DOE/ER/75917--T1

# Collaborative Utility-University Project (CUUP)

# Simulator-Interfaced Light Water Reactor Instruction and Research

## Final Technical Report
## DOE Grant Number DE-FG02-93ER75917


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Collaborators

Nuclear Engineering Program
The Ohio State University

Nuclear Engineering Program
University of Cincinnati

American Electric Power Co.
DC Cook

Centerior Energy Corporation
Davis-Besse, Perry

## DISCLAIMER

## Introduction

In order to develop a comprehensive program of simulator-interfaced instruction and research, the American Electric Power Corporation and Centerior Energy Corporation are working with the Nuclear Engineering programs at the University of Cincinnati and The Ohio State University. Funding and resources for the program are being provided by the Department of Energy and the utilities. The program was initiated in September 1993 as the result of a proposal submitted by the Universities to the DOE [1].

The first phase of the program, the development and presentation of a course sequence on commercial nuclear power plant systems design and operation, has been completed. Program instruction began on January 3, 1994 with the first presentation to 29 undergraduate and graduate engineering students at the University of Cincinnati and the Ohio State University. The sequence covered two academic quarters and included visits to each of the nuclear power plants involved in the collaboration. Class lectures were presented in video-classrooms such that instructors at one site could reach not only their own students but students at the other university as well. Class lecture material was developed primarily from similar materials utilized and developed by the utilities to train their own engineers and operators. The initial development effort was described in an earlier progress report [2].

The collaborative effort required to present the course sequence has produced a variety of benefits, some expected and some unexpected. These include:

- University course material prepared from actual operating plant resources, not merely "textbook cases".
- Enhancement of traditional learning setting with significant time spent at the plant simulators.
- Opportunities for students to tour working nuclear power plants.
- Professional enrichment and development for the collaborators through frequent interaction with peers at various plants and universities.
- Initiation of research projects of mutual interest to utilities and universities.
- Enhancement of students' ability to make early contributions in the plant engineering workforce through more complete understanding of plant operations.
- Bringing the OSU and UC faculty to the forefront of the development of new instructional technologies (multi-media, real-time distance learning applications).

The initial offering of the course on LWR systems and operations was very successful in providing university students learning opportunities they did not have in other classes. Student evaluations indicated their appreciation for the opportunities to visit the plant sites, perform plant evolutions in the simulators and interact with the utility training personnel. Several students were so positive in their reactions that they recommended making the course sequence a required part of the nuclear power engineering curriculum.

**CUUP Working Group**

The development and presentation of the first course was possible only through the coordinated effort of a Working Group of individuals from all participating organizations. The Working Group consists of training personnel from each of the three nuclear plants and instructors from each university. The main participants are listed in Table 1. The activities of the Working Group during the first half of 1994 have been focused in two main areas: 1) Coordination of Effort, and 2) Site Visits. The progress made in each of these areas is discussed in the following paragraphs.

**Table 1 - CUUP Working Group**

| Location | Individuals |
|---|---|
| Davis-Besse | Ted Bergner<br>Bob Morrison<br>Rick Simpkins |
| Perry | Mike Wesley<br>Chris Persson |
| Cook | Paul Carteaux<br>Jack Carney<br>John Stubblefield |
| OSU | Don Miller<br>Brian Hajek |
| UC | John Christenson<br>Eugene Rutz |

## Coordination of Effort

Since the working group is comprised of individuals working at a variety of dispersed locations, monthly conference calls have been established as the optimal mechanism for achieving the required degree of coordination. These calls have minimized travel time and have been quite successful in establishing consistent and coordinated effort among the two universities and the three power plants. In addition to the individuals listed in Table 1, a number of additional plant personnel have substantially contributed to these conference calls. A summary of the conference calls and significant accomplishments made during the first half of 1994 is given in Table 2.

**Table 2 - Conference Call Summary**

| Date (1994) | Accomplishments |
|---|---|
| February 17 | Set initial agenda for Spring Quarter plant visits including plant tours. Provided list of students for Winter Quarter plat visits. |
| March 17 | Established final agenda for Spring Quarter plant visits. Set schedule for Spring Quarter visits. Requested EOP material from plants. |
| April 21 | Received EOP material from plants. Provided list of students for Spring Quarter plant visits. |
| May 19 | Evaluation of collaborative effort. Coordinated initiation of research projects at DC Cook and Perry. |
| June 16 | Reviewed draft Progress Report. Discussed status of CUUP year two proposal and status of research projects. |

## Site Visits

One of the most significant benefits to the students of this class was the opportunity to visit actual operating power plants. Plant visits were conducted during both the Winter and Spring quarters. The plant visits are discussed below and summarized in Table 3.

### Winter Quarter Plant Visits

During the Winter Quarter, each student visited one of the plant sites. The class participants from both OSU and UC were split into three groups with one group visiting the Perry Nuclear Power Plant, another visiting the Davis-Besse Nuclear Power Plant and the third visiting the DC Cook

Nuclear Power Plant. This initial visit provided the students with:

- Familiarization with the particular plant simulator
- Instruction by utility personnel on operation of the plant
- Overview of the procedures utilized by the plants
- Opportunity to perform several normal evolutions on the simulator

The format of the Winter Quarter visits was for the student group to arrive at the plant site around noon on Friday and spend the rest of the day at the site (7-8 hours). The student groups also spent four or five hours at the simulators the next day such that the total instructional time was approximately 12 hours.

Spring Quarter Plant Visits

During the Spring Quarter, each student participated in two plant visits. The visits were scheduled such that the students visited the plants they did not visit during the Winter Quarter. Thus, by the end of the course sequence, students had received instruction about the three principal types of LWRs operating in the United States.

The Spring Quarter visits provided a significant portion of the overall class participation of the students. Each of these visits covered approximately 22 hours of instructional time, beginning at noon on a Friday and concluding around noon on the following Sunday. Attachment A illustrates a typical schedule for the Spring Quarter visits.

The main thrust of these visits was to provide:

- Tours of the plants with emphasis on unique features of each plant
- Familiarization with the simulators of various commercial power plants (PWRs and BWR)
- Opportunities for students to participate in normal plant evolutions using the simulators
- Opportunities for students to observe off-normal and emergency response of the plant
- Opportunities for students to participate in abnormal and emergency plant evolutions using the simulators

Based on student evaluation of the course, these plant visits and the interactions with plant personnel provided significant learning opportunities which were extremely well received by the students.

Table 3 - Plant Visit Schedule

| Plant Site | Dates 1994 | Utility Host<br>University Lead | Number of Students |
|---|---|---|---|
| Perry | 2/25 - 2/26 | Chris Persson<br>Brian Hajek | 10 |
| Davis-Besse | 2/25 - 2/26 | Bob Morrison<br>John Christenson | 11 |
| DC Cook | 3/4 - 3/5 | John Stubblefield<br>Eugene Rutz | 9 |
| Perry | 4/22 - 4/24 | Scot Watkins<br>Brian Hajek | 4 |
| DC Cook | 4/29 - 5/1 | Jack Carney<br>Eugene Rutz | 7 |
| Davis-Besse | 5/6 - 5/8 | Bob Morrison<br>John Christenson | 5 |
| Perry | 5/6 - 5/8 | Scot Watkins<br>Eugene Rutz | 3 |
| DC Cook | 5/13 - 5/15 | Jack Carney<br>John Christenson | 5 |
| Davis-Besse | 5/20 - 5/22 | Bob Morrison<br>Brian Hajek | 8 |

## Course Presentation

The course sequence consisted of two consecutive quarters of 3 credits per quarter available to engineering seniors and graduate students. The sequence was taught during the 1994 Winter and Spring Quarters. The course material introduced these students to the basics of nuclear power plant systems design and operation. The plant systems were presented in a "generic" fashion with specific design features of the collaborating utilities' plants used for illustration. Attachment B includes the syllabi for both quarters of the course sequence.

On campus presentations were made in video classrooms located at both universities. This was the first offering of its kind in Ohio linking universities for academic instruction on a real-time basis. As might be expected during an initial endeavor, there were a variety of challenges to be met. Instructors had to learn to speak to the camera as well as to their own students and prepare video-compatible visual material. An additional challenge was presented by a variety of video and audio transmission problems that in some cases required active intervention by the local instructor. This course demonstrated the benefits from providing this type of multi-location presentation and worked-out a number of the "bugs" in the video systems.

## Utility Contributions

Development and presentation of this course sequence would not have been possible without contributions from the utility collaborators in the form of personnel time, utility developed instructional materials, and use of the plant simulators. Instructors at each of the plants spent considerable time in preparing materials for university use, preparing materials for plant visits, and in the actual presentations during the plant visits. Table 4 summarizes the dollar equivalent contribution of each utility involved in this collaborative effort, the hours of personnel time and the hours of simulator time dedicated to this effort. The instructor hours include time spent in course development, classroom and simulator presentations, and leading plant tours.

**Table 4 - Utility Contributions**

| Plant | Instructor Hours | Simulator Hours | Monetary Equivalent |
|---|---|---|---|
| Perry | 321 | 56 | $44,050 |
| DC Cook | 239 | 66 | $42,990 |
| Davis-Besse | 135 | 50.5 | $32,000 |

## Other Activities

Several further project activities occurred during the first six months of 1994. First, a paper describing the project was prepared and submitted for the 1994 meeting of the American Nuclear Society [3]. The paper was accepted and presented at the ANS meeting in New Orleans during mid-June. Second, a joint effort by OSU and UC produced a proposal [4] for year two of the project. The proposal was completed in late May and submitted to the DOE in early June.

## Future Plans

The emphasis during the Summer Quarter will be on actively pursuing student research efforts directed at plant projects. Specific topics have been identified for the DC Cook plant and for the Perry Nuclear Power Plant. A graduate student from the University of Cincinnati will begin work on an improved model of the Reactor Coolant Pump seals for the DC Cook plant. At Perry, an Ohio State University student will begin work on a model of radiation transport through plant systems for the Perry simulator.

The Summer and Fall Quarters will also be used to review the course material developed during the first year. Instructors at both universities will be working to enhance the material based on lessons learned during the course presentation. Expected enhancements include:

- consistency of format
- clarity of learning objectives
- improvements in student handouts
- availability of a set of course notes at the first class session of each quarter
- improved coordination between on-site and on-campus instruction

Instructors at the universities may also take part in operator training courses being given at the various plants. University professors hope to increase their own knowledge of certain plant systems in order to be more effective presenters of this material during the next university course offering.

## References

[1] "A Collaborative Utility-University Project to Initiate a Comprehensive Program of Simulator Interfaced Light Water Reactor Instruction and Research",a proposal submitted to the DOE by UC and OSU under the provisions of the Nuclear Engineering Education Program (February, 1993).

[2] Collaborative Utility-University Project (CUUP) Progress Report (January, 1994).

[3] "Collaborative Utility-University Project for Year Two of a Comprehensive Program of Simulator Interfaced Light Water Reactor Instruction and Research",a proposal submitted to the DOE by OSU and UC under the provisions of the Nuclear Power Engineering Education Program (May, 1994).

[4] "Initiation of a Program of Simulator-Interfaced Instruction and Research", J.M. Christenson, B.K. Hajek, D.W. Miller, E.E. Rutz, Trans Am. Nucl. Soc., 70, 26-27 (June, 1994).

## Attachment A

## Spring Quarter
## Typical Plant Visit Schedule

Friday

| | |
|---|---|
| 1200 - 1830 | Plant Tour |
| 1830 - 1900 | Control Room Orientation |
| 1900 - 2030 | Perform Normal Plant Evolutions (e.g., control rod maneuvers) |

Saturday

| | |
|---|---|
| 0800 - 0830 | Classroom Presentation |
| 0830 - 1200 | Perform Normal Plant Evolutions (e.g., feedwater flow changes) |
| 1200 - 1300 | Lunch |
| 1300 - 1800 | Perform Abnormal Plant Evolutions (e.g., stuck open SRV) |
| 1800 - 1830 | Break |
| 1830 - 2000 | Perform Abnormal Plant Evolutions (e.g., loss of FW heating) |

Sunday

| | |
|---|---|
| 0800 - 0830 | Classroom Presentation |
| 0830 - 1300 | Perform Emergency Plant Evolutions (e.g., LOCA response) |

**Attachment B**

**Winter and Spring Quarter Syllabi**

## Winter Quarter Syllabus

| Class # / Date | Topic<br>Instructor | |
|---|---|---|
| 1 / Jan 3 | Course Overview/Intro to LWRs<br>Prof. Rutz | |
| 2 / Jan 5 | Design Criteria / 10CFR<br>Prof. Christenson | |
| 3 / Jan 10 | Technical Specifications<br>Prof. Hajek | |
| 4 / Jan 12 | Operating Procedures/Drawings<br>Prof. Hajek | Homework Set 1 |
| 5 / Jan 17 | No class ML King Day | |
| 6 / Jan 19 | Water Handling System<br>Prof. Rutz | **Quiz 1** |
| 7 / Jan 24 | Electrical Systems<br>Prof. Hajek | Homework Set 3 |
| 8 / Jan 26 | Reactor Coolant System<br>Prof. Rutz | |
| 9 / Jan 31 | Reactor Recirculation<br>Prof. Hajek | Homework Set 4 |
| 10 / Feb 2 | Steam Cycle<br>Prof. Hajek | |
| 11 / Feb 7 | Reactivity Control<br>Prof. Rutz | Homework Set 5 |
| 12 / Feb 9 | Turbine/Generator<br>Prof. Christenson | |
| 13 / Feb 14 | Nuclear Instrumentation<br>Prof. Miller | Homework Set 6 |
| 14 / Feb 16 | Main Generator & Exciter<br>Prof. Christenson | **Quiz 2** |
| 15 / Feb 21 | ECCS<br>Prof. Rutz | |
| 16 / Feb 23 | Electrical Systems<br>Prof. Hajek | Homework Set 7 |
| **Feb 25-26** | Plant Visits: Davis-Besse & Perry | |
| 17 / Feb 28 | No class | |
| 18 / March 2 | Closed Loop Cooling<br>Prof. Rutz | |
| **March 4-5** | Plant Visit: DC Cook | |
| 19 / March 7 | No class | |
| 20 / March 9 | Review<br>Prof. Hajek | |

## Spring Quarter Syllabus

| Class # / Date | Topic & Instructor | Assignment |
|---|---|---|
| 1 / March 28 | Engineered Safety Features I (ER) | |
| 2 / March 30 | Engineered Safety Features II (ER) | |
| 3 / April 4 | Emergency Operating Procedures I (BH) | |
| 4 / April 6 | Emergency Operating Procedures II (BH) | Homework Set 1 |
| 5 / April 11 | No Class | |
| 6 / April 13 | Residual Heat Removal (ER) | |
| 7 / April 18 | No Class | |
| 8 / April 20 | Control Room Orientation (JC) | Quiz 1 |
| 9 / April 25 | No Class | |
| 10 / April 27 | LWR Containments (JC) | |
| 11 / May 2 | No Class | |
| 12 / May 4 | Reactor Engineering Overview (ER) | Homework Set 2 |
| 13 / May 9 | No Class | |
| 14 / May 11 | LWR Operating Events (JC) | |
| 15 / May 16 | No Class | |
| 16 / May 18 | Reactor Operator Licensing (BH) | |
| 17 / May 23 | No Class | |
| 18 / May 25 | Last day of class | Final |

JC Professor Christenson

BH Professor Hajek

ER Professor Rutz