TEXAS A&M UNIVERSITY
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Nuclear Engineering
Health Physics

Safety Engineering
Industrial Hygiene

June 23, 2000

50-59

Mr. Ledyard B. Marsh, REXB
United States Nuclear Reactor Commission
Mail Stop: 012-D3
Washington, DC 20555-0001

Dear Mr. Marsh:

Thank you very much for your call on June 19, in which you discussed the impressions of your recent trip to College Station, Texas. I understand that you visited both the AGN-201 and our TRIGA reactor and talked to staff members of both facilities.

We appreciate your kind words about the upbeat atmosphere within our Department and the recent success we have had in building student enrollment. Our entire faculty and staff have been working hard to attract bright, young students into our program and we seem to be having some success.

As you pointed out, it would certainly seem that we should be better utilizing and leveraging the fortunate position we have in being the only nuclear engineering program in the nation to have two nuclear reactors. We need to get the AGN-201 reactor up and running again and, in fact, would very much like to incorporate a major upgrade in the instrumentation and control package for this reactor so that we could operate it in a more reliable fashion. To this end, we have enlisted the help of our TRIGA facility electronics staff. However, we view this as only a temporary fix, a way of getting the AGN up and running by mid-July. In addition, we plan to prepare a new instrumentation upgrade proposal for the next fiscal year. We have submitted a similar proposal to DOE several times during the nineties, to both DOE and State-based programs, but were unsuccessful in obtaining funding (see attachments of both 1992 and 1994 upgrade proposals). We currently run the reactor with drawers based on 1950's vacuum tube technology. We would like to upgrade to at least an analog circuits-based technology. As you will see in

A020

our attachment, we have been very aggressive in the past (perhaps too aggressive) as we requested funds to upgrade to the latest digital electronics.

As I mentioned during our conversation, I would personally like to incorporate this reactor into the freshmen orientation class that I teach (NUEN 101 – Principles of Nuclear Engineering). Our faculty, and in fact, our curriculum incorporates it into some of our laboratory courses: NUEN 402 – Radiation Detection and Isotope Technology Laboratory, and NUEN 405 – Reactor Experiments Laboratory. The latter class especially lends itself to a natural synergy between the AGN-201 and the much larger TRIGA reactor, as we start our students out in the AGN facility for the first five weeks, and then finish the semester at the TRIGA facility. I feel that such synergy should be exploited in the area of research, as has been done in the past; we need to work harder to make this happen.

In order to demonstrate our resolve to move more forcefully toward these goals, I would like to suggest that the following implementation schedule be considered. I understand that such a schedule would be useful to you as you make crucial decisions in the allocation of your resources (required to provide the regulatory oversight necessary for the proper operation of these facilities).

1. Complete all Requirements for the Renewal of Robert O. Berry's Operating License for the AGN-201 ------ July 10, 2000

2. Submit all materials needed for the extension of the current operating license for the AGN-201 ------ July 17, 2000

3. Hold a TRIGA/AGN-201 staff meeting to strategize on ways to better integrate the resources of these two facilities for optimal student learning and research opportunities ------ August 18, 2000

4. Submit a detailed request to the DOE (or other appropriate funding agency) for a major upgrade in the instrumentation module for the AGN-201 ------ In advance of required programmatic deadline(s).

Please let me know how this schedule meshes with your planning base in being able to allocate the resources you need to help us move forward. I know you would like to use these facilities in a more optimal fashion, and we very much appreciate your willingness to collaborate in an appropriate manner.

Thanks again for visiting us. I will talk to Dr. Paul Nelson, Associate Department Head and organizer of our fall seminar series, to see if it may be possible to induce you into returning to College Station in the relatively near future to talk to our students in faculty in a somewhat larger forum.

Best regards,

Alan Waltar
Professor and Head
Department of Nuclear Engineering

Attachments: 1992 Proposal for AGN-201M Instrumentation Upgrade
1994 Proposal for AGN-201M Instrumentation Upgrade

cc: Bob Berry
Ian Hamilton
W. Dan Reece
Paul Nelson

NUCLEAR INSTRUMENTATION AND CONTROLS UPGRADE OF THE AGN-201M REACTOR AT TEXAS A&M UNIVERSITY

A Proposal for Department of Energy Equipment Upgrade Program

by

Department of Nuclear Engineering
Texas A&M University
College Station, Texas 77843
SEPTEMBER 1992

Proposal for Department of Energy Equipment Upgrade

INTRODUCTION

The Aerojet General Nuclear 201M (AGN-201M) training reactor located at Texas A&M University is currently used by the Department of Nuclear Engineering for student training and indoctrination. The AGN-201M reactor was originally designed for large scale applications as a teaching and research reactor and has many uses contained in a fairly basic design. While the reactor has a rated power of only 5 watts, it remains a valuable teaching tool for students enrolled in the undergraduate program in nuclear engineering. The main function of this training reactor is to provide practical application of concepts taught in the classroom through actual operation of the training reactor. All undergraduate students in the department enrolled in NUEN 405, Nuclear Engineering Experiments, are required to perform a supervised reactor startup and also operate the reactor during some of the laboratory experiments. These reactor operations provide our students with hands on reactor operating experience that few other nuclear engineering departments are able to obtain. The sole function of this reactor system is to provide training for nuclear engineering students and for reactor operators (primarily graduate students in nuclear engineering).

DESCRIPTION OF PROPOSED PROJECT

Currently, the AGN-201M training reactor and support systems are badly in need of upgrading. The age of some of the components in these systems leads to frequent failures and repairs are difficult due to the limited availability of spare parts. During the last 18 months the nuclear instrumentation system has suffered two major component failures which have caused the cancellation of operations for long periods while repairs were completed. The major goal of this equipment upgrade is to replace all of the older reactor control and instrumentation systems with currently available and supported equipment and technology. This upgrade will ensure continued reactor operations in support of nuclear engineering education at Texas A&M.

The major system that will be most affected by this proposed equipment upgrade is the nuclear instrumentation system. This upgrade will involve the replacement of essentially all components in the three nuclear instrumentation channels with the exception of the detectors. Currently, channel 2 is a vacuum-tube based system which only has limited reliability. In addition, replacements parts have been difficult to obtain. The other two nuclear instrumentation channels system will be updated and many of the current components will be replaced with newer components. This equipment upgrade will not only improve the reliability of each of these channels but will also allow for a computer interface to

be introduced into the system. The computer interface will use output from the new channels to provide a large remote display of the three instrumentation channels. Use of the computer will allow for replacement of the rod position indications and the rod control switches. The rod control switches currently in use are 1950's style telephone switches.

The computer interface is intended to provide a more modern system for the monitoring of reactor operations. The reactor operator will continue to have complete manual control of the reactor. All safety system signals will be generated from the analog replacement meters incorporated in the three channels. This new equipment will allow redesign of the reactor console so that the operator can observe all three nuclear instrumentation channels with greater ease.

Other proposed upgrades include installation of signal boosters on all installed nuclear detectors, this will reduce the effect of background noise on reactor operations at low power. Another important feature of this proposed upgrade is the installation of an uninterruptible power supply for the nuclear instruments. This new power supply will serve as an emergency source of power to the reactor console and allow operation of the reactor's nuclear instrumentation systems following a scram due to the loss of facility power.

A complete list of the equipment needed for the reactor nuclear instrumentation upgrade is provided in Appendix A. This equipment list is

based upon the initial design for the upgrade and is intended as only a guide. The equipment selected and the cost may change depending upon future design considerations. Several telephone conversations have taken place between facility personnel and members of the Nuclear Regulatory Commission. The final design for this proposed equipment upgrade must meet with their approval, at this point no major areas of concern appear to exist.

Included in the overall cost of this proposal is the cost of supporting a graduate student to assist in installation and testing of the system. Funds for the reactor supervisor and the electronics technician are not included and will be borne by the department. The electrical design and computer programing required for this upgrade will require the assistance of a graduate student in electrical engineering. This student has been actively participating during the initial design phase of this project. The estimated cost of the support of this student is presented in Appendix B.

This proposed upgrade is needed very badly and if the proposed design is fully implemented this reactor facility should easily operate into the next century. The upgrade will allow for us to continue to provide our students an opportunity to operate a reactor and to use a reactor during laboratory courses in nuclear engineering. In addition, the upgrade will provide our students experience on a reactor with modern nuclear instrumentation and operating systems similar to those currently in use.

Total Estimated Cost of Proposed AGN-201M Upgrade

1) Equipment	$51,735.00
2) Support Personnel	$10,080.00
Total Direct Cost	$61,815.00
Indirect Cost (45% of Direct Personnel Cost)	$4,536.00
Total Estimated Cost:	**$66,351.00**

APPENDIX A: EQUIPMENT LIST WITH COSTS

QUANTITY	DESCRIPTION	PRICE	AMOUNT
1	Computer enclosure with an Uninterruptible Power Supply. This enclosure will be used to house all of the computer components, including all of the data acquisition expansion boards, in a 19" form factor that will allow mounting into a standard 19" lab rack. This enclosure will feature a 220 Watt uninterruptible power supply that will power the computer in case of a brown, or black out in the building's power system. PART # RME-115; RECORTEC CO.	$1,105.00	$1,105.00
1	Membrane Keyboard. This keyboard features a 19" mounting plate that allows for vertical installation in a standard 19" lab rack. PART # RMK-020; RECORTEC CO.	$335.00	$335.00
2	SVGA Monitors. These video monitors will be used to display the control rod positions on one monitor, and real time power levels on the second monitor. The monitors will be connected to the dual SVGA card located inside of the computer. PART # RMM-235; RECORTEC CO.	$665.00	$1330.00
1	Computer Mother Board, 486-33, with a 256 Kilobyte Cache. This board will have an Intel 80486 Microprocessor operating at 33 megahertz. Additionally, the processor will have a 256 Kilobyte static ram cache to improve it's overall speed performance. This computer board will be the host in which all of the data acquisition boards, and computer peripheral boards will be connected. All system software will be run off of this board. NO PART #; RECORTEC CO.	$2,695.00	$2,695.00
1	Memory Upgrade Of 8 Megabytes. This dynamic random access memory upgrade will allow the computer to run more efficiently with the software that is to be used in this computer system. NO PART #; RECORTEC CO.	$500.00	$500.00
1	Additional 3.5" Floppy Drive. The additional floppy drive will allow the computer system to accept both forms of magnetic media (1.44MB-3.5",1.2MB -5.25"). This can be an asset when some of the required programs are only available on one type of media. NO PART #; RECORTEC CO.	$75.00	$75.00

QUANTITY	DESCRIPTION	PRICE	AMOUNT
1	200 Megabyte Hard Disk Upgrade. The additional hard disk space will ensure that any program upgrades, and any data logging applications will be fully supported in the future. NO PART#; RECORTEC	$400.00	$400.00
1	Dual SVGA Video Card. This video card will drive two SVGA (SUPER VIDEO GRAPHICS ADAPTER) monitors. The card will be placed inside the computer where concurrently running programs will display their output on the two monitors. This will allow the plant operator to view only the control information as allowed by the Nuclear Regulatory Commission. PART #611175; MFG. COLORGRAPHIC VENDOR; COMPUTER ACCESS	$1,190.00	$1,190.00
1	AT-GPIB Interface Board. This provides an industry standard IEEE-488.2 interface that is used for data communication, and control between a host controller, such as a computer with this card, and a variety of laboratory instrumentation. In this application there will be two Keithley picoammeters (mod#486) that will read the ion chamber currents from the channel's two and three ion chamber sensors. The pico-ammeters will be strategically located close to the sensors so that there will be less opportunity for any noise to be injected into the sensor output current. The value of the current will then be transformed into a digital word that will be transmitted over the IEEE-488.2 bus to the computer (all in real time). This operation will be conducted for both channels #2, and #3, where channel #2 gives indication of ion chamber current, and the period($1/(\partial i/\partial$); channel #3 gives an indication of the instantaneous reactor power output. Additionally, The host computer will send data signals to a Gould chart recorder (mod#3008-A1506-17), over the IEEE 488.2 bus to log the data for permanent record keeping. PART # 776207-51; NATIONAL INSTRUMENTS	$517.00	$517.00
2	Channel 2 Meter Signal Conditioner. This circuit board is yet to be designed by the instrumentation systems engineer. This signal conditioner will receive an analog voltage, from the AT-AO-A10 analog output board that is located in the host computer, and convert the voltage to drive the analog meters that are required to display the ion chamber current, and the ion chamber period for channel 2. PART # CH2MSCR.1; TEXAS A&M UNIVERSITY	$200.00	$400.00

QUANTITY	DESCRIPTION	PRICE	AMOUNT
2	Channel 3 Meter Signal Conditioner. This circuit board has not yet been designed by the instrumentation systems engineer. This signal conditioner will receive an analog voltage, from the AT-AO-A10 analog output board that is located in the host computer, and a scale select reading from the operators panel; the output voltage will then drive the analog meter that is used to display the instantaneous reactor power output in watts. PART # CH3SCR.11; TEXAS A&M UNIVERSITY	$200.00	$400.00
1	AT-AO-A10 Analog Output Board. This board will operate in conjunction with the AT-GPIB board, and the AT-DIO-32F digital input/output board. The software, Lab Windows, will integrate all three of these boards to work together. The data received from the two Keithley picoammeters will be transmitted over the IEEE 488.2 bus into the computer via the AT-GPIB card. The data will then be processed by the host computer. The AT-AO-A10 board will then be instructed, by the host computer, to output an analog voltage that is proportional to what the analog display meters, for channels one and two, are supposed to display (based on the data received by the host computer from the two Keithley picoammeters). The outputs of the AT-AO-A10 board are directly connected to both channel two, and channel three, meter signal conditioner modules. PART # 776542-01; NATIONAL INSTRUMENTS	$1,255.50	$1,255.50
1	AT-DIO-32F Digital Input/Output Board. This board interfaces the host computer to the control rod position motors, and the microswitches that indicate control rod positioning. There is a interface board (SC2052 adapter board) that connects the AT-DIO-32F to three other boards. The first two boards are the SC2060, this board will accept optically isolated, digital input signals that can be easily generated with the existing microswitches that are now in place in the reactor. The third board is a SC-2062. This board will accept digital signals that in turn activate an electromechanical relay that can handle 6 amps at 30volts direct current. This board will then be used to control the control rod positioning motors. PART # 776246-01; NATIONAL INSTRUMENTS	$535.50	$535.50

QUANTITY	DESCRIPTION	PRICE	AMOUNT
2	SC2060 Optical Isolation Input Board. This board will be used to receive microswitch settings from the control rod position switches in order to indicate to the plant operator where the control rods are. (for additional information see description of the AT-DIO-32F BOARD). PART # 776336-10; NATIONAL INSTRUMENTS	$202.50	$405.00
1	S2062 Digital Relay Interface. This board will interface the host computer to the control rod motors for positioning control of the rods. The emergency scram procedures will be unaffected by this control implementation. (for further information see description of the AT-DIO -32F BOARD). PART # 776336-12; NATIONAL INSTRUMENTS	$211.00	$211.00
1	SC2052 Adapter Board. This board is used to interface the 50 pin connector from the AT-DIO-32F board to the 26 pin SC 2060, and the 26 pin SC2062 boards. PART #776335-12;NATIONAL INSTRUMENTS	$144.00	$144.00
1	NB4 Cable. A shielded cable used to connect the AT-DIO-32F board to the SC2052 cable adapter board. PART #180554-10; NATIONAL INSTRUMENTS	$58.50	$58.50
1	AT Series RTSI Bus Cable. This cable is used to connect the AT-DIO-32F to the AT-AO-A10 board so that their timing will be synchronous. PART # 776249-03	$27.00	$27.00
1	Lab Windows. A graphical interface that speeds up application software development for all of the data acquisition boards. PART # 776475-01; NATIONAL INSTRUMENTS	$1,121.00	$1,121.00
2	Nim Bin Rack with Power Supply. These 19" wide bins will be used to house the channel 1 nim module, and four Ortec (mod#461) alarm modules, the channel two, and channel three meter signal conditioner modules, and a Canberra (mod#1481l) log/lin ratemeter that is to be used as a skirt monitor. The power supply provides +/- 24 volts direct current, and +/-12 volts direct current. PART # 4002-A; ORTEC	$1,100.00	$2,200.00

QUANTITY	DESCRIPTION	PRICE	AMOUNT
1	Lin/Log Rate Meter. This is an additional counting meter that has an alarm module built into it. The trip is set on the module itself. This will be a nim bin skirt monitor. MODEL # 1481L; CANBERRA	$1,700.00	$1,700.00
2	Log/Lin Rate Meter. This nim bin module is to be used for channel 1. In the linear mode there are eleven different scales to chose from. The log range counts from ten counts per a second to one million counts per a second. When the count drops below a preset minimum, the Ortec alarm controller sets off an alarm. The second meter is to be used as a spare. MODEL # 449; ORTEC	$1,400.00	$2,800.00
5	Alarm Control Module. These modules will be connected to the analog outputs of the three different channels. For channel one an alarm module will be used for a low count alarm. This signal will come from the Ortec lin/log rate meter output (channel one). For channel two, the low current alarm will be set by the relay trip inside the display current meter. And the high trip will be set with a Ortec alarm module. The period meter has only one alarm, when it exceeds five seconds. This alarm is to be set by the trip within the period meter. Channel three will require two alarm modules. One for when the power reaches below 5% of the current scale, and when the power exceeds the recommended setting of five Watts, by 150%. MODEL # 461; ORTEC	$935.00	$4,875.00
2	Picoammeter. This picoammeter is capable of measuring currents as low as 10 femptoamps with five and a half digits of resolution. This ammeter is able to sample the current value at over 180 Hertz. An IEEE 488.2 bus is a standard feature that allows quick communications between the ammeter and the host computer. MODEL # 486; KEITHLEY	$3000.00	$6000.00
1	Analog Current Meter with Trip Relay. This meter is to be used to display the ion chamber current for channel two. The trip will be used to connect to a relay to scram the reactor when necessary.	$675.00	$675.00

QUANTITY	DESCRIPTION	PRICE	AMOUNT
1	Analog Period Meter with Trip Relay. This meter is to display the ion current period, as described in the AT-GPIB description. The trip will be set when the period reaches 5 seconds.	$675.00	$675.00
1	Analog Power Meter. This meter is used to display the current power output of the nuclear reactor. The scale is linear, selectable, and reads out in Watts.	$650.00	$650.00
1	Uninterruptible Power Supply. This unit is designed to continuously provide clean power to all of the instrumentation in case of a power failure, or a brown out. This unit will allow the plant operator to safely shut down the reactor, in the total absence of electrical power (emergency battery), while maintaining a accurate picture of how the reactor is shutting down. PART # TL049-ND ; DIGIKEY	$2,964.57	$2,964.57
1	Chart Recorder with IEEE 488.2 Interface. This chart recorder will interface with the host computer through the IEEE 488.2 GPIB card. The outputs from channel two and channel three will be recorded on this chart recorder. The exterior casing allows this recorder to be mounted into a standard 19" lab rack. MODEL # 3008-A1506-17; GOULD	~~$16,490.00~~ 9,500	$16,490.00
	ergonomic cabinet	7,000	
	GRAND TOTAL:		**$51,734.07**

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Nuclear Engineering
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Dear Dr. Barker,

Please find enclosed an application for funding under your Program notice 94-11 to be used to upgrade our AGN-201 research reactor. Hopefully our proposal is clear in its presentation of our need for an equipment upgrade of this reactor. Currently this reactor is used solely by our students for training without any outside financial assistance or research commitments. We feel this reactor is a valuable training tool and with this proposed upgrade will continue to serve our students well into the future. If you have any questions concerning this matter feel free to contact me at my office (409)-845 -4988. Thank you for your consideration in this matter. I am sorry this proposal arrived a day late but at this point the semester it was difficult putting together all of the available information.

Thank you

Robert O. Berry
Reactor Supervisor
AGN-201M

NUCLEAR INSTRUMENTATION AND CONTROLS UPGRADE OF THE AGN-201M REACTOR AT TEXAS A&M UNIVERSITY

A Proposal for Department of Energy Equipment Upgrade Program

by

Department of Nuclear Engineering
Texas A&M University
College Station, Texas 77843
May 1994

PROPOSAL FOR DEPARTMENT OF ENERGY EQUIPMENT UPGRADE

INTRODUCTION

The Aerojet General Nuclear 201M (AGN-201M) training reactor located at Texas A&M University is currently used by the Department of Nuclear Engineering for student training and indoctrination. The AGN-201M reactor was originally designed for large scale applications as a teaching and research reactor and has many uses contained in a fairly basic design. While the reactor has a rated power of only 5 watts, it remains a invaluable teaching tool for students enrolled in the undergraduate program in nuclear engineering. The main function of this training reactor is to provide in-depth reinforcement of the practical application of advanced concepts taught in the classroom through the actual "hands on" operation of the training reactor. All undergraduate students in the department enrolled in NUEN 405, *Nuclear Engineering Experiments*, are required to perform a supervised reactor startup and also operate the reactor during some of the laboratory experiments. These reactor operations provide our students with actual reactor operating experience that few other nuclear engineering departments are able to obtain. The sole function of this reactor system is to provide training for nuclear engineering students and for reactor operators (primarily graduate students in nuclear engineering). Such training has been recognized throughout the power industry for its value in producing a more "polished" junior nuclear engineer just entering the workforce.

DESCRIPTION OF PROPOSED PROJECT

Currently, the AGN-201M training reactor and support systems are badly in need of upgrading. The age of some of the components in these systems leads to frequent failures with repairs being difficult to perform due to the limited availability of spare parts. During the last 18 months the nuclear instrumentation system has suffered two major component failures which have caused the cancellation of operations for long periods of time while repairs were completed. The major goal of this equipment upgrade is to replace all of the older reactor control and instrumentation systems

with currently available and supported equipment and technology. This upgrade will ensure continued reactor operations in support of nuclear engineering education at Texas A&M.

The major system that will be most affected by this proposed equipment upgrade is the nuclear instrumentation system. This upgrade will involve the replacement of essentially all components in the three nuclear instrumentation channels with the exception of the detectors. Currently, channel 2 is a vacuum-tube based system which only has limited reliability. In addition, replacements parts have been difficult to obtain. The other two nuclear instrumentation channels system will be updated and many of the current components will be replaced with newer components. This equipment upgrade will not only improve the reliability of each of these channels but will also allow for a computer interface to be introduced into the system. The computer interface will use outputs from the new channels to provide a large remote display of the three instrumentation channels for students to view reactor operations from beyond a secondary shield (enforcement of ALARA concepts in the classroom). Use of the computer will allow for replacement of the rod position indications and the rod control switches. The rod control switches currently in use are 1950's style telephone switches.

The computer interface is intended to provide a more modern system for the monitoring of reactor parameters. The reactor operator will continue to have complete manual control of the reactor. All safety system signals will be generated from the analog replacement meters incorporated in the three channels. This new equipment will allow redesign of the reactor console so that the operator can observe all three nuclear instrumentation channels with greater ease.

Other proposed upgrades include installation of signal boosters on all installed nuclear detectors, this will reduce the effect of background noise on reactor operations at low power. Another important feature of this proposed upgrade is the installation of an uninterruptable power supply for the nuclear instruments. This new power supply will serve as an emergency source of power to the reactor console and allow operation of the reactor's nuclear instrumentation systems following a scram due to the loss of facility power.

A complete list of the equipment needed for the reactor nuclear instrumentation upgrade is provided in Appendix A. This equipment list is based upon the initial design for the upgrade and is intended only as a guide. The equipment selected and the cost may change depending upon future design considerations. The Nuclear Engineering Department is now capable of covering up to 25% of the equipment costs outlined in the original proposal. Several telephone conversations have taken place between facility personnel and members of the Nuclear Regulatory Commission. The final design for this proposed equipment upgrade must meet with their approval, at this point no major areas of concern appear to exist.

Originally included (1992 proposal) in the overall cost of this proposal is the cost of supporting a graduate student to assist in installation and testing of the system. Funds for the reactor supervisor and the electronics technician were not included and will be borne by the department. In addition, the graduate student will be supported by the department. The electrical design and computer programming required for this upgrade will require the assistance of a graduate student in electrical engineering. This student has been actively participating during the initial design phase of this project. The estimated cost of the support of this student as presented in Appendix B is no longer applicable because the Nuclear Engineering Department will be handling all personnel costs..

This proposed upgrade is needed very badly and if the proposed design is fully implemented this reactor facility should easily operate into the next century. The upgrade will allow for us to continue to provide our students an opportunity to operate a reactor and to use a reactor during laboratory courses in nuclear engineering. In addition, the upgrade will provide our students with experience on a reactor with modern nuclear instrumentation and operating systems similar to those currently in use.

Total Estimated Cost of Proposed AGN-201M Upgrade

1) Equipment	$51,735.00*
2) Support Personnel	$10,080.00
	Total Direct Cost $61,815.00
Indirect Cost (45% of Direct Personnel Cost)	$4,536.00*
	Total Estimated Cost: $66,351.00

* Note Nuclear Engineering will contribute 25% of the equipment cost and will cover all the cost for personnel involved in this project.

Total funding request $38,800.00

QUANTITY	DESCRIPTION	PRICE	AMOUNT
1	200 Megabyte Hard Disk Upgrade. The additional hard disk space will ensure that any program upgrades, and any data logging applications will be fully supported in the future. NO PART#; RECORTEC	$400.00	$400.00
1	Dual SVGA Video Card. This video card will drive two SVGA (SUPER VIDEO GRAPHICS ADAPTER) monitors. The card will be placed inside the computer where concurrently running programs will display their output on the two monitors. This will allow the plant operator to view only the control information as allowed by the Nuclear Regulatory Commission. PART #611175; MFG. COLORGRAPHIC VENDOR; COMPUTER ACCESS	$1,190.00	$1,190.00
1	AT-GPIB Interface Board. This provides an industry standard IEEE-488.2 interface that is used for data communication, and control between a host controller, such as a computer with this card, and a variety of laboratory instrumentation. In this application there will be two Keithley picoammeters (mod#486) that will read the ion chamber currents from the channel's two and three ion chamber sensors. The pico-ammeters will be strategically located close to the sensors so that there will be less opportunity for any noise to be injected into the sensor output current. The value of the current will then be transformed into a digital word that will be transmitted over the IEEE-488.2 bus to the computer (all in real time). This operation will be conducted for both channels #2, and #3, where channel #2 gives indication of ion chamber current, and the period($1/(\partial i/\partial)$; channel #3 gives an indication of the instantaneous reactor power output. Additionally, The host computer will send data signals to a Gould chart recorder (mod#3008-A1506-17), over the IEEE 488.2 bus to log the data for permanent record keeping. PART # 776207-51; NATIONAL INSTRUMENTS	$517.00	$517.00
2	Channel 2 Meter Signal Conditioner. This circuit board is yet to be designed by the instrumentation systems engineer. This signal conditioner will receive an analog voltage, from the AT-AO-A10 analog output board that is located in the host computer, and convert the voltage to drive the analog meters that are required to display the ion chamber current, and the ion chamber period for channel 2. PART # CH2MSCR.1; TEXAS A&M UNIVERSITY	$200.00	$400.00

QUANTITY	DESCRIPTION	PRICE	AMOUNT
2	Channel 3 Meter Signal Conditioner. This circuit board has not yet been designed by the instrumentation systems engineer. This signal conditioner will receive an analog voltage, from the AT-AO-A10 analog output board that is located in the host computer, and a scale select reading from the operators panel; the output voltage will then drive the analog meter that is used to display the instantaneous reactor power output in watts. PART # CH3SCR.11; TEXAS A&M UNIVERSITY	$200.00	$400.00
1	AT-AO-A10 Analog Output Board. This board will operate in conjunction with the AT-GPIB board, and the AT-DIO-32F digital input/output board. The software, Lab Windows, will integrate all three of these boards to work together. The data received from the two Keithley picoammeters will be transmitted over the IEEE 488.2 bus into the computer via the AT-GPIB card. The data will then be processed by the host computer. The AT-AO-A10 board will then be instructed, by the host computer, to output an analog voltage that is proportional to what the analog display meters, for channels one and two, are supposed to display (based on the data received by the host computer from the two Keithley picoammeters). The outputs of the AT-AO-A10 board are directly connected to both channel two, and channel three, meter signal conditioner modules. PART # 776542-01; NATIONAL INSTRUMENTS	$1,255.50	$1,255.50
1	AT-DIO-32F Digital Input/Output Board. This board interfaces the host computer to the control rod position motors, and the microswitches that indicate control rod positioning. There is a interface board (SC2052 adapter board) that connects the AT-DIO-32F to three other boards. The first two boards are the SC2060, this board will accept optically isolated, digital input signals that can be easily generated with the existing microswitches that are now in place in the reactor. The third board is a SC-2062. This board will accept digital signals that in turn activate an electromechanical relay that can handle 6 amps at 30volts direct current. This board will then be used to control the control rod positioning motors. PART # 776246-01; NATIONAL INSTRUMENTS	$535.50	$535.50

QUANTITY	DESCRIPTION	PRICE	AMOUNT
2	SC2060 Optical Isolation Input Board. This board will be used to receive microswitch settings from the control rod position switches in order to indicate to the plant operator where the control rods are. (for additional information see description of the AT-DIO-32F BOARD). PART # 776336-10; NATIONAL INSTRUMENTS	$202.50	$405.00
1	S2062 Digital Relay Interface. This board will interface the host computer to the control rod motors for positioning control of the rods. The emergency scram procedures will be unaffected by this control implementation. (for further information see description of the AT-DIO -32F BOARD). PART # 776336-12; NATIONAL INSTRUMENTS	$211.00	$211.00
1	SC2052 Adapter Board. This board is used to interface the 50 pin connector from the AT-DIO-32F board to the 26 pin SC 2060, and the 26 pin SC2062 boards. PART #776335-12;NATIONAL INSTRUMENTS	$144.00	$144.00
1	NB4 Cable. A shielded cable used to connect the AT-DIO-32F board to the SC2052 cable adapter board. PART #180554-10; NATIONAL INSTRUMENTS	$58.50	$58.50
1	AT Series RTSI Bus Cable. This cable is used to connect the AT-DIO-32F to the AT-AO-A10 board so that their timing will be synchronous. PART # 776249-03	$27.00	$27.00
1	Lab Windows. A graphical interface that speeds up application software development for all of the data acquisition boards. PART # 776475-01; NATIONAL INSTRUMENTS	$1,121.00	$1,121.00
2	Nim Bin Rack with Power Supply. These 19" wide bins will be used to house the channel 1 nim module, and four Ortec (mod#461) alarm modules, the channel two, and channel three meter signal conditioner modules, and a Canberra (mod#1481l) log/lin ratemeter that is to be used as a skirt monitor. The power supply provides +/- 24 volts direct current, and +/-12 volts direct current. PART # 4002-A; ORTEC	$1,100.00	$2,200.00

QUANTITY	DESCRIPTION	PRICE	AMOUNT
1	Lin/Log Rate Meter. This is an additional counting meter that has an alarm module built into it. The trip is set on the module itself. This will be a nim bin skirt monitor. MODEL # 1481L; CANBERRA	$1,700.00	$1,700.00
2	Log/Lin Rate Meter. This nim bin module is to be used for channel 1. In the linear mode there are eleven different scales to chose from. The log range counts from ten counts per a second to one million counts per a second. When the count drops below a preset minimum, the Ortec alarm controller sets off an alarm. The second meter is to be used as a spare. MODEL # 449; ORTEC	$1,400.00	$2,800.00
5	Alarm Control Module. These modules will be connected to the analog outputs of the three different channels. For channel one an alarm module will be used for a low count alarm. This signal will come from the Ortec lin/log rate meter output (channel one). For channel two, the low current alarm will be set by the relay trip inside the display current meter. And the high trip will be set with a Ortec alarm module. The period meter has only one alarm, when it exceeds five seconds. This alarm is to be set by the trip within the period meter. Channel three will require two alarm modules. One for when the power reaches below 5% of the current scale, and when the power exceeds the recommended setting of five Watts, by 150%. MODEL # 461; ORTEC	$935.00	$4,875.00
2	Picoammeter. This picoammeter is capable of measuring currents as low as 10 femptoamps with five and a half digits of resolution. This ammeter is able to sample the current value at over 180 Hertz. An IEEE 488.2 bus is a standard feature that allows quick communications between the ammeter and the host computer. MODEL # 486; KEITHLEY	$3000.00	$6000.00
1	Analog Current Meter with Trip Relay. This meter is to be used to display the ion chamber current for channel two. The trip will be used to connect to a relay to scram the reactor when necessary.	$675.00	$675.00

QUANTITY	DESCRIPTION	PRICE	AMOUNT
1	Analog Period Meter with Trip Relay. This meter is to display the ion current period, as described in the AT-GPIB description. The trip will be set when the period reaches 5 seconds.	$675.00	$675.00
1	Analog Power Meter. This meter is used to display the current power output of the nuclear reactor. The scale is linear, selectable, and reads out in Watts.	$650.00	$650.00
1	Uninterruptible Power Supply. This unit is designed to continuously provide clean power to all of the instrumentation in case of a power failure, or a brown out. This unit will allow the plant operator to safely shut down the reactor, in the total absence of electrical power (emergency battery), while maintaining a accurate picture of how the reactor is shutting down. PART # TL049-ND ; DIGIKEY	$2,964.57	$2,964.57
1	Chart Recorder with IEEE 488.2 Interface. This chart recorder will interface with the host computer through the IEEE 488.2 GPIB card. The outputs from channel two and channel three will be recorded on this chart recorder. The exterior casing allows this recorder to be mounted into a standard 19" lab rack. MODEL # 3008-A1506-17; GOULD	$16,490.00	$16,490.00
	GRAND TOTAL:		**$51,734.07**

APPENDIX B: PERSONNEL COST FOR PROPOSED UPGRADE

Description	Cost
Support of one graduate student at a level of $800/month.	$7,200
Benefits (15%)	$1,080
Insurance coverage at a rate of	$200/month. $1,800
Personnel Cost	Estimated* $10,080

*It should be noted that the cost of salaries and benefits of all support personnel involved in this project will be bore by the Nuclear Engineering. Over the life span of this project the total cost of this project to the University will be approximately **$30,000.00.**