	Main Steam Flow	+/- 1%
6.	Turbine Control Valve Position	+/- 1%
7.	Bypass valve position	+/- 1%
8.	Ambient air temp (7^o-105^o F)	+/- 1%
9.	CEMS data	+/- 1%
10.	Generator Megawatts	+/- 1 %
11.	Feedwater Flow	+/- 1%
12.	Hot Reheat Steam Flow	+/- 1%
13.	Condenser Vacuum	+/- 1%
14.	Drum Level	+/- ½"
15.	Steam Generator Pressure (Vacuum)	+/- .25" H_2O
16.	Feedwater Temperature	+/- 1 %

7.3.2 Transient Operation

Simulation performance under transient conditions shall meet the following conditions:

- The observable change in parameters shall correspond in time response and direction to those expected from a best estimate for the simulated transient, and will not violate the physical laws of nature
- The simulator shall not fail to cause an alarm or automatic action if the reference plant would have caused an alarm or automatic action, and, conversely, the simulator shall not cause an alarm or automatic action if the reference plant would not have caused an alarm or automatic action

- The Simulator shall demonstrate realistic response to operator action
- The shape of any plant performance curve shall be similar to that of the operational power plant. The transient responses of the displayed variables shall have slopes and trends that are characteristic of the actual power plant and shall have the proper time-dependent relationship to the related parameter.
- The overall system transient characteristics' time shall be within 20% of the reference plant when under the same operating conditions.

Malfunctions and transients not tested in accordance with the above stated criteria will be tested and compared to best estimate or other available information.

The rate of simulation software processing shall be sufficiently fast to assure that the response of the display meters and recorders shall be smooth and that control delays shall not be noticeable to the operator. Instrument noise that simulates typical variations in steady-state signals from plant processes shall be provided. Instrument noise shall either be random or instructor selectable:

- Random Noise - The noise frequency shall be random in nature and there shall be no detectable noise correlations between any two displays in close physical proximity to each other. The frequency spectrum of the noise should be appropriate to the process variable being simulated.
- Instructor Selectable Noise - The instructor shall be able to define the period and amplitude of the noise.

7.3.3 Simulator Operating Limits

The requirements of real-time simulation may necessitate simplification in mathematical modeling that result in limited ability to simulate certain events. In addition, it may be possible to create events on a simulator which progress beyond plant design limits. To avoid negative training which could result from simulator operation during such events, administrative controls or other means will be provided to alert the instructor when certain parameters approach values indicative of events beyond the implemented model or known plant behavior.

8 Simulator Facility Environment

8.1 Building and Support Equipment

The successful bidder will utilize the existing simulator space for the new simulator. JEA will supply needed information in regards to this space including the following.

- Floor space and type
- Desk space
- Electrical power
- Ceiling clearances
- Access door size
- Any other necessary conditions conductive to a proper simulator environment

9 Simulator Documentation

JEA intends to support and maintain the simulator system using in-house resources. The documentation provided for the Simulator shall be comprehensive and shall include all information necessary for JEA to use, maintain, and modify the Simulator. Documentation to support this goal is required at a minimum. The successful bidder shall include in its base price only documentation requested that will meet the above requirement. Any additional documentation listed in the remainder of this section that is not needed to meet the above requirement is considered desired and should be identified and priced separately as an optional add-on item.

To the greatest extent possible, all documentation provided with the Simulator, including software, test, and hardware documentation, will be provided in electronic format. This will allow updating of the documentation by the JEA as changes are made after delivery.

9.1 Instructor/Maintenance Documentation

The instructor documentation will provide the simulator instructors with sufficiently detailed information to start up, shut down, and operate the Simulator during a training session, as well as detailed instructions for the use of the computer systems and any peripherals.

This documentation will provide descriptions of the physical makeup and components in the system, functional operation of the system, and a listing of system parameters such as operating/design temperatures.

The instructor documentation will, as a minimum, include the following:

- Simulator Operational Manual
- Simulator Maintenance Manual
- Simulator Instructor Quick Reference Manual

The operational manual shall provide operating procedures describing:

- Startup and shutdown of the simulator and associated peripherals, and a description of each
- Operations and features of the instructor's station including descriptions of each feature and how the instructor uses each feature
- Malfunction cause and effect document (text or graphical) detailing the cause of each malfunction, list of resulting alarms and indications associated with each cause, and the primary effects on the respective systems.
- Instructor's station operations description sufficient in detail for the JEA instructor to add and/or delete malfunctions, add and/or delete remote functions, add and/or delete initial conditions, and add and/or delete external parameters.
- Operating instruction and features of the simulator in the engineering mode, which describes how the engineer's work station or the instructor station works with the simulator's host computer.

The quick reference manual shall provide abbreviated procedures of the most commonly used simulator features including startup and shutdown. The manual shall be designed for use by a trained instructor.

The maintenance manual will include a listing and description of recommended periodic maintenance for the Simulator, hardware components, instructor's station, and computer complex.

As a part of its proposal, the successful bidder will describe how it proposes to organize the operational, maintenance, and quick reference manuals, and provide a brief topical outline of each.

9.2 Software Documentation

The successful bidder shall provide detailed and complete software documentation for all programs that are used to produce the Simulator. The documentation shall be organized and prepared to enable JEA personnel to understand all the programs in enough depth to be able to modify these programs, to support changes in the plant model, and to be able to evaluate control and process dynamics.

A program design document will be provided for each module, program, or subprogram used by the successful bidder in connection with the design, operation, testing, and/or debugging of the Simulator. As a minimum, this document will include the following items:

- Narrative description of the purpose of the program and method of implementation.
- Source of all macros used.

A software program listing will be prepared for each module, program, or subprogram used by the successful bidder in connection with the design, operation, testing, or debugging of the Simulator.

Any code used only in testing or debugging of the Simulator will be indicated together with the method of activation and an explanation of the output generated by the program. All significant I/O to data files or hardware devices will be fully described.

9.2.1 Plant System Simulation Software Design Documentation

The documentation for the simulated plant systems will consist of the following parts:

- Design basis of simulation
- Flow diagrams showing modeled components, parameter names, and outputs to controls
- Design approach
- System program listing
- Simulation software program listings
- Constants list - to the extent possible, a list of all constants will be provided for each system as part of the final design specification. Constants will be described with: Type (integer, real, etc.), Engineering units, Reference data, Value of constants
- Analog and digital control logic (including permissives, interlocks, and trips) diagrams for all emulated control simulation.
- Modeling equations, techniques, and the basis for these models, including any assumptions or simplifications for major components such as boiler, furnace, turbines, heat exchangers, pumps, and condenser.
- Listings of remote functions, external parameters, and malfunctions.

9.2.2 Other Software Documentation

JEA realizes the successful bidder may use commercially available software to implement parts of its Simulator. The successful bidder shall provide all documentation associated with this software supplied by the Vendor. In addition, the successful bidder shall provide any source code and required documentation, including line-by-line comments, which show how commercial software is integrated and how to make modifications to any successful bidder proprietary software. This required information is to allow JEA or a third party to make modifications as necessary to the Simulator in the future.

9.3 Hardware Documentation

The simulator hardware documentation will provide sufficiently detailed information to maintain, modify, and troubleshoot the simulator's hardware.

The documentation will include an overview describing the simulator configuration and its component hardware, including cross references to system specific documents.

At a minimum, the documentation will include the following for each simulator component:

- Operational manuals
- Installation manuals
- Maintenance and repair manuals
- Full set of drawings
- Wiring lists (as applicable)
- Electrical Schematics/connection drawings
- Network Diagrams and Topology

10 Simulator Design and Reviews

10.1 Simulator Design Kickoff

Prior to the start of the project, the successful bidder will meet with JEA personnel at the plant site to review the proposed simulator design, the successful bidder's technical approach, and the information available for developing the Simulator. The successful bidder will send the lead engineer to the plant to collect and assess the quality of available data. The result of this meeting will be a simulator design plan that is consistent with this specification and the purchase order/contract. The plan will include a schedule for JEA to supply specific information required to manufacture the Simulator. The plan will include as a minimum:

1. Simulator Design Approach for each System including:
    - Design assumptions and their rationale
    - Design simplifications and their justification
2. S+ Screen Display Scope including scope of instrumentation and control
3. Scope of Panel Emulation
4. Initial Conditions List
5. Alarm List and Setpoints
6. Malfunctions List
7. Remote Functions and External Parameters List

The design plan will be subject to review and approval by JEA.

10.2 Interim Design Reviews

Delivery of the Simulator for the purposes of operator maintainer training that meets JEA training objectives is a key objective of this procurement. To reduce the possibility of the Simulator not being consistent with JEA expectations at the time of factory acceptance testing, JEA expects to be involved in reviewing and validating the progress being made by the successful bidder throughout the simulator development process. This shall be accomplished by holding design review meetings at the successful bidder's facility up to once every two months. During these meetings JEA and the successful bidder shall review progress to date and conduct detailed reviews and validation of the developed simulator models. As deemed appropriate by JEA, additional meetings of shorter duration (typically a few hours in duration) will be held either in person or by teleconference. During the design phase of the project, a weekly phone call shall be established to review concerns, schedule, and any needed information exchange. The JEA project manager will set this up and coordinate with the successful bidder’s agent.

11 Inspection, Testing and Acceptance

11.1 Inspection

As part of the design review process detailed in Section 10.0, JEA shall inspect and observe the progress of any phase of the design, testing and/or construction of the Simulator and its components, during normal business hours.

Prior to commencement of the acceptance tests, the successful bidder shall conduct all inspections and tests called for by successful bidder's manufacturing and quality procedures and good commercial practice. This includes all inspections and tests on subcontracted or purchased materials and equipment.

JEA reserves the right to review all documentation, which supports successful bidder or his supplier's completion of tests and inspections.

The waiving of inspection of equipment or design during the development of the Simulator shall in no way relieve the successful bidder of the responsibility of furnishing equipment in accordance with this specification.

11.2 Simulator Testing

A factory acceptance test procedure shall be developed by the successful bidder to be used for testing. The test program for the Simulator shall consist of:

- Successful bidder Testing
- Factory Acceptance Testing
- On-Site Re-verification Test

A Factory Acceptance Test Report and an On-Site Re-verification Test Report shall be prepared by the successful bidder to fully document the performance of the Simulator during the test program.

During the performance of the successful bidder Testing and Factory Testing, the successful bidder shall allow for observation and participation on a non-interference basis by JEA engineering, operating, training, or other personnel as deemed appropriate by JEA. The successful bidder shall provide appropriate office facilities for JEA personnel during the above tests.

11.2.1 Acceptance Test Procedure

A factory acceptance test plan shall be developed which describes the controls, monitoring, and schedule for the conduct of simulator factory testing. Upon JEA approval of the test plan, an Acceptance Test Procedure (ATP) will be developed by the successful bidder. The ATP will designate the tests and inspections that determine the Simulator’s conformance with the design data and the Simulator specification.

The ATP shall test the Simulator in all modes of operation, including normal, abnormal, surveillance testing, and emergency conditions. Malfunctions, multiple malfunctions, and remote functions shall be tested as set forth in the ATP. The ATP shall also allow for negative logic testing of the simulator, not written as procedural steps in the ATP, as requested by JEA. Failure of these negative logic tests shall constitute a deficiency requiring resolution by the successful bidder. The ATP will identify how the test results are to be documented, acceptance criteria, how identified discrepancies will be processed, and retesting requirements.

The acceptance test procedure shall consist of the following sections:

1. Hardware Configuration Verification
   - Visual Inspection
   - Documentation - wire list, etc.
   - Computer Systems
   - Hardware diagnostics
   - Connection to highway
   - Graphic display format consistency and graphic creation
   - Functional operation of peripheral devices (keyboards, monitors, printers, etc.)
   - Simulator loading and background processing
   - I/O transmission to other computers
2. Documentation (see Section 9)
   - Instructor’s operation manual
   - Software manual
   - Simulation system manual
3. Instructor's Station Functions
   - Freeze/Reset
   - Snapshot
   - Fast, Real, and Slow Time
   - Backtrack
   - Initialization
   - Trainee Performance Review
   - Remote Functions
   - External Parameters
   - Malfunction Control
   - Computer Aided Exercise
   - Logging
4. Operator Station Performance
   - Graphics
   - Trending
   - Acknowledge/silence of alarms
   - Synchronization of clocks
   - Operation of all switches, gauges, M/A stations, LIMS, etc.

5. Simulator Performance Testing
    - Initial Condition Verification
    - Simulator Performance Tests
    - Plant startups
    - Plant warm ups
    - Load range operations
    - Heat balances
    - Plant shutdown
    - Malfunction tests
    - Logic checks
    - Runups, rundowns, runbacks

JEA shall define specific sequences of events and proper plant behavior to further verify simulator performance. Data used for verification of proper simulator performance shall be consistent with the Design Database. The ATP shall be such that the tester can introduce random upsets.

The successful bidder shall demonstrate the system's capability to upload .m6b files obtained from the S+ and begin the simulation process without any other abnormal interactions required from the operator or instructor.

The ATP shall be used by both the successful bidder and JEA in their tests and inspections of the Simulator prior to delivery and during on-site re-verification tests. The ATP will be subject to review and approval by JEA.

11.2.2 Successful Bidder Testing

Once the Simulator is complete, the successful bidder will test the Simulator using the approved ATP. The successful bidder shall provide JEA with documentation of the performance of the Simulator during the conduct of the successful bidder testing. This documentation shall include a copy of all discrepancies found during the successful bidder testing, the status of each discrepancy, and a completed copy of the ATP. Prior to starting factory testing, all successful bidder testing shall be completed and all discrepancies shall be resolved to the satisfaction of JEA. JEA reserves the right to reject the Simulator as unsuitable to begin factory testing if all discrepancies are not resolved.

11.2.3 JEA Factory Acceptance Testing

The Simulator shall be ready for inspection for purposes of acceptance or rejection by JEA on or before the date specified in the milestone schedule agreed to at the kickoff meeting. The successful bidder shall permit access of representatives designated by JEA to the Simulator, parts, and components thereof for inspection as desired by JEA during the Factory Testing period. The successful bidder shall furnish JEA all reasonable test equipment, facilities, and assistance for the safe and convenient inspection of the Simulator during this period.

Acceptance Testing shall be conducted during regular day shift working hours, five days per week, excluding weekends and holidays normally observed by JEA.

If testing is halted due to discrepancies precluding further testing, this time period shall not be included in the contract "test period." JEA reserves the right to suspend testing at any point until all outstanding discrepancies have been cleared to the satisfaction of JEA.

Any hardware or software alterations made by the successful bidder during or after a particular test procedure, which in JEA's opinion will impact previous test results, will cause, at JEA's option, rerunning that test.

At the completion of the Factory Acceptance Testing, a complete system save, including source and binary code, will be provided to JEA. At least two sets of system saves will be provided to JEA in an electronic format.

At the completion of Factory Acceptance Testing, JEA shall submit to the successful bidder, in writing, within five business days, an authorization to ship the Simulator or a rejection of the Simulator.

If the Simulator is rejected, JEA shall state in writing the reasons for the rejection and such reasons shall consist of references to any tests set out in the ATP and any other requirements of the Specification with which JEA considers the Simulator not to be in compliance. In the event of such rejection of the Simulator, the reasons given by JEA shall be immediately discussed with the successful bidder, and the successful bidder shall, at its sole expense, correct all conditions that serve as a basis for rejection by JEA. Upon correction of such conditions, JEA may perform such tests set out in the ATP and any other tests and inspections relating to the requirements of the Specification with which JEA has notified the successful bidder that the Simulator did not comply or which may have been affected by corrective action taken by the successful bidder. If the discrepancy is determined to be a result of an error or omission in the ATP, then the ATP shall be corrected and the test shall be rerun to the corrected portion of the ATP.

A final factory acceptance testing Report shall be prepared by the successful bidder and shall include detailed descriptions of:

1. Test procedures used
2. Successful Bidder testing
3. JEA testing
4. Test results
5. Discrepancies identified during tests
6. Resolution of discrepancies
7. Descriptions and results of retests

The final Factory Testing Report shall be submitted to JEA for review and approval within 10 working days after the satisfactory completion of the factory acceptance testing.

Upon receipt of written notice from JEA of authorization to ship, the successful bidder shall proceed with shipment to the simulator facility. Authorization to ship the Simulator shall constitute a conditional acceptance of the Simulator without prejudice to JEA's rights to resolution of any outstanding discrepancies or faults revealed by the On-Site Re-verification Tests.

Minor deficiencies in the Simulator, which JEA deems not sufficient to delay shipment, shall be listed on a Completion List prepared by JEA. The successful bidder shall complete or correct the items on the Completion List to the satisfaction JEA by the dates specified.

11.2.4 On-Site Re-verification Tests

Upon completion of installation and any required successful bidder testing, JEA shall conduct On-Site Re-verification Tests. These tests shall consist of selected portions of the Acceptance Test Procedure as determined by JEA, which will be rerun and the results compared to factory test results. The test shall involve hardware, software, training functions, and plant operation. The objectives of this test are to ensure that the Simulator has not been damaged in transportation to the site, ensure that any outstanding discrepancies identified in the completion list have been resolved, and to demonstrate that the Simulator is ready for training.

Any non-conformance indicated in such tests shall be promptly corrected by the successful bidder at its sole expense, and the applicable portions of the ATP shall be re-performed to demonstrate satisfactory performance. The successful bidder shall be allowed full time access to the Simulator to make such corrections. Satisfactory completion of the On-Site Re-verification Testing shall be determined by JEA, and be designated as the Ready for Training (RFT) date. Minor discrepancies, which do not deem sufficient to delay RFT, shall be listed on a Completion List prepared by JEA. The successful bidder shall complete or correct the items on the Completion List by a date acceptable to JEA, and reasonable time and access to the simulator will be provided to correct minor discrepancies.

If the On-Site Re-verification Tests reveal faults, JEA shall set forth the faults in detail in writing, and the successful bidder shall correct any conditions that serve as a basis for valid rejection by JEA at successful bidder expense.

11.3 Shipping

The packing and shipping of the Simulator shall be the sole responsibility of the successful bidder. The successful bidder shall adequately package all boxes and crates to prevent damage from handling, damage from weather, or loss during shipment. The exterior of boxes and crates used in the shipments shall carry identification of contents and shall be clearly marked. The successful bidder shall deliver the Simulator to the JEA designated simulator classroom at Northside Generating Station.

Upon completion of shipment, the successful bidder shall uncrate, inspect, and install the Simulator per the agreed schedule.

11.4 Work Completion

The Work shall be deemed completed, accepted, and final payment made upon satisfactory completion of testing, correction of all discrepancies, delivery and approval of all Documentation and completion of initial training. Such acceptance shall not waive any right of JEA under the Purchase order/contract.

12 Maintenance

12.1

12.2 Maintenance Agreement

The bidder's proposal shall include the first year of maintenance in the submitted Base Price. Additionally the Bidder shall includ pricing for years 2 through 5. The maintenance agreement between the bidder and JEA. The maintenance agreement will cover:

- Software upgrades for all simulator software that are required to keep the ABB simulator software at the same level as the live units and to maintain reliable operation or to take advantage of any new developments in the modeling software
- Unlimited Telephone support.
- Unlimited remote access support
- Hardware replacement at cost

13 Personnel Training

The successful bidder shall conduct training sessions for instructors who will operate the Simulator and JEA personnel who will modify and maintain the Simulator. The successful bidder shall provide all handout material for the training. In its proposal, the successful bidder shall provide a description of all courses available, specifically noting those that are included in the project scope. Each course description shall include course objectives, course outlines including a breakdown of classroom versus hands-on training, recommended duration for each course, and recommended qualifications of the JEA participants for each course. The successful bidder shall identify the instructor(s) and provide instructor resume(s) with the proposal.

Included in the bid price shall be the following training:

- Minimum of two days each of initial on-site instructor and engineer training within 30 days of final on-site testing completion and completion of addressing any discrepancies. Pricing shall be provided for 4 to 6 participants for each class.
- An option for additional instructor and engineer training equivalent to that listed above within 12 months after commissioning
- An option to have a successful bidder supplied trainer on site for the first JEA provided training session.

13.1 Instructor Training

The instructor training shall include the following:

- Overview of hardware
- Overview of software
- Overview of simulation model including process and controls
- Overview of modifying simulator models
- Review of instructor functions
- Hands-on practice using the system
- Hands-on practice building malfunctions
- Hands-on practice building scenario's

13.2 Engineer Training

The engineer training shall include the following:

- Details of the hardware
- Details of the software
- Details of the simulation model including process and controls
- Review of instructor functions
- Hands-on practice using the system
- Overview of modeling tools
- Details of diagnostic software
- Removal and reinstallation of specific components
- Hands-on practice troubleshooting
- Hands-on practice creating simulation models

14 Project Management and Payment Schedule

14.1 Project Management

The JEA Project Manager shall manage JEA activities associated with the project. JEA activities include the technical interfacing, supply of plant information, and acceptance / approval of the work performed by successful bidder. Any correspondence to JEA of a technical nature shall be addressed to the attention of the JEA Project Manager and the JEA Technical Lead.

Administration of the Purchase order/contract and Change Orders shall also be performed by the JEA Project Manager. All Purchase Order / contract T&C's / Change Orders will go through the JEA Project Manager before action can be taken by a JEA Purchasing Agent.

The successful bidder shall assign a successful bidder Project Manager to the Work who shall have overall responsibility for directing the Work and shall be the normal successful bidder contact on all matters between the successful bidder and JEA.

The successful bidder shall provide the JEA Project Manager with an update of the project schedule submitted with its proposal within thirty days after receipt of the purchase order / contract. Thereafter, the successful bidder shall furnish to the JEA Project Manager a monthly status report by the 15th of the following month, showing the actual status of each production phase. If the actual milestones lag such scheduled dates, an explanation shall accompany the status report stating the problem area, measures taken to eliminate the problem, and when the item will be back on schedule. The JEA Project Manager shall be notified immediately of any potential problem situations that may affect any of the milestones.

JEA and their agents shall have the right of access to the successful bidder's and Subcontractor's facilities to verify production status, inspect, and expedite the Work.

Once the successful bidder Project Manager, Project Engineer, and Test Operator (operational specialist assigned to evaluate performance of the simulated plant models), are assigned to the Simulator project, the successful bidder shall not change its assignments without the prior written consent of the JEA Project Manager.

14.2 Schedule of Deliverables

Week Number	Milestone	Description	Specification Section
0		Contract Award/PO issued	
2	1	Simulator Design Plan completed and submitted to JEA	10.1
15	2	Design Database Report and design specification completed and submitted to JEA	6.1
28	3	System modeling completed	6.3
40		Integration of individual system models and components into simulator completed	
42	4	Acceptance test procedure (ATP) completed and submitted to JEA	11.2
47	5	Successful Bidder Testing complete and testing documentation submitted to JEA	11.2.2
48		Facility Requirement Report Submitted to JEA	8.1
49	6	Factory Acceptance Testing complete and testing documentation submitted to JEA	11.2.3
52	7	On-site Re-Verification Testing complete and testing documentation submitted to JEA	11.2.4
54	8	All Final Simulator Documentation submitted to JEA	9
56	9	Initial onsite training complete	13

14.3 Payment Schedule

The Dates for the payment schedule will be determined by the schedule of deliverables. All submittals shall be deemed acceptable by JEA before payment is made.

Milestone	Description	Payment Amount	Date
1	Simulator Design Plan complete and submitted to JEA	10%	TBD*
2	Design Database Report and design specification completed and submitted to JEA	20%	TBD*
3	System modeling completed	15%	TBD*
4	Acceptance test procedure (ATP) completed and submitted to JEA	15%	TBD*
5	Successful Bidder Testing complete and testing documentation submitted to JEA	5%	TBD*
6	Factory Acceptance Testing complete and testing documentation submitted to JEA	5%	TBD*
7	On-site Re-Verification Testing complete and testing documentation submitted to JEA	10%	TBD*
8	All Final Simulator Documentation completed and submitted to JEA	10%	TBD*
9	Initial onsite training complete	10%	TBD*

STANDARD

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Preface

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Contents

1 Scope

The scope of this standard is to address the simulation of fossil fuel power plants typically consisting of:

- Boiler, turbine, and balance of plant with steaming capacities of 200,000 lbs/hr (25 kg/s) or greater
- Combustion turbine or combined cycle combustion turbine capacity of greater than 100MWs
- Associated or interactive processes

This standard will address high-fidelity process and control logic models, highly replicated user interfaces, highly functional instructor tools, high-realism physical fidelity trainee environments, simulator platform considerations, and minimum levels of documentation.

2 Purpose

The purpose of this standard is to establish the functional requirements for several types of plant-specific, fossil fuel power plant control room simulators. It sets minimum criteria for the degree of software modeling detail and hardware replication, performance, and functional capabilities of the simulator control room operator interfaces. This standard does not address DCS tie-back simulators, or simulators used primarily for engineering purposes. This standard does not establish criteria for the use of simulators in training programs.

Operating and training practices and procedures differ considerably among the various organizations that operate fossil fuel plant control room simulators, however, the goals of personnel safety, maximum equipment availability and lifetime, and efficiency of operations are common to all. Therefore, this standard is intended to provide flexibility in both design and use.

3 Definitions

The following definitions are included to clarify their use in this standard and may not correspond to the use of the word in other texts.

design control: A design approach that ensures that the initial simulator design and any subsequent changes to it are carried out in a systematic, controlled, and documented manner.

fidelity: The degree of both physical and functional realism.

functional fidelity: The degree of similarity between the simulator and the reference plant relative to the static and dynamic response of the equipment and controls.

part-task simulator: A simulator that incorporates detailed modeling of a single or very limited number of specific reference plant components or subsystems. Such a simulator demonstrates the expected response of those components or subsystems.

physical fidelity: The degree of similarity between the simulator and the reference plant in the physical design and location of the panels, equipment, instruments, and controls.

reference plant: The specific fossil fuel plant from which the simulator control room configuration, the system control arrangements, and the simulator database are derived.

replicate: To imitate the reference plant in such a way as to copy hardware, processes, and data, but not to the point of making substitution possible,

real time: Simulation of dynamic performance in the same time-based relationships, sequences, durations, rates, and accelerations as the dynamic performance of the reference plant.

simulation: The mathematical representation/modeling of physical process and control systems.

stimulation: The use of identical instrumentation or computer systems that have been modified to function in a simulator environment.

4 General elements of a simulator

Fossil-fuel training simulators covered by this standard shall consist of the following major elements:

1) **Trainee environment:** The trainee environment shall include control panels with instruments, an operator CRT that provides the interface by which the trainee interacts with the system, or a combination of both. The realism of the trainee environment may be augmented by means of a communication system, simulated control room noise, and variations of the control room lighting in response to simulated electrical disturbances. The replication of the trainee environment may vary both in physical fidelity and in scope, depending on the simulator type.

2) **Simulation computer:** The simulation computer system shall consist of a general-purpose computer and peripherals that are capable of handling the plant simulation and instructor functions in real time. The simulation computer shall communicate with the control room hardware via a high-speed electronic data interface.

3) **Instructor station:** The instructor station provides a means by which the instructor can control simulator operations and monitor the trainee(s). The instructor station should include, as a minimum, a CRT and a keyboard. It may include additional CRTs and a remote wireless station, strip-chart recorders, and other devices that enhance its capabilities.

4) **Simulator software:** The simulator software shall include, as a minimum, the following software programs:

    a) Software plant models, which simulate continuously in real time the behavior of the simulated reference plant(s) systems over the entire range of normal, abnormal, and emergency conditions. The fidelity and extent of simulation of the plant systems may vary, depending upon the type of simulator. (See Annex A.)
    b) Instructor station software, which provides the instructor with the necessary simulator control and trainee monitoring functions
    c) Development and maintenance software necessary to update the plant models
    d) Computer operating systems and utility software

5) **Spare parts, tools, and documentation:** The simulator should include all hardware, software, and documentation necessary to support simulator maintenance and updates.

5 General requirements

5.1 Simulator capabilities

The response of the simulator that results from operator action, no operator action, improper operator action, automatic plant controls, and inherent operating characteristics within and without plant malfunctions shall be realistic within the limits of the performance criteria and the functional design specifications derived from the training objectives. (See 6, "Performance Criteria.")

5.1.1 Normal operations

The simulator shall be capable of simulating continuously, and in real time, the operations of the reference plant(s). The simulator shall calculate plant system parameters that correspond to particular operating conditions, displaying these parameters on the appropriate instrumentation, and shall provide proper alarm or protective system action, or both. The minimum operations that the simulator shall be capable of performing, using only operator action that is normal to the reference plant(s), are as follows:

a) Plant start-up—cold to 100% load (The starting conditions shall be cold shutdown conditions of temperature and pressure for all systems.)
b) Start-up from hot standby to 100% load
c) Turbine start-up and generator synchronization
d) Boiler/turbine/unit trip followed by recovery to rated load
e) Plant shutdown from 100% load to hot standby and cool-down to cold shutdown conditions
f) Operator-conducted testing on equipment or systems as applicable (e.g., turbine valves)

5.1.2 Plant malfunctions

The simulator shall be capable of simulating abnormal and emergency events in real time, including malfunctions and equipment failures to demonstrate inherent plant response and automatic plant control functions. Where the operator actions are a function of the degree of severity of the malfunction (e.g., boiler tube leaks, loss of vacuum, condenser tubes failing, etc.), the simulator shall have adjustable rates for the malfunction to represent the range of plant malfunction conditions. The remaining events shall consist of a variety of malfunctions associated with the fuel supply, furnace air and gas, condensate and feed water, boiler, steam turbine generator, and the electrical and auxiliary support systems.

The malfunctions available shall include both discrete and variable malfunctions that may be applied to plant equipment, controls, and processes. Discrete failures include the failure of plant equipment, such as control elements, to specific states. For example, a control valve may be forced to fail to an open, closed, or an intermediate position. Variable malfunctions include the failure of plant equipment, controls, or processes to a variable state. An artificially imposed variation in heat exchanger fouling or an imposed drift in the signal from a sensing element are typical of variable malfunctions.

The response of the simulator following the insertion of malfunctions shall be compared to actual plant response or to a best-estimate plant response obtained from operating experience or derived from engineering analysis. Where applicable to the malfunction, the simulator shall provide the operator with the capability of taking action to recover the plant, mitigate the consequences, or both. The simulation shall continue until such time as a stable, controllable, and safe condition is attained that can be maintained to cold shutdown conditions, or until the simulator operating limits are reached.

5.1.3 Simulator operational limits

The simulator is designed to operate within realistic normal operating limits. If the simulation goes beyond these limits, misleading training may result. In order to avoid this situation, administrative controls or other means shall be provided to alert the instructor when certain parameters approach values that are indicative of events beyond the implemented model or known plant behavior.

5.2 Trainee environment

5.2.1 Panel/control station simulation (operator interface)

Operational panels should provide controls, instrumentation, alarms, and other operator-machine interfaces that are necessary to conduct normal plant operations (5.1.1) and to respond to malfunctions (5.1.2).

Control panel/stations should be designed to duplicate the size, shape, color, and configuration of the functionally simulated hardware in the reference plant. Deviations in one or more aspects of physical fidelity of the panels should not detract from training. Control room hardware may be simulated or stimulated. In the latter case, consideration should be given to the functionality of the stimulated hardware in nonreal-time modes (i.e., the modifications to the hardware necessary to implement standard simulator functions such as freeze, restore, etc.). (Refer to Annex E for details.)

5.2.2 Interface controls

Meters, recorders, switches, annunciators, controllers, plant computer interface hardware, and other controls or displays that would function during normal operations or malfunctions should be included in the simulator.

All functionally simulated and visually simulated hardware should replicate or closely resemble in appearance and location that found in the reference plant control room and should be functionally identical to it.

5.2.3 Control room environment

Consideration should be given to simulating as much of the control room environment as is reasonable and practical. Attention should be paid to the following environmental factors:

1) Location of the auxiliary equipment and furnishings in the control room
2) Location and availability of plant communications systems
3) Location and intensity of control room lighting
4) Type and level of noise/vibration from the plant equipment

The presence of any instructional equipment should be such that it does not interfere with the training process.

5.3 Systems to be simulated

5.3.1 Systems run from the control room

The number of systems included and the degree of simulation response should match that which is necessary in order to perform the reference plant's normal operations (5.1.1) and malfunctions (5.1.2) consistent with training objectives that have been identified.

Functional fidelity of the simulator should be based upon one or more of the following sources:

1) Reference plant data
2) Data from a similar plant
3) A "best estimate" engineering computer analysis (when reference/similar plant data does not exist)

It should be possible to perform control manipulations and observe plant response in a manner similar to that of the reference plant (i.e., software models should be based on real time). Interactions among simulated systems should provide total system integrated responses.

5.3.2 Functions run from outside the control room (remote functions)

Control or component operating functions that are performed outside the control room or provide some input to the simulation models and are necessary to perform the reference plant's normal operations and malfunctions should be simulated.

5.3.3 External parameters

Factors such as ambient temperature that exist outside the control room and affect the operation of the plant should be controllable from the instructor station and should realistically affect plant operations.

5.4 Training capabilities

5.4.1 Instructor interface

The instructor shall interface with the simulator via an instructor station that does not restrict access to either the control room panels or the operator station. Through use of the instructor station, the capability shall exist for the instructor to act in the capacity of an auxiliary operator or other operator who is remote from the control room.

5.4.2 Simulator control features

The simulator shall be capable of freezing the progression of all dynamic simulations at any time, initializing at predefined states, inserting malfunctions, and manipulating external parameters and remote functions. In addition, consideration should be given to the incorporation of the following features:

1) **Backtrack:** the ability to continuously record initialization data for later recovery
2) **Record and playback**: a continuous recording of trainee control panel actions for later replay
3) **Snapshot:** the ability to store the particular conditions existing at any instant during a training session in order that they may be recalled in the future as an initialization point
4) **Slow time:** the ability to provide an apparent increase in the time interval for fast-changing phases of plant operation that are characterized by short time constants (i.e., the simulation runs at a rate that is slower than real time)
5) **Fast time:** the ability to provide an apparent decrease in the time interval for less dynamic phases of plant operation that are characterized by long time constants (e.g., warmup, boiler kill, condenser vacuum, water chemistry, etc.)
6) **Trainee monitoring:** the provision of a system to monitor and record selected parameters during a training exercise in order to allow an objective evaluation of trainee performance
7) **Plant efficiency monitoring:** the ability to calculate and display both the unit heat rate and the effect of operationally controllable parameters on plant performance

5.4.3 Initial conditions

The simulator shall be capable of storing initialization conditions as defined by the training objectives. Selection of these conditions shall be made from the instructor's station. The simulator shall be capable of adding, modifying, or deleting initialization conditions as required.

Typical initialization conditions may include some or all of the following:

1) Cold start
2) Hot start
3) Hot restart after unit trip
4) Cold turbine — cold turbine on turning gear
5) Hot turbine — ready for synchronization
6) Half load
7) Full load

Consideration should be given to including some spare initialization points for future use.

5.4.4 Malfunctions

It shall be possible to conveniently insert malfunctions through instructor action or preprogramming.

5.5 Simulation computer system hardware

Computer(s) and associated peripherals shall serve as the control and simulation elements of the simulator. These computer systems and peripherals shall include commercially available components that provide sufficient spare capacity to accommodate the training simulator requirements and background tasks. The computer system(s) shall support a high-level language programming environment.

The control panel input/output interface shall consist of commercially available components and shall be modular in design to facilitate future expansion. I/O transfer rates shall be such that plant responses observed at the control panel(s) are not discernible from those of the reference plant.

In addition, consideration should be given to the incorporation of the following features:

1) **Computer(s):** The computer(s) should be current generation machines, modular in design, and should allow direct memory access, priority, and real-time interrupts. Sufficient spare computation time should be included to allow for background tasks and future expansion.

2) **Memory:** Main memory and bulk-disk storage should provide sufficient capacity for the simulation

software and additional spare capacity for background tasks and future expansion. Spare capacities for computational power and memory should be applied to individual computer systems.

3) **Printers and terminals:** Separate printers should be provided for control-room-specific functions such as data logging and simulator development listings. Industry standard CRT terminals should be provided for simulation software maintenance and system console functions.

5.6 Simulator computer systems software

The simulator computer software shall include the following:

1) **Operating system software:** The simulator shall utilize the computer vendor's operating system software in an unmodified form. This operating system shall be a real-time, multi-programming system. The software shall be easily updated or replaced with future operating systems that may be supplied by the computer vendor.
2) **Plant simulation software:** The plant simulation software shall be written in a high-level language. The software shall be designed in a consistent and well-documented format. A modular framework shall be employed in the program design to permit program additions or deletions without destruction of the overall program. The plant simulation software shall be designed such that the simulator response will be the same as that of the reference plant within the performance requirements for the simulator. The mathematical model equations shall be derived, where possible, from the basic laws of physics and thermodynamics. The simulation software shall interface and respond to all input signals from the control station and shall provide output signals to all control displays.
3) **Instructor station software:** All software required to support the instructor station functions shall be supplied. The software shall be written in such a manner that minimal instructor training is required for performing the functions.
4) **Development software:** Utility and development software shall be provided to allow development of the simulator software. Consideration should be given to the provision of an on-line background software development capability. The software shall include, as a minimum, a Macro Assembler, an optimized high-level language compiler with a runtime support library, a full-screen editor, an object-code linker, and an interactive debugger.
5) **Diagnostic and test software:** Diagnostic and test software shall be included to perform online and off-line diagnoses of simulator hardware faults. Diagnostic programs shall be provided to assist in the detection/repair of the computer system and all peripherals.

6 Performance criteria

6.1 Steady-state operation

The simulator accuracies shall be related to full power plant load and interim power levels for which valid reference plant information is available. The parameters displayed on the control panels may have the instrument error added to the computed values. During testing, the accuracy of computed values shall be determined for a minimum of three points over the power range:

1) The simulator instrument error shall be no greater than that of the comparable meter, transducer, and related instrument system of the reference plant.

2) Principal mass and energy balances shall be satisfied. Examples are:

   a) steam flow to generate electrical power;

   b) feedwater flow to steam flow; and

   c) main and auxiliary steam systems.

3) As a minimum, the simulator-computed value of critical parameters for steady-state, full power operation with the reference plant control system configuration shall be stable and shall not vary more than 2% of the measuring instrument range as observed in the reference plant. Consideration should be given to specifying the allowable deviation of individual critical parameters in process units.

4) The simulator-computed values of critical parameters shall agree within 2% of the reference plant parameters explicitly stated in process units at greater than 25% load and shall not detract from training. Typical critical parameters are defined in 6.1.1.

5) The calculated values of noncritical parameters pertinent to plant operation, that are included on the simulator control room panels, shall agree within the ranges of 10% of the reference plant parameters and shall not detract from training.

6.1.1 Critical parameters

Critical parameters are those related to plant principles of energy and mass balance. Typical critical parameters are as follows:

1) Main steam flow and pressure
2) Feedwater flow
3) Generated electrical power
4) Process steam flows, LP, IP, and HP
5) Superheat and reheat spray flow
6) Superheat outlet temperature and pressure
7) HP turbine inlet temperature and pressure
8) HP turbine first-stage pressure
9) Hot reheat temperature and pressure at the reheater outlet
10) Condenser pressure
11) Fuel flow
12) Combustion air flow

Consideration should be given to other parameters, such as environmental parameters.

6.2 Transient operations

Transient operations include malfunctions, abnormal operations, and any non-steady-state plant condition. Simulation performance under transient conditions shall meet the following criteria:

1) Where applicable, it shall be the same as the plant start-up test procedure acceptance criteria.
2) The observable change in the parameters shall correspond in direction to those expected from a best estimate for the simulated transient and shall not violate the physical laws of nature.
3) The simulator shall not fail to cause an alarm or automatic action if the reference plant would have caused an alarm or automatic action, and, conversely, the simulator shall not cause an alarm or automatic action if the reference plant would not have caused an alarm or automatic action.
4) The overall system transient characteristics' time shall be within 20% of the reference plant when under the same operating conditions.

Malfunctions and transients not tested in accordance with 1- 4 shall be tested and compared to best estimate or other available information and shall meet the performance criteria of 2.

7 Simulator testing

7.1 Simulator performance testing

Simulator performance shall be established by preparing a simulator performance test, conducting the test, and comparing the simulator's performance with the simulator design data within the requirements of Section 6, Performance criteria. Testing shall be conducted and a report prepared for each of the following occasions:

1) Completion of initial construction
2) Simulator design changes that result in significant simulator configuration or performance variations. When a limited change is made, a specific performance test on the affected systems and components shall be performed.

The intent of simulator performance testing is to:

a) verify overall simulator model completeness and integration;
b) verify simulator performance against the steady-state criteria of 6.1 (Steady-state operation); and
c) verify simulator performance against the transient criteria of 6.2 (Transient operations) for a benchmark set of transients.

7.2 Simulator hardware testing

Simulator hardware testing shall include all trainee environments provided by the simulator. These are:

1) Panel/control station simulation:
   a) control and piping mimics;
   b) location and spacing of control panels; and
   c) size, shape, and configuration of panel/control panels.
2) Control of the panels:
   a) identification labels on meters, recorders, switches, controllers, etc.;
   b) annunciator labeling and terminology; and
   c) form and units of displayed plant information.
3) Control room environment:
   a) location and availability of plant communication systems;
   b) location and intensity of control room lighting; and
   c) type and level of noise for the plant equipment.

7.3 Simulator system testing

Simulator system testing shall include all provided simulator system training capabilities as well as computer performance. These include the following:

1) Simulator control features:
   - a) Run/freeze simulator models
   - b) Initialization of initial conditions
   - c) Inserting and removing malfunctions
   - d) Manipulating external parameters and remote functions
   - e) Backtrack
   - f) Record and playback
   - g) Snapshot
   - h) Slow time
   - i) Fast time
   - j) Trainee monitoring

2) Initial conditions:
   - a) Cold start
   - b) Hot start
   - c) Hot start after unit trip
   - d) Turbine on turning gear
   - e) Ready for turbine synchronization
   - f) Half load
   - g) Full load

3) Malfunctions:
   - a) Control valve failures
   - b) Primary sensing element failures
   - c) Heat exchanger fouling
   - d) Utility systems failure
   - e) Tube/pipeline rupture

4) Simulation computer performance:
   - a) Spare computation time
   - b) Spare memory capacity

8 Design control

The simulator shall be designed and maintained using a consistent design control strategy to meet the following objectives:

1) Ensure that the simulator meets the functional/performance requirements given in the technical specification.
2) Ensure that the simulator meets the training objectives.
3) Ensure that the design of the simulator can be traced at all times to a database that defines all critical features of the reference plant. The reference plant need not be a physical plant, but could be a hypothetical plant, provided a consistent set of data is maintained.
4) Ensure that any changes made to the simulator, either during initial design and manufacture or subsequent to its being placed in service, are carried out in a controlled way and are subject to appropriate levels of review and approval.

The design control strategy shall include the following activities:

1) Review and verification of the initial design against the simulator's technical specifications

2) Establishment of a deficiency review plan to identify and correct discrepancies in the simulator
3) Review of the simulator's performance with respect to the technical specifications
4) Maintenance of the reference plant design and performance database that allows simulator design traceability
5) Establishment of a system to identify, request, approve, and implement changes to the simulator. This system should maintain configuration control and traceability to the reference plant.

9 Documentation

Simulator documentation shall be provided to allow the simulator staff to install, operate, and maintain the simulator over its life cycle. Documentation requirements may vary, depending upon the type of simulator considered. Guidelines for documentation requirements for each type of simulator are given in Annex D.

9.1 Instructor documentation

The instructor documentation should provide the simulator instructors with sufficiently detailed information to start up, shut down, and operate the simulator during a training session.

The documentation should include an overview of the plant and of the systems simulated. It should provide the instructor with a clear understanding of the plant model simulation capabilities and limitations as well as the simulated operating procedures. It should also include the information necessary for the instructor to fully understand the simulator training features and to effectively apply them in a training exercise. As a minimum, the instructor documentation should include the following:

1) Simulator operational manual
2) Instructor manual

9.2 Software documentation

The software documentation should provide the simulator software staff with the information necessary to maintain and modify the simulator software.

The software documentation should include information that is related to the computer vendor software, instructor station software, plant simulation software, executive software, and the software tools necessary for software modification and maintenance.

As a minimum, the software documentation should include the following:

1) Reference manuals for all computer vendor software
2) Reference manuals for all simulator vendor tools necessary for software modification and maintenance
3) Plant model functional specifications, including simulation diagrams, simplifications, scope of simulation, and interfaces
4) Plant model detailed design documentation, including model derivation and assumptions, algorithm development, block diagrams or flow charts, and data calculations

9.3 Hardware documentation

The simulator hardware documentation should provide the hardware maintenance staff with sufficiently detailed information to maintain, modify, and troubleshoot the simulator hardware.

The documentation should include an overview that describes the simulator configuration and its component hardware, including cross-references to system-specific documents. As a minimum, the documentation should include the following for each simulator component:

1) Operational manuals
2) Installation manuals
3) Maintenance and repair manuals
4) Full set of drawings
5) Wiring lists

Annex A -- Three types of simulators

This annex is not a part of ANSI/ISA-77.20.01-2012 Fossil-Fuel Power Plant Simulators — Functional Requirements.

This annex describes three types of simulators and lists the key defining characteristics of each:

A.1 Full-scope, high-realism simulator: The full-scope, high-realism simulator is an exact duplicate of a power plant control room, containing duplicates of all actual controls, instruments, panels, and indicators. The unit responses simulated on this apparatus are identical in time and indication to the responses received in the actual plant control room under similar conditions. A significant portion of the expense encountered with this type of simulator is the high-fidelity simulation software that must be developed to drive it.

The completeness of training using a full-scope simulator is obviously much greater than that available on other simulator types since the operator is performing in an environment that is identical to that of the control room. Experienced operators can be effectively retrained on this simulator because the variety of conditions, malfunctions, and situations offered do not cause the operator to become bored with the training or to learn it by rote.

The major drawback of a full-scope, high-realism simulator is its high cost and long lead time, typically two to three years. Relative advantages and disadvantages of the full-scope simulator are shown in Table A.1.

Table A.1 — Advantages and disadvantages of the full-scope simulator

Advantages	Disadvantages
1. Duplicate of unit control room.	1. Highest cost.
2. Capability limited only by capability of instructor.	2. Longest lead time.
3. Any condition or malfunction possible in real plant can be replicated on the simulator.	3. Highest overhead and maintenance costs.
4. Effective training for experienced operators.	4. No portability.
5. Up to four trainees may operate simulator at once.	5. Requires special environmental controls/equipment.
6. Virtually all instructor aids are available.	6. Specially trained computer technician advisable.
7. Plant operating procedures can be validated on simulator.	7. Large space required for housing simulator.
8. Spare time on simulator is highly marketable.	8. Highest training cost per hour per trainee of all types of simulators.
9. Can be used for instrumentation and control training.	9. Requires dedicated, highly qualified instructors.
	10. Simulator must be upgraded each time the plant is modified.

A.2 Reduced-scope, high-realism simulator: If cost were not a prime consideration, a full-scope, high-realism simulator would probably be the choice of most installations. One means to reduce the cost of the simulator is to limit the scope of both hardware and software simulation. Although such a simulator is not identical to an actual control room, all key instrumentation, controls, and plant models (typically 80% or more) are included. Instrumentation may be identical to that installed in the real plant or a reasonable likeness thereof.

This type of simulator is usually designed to be a partial replica of a particular plant and control room and is reduced in scope in that only selected portions of the control room and plant systems are included.

All major plant systems and controls are modeled to provide a high degree of realism to the operators, but only those auxiliaries that directly affect the primary operation of the plant are replicated. Other systems that might have controls and indicators on the panels but do not directly affect most plant operations are not included at all.

The training benefits received are similar to those of the full-scope simulator but at a significantly reduced acquisition cost. Because of the reduction in the complexity of the system modeling, a smaller, less exacting computer system can be used to drive the simulation.

Since the entire control room is not replicated, the space needed for this type of simulator is less than that required for the full-scope model. Even though the simulator does not duplicate the actual control room, trainees should still feel that they are operating an actual plant because of the similarity of the controls and the response of the simulation.

The cost of such a reduced-scope, high-realism simulator will be determined by the completeness, depth, and fidelity of the simulation, the degree of original software development and engineering, the operator interface requirements, the degree of interchangeability, and the number of simulation options. Typically 85% to 95% of the typical plant controls and systems would be modeled, with high realism in about 90% of these systems. Lead time is typically one to two years.

Table A.2 lists the relative advantages and disadvantages of the reduced-scope, high-realism simulator.

Table A.2 — Advantages and disadvantages of the reduced-scope, high-realism simulator

Advantages	Disadvantages
1. Relatively low cost (up to 75% less than full-scope simulator).	1. Limited use in verifying effectiveness.
2. Duplicates critical controls and panels.	2. Limited number of vendors.
3. Replicated systems and controls have realistic response in real time.	3. Some control room panels are not replicated and therefore cannot be used for training.
4. Full instructor aids and features may be incorporated.	4. Relatively long lead time.
5. Simulator may be upgraded and expanded.	5. Procurer must carefully specify systems for high fidelity simulation.
6. For simulated systems, has all features of full-scope simulator.	6. Requires well-trained, experienced instructors.
7. Spare time on this type of simulator should be marketable.	7. Because of reduced scope, it is not possible to satisfy training objectives on non-simulated systems or controls.
8. Any condition or malfunction possible in real plant can be replicated on the simulator.	
9. Effective training for experienced operators.	

10. Can be used for some instrumentation and control training.	
11. Trainee enthusiasm is high because of realism.	
12. Automated performance measurement can be installed.	
13. Authoring capability allows local modifications and creation of special scenarios.	
14. May have ability to test or verify plant procedures.	

A.3 Generic simulator: The generic simulator is the most difficult type to define since the term covers a wide range of possible simulator configurations. For the purposes of this standard, a simulator is considered generic if the operator interface has not been designed to replicate or closely resemble an actual power plant control room configuration.

It should be noted that by this definition, a simulator that completely replicates a particular control room's instrumentation and controls but utilizes generic simulation models, is still considered a generic simulator. Similarly, a simulator that employs plant-specific software models but utilizes graphic monitor-based control stations in lieu of the panel boards installed in the actual plant is also considered generic.

Annex B -- General modeling requirements

This annex is not a part of ANSI/ISA-77.20.01-2012, Fossil-Fuel Power Plant Simulators — Functional Requirements.

The fidelity and realism of a power plant simulation is directly related to the quality and suitability of the mathematical models that describe the plant processes. Differences between the three types of simulators should be found primarily in the level of detail and in the degree of plant specificity, not in the realism of the simulation. Therefore, the following general modeling requirements apply to all three types of simulators covered by this standard.

Modeling requirements for a power-plant training simulator are unique and should cover, as a minimum, the following areas:

1) Scope of simulation
2) Modeling techniques
3) Simulated range of operations
4) Real-time capabilities
5) Modularity

B.1 Scope of simulation: The scope of simulation is the primary cost driver in a training simulator. The scope is defined by the plant systems to be simulated, the components and phenomena to be simulated for each system, and the level of detail to be represented for each component.

To achieve the right balance between simulator costs and training value, it is essential to first define the training objectives. A preliminary definition of the scope of simulation should be established and included in the simulator specifications. A more detailed scope of simulation is then developed during the simulator system design phase and finalized with the detailed functional specifications.

Guidelines to establish the scope of simulation are as follows:

a) Systems, components, and phenomena that are associated directly or indirectly with plant responses that are observable and/or controllable by the trainee should be modeled explicitly.
b) Lumping of plant components (i.e., combining several identical components into a single component of equivalent capacity and performance), should be allowed only if consistent with the required simulated operating procedures.
c) Local equipment (i.e., equipment that cannot be operated directly from the control room) should be simulated if necessary to perform the normal and abnormal simulated operating procedures, consistent with the training objectives.

These simplifications to the plant models should be documented along with their rationale.

B.2 General modeling techniques: The mathematical models for the principal plant systems should be derived from the strict application of the laws of mass, energy, and momentum conservation to the simulated equipment. Principal systems are herein defined as those which significantly contribute to the plant heat balance. Examples of such systems include the following:

a) Main fuel system
b) Air and gas system
c) Furnace
d) Boiler and main steam system
e) Turbine and extractors
f) Generators
g) Main condensers
h) Circulating water system

i) Cooling towers
j) Condensate system
k) Feedwater system
l) Heater drains

Laws of conservation can be expressed in a steady-state or in a non-steady-state form. The steady-state form should be used only if the information contained in the time derivative of the equation cannot be perceived by an experienced control room operator under all possible modes of operation. As a guideline, differential equations that represent transients with time constants of 0.5 seconds or less under all conditions can be expressed in the steady-state form. Examples include mass balances in compressed liquids and momentum balances in low-inertia fluids (e.g., steam, gas).

To completely represent a plant system, it is necessary to complement the conservation equations with a number of correlations. Examples of correlations follow:

a) Heat-transfer and friction-loss calculations: The correlations used should be derived strictly from well-accepted engineering correlations, consistent with the dominant heat-transfer mechanism or flow regimen under consideration.
b) Fluid properties: Fluid properties can be represented by correlations or table look-up techniques. The accuracy of the fluid property representations should be consistent with the steady-state accuracy requirements over the entire range of simulated operations.
c) Equipment characteristics, such as pump curves and valve characteristics can be represented by means of correlations fitted to actual data or table look-up techniques. The accuracy of the curve fit or the table look-up should be consistent with the general accuracy requirements over the entire range of simulated operations.
d) Logic and analog controls should be simulated on a one-to-one basis, consistent with the stated simplifications.
e) The plant electrical system should be simulated on a one-to-one basis, consistent with the stated scope of simulation. In particular, consideration should be given to the level of interaction between the electrical system simulation and the simulated plant components (e.g., effects of bus voltage and frequency).

B.3 Simulated range of operations: The plant models should be capable of simulating the entire range of operations. They should also be able to realistically represent normal and abnormal transients resulting from operator action, lack of operator action, or simulated component failures.

Consideration should be given, as a minimum, to the following requirements:

a) A single model should be capable of continuously representing the entire range of simulated operations. Switching between different models that correspond to various operating conditions can detract from training and should be avoided.
b) Fluid properties should be accurate over the entire range of simulated operations, and discontinuities should be avoided.
c) Component failure should be simulated on a first-principles basis. The cause of each malfunction should be modeled explicitly, and its effects should result from the application of first principles and system interactions.

B.4 Real-time requirements: A training simulator must operate in real time during any normal or abnormal conditions.

To meet this requirement, the differential, algebraic, and logic equations must be solved at equal time intervals consistent with time constants or delays observable by the trainee. A simulator will operate in real time if the computer is capable of updating all the calculated parameters within the selected time frame.

Under some conditions, numerical solution schemes associated with relatively large, constant time intervals may exhibit an undesirable phenomenon called numerical instability. Numerical integration of the differential equations should be based on a fixed time-step algorithm. Numerical schemes should be selected in such a way that a numerically stable solution is obtained during any possible operating condition and for any values of model parameters.

Where first-order lags are used exclusively for the purpose of preventing numerical instability, their time constants should be kept to an absolute minimum to prevent distorting the model transient response.

Annex C -- General data requirements

This annex is not a part of ANSI/ISA-77.20.01-2012, Fossil-Fuel Power Plant Simulators — Functional Requirements.

The following data requirements apply to a typical full-scope, high-fidelity simulator. Data requirements for a reduced-scope, high-fidelity simulator are similar but limited to a subset that is consistent with the systems simulated. Data requirements for a generic simulator vary. Often, the trainee environment does not replicate a specific control room environment and is designed on the basis of training requirements. Plant models are typically “off-the-shelf" models, and data requirements are limited to some areas of redesign identified to accommodate specific training requirements.

Data requirements can be subdivided into four major categories that apply to different phases of the simulator design:

1) Control room hardware data required to order instruments and to proceed with panel fabrication; these include panel construction drawings, bills of materials, panel cutouts, plant computer peripheral descriptions, etc.
2) Plant description data required to proceed with the system design; these include P&IDs, control drawings, logic drawings, electrical one-line diagrams, reference manuals, specifications, plant computer reference manuals, operating procedures, and I/O lists
3) Plant design data required to proceed with the implementation of the mathematical models
4) Plant operating data required to proceed with the tests of the simulation; examples of such data include steady states at one or several load points and transients (e.g., turbine trip)

C.1 Control room data: The control room hardware data is required to procure simulator instruments and to proceed with simulator control room fabrication. The fabrication data is needed for all simulated control room equipment:

a) Control room panel construction drawings with dimensions
b) Control room panel cutout drawings with dimensions
c) Control room panel layout drawings showing location and identification of each instrument
d) Instrument lists, including instrument type, vendor name, model number, scales, number of pens (recorders), transmitter number, and measured variable descriptions
e) Name tags for all instruments, including colors, character styles, dimensions, and location lists
f) Annunciator engraving for all alarms, including colors, dimensions, description, and location
g) Simulator building layout and dimensions
h) Sootblower insert dimensions and layout
i) Dimensions of printers, historian, sequence-of-events recorder, etc.

C.2 Plant description data: The plant description data is necessary to proceed with the simulator system design and the development of the functional specifications. The following data is necessary for all simulated systems:

a) System descriptions
b) Piping and instrumentation drawings
c) Control drawings
d) Functional logic drawings
e) Major equipment specifications (boiler, turbine, generator)
f) Electrical one-line diagrams
g) Plant operating procedures
h) Heat balance diagrams
i) Equipment reference manuals
j) Transmitter list
k) Panel layout drawings, showing location and identification of all instruments

l) Instrument list
m) Control system descriptions

C.3 Detailed design data: The plant detailed design data is required in order to proceed with the design and implementation of the mathematical models. The following data is required, where applicable, for all simulated systems and components:

a) Pumps:
- Pump type
- Manufacturer's characteristics, including differential pressure and brake horsepower as a function of flow and RPM
- Rotor locked current
- Motor current at specified flow, pressure, temperature, and RPM conditions
- Start-up/coastdown times
- Specifications of the bus to which the motor is connected
- Pump motor breaker logic

b) Fans:
- Fan type
- Manufacturer's characteristics, including differential pressure and brake horsepower as a function of flow, RPM, and inlet vane position
- Rotor locked current
- Motor current at specified flow, pressure, temperature, RPM, and inlet vane conditions
- Start-up/coastdown times
- Specifications of the bus to which the motor is connected
- Fan motor breaker logic
- Inlet vane characteristics and stroke time
- Inlet vane logic
- Outlet damper characteristics and stroke time
- Outlet damper logic

c) Valves:
- Valve type
- Characteristic
- Valve capacity at specified position and temperature conditions
- Stroke time
- Fail position on loss of control air/power
- Bus specifications
- Valve logic

d) Dampers:
- Damper type
- Damper characteristic
- Damper capacity at specified position and temperature conditions
- Travel time
- Fail position on loss of power/control air
- Bus specifications
- Damper logic

e) Tanks and vessels:
- Shape and dimensions
- Elevations
- Level tap locations and elevations

f) Heat exchangers:
- Design specifications

• Type, shape, and dimensions
• Elevation (liquid heat exchangers only)
• Temperatures, pressures, and flows at specified conditions
• Level tap locations and elevations
• Number of tubes and dimensions

g) Condensers:
• Design specifications
• Shape and dimensions
• Air ejector or vacuum pump specifications and logic
• Vacuum breaker specifications and logic
• Hotwell elevation
• Number of tubes and dimensions
• Level tap locations and elevations

h) Boilers:
• Design specifications
• Boiler drawings showing heat transfer surface arrangement and locations
• Sootblower locations
• Burner specifications
• Drum dimensions and elevations
• Economizer internal volume and total mass
• Downcomer and waterwall internal volumes and total masses
• Superheater/reheater internal volumes and total masses
• Fuel, water, steam, metal, air and gas flows; temperatures and pressures for each major simulated section at specified steady-state and start-up conditions and for given fuel and ambient conditions
• Draft losses at specified steady-state conditions

i) Air preheaters:
• Type
• Arrangement and dimensions
• Design specifications
• Breaker logic
• Temperatures, flows, and draft losses at specified steady-state conditions
• Internal volumes and total mass of the heat transfer surfaces
• Arrangement and dimensions
• Draft losses
• Transmitter locations

j) Precipitators:
• Design specifications
• Draft loss
• Efficiency

k) Stack:
• Dimensions
• Draft loss

l) Burners:
• Burner characteristics (pressure drop versus flow curves at specified temperature)

m) Sootblowers:
• Locations
• Sootblower logic
• Motor current and pressure at specified operating conditions

- Specifications and operating manual
- Efficiency (cleanup time at specified conditions)

n) Safety valves:
- Capacity
- Set point and dead band

o) Turbines:
- Design specifications
- Turbine thermal kit
- Control valve curves
- Control and logic drawings and descriptions
- Inertia or coastdown curves
- Critical speeds
- Transmitter locations
- Actual start-up charts (steam and metal temperatures, vibrations, differential expansion, pressure)
- Steam and metal temperatures, pressure, flows, extraction pressures, extraction flows, differential expansion at specified steady-state conditions

p) Generators:
- Design specification
- Generator curves
- Transmitter locations
- Damping factor
- Number of poles
- Synchronous reactance
- Stator friction losses
- Armature copper losses
- Stator stray-core losses
- Rotor friction losses
- Rotor stray losses
- Field heat losses
- Hydrogen pressure
- Active and reactive power, terminal voltage, currents, and slip at specified steady- state conditions

q) Exciter/voltage regulator:
- Description and drawings
- Specifications
- Manual raise/lower rate
- Auto raise/lower rate
- Field current time constant
- Voltage upper/lower limits
- Voltage regulator gain
- Maximum field current range
- Maximum field voltage range

r) Transformers:
- Impedance
- Transformer turn ratio
- Taps

s) Breakers and relays:
- Type
- Location
- Functional logic drawings
- Specifications

t) Buses:
- Nominal voltage
- List of all equipment connected to each bus

u) Alarms:
- Functional logic drawings
- Set points
- General alarm, acknowledge, and reset sequence
- Flash rates

v) Controllers:
- M/A station descriptions
- Set points
- Function generator curves
- Lead/lag time constants
- Limits
- Proportional gains
- Reset rates
- Set times
- Raise/lower rates
- Output upper/lower limits

w) Transmitters:
- Specifications
- Location
- Fail value on loss of power

x) Burner and turbine protection:
- Functional logic drawings
- Set points
- Time delays
- Operating procedures

y) Miscellaneous trip and protection:
- Functional logic drawings
- Set points
- Time delays

z) Plant process parameter display:
- Display formats
- Display fill sequence and response time
- Detailed operator communication description, including displays, messages, etc.
- Log formats and contents
- List of analog and digital point IDs with descriptions and all applicable attributes

C.4 Plant performance data: The plant performance data is useful for fine-tuning against actual plant performance and model validation. This data should not be essential to the design of the simulator if the simulation is based on first-principle mathematical models. However, to verify the fidelity and prediction capability of a simulation model, it is best to validate its response at one or several steady states over the entire operational range and during some well-defined transient situations.

To accomplish this, the following data is useful:

1) Actual plant heat balance data
2) Plant computer printouts and instrument readings at one or several steady-state conditions including full load

3) Charts and trend logs during important transients such as start-up, load changes, load rejection, plant trips, etc.

In the absence of such data, best estimates, good engineering judgment, and operator inputs should be used.

Annex D -- Specific documentation for three types of simulators

This annex is not a part of ANSI/ISA-77.20.01-2012, Fossil-Fuel Power Plant Simulators — Functional Requirements.

This annex provides the recommended content of the documentation to be supplied with each type of simulator.

D.1 Instructor documentation

The requirements of Table D.1 apply to the documentation of all the simulated plant systems.

Table D.1 -- Instructor documentation requirements

	Replica	Limited Scope	Generic
Simulator operation manual			
Simulated plant description	Yes	Yes	Yes
Simulated plant operating procedures	Yes	Yes	Yes
Malfunction causes and effects	Yes	Yes	Yes
Instructor manual			
General description	Yes	Yes	Yes
Instructor station operating procedures	Yes	Yes	Yes

D.2 Software documentation

D.2.1 Plant models

The requirements of Table D.2 apply to the documentation of all the simulated plant systems.

Table D.2 — Simulated plant systems documentation requirements

	Replica	Limited scope	Generic
Functional specifications			
System descriptions	Yes	Yes	Yes
Assumptions and simplifications	Yes	Yes	Yes
Simulation drawings	Yes	Yes	Yes
Interfaces with other systems	Yes	Yes	N/A
Interfaces with control room equipment	Yes	Yes	Yes
Interfaces with instructor station	Yes	Yes	Yes
Plant reference data	Yes	Yes	N/A

Detailed design specifications			
Symbol dictionaries	Yes	Yes	N/A
Equation derivation and simplifications	Yes	Yes	N/A
Flow charts, diagrams	Yes	Yes	N/A
Data calculations	Yes	Yes	N/A
Computer listings	Yes	Yes	N/A
Engineering manual			
Nomenclature	Yes	Yes	N/A
Symbols	Yes	Yes	N/A
Conventions	Yes	Yes	N/A
General modeling techniques	Yes	Yes	N/A
Standard algorithms, derivations, and simplifications	Yes	Yes	N/A

D.2.2 System software documentation

The requirements of Table D.3 apply to project-specific application software other than the plant models, such as

1) instructor station;
2) plant computer; and
3) distributed control system.

Table D.3 -- System software documentation requirements

	Replica	**Limited scope**	**Generic**
Functional specifications			
Functional descriptions	Yes	Yes	Yes
Operator-machine interface	Yes	Yes	Yes
Hardware requirements	Yes	Yes	Yes
Interfaces	Yes	Yes	N/A
Detailed design documentation			
Functions	Yes	Yes	N/A
Display formats	Yes	Yes	N/A
Report formats	Yes	Yes	N/A
Input/output formats	Yes	Yes	N/A
Error messages	Yes	Yes	N/A

Pseudo-code or flow charts	Yes	Yes	N/A
Program and file structures	Yes	Yes	N/A
Memory and bulk storage requirements	Yes	Yes	N/A
Maintenance and modification procedures	Yes	Yes	N/A
Listings	Yes	Yes	N/A

D.2.3 Software tools documentation

The requirements of Table D.4 apply to all software tools supplied for the modification and maintenance of the simulator software.

Table D.4 -- Software tools documentation requirements

	Replica	Limited scope	Generic
Reference manuals			
Purpose	Yes	Yes	N/A
Narrative description	Yes	Yes	N/A
Function descriptions	Yes	Yes	N/A
Error messages	Yes	Yes	N/A

D.2.4 Vendor manuals

The requirements of Table D.5 apply to the documentation of all the simulated plant systems.

Table D.5 — Vendor manuals documentation requirements

	Replica	Limited scope	Generic
Operating system	Yes	Yes	Yes
Compilers	Yes	Yes	N/A
Program development	Yes	Yes	N/A
Environment	Yes	Yes	N/A

D.3 Hardware documentation

D.3.1 Computer, peripherals, and I/O equipment

The requirements of Table D.6 apply to all computer and peripheral equipment that is related to:

1) simulation computers;
2) instructor station peripherals;
3) plant computer peripherals;
4) distributed control systems; and
5) I/O interface.

Table D.6 -- Hardware documentation requirements

	Replica	Limited scope	Generic
Hardware description manuals	Yes	Yes	Yes
Equipment description and layout	Yes	Yes	Yes
Assembly drawings	Yes	Yes	Yes
Front-view centerline drawings	Yes	Yes	Yes
Wiring diagrams	Yes	Yes	Yes
Connector termination lists	Yes	Yes	Yes
Cable tabulation and routine sheets	Yes	Yes	Yes
Bills-of-material and parts list	Yes	Yes	Yes
Elementary diagrams	Yes	Yes	Yes
Input/output lists	Yes	Yes	Yes
Calibration sheets	Yes	Yes	Yes
Instrument O&M manuals	Yes	Yes	Yes
Diagnostics	Yes	Yes	Yes

D.3.2 Site manuals

Table D.7 -- Site manual requirements

	Replica	Limited scope	Generic
Space and environmental requirements			
Simulator layout	Yes	Yes	Yes
Equipment dimensions	Yes	Yes	Yes
Environmental specifications	Yes	Yes	Yes
Heat load	Yes	Yes	Yes
Power requirements	Yes	Yes	Yes
Site preparation and installation			
Floor construction	Yes	Yes	Yes
Fire protection	Yes	Yes	Yes
Equipment required for installation	Yes	Yes	Yes
Electrical requirements	Yes	Yes	Yes
Unpacking instructions	Yes	Yes	Yes

Annex E -- Simulation versus stimulation

This annex is not a part of ANSI/ISA-77.20.01-2012, Fossil-Fuel Power Plant Simulators — Functional Requirements.

In a simulator, several methods are available to replicate actual instrumentation. The following discussion and guidelines apply to computer or microcomputer-based instrumentation systems. Three methods are applicable:

1) Stimulation, which uses the actual system hardware and software, modified to function properly in the simulator environment
2) Simulation, which uses alternate hardware and software programmed to emulate the instrumentation system's operator-machine interface, without necessarily replicating all its functions
3) Partial simulation, which uses the actual system hardware and software to replicate the operator-machine interface. However, actual functions (e.g., control loops, efficiency calculations) are emulated in the simulation computer

Selection of the method to be applied for a specific project requires the consideration of a number of technical and cost-related factors. The following provides the user with guidelines to assist in selecting the most suitable method for a specific application.

E.1 Stimulation: The stimulation method involves the interfacing of the stimulated system to the simulation computer. The hardware between the two computer systems can be implemented by means of a high-speed parallel data interface, high-speed asynchronous interface, gateways, or a custom-built interface. Software must be provided for communication and synchronization between the two computers. In addition, the stimulated software should be modified to accommodate the following simulator modes of operation:

a) Freeze/run
b) Fast/slow time
c) Backtrack/replay
d) Initial conditions save/load
e) Snapshots
f) Simulated equipment malfunctions

The following are advantages of the stimulation method:

- Stimulated software and configurations are easier to keep up to date with the plant.
- Plant spare hardware can be used for the simulator.
- Stimulation is potentially more cost-effective, since systems are getting more and more complex and, therefore, more costly to emulate.

The following are disadvantages of the stimulation method:

- Possible limitations in the communication throughput between the stimulated system and the simulator may limit update rates to the point that the simulated processes are difficult or impossible to control (distributed control systems).
- Modification to the stimulated software required to accommodate the stimulator modes of operation are strongly dependent on the system internal architecture and can be extensive.

E.2 Simulation: In the simulation method, either the simulation computer or a dedicated computer integrated with the simulation computer is used as a substitute for the actual plant hardware. Software must be developed to replicate both the operator-machine interface and the system functions. Functions normally inaccessible to the control room operator (e.g., engineering functions) do not need to be reproduced.

The following are advantages of the simulation method:

- Ease of accommodating simulator modes of operation and malfunctions.
- Cost-effectiveness, especially if emulation software is available off the shelf and simulation computer resources can be shared.
- The cost of hardware maintenance, training, and spare parts is lower.

The following are disadvantages of the simulation method:

- There is a possibility of discrepancies in the actual system.
- Software maintenance costs are higher.

E.3 Partial stimulation: The partial stimulation method is an attempt to combine the best of both the simulation and the stimulation methods in that only the operator-machine interface hardware and software are stimulated, while the system functions (e.g., control loops, performance calculations) are simulated on the simulation computer.

Advantages of the partial stimulation method are as follows:

- It is easy to accommodate simulator modes of operation and malfunctions.
- Partial stimulation provides high visual fidelity.
- The lowest combined software/hardware maintenance costs are associated with partial stimulation.

Disadvantages of the partial stimulation method include the following:

- Possible discrepancies exist between simulated and actual system functions.
- Possible interface throughput limitations exist for large systems.

The selection of any of these three methods requires a careful analysis of the complete life-cycle costs associated with each for a specific application, including:

1) hardware equipment;
2) software design, development, and testing activities, including user involvement (e.g., design reviews, data collection);
3) hardware and software maintenance and updates;
4) training; and
5) documentation.

Other cost-related factors should be considered, where applicable, such as

1) availability of in-house spare equipment;
2) importance of visual fidelity versus functionality; and
3) acceptability of a limited functionality during certain modes of operation (e.g., backtrack/replay).

Annex F – Related Standards

This annex is not a part of ANSI/ISA-77.20.01-2012, Fossil-Fuel Power Plant Simulators — Functional Requirements.

1) Standards Referenced in this Document

   None

2) Other Related Standards

   IEEE 315-1975 Graphic Symbols for Electrical and Electronic Diagrams

   ANSI/IEEE 730-2002 Software Quality Assurance Plans

   NFPA 70 National Electrical Code (Current Edition)

   NFPA 75 Standard for the Protection of Information Technology Equipment

   ASME Y14.44 – 2008 Reference Designations for Electrical and Electronics Parts and Equipment

   ANSI/ISO/ASQC Q9001-2008 Quality Management Systems – Requirements

   ISA-18.1-1979 (R2004) Annunciator Sequences and Specifications

   ANSI/ANS-3.5-2009 Nuclear Power Plant Simulators for Use in Operator Training and Examination

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APPENDIX B
RESPONSE FORM

076-19 JEA N02 CFB Boiler Simulator Replacement

COMPANY INFORMATION:

COMPANY NAME:____

BUSINESS ADDRESS:____

CITY, STATE, ZIP CODE:____

TELEPHONE:____

FAX:____

EMAIL OF CONTACT:____

Description	Total Bid Price
Equipment and Services as described in this solicitation 076-19 (Transfer total from the Bid Workbook)	$

The Company shall submit one (1) original Proposal, three (3) duplicates (hardcopies), and four (4) CDs or USB drives. If there is a discrepancy between the electronic copy and hard copy, the hard copy will prevail. JEA will not accept Proposals transmitted via email.

Company's Certification

By submitting this Proposal, the Proposer certifies that it has read and reviewed all of the documents pertaining to this RFP and agrees to abide by the terms and conditions set forth therein, that the person signing below is an authorized representative of the company, that the company is legally authorized to do business in the State of Florida, and that the company maintains in active status an appropriate license for the work. The company certifies that its recent, current, and projected workload will not interfere with the company's ability to Work in a professional, diligent and timely manner.

The Proposer certifies, under penalty of perjury, that it holds all licenses, permits, certifications, insurances, bonds, and other credentials required by law, contract or practice to perform the Work. The Proposer also certifies that, upon the prospect of any change in the status of applicable licenses, permits, certifications, insurances, bonds or other credentials, the Company shall immediately notify JEA of status change.

We have received addenda ___________through_______

___________________________________ ___________________________
Signature of Authorize Officer of Company or Agent Date

___________________________________ ___________________________
Printed Name & Title Phone Number

Appendix B Minimum Qualification Form
076-19 JEA N02 CFB Boiler Simulator Replacement

GENERAL

THE MINIMUM QUALIFICATIONS SHALL BE SUBMITTED ON THIS FORM. IN ORDER TO BE CONSIDERED A QUALIFIED PROPOSER BY JEA YOU MUST MEET THE MINIMUM QUALIFICATIONS LISTED BELOW, AND BE ABLE TO PROVIDE ALL THE SERVICES LISTED IN THIS SOLICITATION.

THE PROPOSER MUST COMPLETE THE PROPOSER INFORMATION SECTION BELOW AND PROVIDE ANY OTHER INFORMATION OR REFERENCE REQUESTED. THE BIDDER MUST ALSO PROVIDE ANY ATTACHMENTS REQUESTED WITH THIS MINIMUM QUALIFICATIONS FORM.

PLEASE SUBMIT THE ORIGINAL AND TWO (2) COPIES OF THIS FORM AND ANY REQUESTED ADDITIONAL DOCUMENTATION WITH THE BID SUBMISSION.

PROPOSER INFORMATION

COMPANY NAME:____

BUSINESS ADDRESS:____

CITY, STATE, ZIP CODE:____

TELEPHONE:____

FAX:____

E-MAIL:____

PRINT NAME OF AUTHORIZED REPRESENTATIVE:________________________________

SIGNATURE OF AUTHORIZED REPRESENTATIVE:_________________________________

NAME AND TITLE OF AUTHORIZED REPRESENTATIVE:____________________

MINIMUM QUALIFICATIONS:

The Respondent shall provide evidence of successful completion of one (1) similar simulator for a power operated boiler at least 150MW in size contract within three (3) years of the Response Due Date. A similar contract is defined as:

The contract shall be of similar complexity as specified in Appendix A – Technical

SIMULATOR REFERENCE ____ of __5__(five required for evaluation)

Selected as the Reference for Site Visit ______ Yes / No

Selected as the Minimum Qualification Reference ______ Yes / No

Customer Name ____

Customer Adderss ____

Reference Name____

Reference Phone Number____

Reference E-Mail Address____

Contract Year/Amount ____

Description of Contract & Demonstrated parity to JEA's Project

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