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Final Report

September 1990 - August 1993

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**PARTICIPATION IN THE UNITED STATES DEPARTMENT OF ENERGY
UNIVERSITY REACTOR INSTRUMENTATION PROGRAM**

Submitted to:

Ms. Renee Irwin
U.S. Department of Energy
Chicago Field Office
9800 South Cass Avenue
Argonne, Illinois 60439

Submitted by:

R.U. Mulder
Director of Reactor Facility and Assistant Professor

P.E. Benneche
Reactor Services Manager

B. Hosticka
Research Scientist

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Nuclear Reactor Facility
Department of Mechanical, Aerospace and Nuclear Engineering

SCHOOL OF ENGINEERING AND APPLIED SCIENCE
UNIVERSITY OF VIRGINIA
CHARLOTTESVILLE, VIRGINIA

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SECTION I

INTRODUCTION

The University of Virginia Reactor Facility is an integral part of the Department of Mechanical, Aerospace and Nuclear Engineering and is used to support educational programs in engineering and science at the University of Virginia and at other area colleges and universities. The University of Virginia Research Reactor (UVAR) is the highest power (two megawatts thermal power) and one of the most utilized university research reactor in the mid-Atlantic states. A major objective of this facility is to support educational programs in the region.

The University of Virginia has received support under the U.S. Department of Energy (DOE) University Reactor Instrumentation Program every year since 1990. The monies from this program have been used to purchase new equipment to replace outdated or inadequate safety-related instrumentation used in conjunction with reactor operations. This report documents the equipment purchased and the status of the installation and use of this equipment from September 1990 through August 1993. This report constitutes the final report for this project period.

SECTION II

EQUIPMENT PURCHASED

There are three fiscal years covered by this report. In each year there was a different grant amount for a specific instrument or group of instruments. Table 1 shows the award amounts, the equipment requested and the equipment actually purchased. Table 2 gives details about the equipment and reports the progress of work toward its installation and/or use. The actual technical specifications that were submitted to vendors prior to receiving bids are included in the appendices.

TABLE 1: DOE REACTOR INSTRUMENTATION GRANTS TO THE UNIVERSITY OF VIRGINIA			
Year	Amount	Equipment Requested	Equipment Purchased
1990-91	\$60,000	Stack radioactive effluent monitor	2 noble gas monitors Linear nuclear instrumentation + reactor power servo control Differential temperature monitor Portable radiation monitors Duct flow measuring device
1991-92	\$35,000	Area radiation monitoring system	Area radiation monitoring system
1992-93	\$55,000	Wide-range nuclear instrumentation for reactor	Wide-range nuclear instrumentation for reactor

TABLE 2: REACTOR INSTRUMENTATION PURCHASED**			
Year	Amount	Equipment Purchased	Current Status
1990-91	\$26,708.87	Two noble gas monitors custom assembled by EG&G Nuclear Instruments / Berthold. Main component is model Micro Gamma LB 111. Also included is associated wiring and other equipment needed for installation. To be used to monitor gaseous radioactive effluents from the reactor room and ductwork associated with experimental facilities.	Received and running in parallel with current instruments
	\$29,968.50	Wide range linear power monitor custom assembled by Gammametrics. Includes servo control instrumentation for reactor power control. To replace current reactor linear power instrument and servo control.	Received, approved for use, awaiting installation and testing
	\$5,750.00	High precision differential temperature monitor utilizing RTD probes. Manufactured by Systemtechnik of Sweden, Model S-1220, sold by Physitemp. To replace current instrument, which was homemade about 20 years ago and monitors the differential temperature across the reactor.	Received, running in parallel with current instrument
	\$2,975.24	Two portable radiation monitoring instruments and associated probes. Manufactured by Ludlum Instruments. Models 3 and 17.	Received and in use
	\$46.39	Venturi tube probe to map air flow in reactor room ventilation stack.	Received, used for testing
	\$65,449.00	Sub-Total	
1991-92	\$28,599.94	Area radiation monitoring system by Nuclear Research Corporation, including five gamma-ray monitoring instruments (Model CR600), four detectors (Model GP100C), two remote alarm units (AX-300A) and associated equipment. This will replace the current system of four area detectors and the output electronics of the current air particulate monitor.	Received, awaiting approval and installation
	-548.94	Paid from department funds	
	28,051.00	Sub-Total	
1992-93	\$54,756.00	Wide-range log intermediate and power nuclear instrumentation by Gammametrics. This unit is on order and should be received before the end of 1993. This instrument is intended to take the place of the current separate intermediate and power range channels. Two mineral insulated compensated ion chambers are also included.	On order

** See Section III, Financial Report, for an explanation of the dollar amounts.

In 1990-91 a grant of \$60,000 was requested to purchase a radioactive gaseous and particulate stack effluent monitor that would quantify both normal and accidental releases from the reactor room. When preparing the request for this instrument phone quotations were solicited from several vendors in order to ascertain the appropriate amount to request from DOE. Once the grant was approved, official requests for bids were sent to these same vendors. Unfortunately, the vendors neglected to inform us in our initial phone conversations of an expensive option which would be required (the necessity for isokinetic sampling equipment and the presence of a laminar flow region in our stack, which we currently do not have, to install it) to enable the system which was recommended to work in our application. Thus, the least expensive final bid which was received was more than twice as expensive as had been anticipated. Through extensive investigation it was concluded that no less expensive alternative that would still meet the necessary requirements was possible. Also, because of the way the vent closing mechanism associated with the stack will work during any significant gaseous radioactive release there would not be any release through the stack for an instrument to monitor during an accident. Spending a large amount of money to only monitor normal argon-41 releases through the reactor room stack did not seem to be prudent so it was decided to purchase instruments to monitor the noble gas concentration in the reactor room and in the ventilation ductwork from the reactor experimental facilities. Once these instruments were purchased there was money remaining in the grant so other items on our initial request to DOE were purchased.

SECTION III

FINANCIAL REPORT

This report covers the period from September 1990 through August 1993, during which the University of Virginia Reactor Facility received three grants from the Department of Energy University Reactor Instrumentation Program. These grants were in the amounts of \$60,000, \$35,000 and \$55,000.

The first two grants were combined together as part of a continuing project and of the \$95,000 total award \$93,500 has been spent. The remaining \$1,500 was intended for a component for one of the systems ordered but the manufacturer was not able to make this particular option work. The 1992-93 grant amount was \$55,000 and \$53,756 of this amount has been committed but has not yet been spent. This left an uncommitted balance in 1992-93 of \$244. The total unspent and uncommitted balance for the three years 1990-93 is \$1,744 and the total which has been spent or committed is \$148,256 from a total award of \$150,000.

It is anticipated that the uncommitted balance will be spent on supplies and small equipment related to the installation of the major pieces of equipment that were purchased.

APPENDICES

Specifications For an Area Noble Gas Monitor
for the
University of Virginia
Reactor Facility

Instruments requirements

The reactor facility will need a commercial grade Noble Gas monitoring system taking local continuous samples with the characteristics as listed below.

It will normally monitor operationally produced Ar-41 in the reactor room where ambient radiation levels in the room are less than 0.5 mr/hr but may be called upon during accident conditions to monitor fission product gasses in much higher ambient radiation fields. Therefore, some means must be provided to monitor the ambient radiation level near the detector and compensating for it such that the actual nobel gas activity can be determined.

Noble Gas Monitor Characteristics

1. Continuous flow, non pressurized chamber
2. Means for subtracting signal from ambient radiation
3. Sensitive enough to detect 2×10^{-7} uCi/ml of Ar-41 in the sampled air
4. Allow remote reading via serial computer interface
5. Have analog output for driving strip chart recorder
6. Read out in Engineering units such as uCi/ml
7. Have Outputs for remote alarms

Possible Vendors

Below is a list of possible vendors for a noble gas monitoring system. This list may not be exhaustive but represents the vendors known to me at this time.

Eberline
P.O. Box 2108
Santa Fe, NM 87504-2108
(505) 471-3232

NRC Industries
125 Titus Ave.
Warrington, PA 18976
(215) 343-5900

EG&G Berthold
100 Midland Rd.
Oak Ridge, TN 37831-0895
(615) 483-0396

Sorrento Electronics
P.O. Box 5189
Cary, NC 27511
(919) 481-4425

General Atomics
P.O. Box 85608
San Diego, CA 92138-5608
(619) 455-4255

Victoreen Inc.
10101 Woodland Ave.
Cleveland, OH 44104
(216) 795-8200

Specifications for a Wide Range Linear Neutron Channel With Servo Rod Control

The University of Virginia Reactor is an open pool, plate type reactor with three shim-safety rods and one regulating rod. The regulating rod is controlled by a servo system that senses deviations between the wide range linear neutron channel and a power-setpoint potentiometer. The reactor facility wishes to replace its wide range linear neutron channel including the servo rod control mechanism.

Specifications:

I. Wide Range Linear Neutron Channel

- A. The channel will utilize a compensated ion chamber detector supplied by the university.
- B. The channel shall supply high voltage and compensating voltage to the detector. The compensation adjustment shall be accessible from the front panel of the instrument.
- C. The channel shall be sensitive to a range of currents from 0.1 nanoamps to 0.1 milliamps
- D. The indication of neutron flux is to include the following:
  - 1. The readout shall be a large analog meter with a parallax mirror
  - 2. The indication of the selected range shall be un-ambiguous
  - 3. The meter shall be linear and scaled with approximately 1/3 decade overlap between adjacent ranges
  - 4. Only a single switch shall have to be manipulated to change to an adjacent range. Separate up-scale and down-scale switches are acceptable but a 1/3 decade switch separate from a decade switch such as found on a Keithly 416 picoammeter is NOT acceptable.
  - 5. The meter, range indication, and range selection switch shall be mountable in a panel space of 8 inches wide by 5 inches high. The actual measuring channel may be larger if it can be mounted remotely.
  - 6. An analog output for a strip chart recorder shall be supplied that follows the indication on the meter.

II. Servo Rod Controller

- A. The servo rod controller shall either utilize the university supplied rod drive motor or the vendor shall supply a motor that can be fitted to the university supplied rod drive mechanism by university personnel.

1. The present motor has the following characteristics.

- a. The drive motor is a 120 V., 60 Hz., two phase motor. The fixed phase current is shifted approximately 90 degrees from line current and the control phase current is either in phase or 180 degrees out of phase with line current.
- b. Load on the control phase is 12 watts maximum
- c. A ten turn potentiometer geared to the motor at 1/30th the ratio of the drive output provides position indication.

2. If a new motor is required for compatibility with the controller, the new motor shall meet the following.

- a. The maximum speed shall be about 200 rpm.
- b. It shall have provisions for remotely indicating the number of revolutions it has turned from a reference position thereby providing an indication of the rod position in inches. The pitch of the lead screw is 10 threads per inch and the stroke of the rod is 26 inches.
- c. It must be small enough to be conveniently mounted to the existing lead screw housing which consists of a 2-3/4 inch diameter aluminum tube.

B. The servo rod control system must be able to operate from any range of the Wide Range Linear Neutron Channel.

C. The rod speed shall be proportional to the deviation between the selected power and the indicated power.

D. Relay contacts shall be provided to signal external logic of an excessive deviation between the selected power and indicated power (either positive or negative).

E. The deviation signal shall be displayed on a remote meter (not necessarily within the confines specified for the linear channel indication).

REQUEST FOR BIDS

Please quote each of the following three items separately

#1 - High Precision, Digital Display, Differential Temperature Meter

Probes: Platinum RTD, 100 ohm, 4 wire

Display Units: either °C or °F, preferably selectable between these two

Display Resolution: 0.001 °C or 0.01 °F

Accuracy: Better than 0.01 °C or 0.02 °F over the range of 10 to 50 °C on both the single and differential readings

Temperatures Displayed: either probe 1, probe 2 or probe 1 minus 2; selectable

Minimum Temperature Range: -5 °C to 105 °C

Analog outputs: there must be an output for the differential temperature and it is desired (but not required) that one or both of the individual probe temperatures have outputs. The individual outputs should be approximately 0 to 10 volts and the differential should be approximately 100mV/°C.

Power supply: 110VAC, 60Hz

Allowable loop resistance: 700 ohms

#2 - RTD Probes

Please quote separately: two platinum RTD 100 ohm probes
approximately 1/4 inch or 6 mm outside diameter
rod type stainless steel
mineral insulation (radiation resistant) for 20 feet

#3 - Extension Cables

Please quote separately: two extension cables for above; 100 feet and 200 feet

**Specifications for an Area Monitoring System
For the
University of Virginia Research Reactor**

Background:

The University of Virginia will be replacing its four commercial ion chamber area monitors, an in-house built ion chamber radiation monitor and two GM tube based radiation counters with new commercial grade equipment that will consolidate measuring functions into four area monitors and two special radiation channels. The radiation measuring systems do not have to be based upon ion chambers. GM tubes are preferred due to their ruggedness and reliability.

Item I constitutes a single system of four monitors. Items II, and III shall be bidd separately except that separate mounting will not be required (all readout modules will be in the same location). It is our desire to have all readout modules of similar design.

I) Area Monitors system consisting of:

- 1) Four detector, readout pairs as follows
  - a) Indicating range of from 0.1 mR/hr to 1,000 R/hr
  - b) Energy range from 100 kev to 2 Mev with a known correction factor for N-16 gamma rays
  - c) Internal, remotely controlled check sources at the detectors
  - d) Rack mounted readouts located up to 300 ft from detectors
  - e) Each Indicator rack module to have
    - i) Both digital and analogue (or digital bargraph) readouts
    - ii) High Radiation Alarm with 2PDT Relay outputs
    - iii) Means of tripping high radiation alarm from the front panel to test downstream control functions actuated by alarm.
    - iii) Failure warning indication
    - iv) Analogue recorder output (0-10v)
    - v) Check source control
    - vi) RS-232 serial communication port so that the radiation level and history of radiation levels may be read from a remote computer.
- 2) A field calibrator for the area monitors
- 3) Two area monitors are to have local readouts (analogue or digital) with both audible and visual high radiation alarms
- 4) 1000 feet of cabling to connect the detectors to the readouts (commercial grade)

5) Mounting hardware and power supplies to mount in 19 inch rack.

II) New electronics for an Eberline AMS 2 consisting of:

- 1) Any preamplifiers and high voltage power supply required to be mounted near the type 10450-B15 pancake GM probe used in the AMS 2.
- 2) Readout module reading in Counts Per Minute with a range of from 10 to 100,000 cpm and the same characteristics as for the Area Monitoring System described above
- 3) No check source is desired.
- 4) 100 feet of commercial grade cabling to go from the AMS 2 shield to the readout module
- 5) Mounting hardware and power supplies to mount in 19 inch rack.
- 6) The University shall supply the shield ,detector, and area handling portions of the AMS -2

III) Duct Radiation Monitor consisting of:

- 1) A 2-pi shielded beta sensitive (and largely gamma insensitive) detector that can be mounted to "look into" a 6-inch ventilation duct.
- 2) A remotely operated check source
- 3) A readout module reading in Counts Per Minute with a rang of from 10 to 100,000 cpm and the same characteristics as for the Area Monitoring System described above.
- 4) 300 feet of cable to go from detector to readout module
- 5) Mounting hardware and power supplies to mount in 19 inch rack.

Possible Vendors

Below is a list of possible vendors for these systems. This list may not be exhaustive but represents the vendors known to me at this time.

Eberline
P.O. Box 2108
Santa Fe, NM 87504-2108
(505) 471-3232

EG&G Berthold
100 Midland Rd.
Oak Ridge, TN 37831-0895
(615) 483-0396

General Atomics
P.O. Box 85608
San Diego, CA 92138-5608
(619) 455-4255

NRC Industries
125 Titus Ave.
Warrington, PA 18976
(215) 343-5900

Sorrento Electronics
P.O. Box 5189
Cary, NC 27511
(919) 481-4425

Victoreen Inc.
10101 Woodland Ave.
Cleveland, OH 44104
(216) 795-8200

Specifications for a Log Neutron Channel and Mineral Insulated Compensated Ion Chambers

The University of Virginia Reactor is two-megawatt forced convection or 200 kilowatt natural convection, open-pool, plate type reactor with 3.5 inch instrument wells extending 30 feet down to the core. The reactor facility wishes to replace its log neutron channel (Log N) and two (2) of its compensated ion chambers. The new compensated ion chambers should have mineral insulation to separate any plastic based cables and connectors far enough from the reactor so that they are not subject to radiation damage.

Specifications:

I. Log N Neutron Channel

- A. The Log N channel is intended to drive 0-10 volt (1 ma) LOG N LEVEL and PERIOD meters and a LOG N Level recorder already installed in the reactor console. The LOG N LEVEL meter spans 8 decades while the PERIOD meter goes from -30 to +3 seconds and is set to read infinity at zero volts.
- B. Bistable trips (high speed form c or compatible 10 volt logic) shall be supplied with two different setpoints for LOG N LEVEL and two for PERIOD.
- C. A Not-Operable relay contact (form c) shall be available to actuate rod interlocks whenever either the high voltage has failed or the instrument is in a test mode.
- D. Internal circuitry shall be provided to align and test the alignment of the instrument and to test the bistable setpoints.
- E. The channel shall supply high voltage and compensating voltage to the detector. The compensation adjustment should be accessible from the front panel of the instrument.

II. Desired Significant Option

As either an option or as part of the standard design, we would like a linear power range instrument which is derived from the top decade of current from the LOG N detector. This linear power range will be used to generate two safety trips as well as provide indication of power. The definition of what detector current constitutes the 100% power should be saleable by a factor of ten using an external contact so that 100% power represents either 2 MW or 200 kW.

III. Mineral Insulated Compensation Ion Chambers (CIC)

As part of the Log N system we would like to purchase a Mineral Insulated Compensated Ion Chamber that is compatible with the Log N channel. An additional CIC is needed to replace the detector of our currently installed Wide Range Linear channel which should use an identical detector. Thus, a total of two detector are requested in this bid.

- A. The compensated ion chambers shall be able to fit in our existing instrument wells which are 3.5 inches inside diameter. They extend from above and behind the reactor core for approximately 30 feet (far above the pool water level).
- B. The mineral insulated leads connecting the ion chambers shall be at least ten feet long to bring the connections to plastic cables well beyond the damaging radiation fields near the reactor.
- C. The average flux in the wells over the sensitive volume of a Westinghouse WL-6377 CIC is 5×10^9 n/cm²-s giving a signal strength of 0.2 ma at full power. The new CICs shall be at least as sensitive as a WL-6377 CIC.

Possible Vendors

Below is a list of possible vendors for this system. This list may not be exhaustive but represents the vendors known to me at this time.

AECL Technologies
2310 Parklake Dr. Suite 300
Atlanta, GA 30345
(404) 938-4098

Framatome
1901 N. Moore St. Suite 600
Rosslyn, VA 22209
(703) 527-4747

EG&G Berthold
100 Midland Rd.
Oak Ridge, TN 37831-0895
(615) 483-0396

Gamma-Metrics
5788 Pacific Center Blvd.
San Diego, CA 92121
(619) 450-9811

General Atomics
Research Reactors
P.O. Box 85608
San Diego, CA 92138-5608
(619) 455-4255

Reuter-Stokes
Contract and Export Control
8499 Darrow Rd.
Twinsburg, OH 44087
(216) 425-3755 (ext 567)

Westinghouse
Instrumentation and Control Systems
111 Schilling Rd.
Hunt Valley, MD 21031
(301) 584-5234

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