Rensselaer | DEPARTMENT OF MECHANICAL, AEROSPACE, AND NUCLEAR ENGINEERING

December 11, 2003

U.S. Nuclear Regulatory Commission
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Dear Sir:

This letter submits a report detailing changes to instrumentation at the Rensselaer Polytechnic Institute Critical Facility. The attached report is provided for information in accordance with 10CFR50.59, Changes, tests and experiments.

The instrumentation changes involved replacements of older equipment with equivalent items. No reduction of protection occurs as a result of these equipment changes, conclusions and assumptions in the Final Safety Analysis Report are not altered, and no Technical Specification changes are necessary. The new instrumentation was thoroughly tested to verify the required functions and accuracy were maintained. The report details the process by which this was done.

Very truly yours,

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Rensselaer Polytechnic Institute

cc:
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Dr. D. Steiner, Chairman
RPI NSRB

IE47

Replacement of Recorders and Picoammeters
December 2003

Prepared by:
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RCF Instrumentation Replacement

This report discusses replacement of several RCF instruments and recording devices with modern equivalents. The report is intended to provide the documentation required for 10CFR50.59.

Current Instrumentation Arrangement and Display

The RCF uses three uncompensated ion chambers for power indication and two BF_3 detectors for startup indication. Two ion chambers are connected to linear power picoammeters (LP1 and LP2) and have a high current scram function that is set to 90% of the selected current range. The lowest range is 1×10^{-10} amps full scale and the highest range is 1×10^{-5} amps. The third ion chamber is connected to a log power picoammeter (PP2) with a range of 1×10^{-12} amps to 1×10^{-4} amps. This instrument also calculates reactor period. The log current and period instrument has a high current scram, a fast period rod outmotion interlock and a fast period scram.

The ion chamber signals are displayed on two strip chart recorders. One shows a single linear power channel, LP2. The second linear power channel is not displayed on a strip chart. Both linear power channels have analog meter indications. The log channel current is displayed on a strip chart calibrated in watts. Log current and period are displayed on analog meters.

Strip Chart Recorders

There are four operable strip chart recorders. Two display ion chamber output from LP2 and PP2, as discussed above. One of the two BF3 chambers is displayed on the third recorder. Thermocouples are displayed on the fourth recorder. Additional recorders were originally available, however, lack of parts has reduced the operable recorders to these four.

Strip Chart Recorder Replacement

The replacements for the strip chart recorders are videographic recorders with data retention on magnetic media. Three new recorders replace all operable strip chart devices. The three recorders are manufactured by ThermoWestronics. A model SV100 replaces the strip chart that displayed temperature from several thermocouples. Two SV180 recorders replace strip charts for both startup channels (S/U A and B), both linear power channels (LP1 and LP2) and the log power channel (PP2). Log power is on its own recorder. S/U A, S/U B, LP1 and LP2 are on the second recorder using one screen for the startup channels and a second screen for linear power. Operation, such as switching from one screen to another, is accomplished with touch sensitive controls on the recorder screen.

The SV100 is a small screen, approximately 5 inches square, recorder. This model was selected for temperature because temperature changes slowly, if at all, and is not of continuous importance to the operator during reactor startup and operation. The SV180 model has a large screen, approximately 10 inches square, and displays as clearly as the strip charts. The switch from the startup channel screen to linear power is easily accomplished without distracting the operator from monitoring reactor operations.

Data retention on all three recorders is by installed floppy discs (1.44M capacity) or remotely over an Ethernet network within the RCF. To date, only floppy discs have been used since the Ethernet setup is incomplete, however, the use of floppy discs has been satisfactory and could be used indefinitely, if necessary. About three hours of data (7 channels, 1 second recording intervals) can be recorded on a disc. The typical RCF operating cycle is less than one hour. Data from the discs is transferred to a desktop computer hard drive each day the reactor was operated, and periodically (at least annually) written to a CD for permanent retention.

The startup channel and linear power recorder was ordered with output channels that implement the low startup count rod outmotion interlock. This directly substitutes for the identical interlock that was provided by a cam-operated micro switch on the S/U A strip chart. Proper function of the interlock is verified as part of the startup checklist.

Experience with the New Recorders

The new recorders have been operated in parallel with the old strip charts for the last several months. Data has been recorded on the recorder disc drives, transferred to computer hard drive and analyzed to determine reactor characteristics, such as reactor period during operation. These recorders have proven satisfactory. All data has been recorded on disc when requested. Checks of recorder alignment show that recorder readings correspond with the instrumentation providing the signal to the recorder.

Replacement Linear Power Instruments

Custom designed picoammeters provided by Circuit Equipment Corporation of Mentor, Ohio have replaced the older linear power instruments. The instruments have a digital display that shows measured current. Range changes are performed with push buttons, each range is a full decade. The lowest decade is 1×10^{-12} amps full scale and the highest is 1×10^{-3} amps full scale. The digital display will show the correct current value to 2.5 times full scale. The picoammeter also generates an analog output signal for the recorders. Analog output is percent of full scale, same as the old linear power meters.

The new instruments (Model CEC1718) have adjustable setpoints to provide a relay contact opening. The relay contact is provided to the RCF scram panel, just as the older linear power instruments were connected. The relay contact is closed (scram signal provided) at any power level if the picoammeters are not energized, or if either generates an internal error code. The two units are identical, however they are not interchanged since both linear power channels are required for reactor operation. Additionally, different ion chamber positions relative to the core result in different sensitivities and scram setpoints. The scram setpoints are verified on both channels as part of the startup checklist.

Experience with the New Linear Power Instruments

Figures 1 and 2 show two operating cycles in July 2002. Both operating cycles used the old linear power and log power instruments. The data was collected by the new videographic recorders and processed with Excel to convert the percent of full scale linear power information to current and to generate the Figures. For both operating cycles the reactor was manually scrammed at a peak power of 2.5 watts indicated on the PP2 strip chart..

Both cycles show significant differences in measured current when the meter range is changed to adjust for the increasing current. The cycle on July 25, 2002 shows a degradation in sensitivity by LP1. This is judged to be caused by dirty range selector switch contacts or deteriorating range circuitry. Nevertheless, these two cycles are a basis for comparison to measurements with the replacement linear power instruments.

One CEC1718 was connected for an operating cycle on September 5, 2002. For this cycle the reactor was manually scrammed at 2.9 watts by PP2. The new instrument was connected to the LP1 ion chamber. Current values for the three ion chambers are shown on Figure 3. The LP1 chamber is showing the same sensitivity as the old instrumentation showed on July 11, 2002 (Figure 1). The data also show several improvements, specifically no discontinuities in current when instrument range changes and more low end sensitivity, especially when compared to measurements on July 25, 2002 (Figure 2).

On September 19, 2002 the second CEC1718 was connected to LP1. The measurements are shown on Figure 4 and display the same relative measured current values as the measurements on September 5, 2002.

The September 2002 cycles showed that the CEC1718 was performing satisfactorily and determining ion chamber current with better characteristics than the older instrument attached to LP1. Specifically the displayed discontinuities in current are not present with the new instruments.

On October 24, 2002 the reactor was operated with both linear power channels connected to CEC1718 picoammeters. Two startup cycles were performed and the recorded currents are displayed on Figure 5. The first cycle was terminated with a manual scram at approximately 0.01 watts. The second was terminated with a manual scram at about 0.1 watts. The LP2 current agreed with prior measurements when compared to PP2.

These measurements determined that the CEC1718 picoammeters are operating satisfactorily and measure ion chamber currents with the same accuracy as the older instruments.

Linear Power Scram Setpoints

The CEC1718 instruments have an adjustable high current scram setpoint. This is absolute current, not percent of scale like the older instruments. Since LP1 and LP2 have different sensitivities, their scram setpoints are different, and both are set for the ion chamber current equivalent to 50 watts reactor power, or 50% of the license limit. In practive, the reactor is not run above 15 watts. The corresponding current is based on the old instrument current measured on July 25, 2002 when the peak power was 2.5 watts. At the peak, LP1 current was 3.60×10^{-9} amps and LP2 current was 8.19×10^{-7} amps These

measurements were scaled up to 50 watts. The appropriate high current setpoints therefore, are 7.2×10^{-8} amps for LP1 and 1.64×10^{-5} amps for LP2. In practice, the LP2 setpoint is reduced to 1.2×10^{-5} amps because the test current device cannot generate the higher current value. High power trips are confirmed during the startup checklist.

Replacement Log Power Instruments

Two custom picoammeters were designed and built by Circuit Equipment Corporation to a specification developed by the staff of the RCF. These instruments (CEC1717) display current on a single log scale from 1.0×10^{-14} to 1.0×10^{-3}. Reactor period is calculated internally and also displayed. The instruments have analog outputs of both current and period to provide signals to recorders. Internal relays provide for high current scram, fast period scram and fast period rod outmotion interlock. Setpoints are adjustable from the front panel and may be viewed without changing them.

Only one instrument has been placed in service although both were tested to verify proper operation.The second instrument is a standby spare and could enable an expansion when another ion chamber is installed.

The instrument was tested in the same way as the two new linear power instruments. After the two CEC1718 instruments had demonstrated satisfactory performance, the PP2 ion chamber was disconnected from the old instrument and connected to the new CEC1717. The scram functions were connected to the scram panel and the rod outmotion interlock function was connected to the existing rod outmotion interlock circuit. All of these protective functions are demonstrated during the startup checklist. A reactor startup with the CEC1717 was performed on February 5, 2003. The recorder output is shown in Figure 6. The relationship between the recorded currents for the three ion chambers is the same as was the case with the old log power instrument.

The high current setpoint was set based on scaling the PP2 peak reading from July 25, 2002 to 50 watts. The corresponding PP2 current is 5.0×10^{-7} amps. Fast period rod outmotion interlock setting is 15 seconds and fast period scram is 5 seconds, the same values as the prior instrument and in accordance with the RCF Technical Specification. These setpoints are verified and the functional operation of the protective features are tested as part of every reactor startup checklist.

Operation of the CEC1717 was not entirely satisfactory. Current measurements were accurate, however reactor period was extremely noisy. The protective functions provided by the period signal were functional, but noise often gave faster period reading than expected and unnecessarily iniated a rod outmotion interlock on one occasion. Consequently the period calculation was revised to include exponential smoothing. The original vendor implemented this change by providing new programming chips for both units. These changes were implemented in October 2003 and have proven entirely satisfactory.

The exponential smoothing constant is adjustable by the operator from the front panel of the instrument. This constant is the fraction of the most recent measured current that is added to the sum of all previous currents values. Period is calculated from the change in these current values. The constant found to best reduce noise yet provide a responsive period value is 3%.

Conclusion

New videographic recorders have replaced strip chart recorders that had outlived their usefulness. Failing picoammeters have been replaced with custom equipment designed to meet the specific needs of the RCF. All new instrumentation has been tested to verify accuracy and functionality. All protective functions required by the Technical Specification have been maintained with the new instruments.

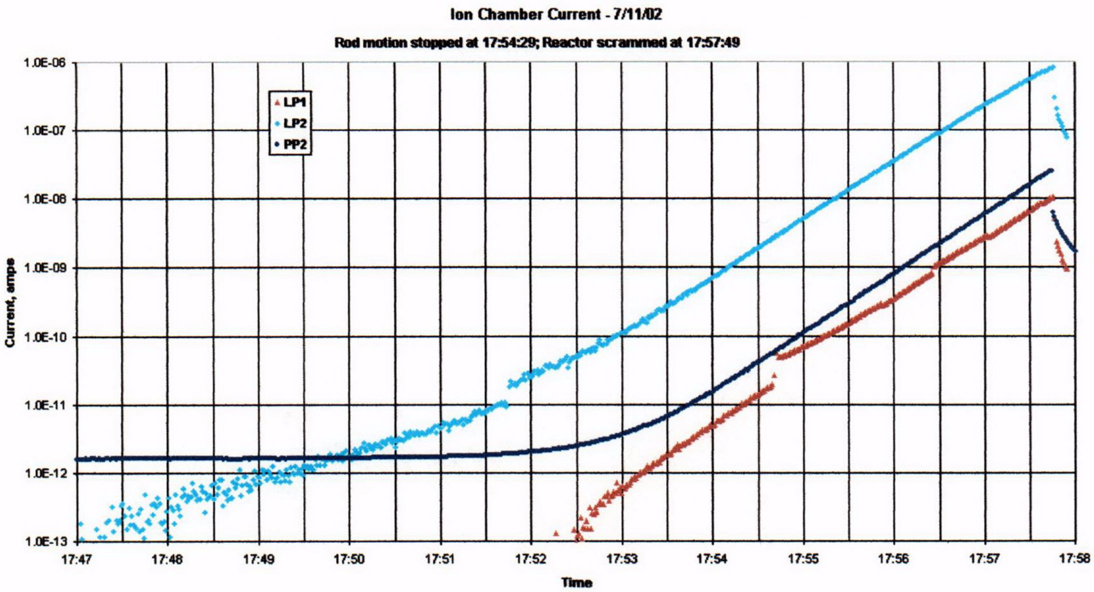

Figure 1: RCF Operating Data for July 11, 2002

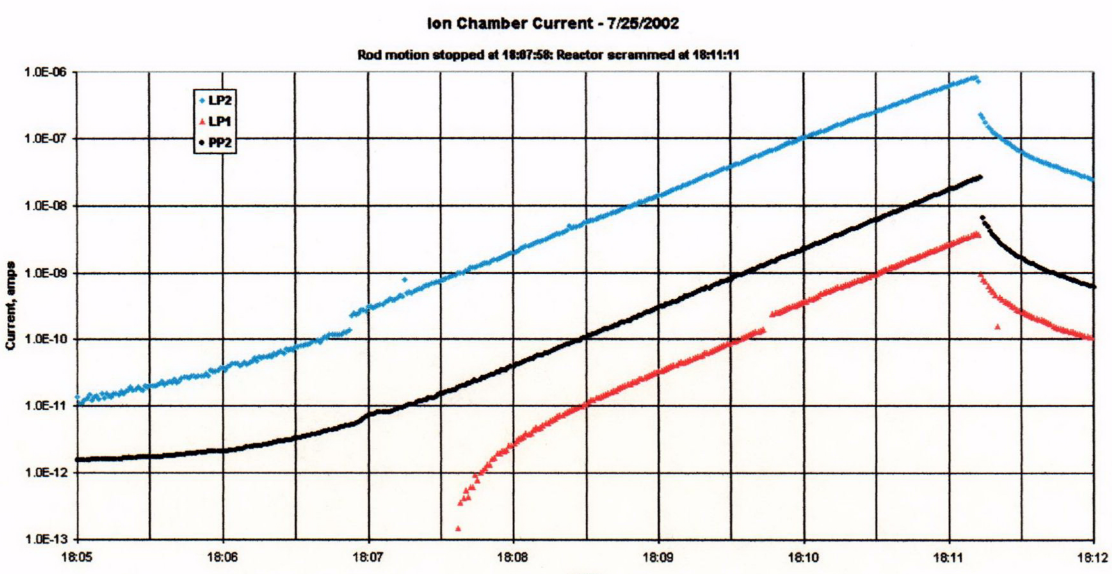

Figure 2: RCF Operating Data for July 25, 2002

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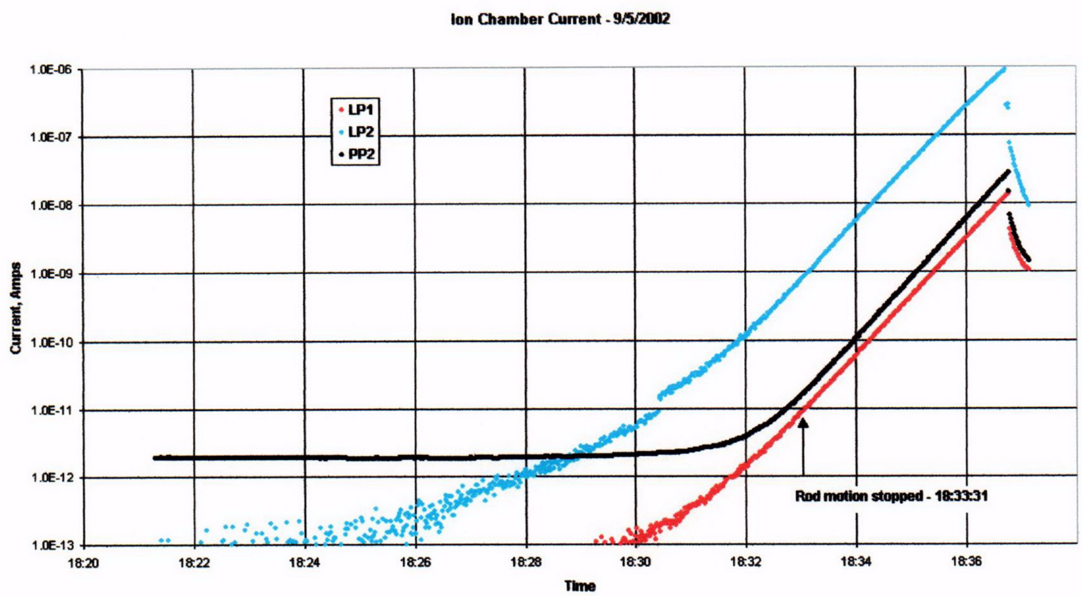

Figure 3: RCF Operating Data for September 5, 2002

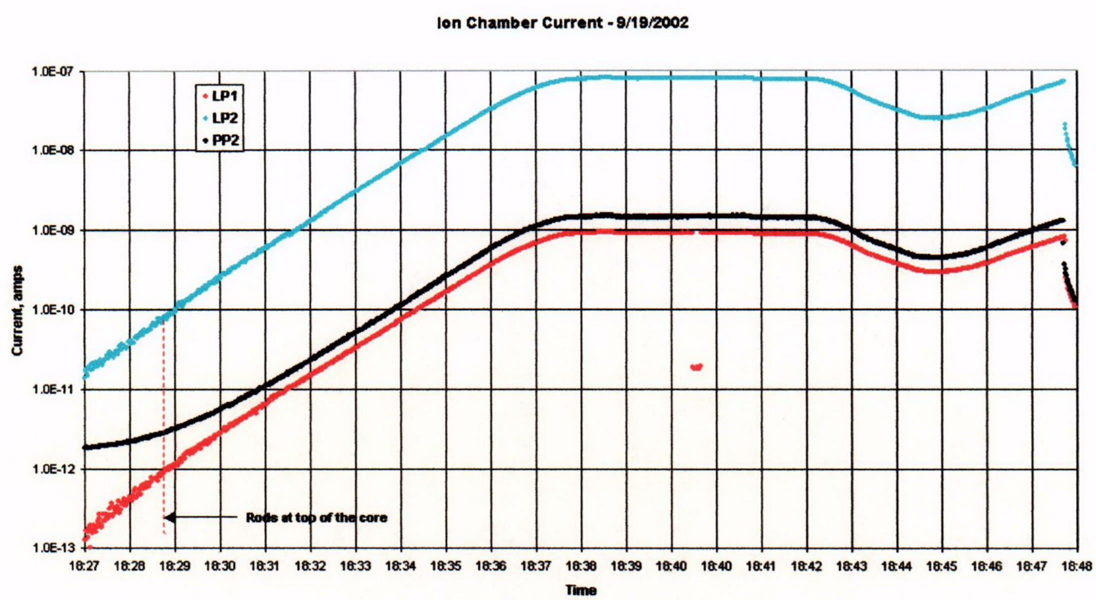

Figure 4: RCF Operating Data for September 19, 2002

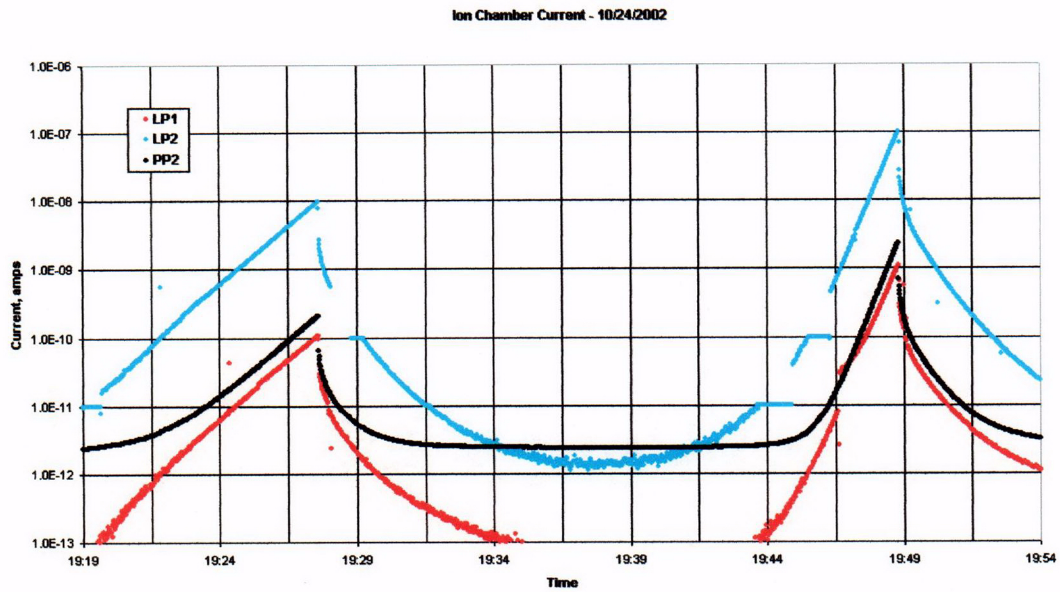

Figure 5: RCF Operating Data for October 24, 2002

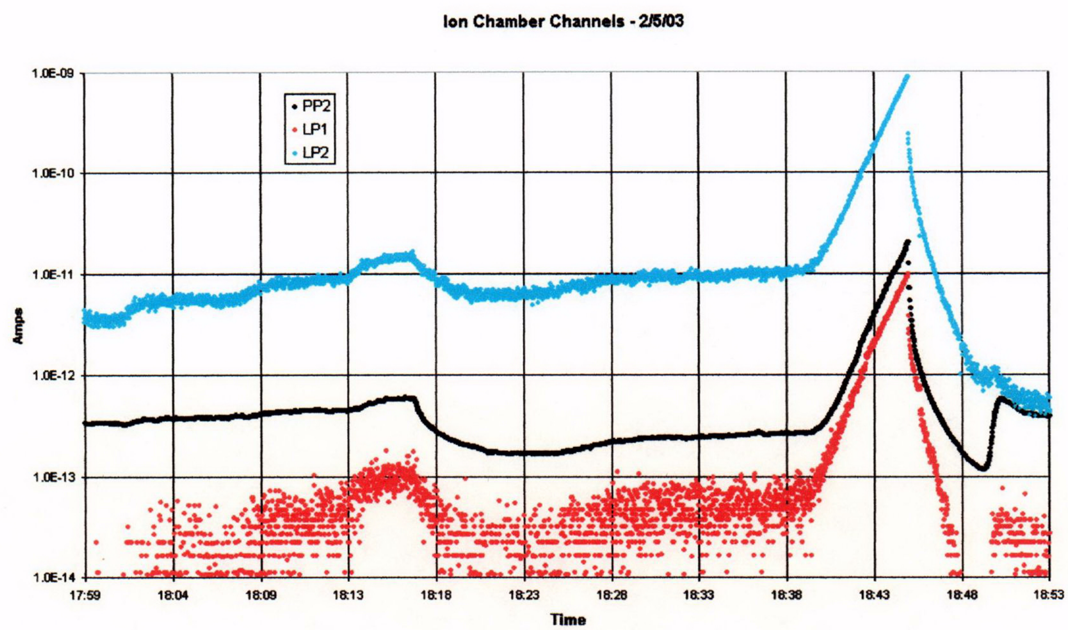

Figure 6: RCF Operating Data for February 5, 2003

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