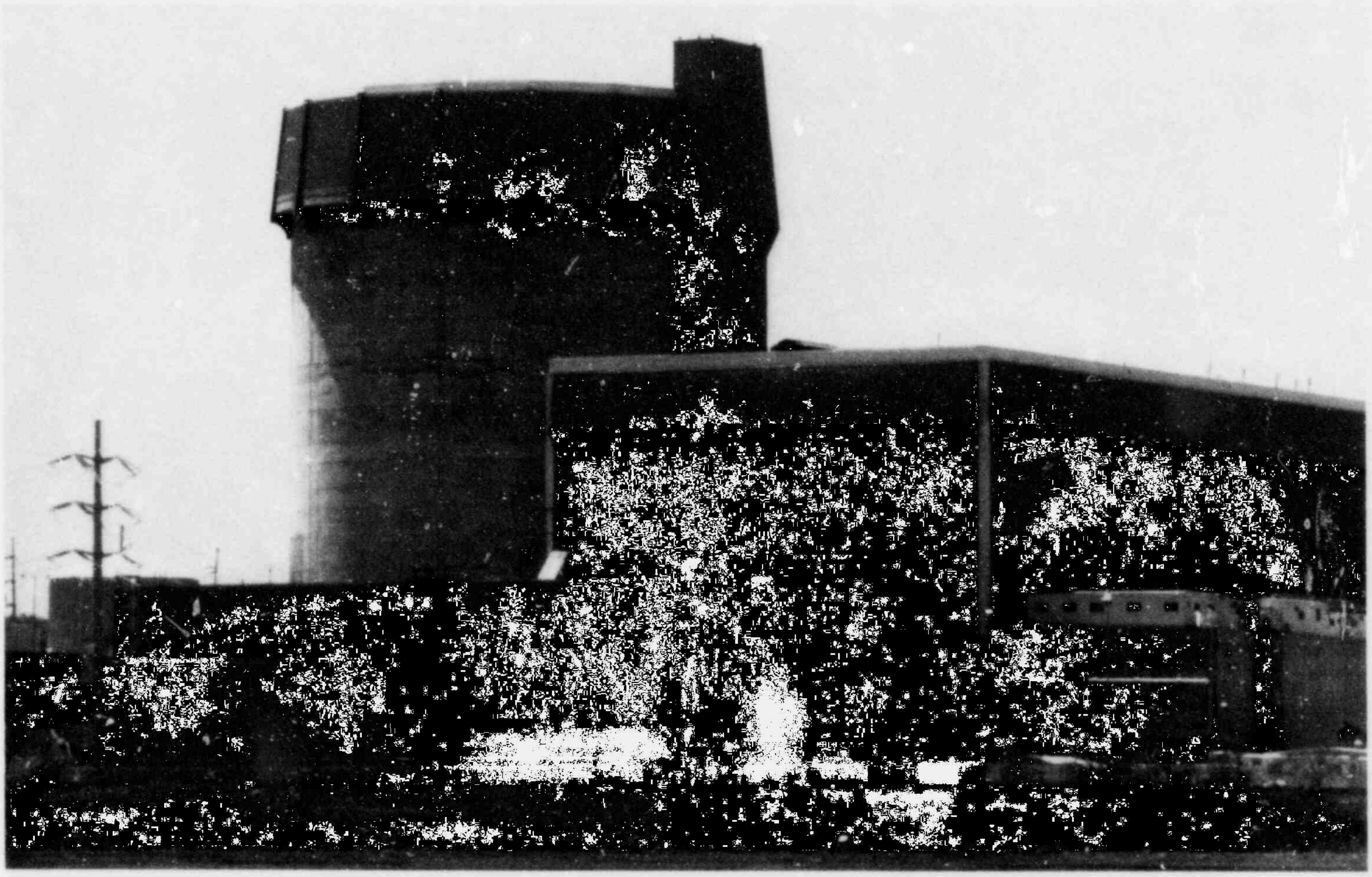
GA-C16873

FINAL REPORT



INDEPENDENT VERIFICATION
SHOREHAM NUCLEAR POWER STATION

VOLUME I - EXECUTIVE SUMMARY

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TORREY
PINES
TECHNOLOGY

A DIVISION OF GENERAL ATOMIC COMPANY

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FINAL REPORT

INDEPENDENT VERIFICATION
SHOREHAM NUCLEAR POWER STATION

VOLUME I - EXECUTIVE SUMMARY

Prepared for
LONG ISLAND LIGHTING COMPANY

GENERAL ATOMIC PROJECT 2434
SEPTEMBER 30, 1982

TORREY PINES TECHNOLOGY

A DIVISION OF GENERAL ATOMIC COMPANY

FOREWORD

This is Volume I of the three-volume final report on the independent construction verification of the Shoreham Nuclear Power Station. Volume II presents detailed results of the independent construction verification effort and Volume III contains copies of all Potential Finding Reports, Discrepancy Reports, and Corrective Action Plans generated during the program.

CONTENTS

FIGURES

1. INTRODUCTION

Torrey Pines Technology (TPT) was engaged by Long Island Lighting Company (LILCO) to conduct an independent review of the construction of LILCO's Shoreham Nuclear Power Station (Fig. 1-1). The review, conducted May through September 1982, reviewed the complete construction process beginning with procurement of items according to design requirements (the design requirements are assumed to be adequate for purposes of this review) and traced the activity through final construction inspection and turnover to startup. The review also included an assessment of the effectiveness of the quality assurance (QA) program for construction (those actions taken during the construction phase to ensure a product of adequate quality).

The program was structured to determine whether the construction process converted the specified design requirements into sound plant systems. Procedures used in the construction process were reviewed to determine if the basic process was adequate. A selection of specific components was reviewed to ensure that the procedures were indeed implemented as they should have been. Finally, a selection of hardware and systems that are the products of the construction process was physically inspected to determine if the product as constructed met design requirements. This entire program taken together provided a discerning basis on which to judge the adequacy of construction.

An on-site contingent of 60 engineers and technicians applied more than 33,000 manhours to this program during a four-month period. The program included reviewing more than 11,000 documents, inspecting more than 6000 components and structures, and checking about 150,000 documentation and hardware particulars (individual facts, points, circumstances, or details).

General Atomic (GA), through its TPT Division, brought special qualifications to this evaluation for LILCO. General Atomic has been in the

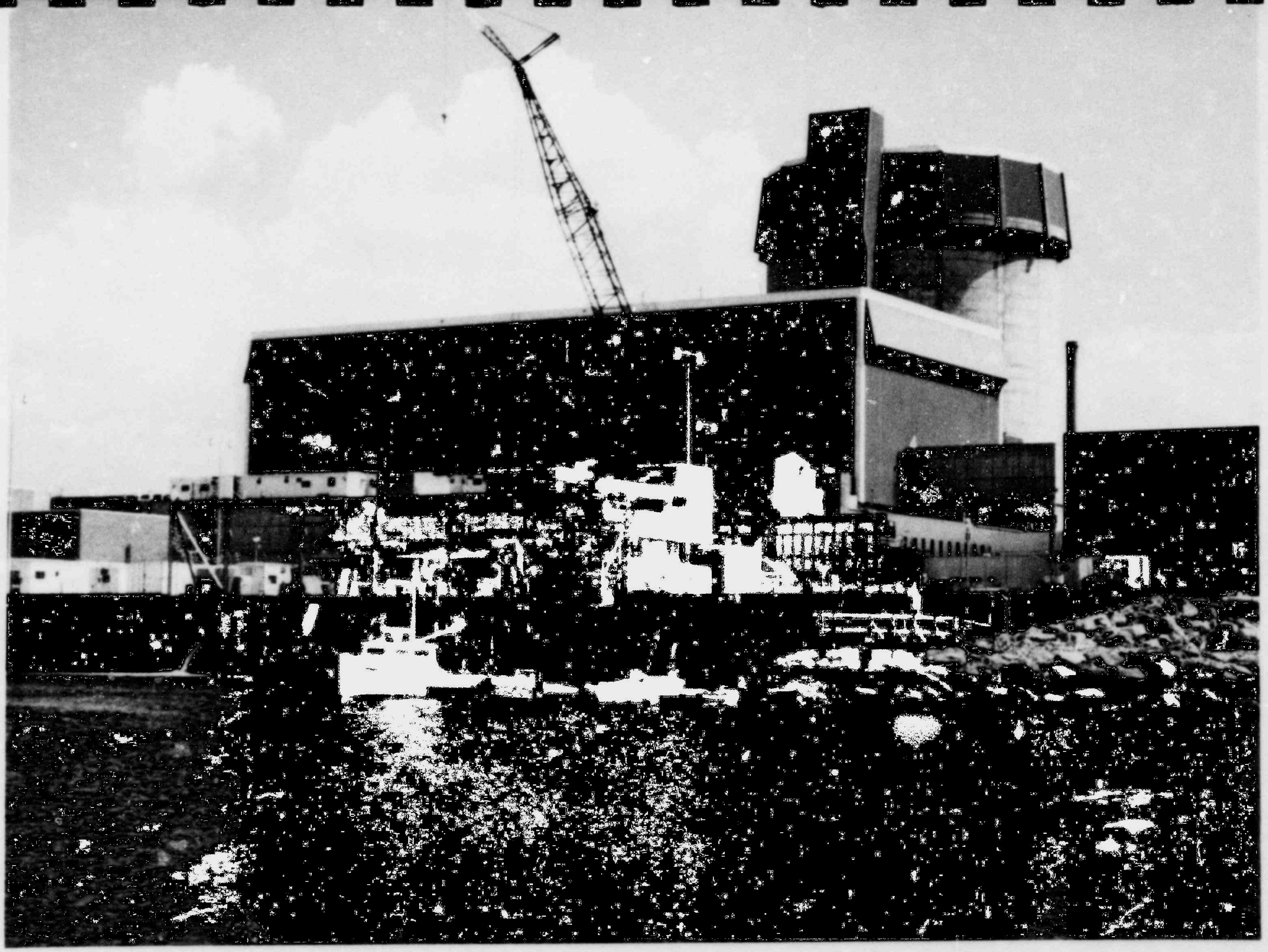

Fig. 1-1. Shoreham Nuclear Power Station

nuclear power plant industry for more than 20 years and has a large staff of competent, experienced, technically trained personnel. General Atomic operates under the first NRC (Nuclear Regulatory Commission) approved QA program, and the construction verification for LILCO was conducted under the provisions of that program.

General Atomic and all GA personnel who were involved in this program are independent of LILCO, the owner of the Shoreham Nuclear Power Station. Revenues from LILCO are not a significant portion of GA's revenues. No person working on this program has a financial interest in LILCO, nor does any person on this program have any family members who are now employed by LILCO or engaged directly or indirectly in the design or construction of the Shoreham Nuclear Power Station.

The report consists of three volumes. This first volume, the Executive Summary, contains a complete overview of the program, a description of work performed, and the major conclusions drawn. Volume II, Program Results, presents a thorough description of the program, particularly of the actual work performed, the questions raised during the review, the resolution of these questions, and the final conclusions associated with each part of the program. Volume III, Potential Finding Reports, consists of two books. These two books contain a compilation of all potential safety questions raised, corrective actions developed, and all perceived differences between observed and required conditions.

During the course of the program, any valid deviation from requirements that resulted in a safety question was classified as either a Finding or an Observation. A Finding was (1) a deviation that could potentially result in a substantial safety hazard or (2) an indication that there was a repetitive or generic deviation that could potentially create a substantial safety hazard. An Observation was a deviation that could not create a substantial safety hazard. Each Observation and Finding, together with its implication on the task conclusions, is discussed in the appropriate section of Volume II.

Based on the data reviewed during this independent construction verification effort, the QA program for construction of safety-related equipment at the Shoreham Nuclear Power Station is judged satisfactory, and the implementation of the program requirements during plant construction is judged satisfactory. The safety-related hardware and systems in the plant are also judged to satisfactorily meet the construction requirements of the design documents obtained from LILCO.

2. SCOPE

The purpose of the program was to conduct an independent review of the construction of the Shoreham Nuclear Power Station from approved design documents through functional hardware and to document that review in a final report. The effort included a review of the effectiveness of the applicable portions of the QA program.

Effort on a nuclear power plant proceeds through four basic phases: design, construction, startup, and commercial operation. The design phase establishes the requirements; the construction phase turns those design requirements into a physical plant; the startup phase conducts performance testing and integrates (fine tunes) operation of the numerous plant systems; and the commercial operation phase primarily involves production of electric power. Since some overlap between phases is necessary (i.e., electric power will be produced during startup), the interface between the phases is never static. Procedures and controls are applied in each phase, and are designed to accommodate the necessary overlaps.

The subject of this independent verification effort was the construction phase. The construction phase begins with procurement of materials and continues through fabrication and construction of the plant until a system is declared complete and is turned over to the startup phase. The TPT independent construction verification program reviewed the complete construction process beginning with procurement of items according to design requirements (the design requirements are assumed to be adequate for purposes of this study) and traced the activity through final construction inspection and turnover to startup. Most of the systems in the Shoreham plant have been turned over to startup. Control of necessary design changes during the construction phase (part of the overlap) and control of necessary construction work during the startup phase (more of the overlap) were also reviewed as part of the independent verification.

A program plan was prepared early in the project to define the specific tasks required for the independent construction verification. The program was structured to determine whether the construction process properly converted design document requirements into sound plant features. This was accomplished by first identifying the construction control process that was utilized at the Shoreham plant (Task A) and reviewing it for adequacy. The implementation of the process was then reviewed (Task B) to determine how the process was applied in a number of selected situations. The installed product of the construction process was then physically checked (Tasks C, D, and E) in various degrees of detail to determine if it complied with design requirements. Safety-related features were given primary consideration in the selection of items and features reviewed. During this process, any identified discrepancy was documented and reviewed (Task F). Status reports and a final report on the adequacy of the Shoreham plant construction were prepared and issued (Task G). In all reviews, areas of conformance and nonconformance were documented in review packages that are retained as controlled documents in the project files. More detailed descriptions of the above tasks are included in the following subsections.

2.1. TASK A - CONSTRUCTION CONTROL PROGRAM

The purpose of this task was to identify the controls (i.e., those systems and procedures which assure that the plant is built as designed) applied to construction of the Shoreham plant and to review those controls for adequacy in assuring that the plant was built in accordance with design requirements. The controls were compared with the requirements of 10CFR50 Appendix B as reflected in the Shoreham Final Safety Analysis Report (FSAR), Section 17. The comparison utilized a detailed review procedure and checklists. A review of both current and past controls was made to cover the complete construction period.

2.2. TASK B - CONSTRUCTION PROGRAM IMPLEMENTATION REVIEW

Documentation related to implementation of the procedures and controls identified in Task A was reviewed to evaluate conformance of these documents to the respective procedures and controls. Documents were reviewed relating to procurement, inspection, document control, installation, field change control, and QA audits of construction activities.

2.3. TASK C - PHYSICAL INSPECTION, WALKDOWN

The physical installation and construction of selected portions of safety systems and structures at the Shoreham Nuclear Power Station were inspected by walkdowns in the plant to determine compliance with design documents. Selection criteria were established to guide selection of specific systems and features for the walkdown inspections. Features were selected and walkdowns conducted using detailed procedures to compare constructed items with design documents. Walkdown documentation packages were prepared for each inspection activity. They included applicable design documents and the results of the inspections.

2.4. TASK D - PHYSICAL INSPECTION, TESTS

As part of the verification effort, specific tests were performed relating to the integrity of large-bore American Society of Mechanical Engineers (ASME) pipe welds and primary containment concrete strength, and the pressure capability test of the primary containment structure was witnessed.

Selected large-bore ASME pipe welds were reinspected by visual and ultrasonic methods, and the results were compared with preservice inspection test results for those welds. Testing and the comparison of results with acceptance criteria were performed by qualified inspectors using detailed procedures.

Thirty-five accessible primary containment concrete lifts were tested for strength by the Windsor probe method, and the results were compared with concrete strength specifications.

Testing of the primary containment structure was witnessed for both the total pressure test and the drywell floor pressure test. Other aspects of the primary containment structural acceptance test were also observed.

2.5. TASK E - CONSTRUCTION DOCUMENT REVIEW

Selected documents relating to plant construction were reviewed for conformance to requirements. Certified Material Test Reports (CMTR's) for ASME Code piping and weld filler material were reviewed for compliance with requirements. Preoperational test reports completed through August 1982 were reviewed for compliance with acceptance requirements.

2.6. TASK F - POTENTIAL FINDING PROCESSING

Differences between documents or hardware and the respective requirements were documented on Discrepancy Reports (DR's). Any concerns in the DR's relating to nuclear safety were further documented in Potential Finding Reports (PFR's). These concerns were reviewed by task leaders, original design organizations, a senior-level TPT review committee (Findings Review Committee), and the project manager. Any substantial safety concerns were classified as Findings and returned to LILCO for preparation of Corrective Action Plans that were subsequently reviewed.

2.7. TASK G - ADMINISTRATIVE AND REPORTING

Administrative and management support for the project was provided in this task. Monthly status reports were prepared and issued. This final report presents the results of the construction verification effort and conclusions on the adequacy of the Shoreham Nuclear Power Station construction.

3. RESULTS

3.1. TASK A - CONSTRUCTION CONTROL PROGRAM

This task was designed to determine if the controls (i.e., those management systems and procedures which assure the plant is built as designed) that were applied to the construction of Shoreham Nuclear Power Station were adequate.

Task A was accomplished by (1) identifying the time period over which safety-related construction activities took place, (2) identifying current LILCO and Stone & Webster Engineering Corporation (SWEC) construction QA manuals and procedures, (3) identifying QA commitments from the FSAR, (4) evaluating compliance of these procedures with the FSAR requirements, (5) identifying QA commitments from the Preliminary Safety Analysis Report (PSAR), and (6) evaluating earlier revisions of manuals and procedures for compliance with PSAR requirements.

Current revisions of manuals and procedures were identified and reviewed to determine whether these documents represented a satisfactory construction control program. This was accomplished by initially reviewing FSAR Sections 17.1A and 17.1B, which describe the NRC-approved QA programs of LILCO and SWEC, respectively. LILCO and SWEC implementing manuals, procedures, instructions, and standards were then reviewed to verify that each FSAR QA program commitment identified on the checklist was adequately addressed in the implementing procedures, instructions, etc.

Earlier revisions of the manuals and procedures were reviewed to determine whether these documents demonstrated that adequate controls were applied to the construction process over the entire calendar period identified. This was done by reviewing PSAR Sections E.2 and E.3, dated August 15, 1969, which describe the QA program commitments of LILCO and

SWEC, respectively. Earlier revisions o' 20 LILCO and SWEC procedures were then selected, predominantly from the years 1972 to 1976 and were reviewed in detail to determine whether applicable PSAR commitments were addressed. In addition to the PSAR general commitments, the supplementing detailed procedures were also reviewed for adequacy.

Reviews of the current manuals and procedures were documented on checklists. The checklists contain the pertinent commitments extracted from FSAR Sections 17.1A and 17.1B. The contents of the manuals and procedures were compared against the FSAR requirements to determine whether they adequately satisfied the commitments. The method used to review the earlier revisions of manuals and procedures was the same used on the current manual and procedures except that pertinent commitments were extracted from PSAR Sections E.2 and E.3.

A total of 606 procedures were identified and reviewed during this task. The review took approximately 500 manhours. No DR's were issued. Based on the Task A review, the contruction control process for the Shoreham Nuclear Power Station is judged to be satisfactory.

3.2. TASK B - CONSTRUCTION PROGRAM IMPLEMENTATION REVIEW

This task was designed to verify that construction-related procedures and controls identified in Task A were implemented during the construction process.

Task B was accomplished by (1) preparing a procedure and checklist to perform the review, (2) identifying the records to be reviewed, and (3) reviewing the records identified for compliance with the applicable program requirements identified in Task A.

Construction records for 45 safety-related components were reviewed. A total of 1150 documents were examined, with approximately 31,000 particulars checked as the documents were being reviewed for correctness and completeness. The components were selected from the Task C walkdown list and spanned the entire period of safety-related construction activities. The components were reviewed on a life-cycle basis beginning with procurement and continuing up to turnover of the component to LILCO startup (the startup organization takes the plant from completion of construction to commercial operation). Each document examined was listed on a checklist for the component reviewed. The particulars on each document were compared with applicable SWEC, LILCO, or Courter (a piping subcontractor) procedure requirements to determine whether the document satisfactorily implemented the procedure. Elements included on each checklist were procurement, inspection, personnel qualifications, field design change control, equipment calibration, nonconformance reporting, and storage and handling. These elements were modeled after the 18 criteria of 10CFR50 Appendix B and were selected because of relevancy to construction work. Document control and QA audits of construction activities were also checked. This review required over 1200 manhours to complete.

Twenty-five DR's led to initiating seven PFR'S as a result of Task B. Based on the review performed under this task, it was concluded that the construction procedures and controls identified in Task A were effectively implemented. Only one Finding resulted from the review of the PFR's. LILCO has established an acceptable Corrective Action Plan to resolve the safety concern expressed in the Finding. The implementation of construction procedures and controls is judged satisfactory.

3.3. TASK C - PHYSICAL INSPECTION, WALKDOWN

Task C was designed to verify that the installation of components and the construction of the Shoreham Nuclear Power Station were done in accordance with the applicable design documents.

Task C was accomplished by (1) preparing procedures and checklists to perform the walkdowns, (2) defining criteria and selecting systems and components to be inspected, (3) obtaining design documentation related to the selected items and preparing walkdown packages with specific requirements that were to be inspected, (4) performing the physical inspections (walkdowns), and (5) preparing required reports on observed differences between the plant condition and design requirements. Also included in Task C was the walkdown of large-bore pipe supports on 15 safety-related systems. Over 21,000 manhours of effort were expended in the Task C effort.

Systems that serve a safety function in plant operation were chosen for inspection, or walkdown. Various features were chosen to include both electrical and mechanical devices, considering the broadest spectrum of equipment type, design organization, safety function, and construction complexity. The walkdown was divided into mechanical, electrical, and pipe support sections. The walkdown was further divided into levels of increasing detail. For the system level walkdowns, safety-related portions of 37 systems were walked down. One thousand and eighty-eight lines, 1458 mechanical components, and 531 electrical items were included in the system-level walkdowns. These walkdowns verified that features were properly identified and that they were as shown on the appropriate design documents. Piping, ducts, and mechanical components were further verified to be installed in the proper sequence. More detailed walkdowns were conducted on 350 selected mechanical and electrical items. Detailed dimensions, weld inspection, material, weld type and size, and electrical connections, were inspected. The pipe support walkdown consisted of verifying approximately 2640 pipe supports used on large-bore pipelines, and included various support types and configurations.

In the process of performing these walkdowns, approximately 102,000 separate particulars were checked on over 6000 different pieces of equipment and structures. Two hundred and sixteen DR's and 109 PFR's were initiated as a result of the Task C effort.

Seventeen Findings resulted from the review of the PFR's. Most of these (10) were in the area of pipe supports, which are currently being revised to reflect final stress analysis. Only one Finding relating to the installed position of a solenoid valve probably would not have been corrected in final inspections of the construction (which were not complete at the time of the inspection effort). Similar solenoid valve installations have been inspected and determined to be satisfactory. LILCO has established acceptable Corrective Action Plans for all the Findings to resolve the safety concerns expressed. The construction characteristics of safety-related components and systems inspected are therefore judged satisfactory.

3.4. TASK D - PHYSICAL INSPECTION, TESTS

3.4.1. ASME Piping Weld Inspection - Subtask D1

This task was designed to reinspect a sample of ASME large-bore piping welds covered by the Shoreham preservice inspection (PSI) program and to determine acceptability of the welds.

A sample, consisting of 75 ASME large-bore pipe welds that were examined on the LILCO PSI program, was reexamined by visual and ultrasonic tests. The TPT ultrasonic examination used techniques equivalent to those used in the PSI. Results of the original PSI compared favorably with the results of this reexamination.

The reexaminations required three separate directional examinations of each weld, one for laminar flaws (straight beam), one 45-deg angle beam applied perpendicular to the weld axis, and one 45-deg angle beam applied parallel to the weld axis. The comparison of PSI and TPT data for all three examinations showed 88% agreement in these 75 welds. The differences reported are normal and are to be expected during hand scanning ultrasonic examination of welds.

All 75 welds were found free of rejectable defects per Section III of the ASME Code 1971, winter 1972 addenda. This task required over 1100 manhours to complete. No DR's were issued. The ASME large-bore piping welds inspected are therefore judged satisfactory.

3.4.2. Primary Containment Concrete - Subtask D2

This task was designed to verify that the Shoreham plant primary containment concrete compressive strength met specifications.

Thirty-five of the 36 lifts were tested for compressive strength using the Windsor probe and Swiss rebound hammer technique. Lift 26A, a 5.75-in.-high layer of grout under the head flange, was not accessible and could not be tested. Approximately 100 Windsor probes were inserted into the primary containment concrete, and 3500 Swiss rebound hammer readings were taken during the inspection. Over 240 manhours were required for this inspection.

The specified compressive strength of the primary containment concrete was 3000 psi at age 28 days for all lifts. The Windsor probe test results indicated that the average compressive strength of the primary containment concrete was 6130 psi and ranged from 5000 to 7600 psi. When compared with published information on strength development of concrete with age, the Windsor probe tests indicated that the average compressive strength of the primary containment concrete at age 28 days was on the order of 5000 psi, well above specifications. No DR's were issued. The strength of the primary containment concrete is therefore judged satisfactory.

3.4.3. Primary Containment Structural Acceptance Witness - Subtask D3

This task was designed to witness the primary containment structural acceptance test (SAT) and to record observations verifying that the test was conducted in accordance with the procedure and specifications.

The SAT for the primary containment pressure test proceeded through four pressure levels to reach the required maximum pressure of 55.2 psig. After depressurizing in four pressure levels as required, to atmospheric pressure, the dry well was entered and the open downcomers were capped. This was done to seal off the dry well volume of the containment from the suppression pool in order to test the structural integrity of the dry well floor. The dry well pressure was raised in four pressure levels to the required maximum 35 psig. The pressure was held for 1 hour and then the dry well floor was depressurized in four stages as required by the procedure.

The SAT was conducted in accordance with the requirements of the procedure and specifications. The results were witnessed and documented. This task required 200 manhours to perform. No DR's were issued. The primary containment structural acceptance test is therefore judged to have been satisfactorily performed.

3.5. TASK E - CONSTRUCTION DOCUMENT REVIEW

3.5.1. ASME Piping Material Certification Review - Subtask E1

This task was designed to verify that the piping and weld filler material vendors' certified test data showed that the materials complied with applicable specification requirements.

Certified Material Test Reports (CMTR's) were reviewed for selected items in 26 safety-related piping systems. The CMTR's were compared with requirements of the ASME Boiler and Pressure Vessel Code, Section III, Division 1. More than 1600 CMTR's were reviewed. ASME Code safety class 1, 2, or 3 items were selected for review, with preference being given to the larger and more important systems. Specific attention was given to selecting both large-bore (greater than 2-in.-diameter) and small-bore pipelines, in addition to a variety of fittings, valves, and weld filler materials. Weld materials CMTR's were reviewed for a selected number of the welds that were reinspected in Task D1.

The CMTR's reviewed were found to be satisfactory. Records of the CMTR reviews were made on checksheets that were assembled in a notebook subdivided by reactor system. This task required 240 manhours to complete. Eleven DR's were issued, and one PFR was generated. The PFR was determined to be a Finding and LILCO has provided an acceptable Corrective Action Plan to resolve the safety concern. The ASME piping material certifications examined are therefore judged satisfactory.

3.5.2. Preoperational Test Review - Subtask E2

This task was designed to review all preoperational tests (POT's) completed and accepted as of August 1982 to verify that POT test data comply with acceptance requirements. Fifty-three POT packages were identified as being approved and complete. Each of the packages was reviewed by a specific procedure and checklist. The checklist was developed from the requirements stated in Section B, "Preoperational Phase," of the LILCO startup manual.

The review of the 53 POT packages indicated that the systems tested met the functional requirements of the tests. The POT review accounted for 37 DR's being issued and three PFR's being generated. Most comments resulting from the review of the POT packages centered around procedural errors. No Findings resulted from the PFR reviews. The review required over 450 man-hours to complete. The results of the review indicated that the POT's were properly conducted. Performance of the preoperational tests is therefore judged satisfactory.

4. TOTAL PROGRAM OVERVIEW

More than 11,000 documents and 6000 hardware items, including more than 150,000 particulars, were reviewed during the course of this independent construction verification effort. The review exceeded 33,000 man-hours of effort. Documents reviewed included manuals, procedures, specifications, purchase orders, various inspection forms, flow diagrams, safety analysis reports, federal regulations, detail design drawings, vendor drawings, piping isometrics, electrical diagrams, certifications, test reports, and numerous forms used to control activities and the flow of material in the construction process. Each of these documents was either compared with a controlling requirement (e.g., the QA manual was compared with the FSAR requirement) or was used as a design definition document against which the plant hardware was compared (e.g., a valve configuration was compared with the vendor drawing that described the valve). Hardware items in the plant were compared with their respective requirement documents in varying degrees of detail to determine whether the installed hardware was as the design required.

When any difference between an observed condition (document or installed hardware) and a required condition was perceived by the walkdown team or document investigator, that difference was recorded on a DR to document the fact that a difference was observed. The DR was then reviewed, according to the established procedure, by both the respective team leader and the task leader to determine (1) if the difference was a valid departure from a requirement and (2) if the difference could possibly impact the nuclear safety of the plant. If either of these two reviewers believed there might be a potential safety impact question, a PFR was initiated. Copies of all DR's and PFR's are included in Volume III of this report. Copies of documents reviewed and determined to be adequate are not included in this report because of their overwhelming volume. All documents used in the review are stored in the project file or referenced in the file to allow retrieval from LILCO or SWEC files. A discussion of areas of safety concern recorded on PFR's is presented in Volume II under each specific task. A complete listing of all PFR's prepared and their final disposition is presented in Tables 7.2-1 and Appendix 4A of Volume II.

Of 371 DR's generated as perceived differences between observed and required conditions, 268 were judged to be valid differences. Upon further review those perceived to result in nuclear safety-related questions caused 120 PFR's to be generated. Some of the DR's that were nonsafety-related would probably have been determined to be invalid also if they had been subjected to a more thorough review such as that to which the safety-related discrepancies were subjected. Further program review of the 120 PFR's resulted in a total of 69 invalid PFR's and 51 valid PFR's. Reviews of the valid PFR's resulted in 32 classified as Observations and 19 classified as Findings. Thirteen of the Findings related to the lack of appropriate documentation for plant hardware, and corrective actions to accomplish the necessary documentation have been identified. The other six Findings relate to plant hardware problems, and corrective actions relating to these items have also been identified.

Two major areas were documented as potential safety concerns that were later determined to be invalid: (1) mechanical and electrical items that were not complete in terms of hardware or documentation and (2) pipe supports that were in the process of change and were therefore not complete. Thirty-five PFR's on mechanical and electrical concerns were determined to be invalid as a result of the PFR review process by either identification of the appropriate document to support the plant condition or by identification of the appropriate existing document to show that construction of the area of concern was being completed in a controlled and orderly manner. In the pipe support area LILCO is currently involved in a program of final reconciliation between the actual plant configuration and the final piping stress analyses, and some of the supports are being modified to agree with the final analysis. Twenty-seven potential pipe support safety concerns were determined to be invalid as a result of the PFR review process, since required completion of the final support configuration was being accomplished in a controlled and orderly manner. Seven potential safety concerns resulting from documentation reviews were determined to be invalid when appropriate documentation was identified to resolve the concern. The remaining PFR's were processed to conclusion and were classified as Findings (having potential for significant safety impact requiring corrective action) or as Observations (valid discrepancies not having potential for significant safety impact).

Both DR's and PFR's were investigated to determine if any trends were evident. The number of reports in both categories generally paralleled the number of items investigated, both by engineering discipline and by plant system. Pipe support discrepancies and concerns were more numerous relative to their percentage of items investigated. This was because of the incomplete status of the final stress analysis reconciliation program. Electrical discrepancies and concerns were more numerous and mechanical discrepancies and concerns fewer relative to their percentages of items investigated. The higher electrical number was due to the greater relative complexity of electrical systems.

A total of 268 differences between observed and required conditions were identified in the review of over 6000 components, 11,000 documents, and 150,000 particulars. Fifty-one of these differences involved potential safety concerns and only 19 of the concerns required corrective action to assure the adequacy of safety-related plant construction. (See Figs. 4-1 and 4-2.)

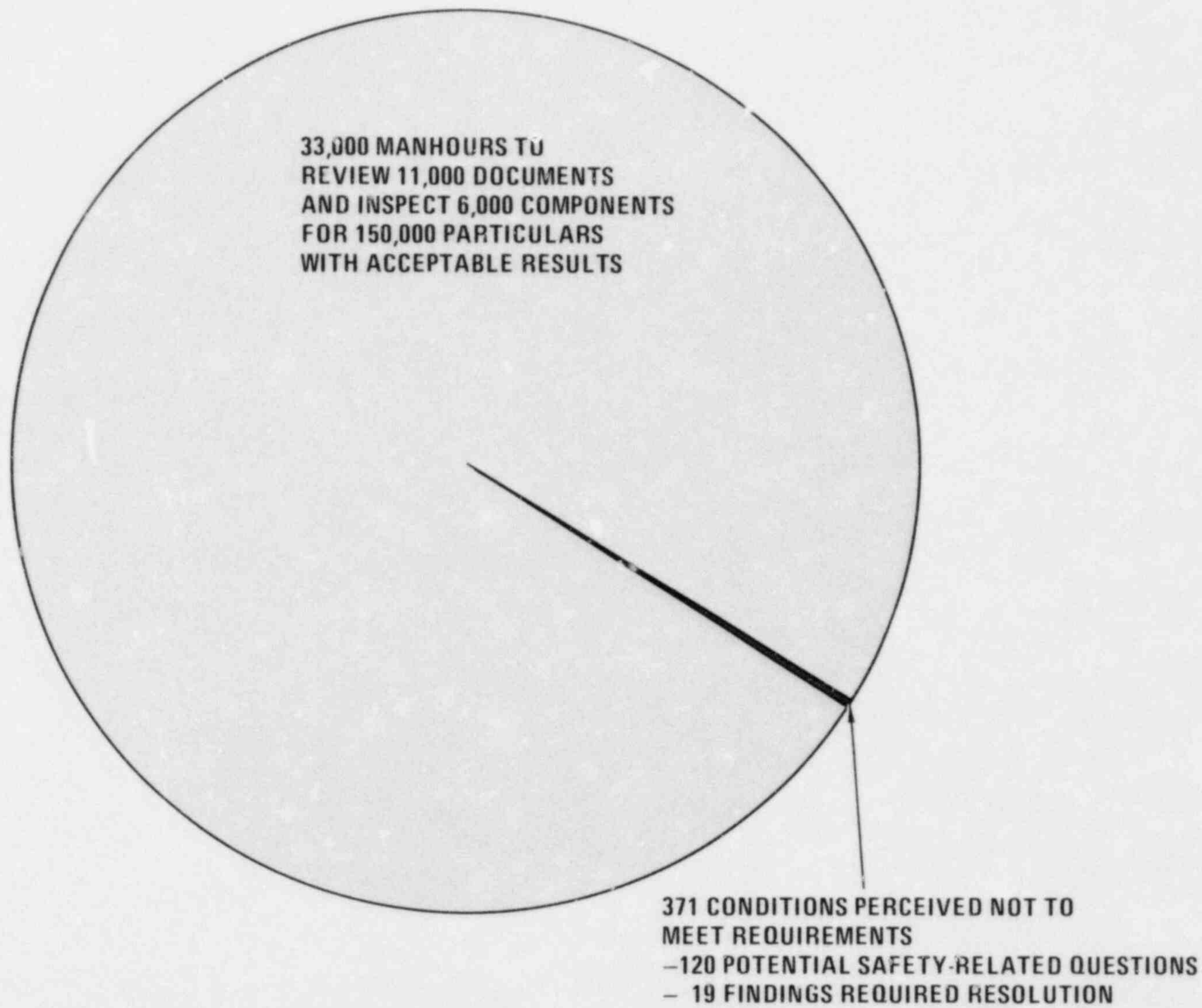

Fig. 4-1. Inspection results

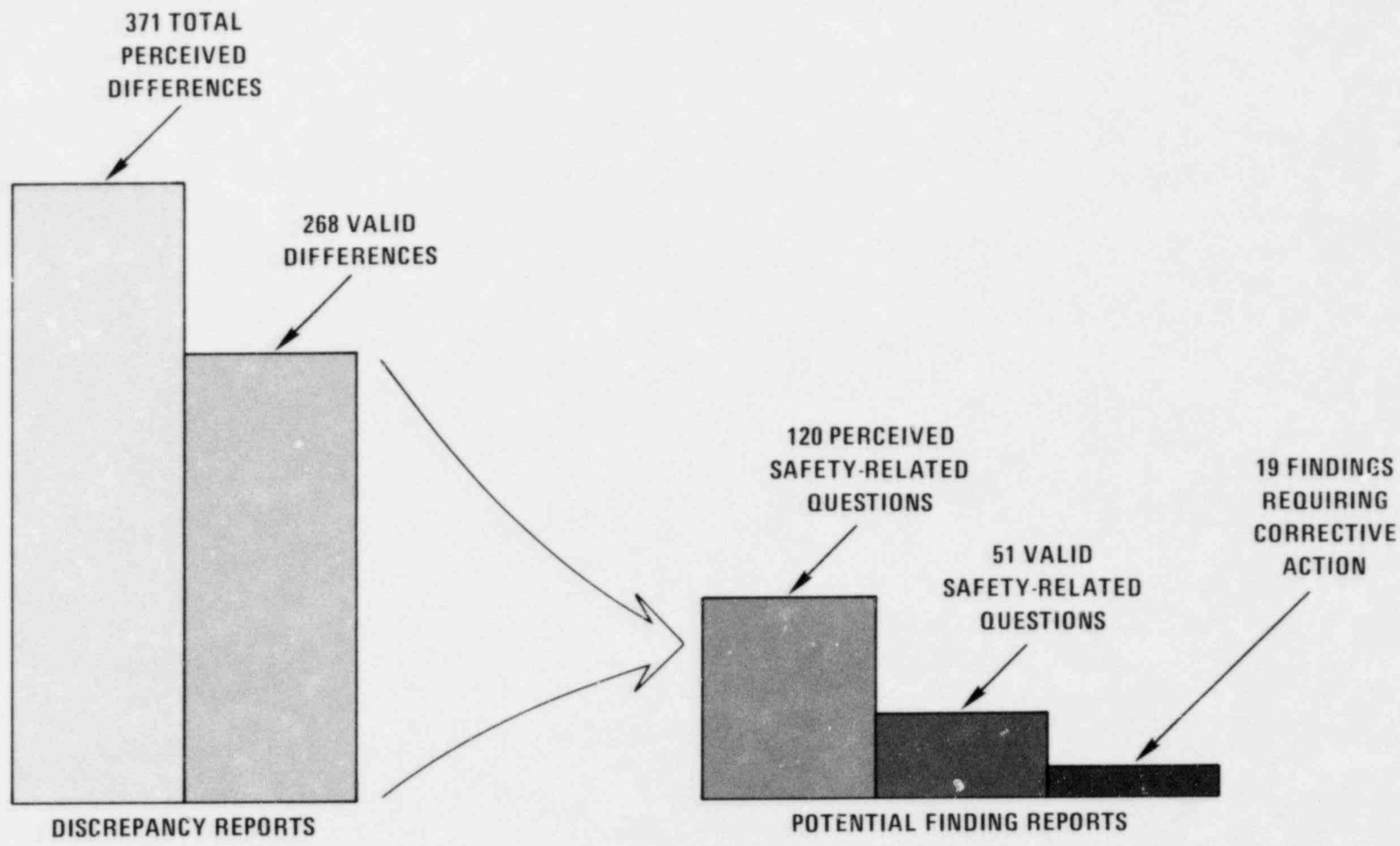

Fig. 4-2. Inspection results

5. CONCLUSIONS

The independent verification program for the Shoreham Nuclear Power Station was structured to determine whether the construction adequately converted the safety-related plant design requirements into constructed hardware and systems that met the design requirements. The major tasks, Tasks A, B, C, D, and E, taken together, provided a discerning basis to judge the adequacy of the safety-related construction.

Approximately 150,000 particulars were checked in the application of over 12 man-years of inspection effort on the Shoreham construction verification project. Two hundred and sixty-eight differences between observed and required conditions were identified. Fifty-one concerns relating to the safety of the plant were identified. Nineteen of these concerns were judged important enough to be classified as Findings and require corrective action. Most of these concerns related to a need to upgrade design requirement documents to match the plant configuration, or related to hardware problems that would probably have been identified during final inspection of the systems. Only one of the concerns (PFR-120) related to an improper condition in safety-related hardware that probably would not have been corrected at final inspection. The improper mounting orientation of a solenoid valve could have affected operation of a safety system, but the effect would have been that of a single active failure, a condition that the safety system is designed to accommodate. LILCO has inspected similar solenoid valve installations and determined that no similar problems exist. LILCO has provided satisfactory Corrective Action Plans for resolving or correcting all the safety-related Findings.

The small number of discrepancies identified, the very small number of potential safety concerns identified, the lack of trends in the discrepancies or safety-related concerns, and the availability of QA documentation on the construction activity from the beginning of the project demonstrates that the QA program has been effectively applied over the duration of the project and that the resultant safety-related plant hardware meets construction requirements of the design documents.

Conclusions relating to the construction are as follows:

1. LILCO and SWEC each have, and have had, construction control procedures in place during the construction activity. The procedures were reviewed in detail and were judged adequate to provide a reasonable and required QA program for the construction. It is concluded that the procedures in effect for the entire life of the construction activity are adequate and can be reasonably expected to produce adequate nuclear safety-related systems and hardware.

2. The review of implementation of the construction control system indicated that the system was effectively implemented over the duration of the construction activity.

3. Results of the extensive inspections performed on actual plant hardware as well as review of large-bore ASME Code piping material certifications and available preoperational test results on plant systems indicate that the implementation of the construction control program has resulted in adequate construction of nuclear safety systems and components in the Shoreham plant. Hardware inspected included nuclear safety-related portions of 37 plant systems, 350 selected components, 2640 large-bore pipe supports, 75 large-bore ASME Code piping welds, and the primary containment concrete strength. Over 6000 components were inspected. Pressure testing of the primary containment was also witnessed.

The favorable results indicated in items 1, 2, and 3 above add confidence that the Shoreham plant construction is of a quality adequate for the nuclear industry because the results reflect a detailed attention to QA requirements early in the construction period as well as now.

Based on the data reviewed during this independent construction verification effort, the QA program for construction of safety-related equipment at the Shoreham Nuclear Power Station is judged satisfactory, and the implementation of the program requirements during plant construction is judged satisfactory.

Since an adequate construction system existed, since the system was implemented, and since it will result in satisfactory construction of all nuclear safety-related features inspected when planned actions are completed, the construction of the Shoreham Nuclear Power Station is judged to meet the construction requirements of the design documents obtained from LILCO.

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