THE PALO VERDE STORY:

A FOUNDATION FOR FUTURE MULTI-STATION NUCLEAR POWER PLANTS.

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ABSTRACT:

In 1973, the design and planning for the Palo Verde Nuclear Generating Station was started featuring three 3800 MWt Combustion Engineering Standard System 80 Nuclear Steam Supply Systems. Arizona Public Service Company (APS) was the Project Manager and Operating Agent and Bechtel Power Corporation the architect/engineer and constructor. The Palo Verde units are located in a desert environment some 50 miles west of Phoenix, Arizona. It is a "dry site" in that there are no liquid discharges from the site. The cooling tower makeup water sewage is waste effluent from the City of Phoenix treated at an on site reclamation facility. The effluent has had primary and secondary treatment at the Phoenix plant prior to delivery to PVNGS. The units are physically separate from each other but are of identical design. There are no shared safety systems between the units.

Unit 1 and Unit 2 are both in commercial operation (January, 1986 and September, 1986 respectively). Unit 3 is scheduled to load fuel late in the first quarter of 1987.

This paper presents some of the engineering and management practices used during design, construction, and startup and operational experiences and other unique features of this multi-unit nuclear station. The site arrangement is shown in Figure 1.

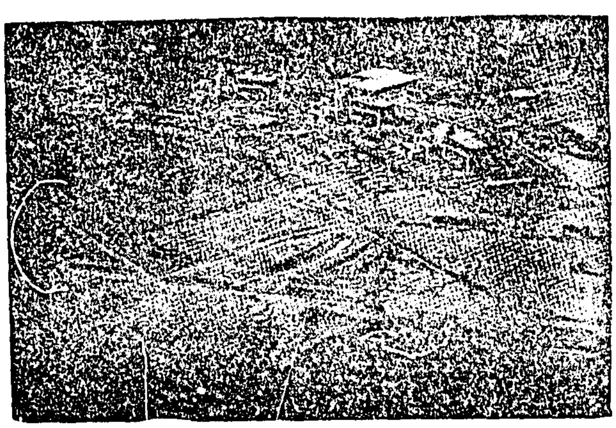

Fig. 1 PVNGS Site

INTRODUCTION

The Palo Verde Nuclear Generating Station (PVNGS) consists of three nominal net 1270 MWe nuclear power units located at a desert site approximately 50 miles west of Phoenix, Arizona. Each unit is identical and features a Combustion Engineering (C-E) Standard System 80 pressurized water reactor (PWR) Nuclear Steam Supply System (NSSS); a General Electric six-flow, tandem-compound turbine generator; and concrete, mechanical forced-draft cooling towers. When all three units are placed into operation, PVNGS total electric generation of 3810 MWe will make it the largest nuclear generating station in the United States. Units 1 and 2 are in commercial operation and Unit 3 is scheduled for commercial operation during the last quarter of 1987.

The PVNGS is a participant project called the Arizona Nuclear Power Project (ANPP) with Arizona Public Service Company (APS) responsible for the construction, startup, testing and operation of the three unit complex. The participants include Salt River Project, Southern California Edison Company, El Paso Electric Company, Public Service Company of New Mexico, the Southern California Public Power Authority, and the Los Angeles Department of Water and Power.

This paper will touch on some of the more significant aspects of the project; design objectives, management's role, fundamental philosophy which emphasized safety and quality from the onset, site features, regulatory process and the startup experiences of this very successful undertaking which can be viewed as a foundation for future standardized multi-station nuclear power facilities.

SELECTION OF AN NSSS AND BOP DESIGNS

The project management determined early in the project that they would make maximum use of consultants, contractors, and suppliers with demonstrated expertise and capability. In January, 1973, with the assistance of S. M. Stoller Corporation, Bechtel Power Corporation of Norwalk, California was selected as the engineer-constructor. Bechtel was responsible for a range of activities that included project management, engineering, procurement, construction and control of quality, cost and schedule for those tasks within the scope of the balance of plant.

The decision to either select an engineer-constructor or an engineer-construction manager was given considerable attention. After much study by ANPP, it was concluded that the engineer-constructor approach was most appropriate because (1) it permitted the concept of unified responsibility, (2) it minimized the number of communication and coordination interfaces; a key concern and (3) permitted more efficient use of crafts.

Subsequent to the selection of the engineer constructor, the project along with consultants, prepared a comprehensive specification for the procurement of the Nuclear Steam Supply System (NSSS) and related initial core and reload fuel. After several months of evaluation which ended in August, 1973, Combustion Engineering, Inc. of Windsor, CT was selected to provide three 3800 MWt System 80 standardized NSSS's, associated support systems and fuel for the first core and first reload.

PVNGS DESIGN ARRANGEMENT

The PVNGS uses a "slide along" approach; that is, each unit is identical and each constructed from the same set of drawings. Each unit is separated by approximately 1200 feet and positioned on a circular arc configuration, with the switchyard located at the center and common to each unit. This arrangement offered the best overall arrangement because it permitted each unit to be located as close together as possible thus centralizing support services yet providing sufficient area for cooling towers to minimize the impact of tower drift on other towers and the plant overall. The arrangement also minimized impact considerations for postulated turbine generated missiles and resulted in a optimum location of the switchyard; it being the focal point for all the units. This in turn, provided an economical approach to the transmission of power offsite. This concept of plant design layout permitted maximum use of standardization of the design and equipment, an initial objective of the project, and provided means for expansion to additional units.

The various system functions were conceived as modules and the modules were arranged based on their functional relationships. The outcome was a standard plant arrangement with each building a module, housing a particular function and taking into account construction and operational considerations. The principal modules at PVNGS are the containment, auxiliary, control, turbine radwaste, diesel-generator, and fuel buildings. The buildings required considerable initial design review to determine the optimum size based on construction, operations, maintenance and laydown space requirements.

In addition to the unit buildings, the PVNGS site also includes administration and engineering support structures, storage and warehouse facilities, a maintenance building with a well equipped machine-shop, a water reclaimation facility and a makeup water storage reservoir and evaporation pond.

A unique feature of PVNGS is that there is no liquid discharge from the site during construction or operation. As a result, the site is defined as a "dry site".

NSSS DESIGN

PVNGS has three System 80 NSSS's. The System 80 is not a new design as much as it represents an evolution of the design process incorporating proven and improved design features of earlier plants. The design addresses such industry developments as fuel densification, emergency core cooling, inservice inspection, power limitations, standardization, and the regulatory concerns such as those voiced as a result of the TMI experience. Looking to the future, the design considers such developments as power escalation, plutonium recycle, decreased refueling time, extended fuel cycles and improved maneuverability. The design is approved by the Nuclear Regulatory Commission (NRC) which issued a generic Preliminary Design Approval (PDA) in December, 1975 and a Final Design Approval (FDA) in December, 1983. The System 80 design is described in a document entitled "Combustion Engineering Standard Safety Analysis Report (CESSAR)" which was the vehicle used to submit the design to the U.S. NRC for approval.

The major components of the System 80 NSSS primary system consist of the reactor vessel containing the oxide fuel core, core internals, control element assemblies and drives, pressurizer, reactor coolant pumps, and U-tube steam generators. Although similar to previous C-E units, specific enhancements that were made included; a larger number of Zircoloy clad fuel assemblies to achieve lower linear heat rating in a core sized to meet a regulatory imposed core power limit of 3800 MWt in a conservative manner; a bottom-mounted incore instrumentation system including both fixed and movable detectors, which is combined with a core monitoring computer system to allow accurate on-line determination of core performance and to provide operational flexibility; an integral economizer steam generator to improve heat transfer efficiency and more tubes for increased heat transfer area; faster refueling capabilities achieved by designing the control rods to be removed with the upper internals without unlatching the control rod extension shafts; control rod assembly (CEA) design and patterns which allows flexibility to provide sufficient shutdown margin for plutonium recycle cores; an improved plant protection system which allows better use of available plant margins to improve operational flexibility; a Reactor Power Cutback System (RPCS) that accommodates load rejections; or loss of single feedwater pump from full rated power without a reactor trip and without requiring 100% steam bypass capacity; a reactor coolant system support system designed for a wide variety of site characteristics; and a CEA shroud assembly designed to allow CEA insertion under adverse seismic and LOCA loads.

Early in the project a design criterion was established that the plant would maximize availability. To meet this criteria numerous design features were incorporated into PVNGS. Various nuclear stations had experienced problems with steam generator tubes, therefore, to address these concerns the project took the following steps to minimize plant down time:

- The steam generators were designed with improved materials and flow patterns.
- All volatile chemistry was adapted as the best method of chemistry control.
- An increased steam generator blowdown rate capability was incorporated.
- Full flow condensate polishing capabilities were included in the base design.
- Titanium condenser tubing and condenser leak detection capability.
- Stainless steel feedwater heater tubes.
- Minimized the use of copper in the feedwater/condensate system.
- Added a chemical monitoring and addition system for control of the secondary side chemistry.
- Included in the design, the capability to remove the lower section of a steam generator from containment.

The plant design also includes redundant capability to assure high plant availability. Some examples are; use of three fifty percent condensate pumps to allow maintenance during operation, bypasses and cross ties to permit maximum operational levels during occurrences of feedwater heater failure or maintenance; a split condenser design to permit tube repair while at reduced power; and circulating water pump cross ties to permit operation at full load with one pump out for maintenance.

Refueling outage durations are minimized by the use of multiple stud tensioners for the reactor vessel, steam generator manways, a simplified pool seal arrangement, grouping of radioactive filters and ion exchangers together to maximize utilization of remote handling systems, separation of non-radioactive equipment from that located in radiological control zones, and allowing, adequate work access and equipment laydown area for maintenance purposes. Compartmentalization and separation between safety trains and between piping and electrical cabling also were features at PVNGS. These features contributed to a significant reduction in the number of pipe restraints required (none required in the auxiliary building), and permits maintenance to take place on one piece of equipment while the redundant equipment is kept in operation. Locations of hatches, doors and elevators, and provisions for hoists and cranes and the placement of platforms were optimized in the design phase of the project.

With the goal of reducing downtime for equipment maintenance and repair, considerable attention was given to the location and provisions for onsite decontamination and maintenance facilities. In addition to the central maintenance facility which includes a well equipped machine shop, smaller maintenance shops are provided at each unit adjacent to the turbine building and within the radwaste building. These smaller facilities are intended for the majority of the routine maintenance with decontamination capability available in the radwaste building maintenance shop.

Unit 1 has a central decontamination facility for handling those components which can not be handled in each units radwaste building facility. The central facility, which also includes a central laundry for contaminated clothes, returns the decontaminated equipment to the appropriate maintenance facility for repair.

These features of PVNGS demonstrate the project commitment to provide a standard design plant that addressed not only the needs of construction but also those of startup, and operation and the radiological, maintainability and availability objectives established early in the project.

PVNGS SITE FEATURES

The PVNGS is set in a desert location approximately 50 miles west of Phoenix, Arizona. It is a remote site with a population density of approximately 1500 within a ten mile radius. As remote as the site may appear,it is only a few miles from a main interstate highway and there are railroad spurs to each unit which permits easy access for the delivery of equipment and to provide for services. Because of the remoteness, the project provided living accommodations for up to 501 people within a few miles of the site during plant construction.

Arizona is a state with limited cooling water for the condensers such as might be found at sites located on lakes and rivers. Because of this, the use of reclaimed wastewater from Phoenix and adjacent cities was a desirable goal. In pursuit of this goal, APS contracted with the municipalities to use the reclaimed wastewater from the Phoenix 91st Avenue Sewage Treatment Facility for cooling tower makeup water supply.

The treated waste water is conveyed in a 114 inch diameter pipeline by gravity some thirty miles to a pumping station where it is pumped to the site treatment plant called the Water Reclamation Facility (WRF) (Figure 2). Onsite sewage is also pumped to the WRF. At the WRF it is treated in a 90 million gallon per day (supports three units operation for seven days) denitrification and water softening plant before being discharged to an 80 acre (670 million gallon) reservoir. Detailed process studies, laboratory tests, and demonstration plant tests were performed to provide the input for the design of the WRF and power plant materials selection. This facility is one of the largest advanced water treatment plants of this kind in the United States.

Because of "dry site" considerations, blowdown from the cooling towers is discharged into a lined on-site evaporation pond. Optimum methods are used to reclaim the blowdown and to most economically handle sludge disposal.

With water conservation a must objective, criteria was established to operate the cooling tower system at up to 20 cycles of concentration, however, for operational conservatism the system operates on an average of 15 cycles of concentration. Domestic water and water for plant systems and service are obtained from existing onsite wells.

ENGINEERING MANAGEMENT

The project from its inception, has stressed safety first, closely followed by quality. This theme was reinforced throughout the design, construction, startup and operation of PVNGS. With these policies and the objectives of operability, maintainability, and availability in mind, the PVNGS was designed and constructed as standard units to reduce the time from construction to operation. Standardization concepts such as identical units built from a single set of drawings and a design freeze at about the time construction was started, were used to develop appropriate criteria for a standard modular plant design. Inherent in this effort were the experiences gained from earlier nuclear plants to extract the good practices and to avoid wherever possible the problems of the past.

Recognizing it is the people who accomplish tasks, PVNGS provided an environment which allowed a close working relationship among the highly motivated people assigned early in the project from the utility, the architect-constructor and NSSS supplier. Mutual participation by technical personnel and senior management was critical to completion of the design, construction and operation of the PVNGS units within acceptable budget and schedule limits.

Figure (3) depicts a flow diagram for the development of the PVNGS standard design. The design criteria is the fundamental document defining the basis for the project scope. Once the design criteria were formulated, preliminary engineering was started, licensing documents were prepared and the plant arrangement was developed. Feedback from the licensing process, and from other sources, was evaluated as to need for modifying the design criteria. Once construction was started, further changes were evaluated against a set of acceptance criteria before they were allowed to be incorporated in the design. These criteria were based on safety needs, functionability needs and/or a licensing requirement.

For PVNGS, the standardization concepts were made a reality through the utilities' commitment to a standard plant, the development of mandatory

Fig. 2 Wear Reclamation Facility (WRF)

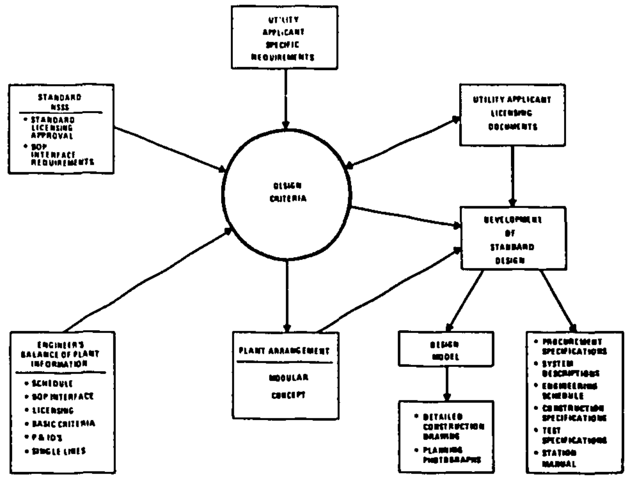

Fig. 3 Development of Standard Design

and firm standard plant criteria, the use of System 80 NSSS, and the Bechtel Modular PWR design.

Coordination is an important element to successfully conclude a multi-faceted project like PVNGS. To accomplish the required level of coordination, frequent meetings were held among APS, Bechtel and C-E to review design, procurement and construction activities and to identify and resolve problems. The participation at all levels of management, including senior management, was essential to review in detail, the overall project performance as it relates to safety, quality, schedule, budgets and accomplishments of major project milestones and objectives. The coordination meetings were a prime opportunity to identify and develop plans to solve problems.

A project plan, also a key element, was developed involving engineering, procurement, and construction activities. The plan encompassed scope definition, design and interface criteria, project procedures, detailed engineering, procurement, construction, and startup planning, as well as the development of schedules, manning charts, budgets, and methods to control costs, schedule, and quality.

Another important engineering tool for verification of the adequacy of the plant design was the use of a detailed scale model (Figure 4). The PVNGS model (3/4 inch to the foot scale) facilitated design review, provided a three-dimensional guide for construction planning and training of operational personnel for maintenance services, and provided an opportunity to construct the plant in plastic one to two years prior to actual construction. The model was used for elimination of interferences, review of design changes to minimize costs and schedule delays, the conduct of maintenance reviews including access, time studies, equipment replacement, resolution of equipment placement problems, clarification of interface criteria and a reduction in manhours for the preparation of isometric drawings. This model is being maintained at PVNGS and it continues to provide valuable assistance for the maintenance and outage planning activities for the operating units.

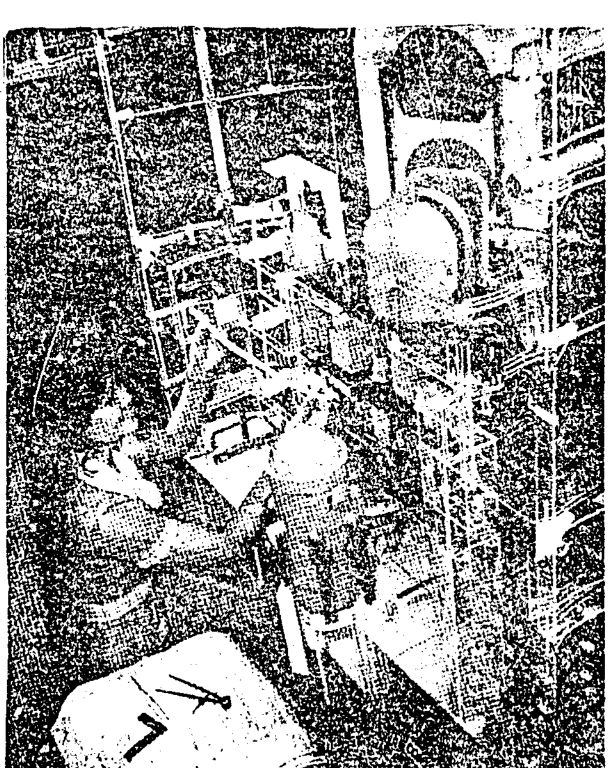

Fig. 4 NSSS Portion of the PVNGS Unit Model

SITE MANAGEMENT

The construction of PVNGS, which is now completed, was done by Bechtel Construction Incorporated. Many of the management tools utilized for the design and engineering phases were used during construction such as the coordination and design review meetings, preparation of a construction plan, and the use of the model to assist in the construction planning and problem resolution. Some of the more important construction techniques used at PVNGS included:

- Maximized use of pre-assembled structures & piping sections using on site pre-assembly areas and pipe welding shops, preassembly of delivered components such as condenser sections, instrument racks, pipe supports, and large pipe spools.
- Utilized experience gained on Unit 1 for Units 2 & 3 construction by transfer of key people or by training of the new personnel by those who gained experienced on Unit 1.
- Use of embedded steel framing in the walls such that it could provide support for such items as pipe and duct.
- Use of a labor stabilization agreement which provided uniform working conditions, processes for handling grievences, and appropriate no strike-no lockout provisions.
- The utilization of standardized, approved designs using one set of drawings for the three units permitted increased worker efficiency and a high utilization of construction equipment.
- Use of the most modern computerized planning and scheduling tools available for control of costs and schedule including PREMIS and System 38 Tracking systems.

- Availability of suitable storage facilities for proper handling of components prior to installation.
- Common pipe racks and instrument racks to permit low cost structural supports for pipe and instruments.
- Use of oversized polar crane girders and supports (800 ton capacity) to support a temporary trolly to assist in installation of heavy components such as the steam generators and reactor vessel.
- Use of a concrete batch plant and associated ice house located on site along with an independent test laboratory. Concrete was placed at night to the maximum extent possible to avoid interference with other operations and to allow lower ambient temperatures which is necessary during the hot summer at a desert site.
- Use of monolithic placement of the base mats (Units 2 & 3) and the preparation of forms (and their reuse) at a nearby onsite area reduced form work costs.
- Use of an onsite coating facility to minimize coating damage repairs.
- Decision to use only Quality Class 1 materials for concrete, reinforcing steel, weld rod and instrument fittings to eliminate the extensive administrative controls that would be needed to assure proper material segregation.
- Establishment of a resident engineering staff on site to expedite design changes and handling of non-conformances.

Consistent with the engineering activities, APS played a significant role in the construction phase with active participation at all levels of management up to and including senior management.

These coordinated and planned efforts of the involved parties resulted in substantial improvements in the construction work. As an example, wire and cable pulling rates on Unit 3 were 25% more productive than on Unit 2 and 40% better than in Unit 1. The use of a standard design and a single set of drawings produced significant improvements in productivity as construction progressed from unit to unit.

The PVNGS Safety Record, one of the best in the industry, was attributed to strict adherence to firm housekeeping and safety rules by management, supervisors, engineers and craftsmen. Significant dollar savings were realized as a result of insurance refunds.

During construction, access to the site was controlled by appropriate security forces using limited access and badge control practices. Vehicles searches were conducted as they entered and left the enclosure fence around the site. Security measures were increased as the units went into startup and to a much greater extent for fuel load and subsequent operations. Each unit is enclosed separately and access is restricted to a single entrance. A computerized security and radiological access system is used to account for onsite personnel and their radiation histories.

PVNGS REGULATORY PROCESS

In 1973, ANPP made a commitment to the NRC that it would file its initial licensing application in July, 1974 with a schedule for receiving the construction permit from NRC in May, 1976. A thirty three volume Preliminary Safety Analysis Report (PSAR) including technical, safety, environmental, economic, and the required anti-trust information was submitted in July, 1974. The formal review lasted one year during which time 836 NRC questions were answered in amendments. Every scheduled amendment submittal date was met.

The PSAR referenced the C-E Standard Safety Analyses Report (CESSAR) for those systems in the C-E scope of supply. This document was docketed in October, 1973 and received a Preliminary Design Approval(PDA) in December, 1975. Some 700 questions were resolved by C-E on the CESSAR docket.

The construction permit was issued in May, 1976 for Units 1, 2, and 3 consistent with the schedule set in 1972 based on the CESSAR PDA and the NRC review of the PVNGS PSAR.

The Final Safety Analyses Report (FSAR) application was similar to that of the PSAR in that CESSAR-FSAR docketing preceded the PVNGS FSAR submittal. CESSAR-FSAR was docketed by the NRC in December, 1979 and received a Final Design Approval (FDA) in December, 1983. The PVNGS FSAR was docketed for acceptance review in June, 1980. The full power operating license for Units 1 and 2 were issued in June,1985 and April, 1986 respectively and were based on the CESSAR FDA and review of the PVNGS FSAR. The Unit 3 low power operating license is expected in the first quarter of 1987.

Licensing was never on the critical path at PVNGS, however, an innovative approach was needed to assist the NRC to conduct the initial FSAR review because of their inability at that time to support the review. An Independent Design Review (IDR) concept was initiated wherein the project made presentations of specific safety related design areas before a board of experts. Those experts consisted of personnel from ANPP, Bechtel, C-E, and other utilities and/or consultants as needed who were not associated with the project. The NRC attended the IDR's and they were able to get immediate responses to their questions. The process was well received and proved to be an effective method of licensing review.

The standardized approach to the licensing process proved to be extremely effective with PVNGS being the first licensed operating facility to reference an NRC approved standard NSSS design.

PVNGS STARTUP

The startup to operational period can be divided into two phases; (1) Startup activities and (2) plant testing. The startup activities included such typical functions as field calibration of instruments, loop testing, motor bumping, system flushes, completion walkdowns, pre-operational testing, and pre-core hot functional testing. The unit was then turned over to operations for fuel load, post-core hot functional testing and culminating in low power physics and power ascension tests.

The early phase of startup was an evolutionary one as the project progressed from Unit 1 to Unit 3. Initially, the engineer-constructor was responsible for the first phase of testing. By 1979, due largely to the evolution of NRC testing requirements APS decided to form a single group to perform the startup functions. This group operated under the direction of APS. APS maintained the responsibility for Units 1 & 2 and continues to do so for the Unit 3 efforts currently in progress. Those management tools so successfully used and described for the design and construction activities were carried over into the startup and operations phase. Here, as elsewhere, senior management played an active participative role in this crucial phase of the project.

The FSAR (CESSAR and PVNGS) Chapter 14 defines the initial startup test program which meets the requirements of USNRC Regulatory Guide 1.68.2 (Preoperational and Initial Startup Test Programs for Water-cooled Power Reactors). The test program met the intent of revision 2 of the guide; the current revision. Testing of systems added or refined after the TMI-2 event were incorporated, hence, the test program meets all currently defined regulatory requirements.

The post core test program for the NSSS is outlined in Table 1 wherein the requirements for the follow on units also are delineated. As noted, the testing for Units 2 & 3 is reduced in scope because the design features were adequately demonstrated during the Unit 1 testing. The follow on unit testing is primarily directed toward demonstrating that the NSSS was constructed in accordance with the designs and responds as expected, and for certain tests to provide operator experience. In general, the testing of a follow on plant at a multi-plant site such as PVNGS will typically be done in about two-thirds the time required for the first unit. Time savings can also be realized by other utilities with similar System 80 units.

Low Power Physics Test	*Lead Unit*	*Follow-on Unit*[1]
• Biological Shield Survey	Low Temp/HZP[2]	HZP
• Core Symmetry Verification	HZP	HZP
• Isothermal Temperature (ITC) Measurement	Low Temp/HZP	HZP
• Control Rod Worth Measurements		
a. Regulating Groups	Low Temp/HZP	HZP
b. Shutdown Groups	Low Temp/or HZP	Not Required
• Differential Boron Worth	Low Temp/HZP	HZP
• Critical Boron Measurement	Low Temp/HZP	HZP
• Dropped and Ejected Rod Worths	HZP	Not Required
Power Ascension Tests		
1. Core Performance		
ITC and Power Coefficients	20,50, 80,100%	50,100%
Power Distribution Measurements	20,50, 80,100%	20,50,80, 100%
Dropped Control Rod (Power Distribution)	50%	Not Required
Ejected Control Rod (Power Distribution)	50%	Not Required
Xenon Oscillation Control Test	>50%	Not Required
2. Protection System Calibration		
Incore-Excore Detector Calibration	20,50%	50%
Core Protection Calibration/Excore Detector Adjustments		
Excore Detector Shape Annealing Factors	20,50%	50%
Excore Detector Temperature Annealing Factors	50%	50%
Control Rod Insertion Shadowing Factors	50%	50%
Core Protection Calculator (CPC) and Core Operating Limit Supervisory System (COLSS) Verification	20,50,80,100%	20,50,80, 100%
CPC and COLSS Peaking Factor Verification	50%	50%
Incore Detector Test	20,50,80,100%	20,50,80, 100%
Reactor Coolant Flow Determination	20,50,80,100%	20,50,80, 100%
3. Transient Testing		
Reactor Power Cutback System (RPCS) Tests	50,70,80,100%	100%
Load Following Tests	50,100%	50,100%
Control Systems Tests	20,50,80,100%	50,100%
Shutdown Outside Control Room	≥10%	≥10%
Turbine Trip Test	100%	100%
Full Load Rejection Test	100%	100%
Loss of Offsite Power Test	≥10%	≥10%
Loss of Forced Flow/Natural Circulation Test	≥80%	Not Required

Notes:

1 To qualify for Follow-on-Status and reduced scope testing, a plant must respond in an identical manner to the Lead unit through conformance with specified acceptance criteria.

2 HZP refers to measurements performed at hot, zero power conditions (565°F/2250 psia or 296°C/158kg/cm²). Low Temp refers to measurements performed at RCS conditions other than HZP

Table 1

To facilitate the testing, two special test devices were used in addition to the normal test equipment. The first was a C-E digital reactivity calculator used for reactivity measurements at zero power. The equipment facilitates setup and alignment and eliminates errors due to electronic component drift.

The second special equipment device used was a C-E Test Data Acquisition System (TDAS) to record relevant plant parameters. High speed data acquisition has proven extremely valuable for evaluating responses of control and protective systems and for expediting data reviews between test plateaus. It is also being used for post-trip review analysis.

The testing on Units 1 and 2 demonstrated that reactor coolant flow, reactor coolant pump flow coastdown and control rod drop times were within the acceptance criteria and the remainder of the hot functional testing verified that the operation of the units conformed to design requirements. The core performance tests and the safety and core monitoring calibration were successfully completed on both units. The transient response testing of the Reactor Power Cutback System confirmed that the response of the units is in accordance with the expected responses as generated with the System Performance Code, LTC. This system is intended to keep the reactor on-line (no trip) following a load rejection (including loss of turbine) or loss of one of the two main feedwater pumps without requiring a 100 percent steam bypass capability. A loss of flow natural circulation test was successfully conducted on Unit 1 to demonstrate compliance with USNRC Branch Technical Position RSB 5-1 which deals with taking the plant to long term decay heat removal under natural circulation conditions using only safety systems. This test was not required on Unit 2 since Unit 2 is essentially a duplicate of Unit 1 which, again, is another example of the benefits of standardization. All the test data is archived for later use in validation of the full scope training simulator.

The comprehensive testing performed on Units 1 & 2 demonstrated that the controls system performed in accordance with the design. The test time on Unit 2 was 30 percent less than that on Unit 1.

Units 1 & 2 have accumulated 285 and 133 Effective Full Power Days(EFPD) of operation, respectively as of January, 1987. Unit 3 will proceed into fuel load and post-core testing in the first quarter of 1987 and will be commercial in the third quarter of 1987.

SUMMARY

With the approach of fuel load on Unit 3, the PVNGS will soon be completed and it will be the largest nuclear electric generating station in the United States. Most of the success of PVNGS must be attributed to the effectiveness of the management team, the dedication and competency of the personnel working on the project, and the continuity that was maintained by the assignment of key personnel to the project for extended periods, many since its inception. The use of appropriate and effective management tools, a full spectrum of management participation, and the flexibility to do what was best when it was needed in the face of changing conditions, and very importantly, the adherence to the initial project objectives of safety, quality, operability, maintainability, and availability contributed to the success of this project. The end result is that the PVNGS is one of the lowest cost nuclear projects constructed in the U.S during the same time frame, and Unit 1 was completed in fourteen months less than average of other comparable plants.

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