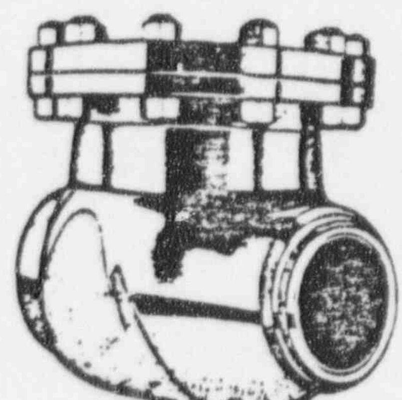
MILLSTONE NUCLEAR POWER STATION UNIT 2

NORTHEAST UTILITIES SERVICE COMPANY

CHECK VALVE DESIGN APPLICATION REVIEW



"World Class Valve Engineering"

by

Gilbert/Commonwealth, Inc.

engineers and consultants · Reading, Pennsylvania

RECORD OF REVISIONS

REVISION	*DATE*	*SECTIONS REVISED*
0	*June, 1990*	*Original Issue*

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MILLSTONE UNIT TWO
CHECK VALVE DESIGN APPLICATION REVIEW

1.0 INTRODUCTION AND METHODOLOGY

1.1 OBJECTIVE

Provide a design application review for critical check valves installed in Millstone Unit 2 and establish an inspection priority for each valve.

Check valves are used in many nuclear power plant systems related to safety, availability and reliability. Failure of any of these valves could lead to overpressurization of upstream systems, water hammer and resulting component damage, or flow blockage. As check valves are not often disassembled and inspected, deterioration leading to failure may not be discovered and the failure itself could go unnoticed for a time thus adding to the severity of the failure consequences. The "Application Guidelines for Check Valves in Nuclear Power Plants" issued by EPRI in January 1988 concludes that the two most likely causes of check valve damage are insufficient flow velocity and turbulent flow caused by upstream piping components.

Critical check valves should be periodically inspected so that incipient failures can be detected. Since it is not practical to disassemble and inspect every check valve at every outage, the most important systems and valves must be identified and a basis established to prioritize the valves for inspection.

1.2 SELECTION OF SYSTEMS

1.2.1 The following systems included in this review are the systems identified in INPO SOER 86-3. Because of industry experience, the SOER considers that valves in these systems should be included in the program.

Main Steam

Nuclear Service Water

Main Feedwater

Auxiliary Feedwater

Chemical And Volume Control (includes Charging and Boric Acid)

Diesel Air Start

Low Pressure Safety Injection (includes Shutdown Cooling)

1.2.2 Additional systems have been included because they are Nuclear Safety Related and influence plant reliability. They are not primary shutdown systems though some can act as alternate shutdown systems.

Other Safety Injection Sub-Systems
(High Pressure Safety Injection)
(SI Tank System)

Containment Spray

Reactor Building Closed Cooling Water
(RBCCW)

1.3 SELECTION OF FLOWPATHS AND VALVES

1.3.1 All the check valves in the 10 systems listed in Section 1.2 have been included in the review with only the exceptions listed below. For the purposes of this review the system alpha prefix; e.g. SI, FW, DG; has been used to define the valves in each system.

1.3.2 Charging System - Check Valve 2-CH-435 is not included because flow through it is prevented by locked closed valve 2-CH-434. Check valve 2-CH-112 is not included because it is in the H_2 and N_2 supply to the VCT. This line is only used to fill the VCT and is normally isolated by closed valves 2-CH-107 and 109.

1.3.3 Boric Acid System - Only the flowpaths which provide boric acid to the Charging Pumps' suction are included, since this is the emergency function of this system. This flowpath includes check valves 2-CH-154, 155, and 177 in the Boric Acid Pump discharge to the Charging Pumps and 2-CH-190 in the gravity feed from the Boric Acid Tank to the Charging Pumps. The flowpath from the Boric Acid Pumps to the Volume Control Tank with check valves 2-CH-186 and 2-CH-188 is not included because it is not the direct path for boric acid injection via the Charging Pumps.

1.3.4 Safety Injection Tanks - Check valves in the N_2 supply lines are not included because once the tanks are pressurized these valves are isolated and perform no function in the operation of the Safety Injection Tanks.

1.3.5 Containment Spray - Check valves 2-CS-10B, 11, 12, 26, and 38 are not included because they are located in circulating, test, and fill lines to the RWST. They are not in the principal flowpath of Containment Spray and are not required for Containment Spray to perform its emergency function.

1.3.6 Main Steam - Check valve 2-MS-366 is not included as it is a 3/4" valve in a drain from a steam trap and its function is not critical to the operation of the system.

1.3.7 Feedwater - Check valves 2-FW-16A/B are not included because they are 1" valves for hydrazine injection and are isolated from flow by locked closed valves 2-FW-15A/B. Check valve 1-FW-53 is not included because it is a 1" valve and not in the principal system flowpath.

1.3.8 *Service Water* - Check valves 2-SW-6 and 2-SW-9 are not included since they are in discharge lines from non-safety systems to the S.W. discharge conduit. They are not required to function in the emergency mode. Valves 2-SW-163, 164, and 17 are not included because they are not necessary for system operation.

1.3.9 *Diesel Generator Starting Air* - Check valves 2-DG-32A, B, C, and D are not included because their internals have been removed per note 2 on P&ID 25203-26018 Sht 1. Check valves 2-DG-37A, B, C, and D; 2-DG-41; and 2-DG-42 are in supply lines to the Starting Air Tanks. The supply lines are not required for diesel operation since sufficient air is stored in the Starting Air Tanks to start the diesels. Since these check valves are involved with five separate sources of supply air, it is unlikely that all sources would be interrupted at once. Even if this happened, the tanks are monitored so that a loss of pressure in any of the tanks would be immediately known and necessary actions taken.

1.3.10 *Reactor Building Closed Cooling Water* - Check valves 2-RB-38, 40, 42, 45, 47, and 49 are not included. These are all 1/2" valves with two in the flow indicating loop for each R.B.C.C.W. pump. They are not required for system operation.

1.3.11 Flow diagrams showing the flow paths and check valves included in this review are provided in Section 2.0.

1.3.12 This report shall be revised for any modifications or changes in procedures that may have an impact on any of the check valves included in this report. Any check valves that are added to any of the systems shall also be added to the report if they meet the guidelines to be included. Examples of changes that should result in revisions are:

- *Installation of a new check valve in one of the systems included in the report.*
- *Replacement of an existing check valve with one of a different type or size.*
- *A change to the system operating conditions that may change the flow rate through the valve.*
- *Permanent removal of a check valve or its internals.*

1.4 BASIS FOR CATEGORIZING CHECK VALVES

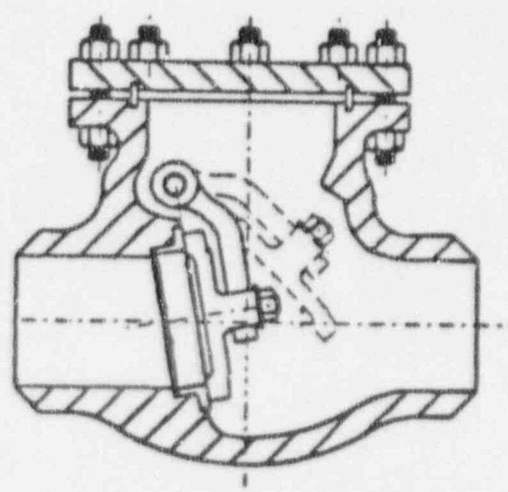
Since it is not practical to disassemble and inspect all the check valves covered by this review in any one outage, it is necessary to categorize the valves and establish priorities so that the limited time and resources available for check valve inspection can be spent on those valves more likely to be experiencing excessive wear or other damage which could in time result in failure of the valve to perform its function. There are four parameters considered in the categorization: valve type, service flow velocity, piping arrangement and maintenance history. The inspection priorities are tabularized in Section 3.0 and are given on the individual valve data sheets attached in Appendix A.

1.4.1 Valve Type

The check valves covered by this review fall into one of four basic types: swing, tilting disc, lift (includes stop-check), and dual plate. Because of its widespread use in the nuclear power industry, the swing check valve type is the most studied. The greater part of the EPRI Report NP-5479 *"Application Guidelines for Check Valves in Nuclear Power Plants"* is concerned with swing check valves. Attention has been focused to a lesser extent on tilting disc and lift check valve types, and almost not at all on dual plate types. This review follows the guidelines as it applies to the various types, and also extrapolates conclusions on one type of valve to another type when it is reasonable to do so.

1.4.2 Flow Conditions

Swing check valves are sensitive to flow velocity and most vendors suggest a recommended velocity range, or at least a minimum recommended velocity, for their valves. Within the recommended range, the disc should be firmly seated against its stop. At flow velocities below the recommended range, the flow will not be sufficient to hold the disc against its stop and the disc will tend to "flutter" and perhaps tap against its stop. Due to the added motion, this fluttering will result in higher than normal wear to the moving parts of the valve, i.e., the hinge shaft or its bushings and the hinge arm or hinge support, whichever is moving relative to the shaft. The gradual wear due to friction will increase clearances and this may eventually result in the disc and hinge arm assembly cocking and binding.



Typical Swing Check Valve
Figure 1.4.2.1

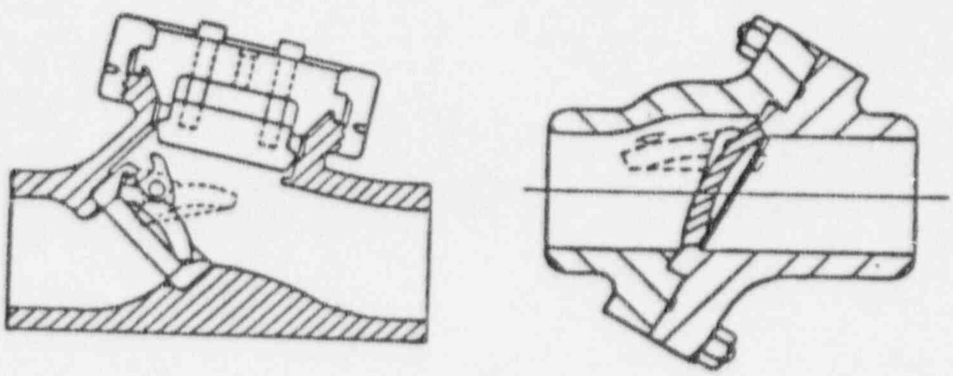
Some check valve designs use a two-piece disc and hinge arm assembly. Prolonged tapping in this type of valve can result in damage to the disc stud and may contribute to enlarging the disc stud's hole in the hinge arm, creating additional and unwanted freedom of motion for the disc. Tapping can also transmit forces to the hinge pin and its support with possible adverse consequences such as accelerated wear and fatigue.

At velocities above the recommended range, turbulence in the valve body becomes severe and can cause unwanted disc motion with many of the same consequences described for the low velocity case.

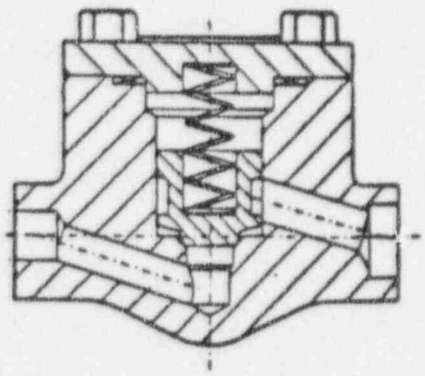
The recommended velocities used for this study were those compiled for the EPRI guidelines. The experimental results reported in the EPRI guidelines seem to indicate that the manufacturer's recommended velocities may be on the low side. The Pacific valves tested required velocities of as much as 16 ft./sec. to achieve full disc opening with the as-manufactured full-open disc angle as opposed to Pacific's recommended minimum velocity of $55\sqrt{\bar{V}}$ (approximately 7 ft./sec.). The EPRI testing also showed that the velocity required for full disc lift decreases dramatically as the full-open disc angle is decreased by lengthening the disc stop.

It should be noted, however, that the recommended flow velocities may not apply precisely to any specific valve. The internal configuration of the valve body, the shape of the disc and the disc's weight will differ from one valve size to another, from one pressure class to another, and especially from one vendor to another. For any one valve, its individual characteristics and the service it sees may give it a flow velocity envelope slightly different than the one recommended. Nonetheless, the manufacturer's recommended velocities are useful reference points for selecting valves deserving closer attention.

Typical Tilting Disc Valves
Figure 1.4.2.2

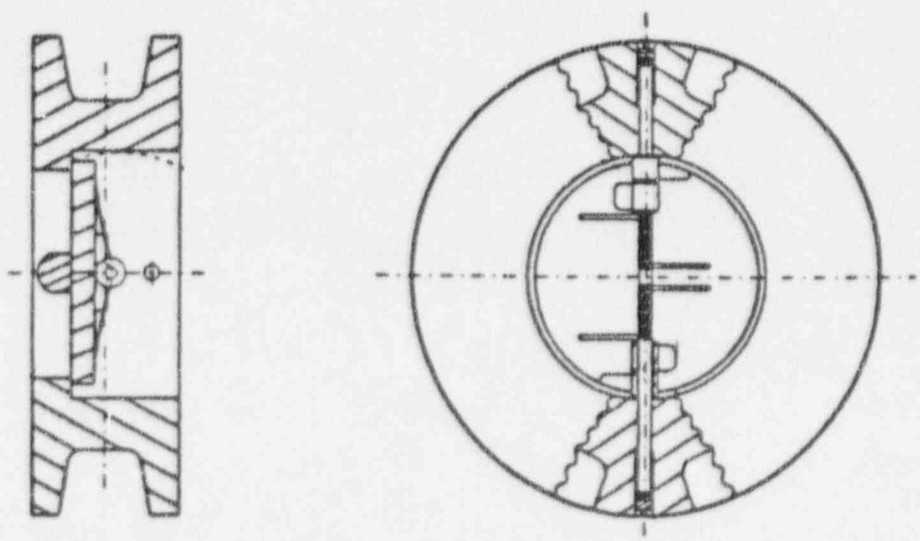


Tilting disc check valves are designed to achieve full disc lift at lower fluid velocities than swing check valves. Recent valve designs by Rockwell and Anchor/Darling utilize a dynamic lift created by the disc shape to increase the disc opening forces at low velocities. However, the older Crane style of tilting disc valve may not show as much of that effect. The testing performed by EPRI in preparation of the check valve application guidelines did not include tilting disc valves so there is no check on the manufacturer's recommendations.



Typical Lift Check Valve
Figure 1.4.2.3

Lift check valves are even less sensitive to low flow conditions. Although the velocity required for full disc lift is not much different from other check valve types, the simplicity of the valve, which ordinarily only has one moving part, seems to make the lift check type less prone to failure. Anchor/Darling states that operation in the partially open conditions at flow velocities as low as 1.5 ft./sec. are acceptable. As in the case of tilting disc valves, the EPRI testing did not include lift check valves.



Typical Dual Plate Check Valve
Figure 1.4.2.4

Dual plate check valves were not addressed by the EPRI guidelines. It is reasonable to assume, however, especially as there is some supporting empirical evidence, that dual plate check valves can be adversely affected by fluid velocities less than that required to hold the valve fully open and by turbulence in the flow similarly to other types of check valves. The minimum required velocity for full plate opening was calculated based on information provided by the largest manufacturer of dual plate check valves - TRW Mission.

1.4.3 Piping Arrangement

The piping arrangement immediately upstream of the check valve is shown graphically on the data sheet (in Appendix A) by a copy of the appropriate part of the piping isometric or arrangement drawing. The piping arrangement is important because it is the flowing fluid which imparts motion to the moving parts of the check valve and valves are designed on the assumption of symmetric velocity distribution over the valve's cross section. An asymmetric velocity distribution caused by a nearby elbow, for example, could result in uneven wear of the moving parts due to the off-center thrust on the disc. Additionally, the turbulence caused by an upstream fitting or device could also result in the flutter and tapping discussed in Paragraph 1.4.2.

Testing performed as part of the EPRI application guidelines project has shown that the flow disturbance caused by a 90° elbow does not significantly affect the performance of a check valve provided the elbow is located more than five diameters upstream of the valve. Tees were not tested but are expected to have only slightly more effect than elbows.

The testing also found that the turbulence caused by a throttled butterfly valve, and by extension a control valve or pump, takes up to ten diameters to dissipate.

This review follows the EPRI guidelines and uses the distances of five diameters from tees and elbows and ten diameters from control valves, orifices and pumps as the cut-off for determining the possible existence of turbulence detrimental to the valve.

Lift and piston check valves are assumed to be less affected by piping arrangement since the flow path inside the valve body has sharp bends of its own, but credit is not generally taken for this.

1.4.4 Maintenance History

The maintenance records for the check valves in this review were reviewed and items which described effects on valve operation or damage to valve internals have been included on the data sheets and considered in the prioritization of the valve.

1.4.5 Summary

The last item on the data sheets (Appendix A) is a summary discussion of the above parameters and how they affect the valve.

Each valve is given an "Inspection Priority" from 1 to 4, where 1 is highest priority. The priority is a subjective ranking of each valve based on valve type, function, piping arrangements and service conditions.

The general criteria for the four priorities are:

Priority 1: *Flow velocity is outside recommended range in one or more modes of operation and upstream piping arrangement may create significant flow disturbances.*

Priority 2: *Flow velocity is outside recommended range in one or more modes of operation, or upstream piping arrangement may create significant flow disturbances. Also included are valves which otherwise would qualify for Priority 1, but which experience flow only occasionally.*

Priority 3: *Flow velocity is within recommended range; upstream piping is straight and unobstructed for five or ten diameters as appropriate. Also included are valves which would otherwise qualify for Priority 2, but which experience flow only occasionally.*

Priority 4: *Valves with this priority are isolated from flow in all normal and test modes.*

Priorities on specific valves may be adjusted due to special circumstances. For example, a valve with a history of mechanical failure would be given a higher priority.

1.4.5.1 *EXPLANATION OF TERMS:*

Flow velocity: The valves' flow velocities are calculated from the volumetric flow rate divided by the flow area. Where the valve outline drawing gives the valve port diameter, that dimension is used to determine the flow area, otherwise the nominal pipe diameter is used.

Flow in vertical valves: The correction factor for vertical installation as given in EPRI Application Guideline 2.3.2 (Ref 2) has been used for swing check and tilting valves. The Guideline does not apply to lift check valves, which are inappropriate for installation in vertical lines unless spring assisted.

Flow velocity recommended range: The recommended range is the range of flow velocities in which the valve disc is stable, i.e. not fluttering. The lower end of the range is determined from the formula $V_{min} = C\sqrt{\bar{V}}$, where C is a constant supplied by the valve manufacturer, and $\bar{V}$ is the specific volume of the fluid in cubic feet per pound in accordance with Section 3.2 of the EPRI Guidelines (Ref. 2). The upper limit on the range is 25 feet per second. (Section 3.3 of Ref. 2).

Upstream piping arrangement: Turbulence is considered to have an effect on the valve if:

1. *An elbow or tee is located less than five diameters upstream of the check valve, or*

2. *The check valve is located less than ten diameters from a control valve, pump, or orifice. (Ref 2, Application Guideline 2.3.1)*

Occasional flow: Flowpaths which function only post-accident (except for periodic surveillance testing) are considered to have occasional flow. Those flowpaths which function during normal power operation, including start-up and shutdown, are treated as having continuous flow.

Mechanical failure: In reviewing the valves' maintenance histories attention was concentrated on problems having a direct impact on the ability of the valve to operate. Thus, reported abnormal wear of moving parts, cracking or failure of internal parts, or loss of internal parts, were considered significant. Minor damage to the exterior of the valve, packing or gasket leakage, or repairs to externally mounted actuators or limit switches were not considered significant. In addition, valve seat leakage, unless associated with other problems, is considered a normal maintenance item and not significant to this study.

Special circumstances: Any special circumstances having an effect on a valve's priority are identified on the applicable valve data sheet. Examples of such circumstances are: recent surveillance, nitrogen service, and industry experience with some applications, i.e. Diesel Air Start valves.

1.5 BASIS FOR GROUPING, INSPECTION SAMPLE SIZE AND FREQUENCY

There are 99 valves under review so it is unwieldy to specify a single inspection frequency, even for each inspection priority, as it may result in some valve types not being inspected for a long period of time. Since it often happens that the same make and model of valve will see the same service in different branches of the same system, it makes sense to group these similar valves for inspection purposes. By inspecting a sample of valves from each group, all the different valve types and applications can be efficiently inspected in the shortest time. A listing of valve groups is included in Appendix B.

For Priority 1 valves, the basis for grouping is that a group will consist of valves with the same size, vendor, model, and service. This is a rigorous basis for grouping, but it is justified, since the Priority 1 valves have been judged to be the most likely to suffer wear and degradation and no variable should be ignored.

It is felt that a period of three fuel cycles is the most time that ought to be allowed for inspection of all the Priority 1 valves. Thus, the valves should be inspected within three fuel cycles.

The groups for Priority 2 and 3 valves are based on priority, vendor and type. As valves in these priority levels have been judged to be at less risk than the Priority 1 valves, the frequency of inspection can be reduced. Valves in Priority 2 should be subject to disassembly and visual inspection within four fuel cycles.

Valves in Priority 3 groups should be subjected to disassembly and visual inspection within a period of five fuel cycles.

Inspection of Priority 4 valves is not required since by definition these valves do not see flow.

1.5 BASIS FOR VALVE INSPECTION CRITERIA AND CORRECTIVE ACTIONS

The Inspection Requirements and recommended corrective action are presented in Appendix B. These are based on the findings of EPRI Report NP-5479 which considered both historical experience with check valve degradation and failure and theoretical modes of degradation. The EPRI Report identifies places to look at and things to look for when inspecting check valves and this advice has been considered in formulating the inspection guidelines given in Appendix B.

Attachment 2

Millstone Nuclear Power Station, Unit No. 2

Correction to Presentation Slides

March 1997

Qualifications of Project Team

- General Qualifications
  - Core Team includes 13 MS degrees, 6 Ph.D degrees, 23 Professional Engineers, and 3 former Senior Reactor Operators (SROs)
  - Core Team has approximately 25.5 years average experience in the power industry
  - Team leader is a Parsons executive

Qualifications of Project Team

(continued)

- Engineering Disciplines
  - Mechanical Engineering (10)
  - Electrical Engineering (5)
  - Instrument and Control Engineering (4)
  - Civil/Structural Engineering (3)
- Plant Operations and Maintenance (5)
- Probabilistic Risk Assessment (6)
- Licensing (3)
- Other Specialists (4)

Docket No. 50-336
B16358

Attachment 3

Millstone Nuclear Power Station, Unit No. 2

Resumes of Additional Personnel

March 1997

ADDITIONAL PROJECT PERSONNEL
EXPERIENCE, EDUCATIONAL AND PROFESSIONAL CREDENTIALS

Project Role	Title	Years Experience	Degree/ Certification
Safety Analysis and PRA	Consultant	26	MS Physics BS Physics BS Chemistry
Safety Analysis and PRA	Manager - Engineering Projects	18	BSCE
Safety Analysis and PRA	Safety Analysis Engineer	24	BSNE / PE

[redacted]
P.O. Box 1751
Aiken, S. C. 29802

EXPERIENCE:	AHMAD Consultants
1993 to Present	Owner of a small engineering and technical consulting firm providing services to various power generating utilities and other major engineering firms. Services provided are in the areas of nuclear mechanical engineering, design engineering, waste management (LL & HL radwaste, and hazardous wastes and D&D), and environmental engineering. Services include reviewing documents, performing safety analyses, resolving issues (DOE orders and reg. guides), and providing information on codes and regulations. Review of QA-related documents. Provided Duke Power Co's Senneca Nuclear station with technical support for developing and reviewing of design basis documents.
1992	Westinghouse Savannah River Company (DOD/DOE Savannah River Site) Senior Safety Analysis Engineering Consultant - Reviewed documents on thermal hydraulics analysis and performed safety analysis on NON-LOCA plant transients for initial charge and/or subsequent charges and on system design changes. Reviewed and defined plant technical specification and associated set points that remain within the bounds of the plant NON-LOCA assumptions. Reviewed DOE/Savannah River Site plant (K-Reactor) document on the Safety Evaluation Program (SEP)/Topic Evaluation Plan for accident analysis. Reviewed as well as generated supporting documents for ongoing safety analysis and programmatic efforts of the WSRC/SRS, Safety Analysis - transient analysis group. Familiar with the SRS production reactor operations (K-Reactor). Tech. Specs. and safety analysis standards used in safety analysis for Chapter 15 of the Safety Analysis Report (SAR). Reviewed safety analysis documents on reactor shielding and high level radioactive material cask/container shielding. Was involved in the technical review of and development criticality analysis for feasile materials and for SAR chapter VI Familiar with MARY code for SRS K-Reactor.
1990-91	NUS/Haliburton Environmental Corp. Senior Consulting (Project) Engineer, Project Engineering and Project Management -involved with various NSSS and BOP modification projects for the Calvert Cliffs Nuclear Power Plant (BG&E) and H.D. Robinson Nuclear Power Plant (CP&L). At Calvert Cliffs, worked in the areas of safety injection system, NSSS sampling system, AFW system, component cooling water system, and components related to various other safety systems. Reviewed and performed thermal hydraulic calculations for various plant modifications. Was responsible for developing proposals, scoping, project management, and obtaining funds for project implementation. Familiar with and performed analysis for various LOCA and other accident conditions using RELAP codes.

1990-91 <u>Gilbert/Commonwealth, Inc</u>.

Senior Safety and Licensing Engineer (on contract) to South Carolina Gas and Electric Company's V. C. Summer Nuclear Power Station. Provided consultation and engineering expertise on plant safety and licensing issues. Reviewed industry operating experience and NRC information bulletins to identify plant operating problems and to provide solutions to resolve them. Provided expertise in the areas of NSSS, core analysis and balance-of-plant evaluations. Have a sound knowledge of codes and NRC reg. guides. Reviewed analysis that used RELAP codes. Reviewed safety analysis documents on reactor shielding and high level radioactive material cask/container shielding in regards to plant minor modification. Reviewed SAR documents pertaining to cricality analysis using various codes and models.

Assigned as a senior contract lead engineer/supervisor to the Tennessee Valley Authority's Sequoyah Project, to Sacramento Municipal District's Rancho Seco Nuclear Plant, and the Philadelphia Electric Co.'s Peach Bottom Nuclear Plant. The work included performing a review and analysis of reactor safety systems and related calculations; was involved with the Safety Systems Functionability Inspection (SSFI). Generated, developed, and reviewed NSSS and BOP systems operating mode calculations for the stress and the structural group. Provided systems modification evaluation and responded to NRC/IE notices. Was also involved in providing information on Equipment Qualification and for the rededication of commercial grade equipment for nuclear use. Supervised, reviewed, and directed the updating of Design Basis Documents.

1984-88

Westinghouse Electric Corp.

Senior Level Contract/Project Engineer, Fluid Systems Design Department - Developed detailed design information for the fluid systems and thermal hydraulics associated with the NSSS and the waste process systems for the nuclear reactors supplied by Westinghouse at Byron, Braidwood, Calloway, South Texas project, Shearon Harns, TVA (Watts Bar and the Sequoyah plants), Comanche Peak, and Seabrook. Performed detailed calculation and analysis and reviewed system perf ..ances and Emergency Operating Procedures for safety shutdown d ..g accident conditions. Performed calucations on fire hazards analay. nd safety plant shutdown for Appendix R program for the South Texas Project. Reviewed and responded to audit findings on valve and pump performance functional requirements, and provided data on NRC/IE-related questions for specific LOCA conditions. Worked on I&C and electrical separation aspects, revised system descriptions and flow diagrams, issued ECNs, reviewed and updated design documents, and reviewed and developed plant operating procedures. Also worked in the areas of equipment qualification and re-dedication of commercial grade equipment for nuclear use. Was responsible for the fire protection modification of one of these plants.

As Senior Engineering Consultant was assigned to TVA's Watts Bar project. Reviewed analysis and performed evaluation of the plant nuclear safety systems. Was responsible for the Appendix R and fire protection program review from the nuclear safety systems and the electrical and I&C aspects. Generated, developed, and reviewed NASSS, thermal hydraulic calculations and analysis. Reviewed NSSS operating mode procedures and design basis documents. Reviewed safety analysis documents on reactor shielding and high level radioactive material cask/container shielding and criticality calculations.

1981-84

Consumers Power Co.

Lead Engineer in the technical support department - Was involved with pre-operational startup, testing, and operation support activities. Served as reactor engineer for one year. Developed startup physics test procedures and performed modifications on the reactor canal and the pool area lighting systems. Supervised radioactive materials handling, fuel receipt and storage. Was involved in performing analysis and study of spent fuel rack and radioactive (HL & LI) materials cask shielding requirements. Provided licensing expertise to the Reactor Engineering Group. Supervised the development and the implementation of the plant Q-List procedures and the Q-list data base for the pre-operational and the operational phases. Reviewed SAR documents pertaining to criticality analysis using various codes and models. Was involved in reviewing thermal hydraulic Calculations and documents as a systems engineer.

Plant Technical Department Nuclear Industry Experience Coordinator/Supervisor - Reviewed Licensing Event Reports (LER), Significant Event Reports (SER), and Significant Operating Event Reports (SOER), and NRC/IE bulletins to identify probable problem areas prior to plant startup. Earlier, served as mechanical Level III startup engineer for the systems engineering group.

Plant Equipment Data Base and Advanced Maintenance Management Coordinator/Supervisor - Was responsible for the development and implementation of the program. Performed technical review and supervised the input of data of reliability-related non-nuclear equipment.

1976 - 1980 EG&G Idaho Inc. (DOE INEL)

Project Engineer - Technical Support Department, Power Burst Facility - Was senior engineer for Aerojet Nuclear and EG&G Idaho at the DOE test reactor site (PSF). Participated in conducting thermal fuel behavior tests. Was project engineer to the Technical Support Branch on major and minor plant modification on the reactor safety systems. Supervised and directed detailed performance and analysis and calculations review and upgrade of systems. Supervised Plant Waste Management Group. Was responsible for three major plant projects for high level and low level radwaste and chemical waste systems. Generated proposals and feasibility reports; provided engineering judgements; procured funding; implemented, controlled, and provided direction to these projects. Was responsible for plant HVAC system and related plant FSAR updates. Initiated and designed for approval the construction of radwaste resin disposal casks for transportation and disposal of high-level radioactive resins for the facility site. Other assignments included system startup and testing in conjunction with reactor systems modifications and containment lead rate test and related modification test. Was project engineer for the development design and the construction of shielded cask for the transportation and storage of high level radioactive depleted resins used for reactor coolant purification system.

1974 - 1975 Cochran Western Corp.

Contract and Staff Engineer - Was responsible for mechanical design and fluid power engineering and stress analysis for cargo handling and ground support transport projects for the U.S. Army and the U.S. Air Force Performed chemical analysis for verification of proper welding performed as required per Mil. Specs Was involved in mechanical design work and analysis for a Chinese shibuilding project.

1971 - 1973 Olson Bodies/Grumman Corp.

Mechanical Engineer - Performed mechanical design and analysis on fabrication and tooling for automotive buses, health units, and utility vans.

Supervised a small engineering group.

1970 International Research and Development Corp.

Analytical Chemist - Performed analytical work, and developed method studies for new chemical products, compounds, and pesticides.

East Pakistan Water and Power Development Authority

Assistant Technical Officer - Responsible for residential and commercial power distribution, sales and planning section. Supervised 50 employees.

EDUCATION: B.S., Physics (Honors), University of Dacca
B.S. Chemistry, University of Dacca
M.S. - Physics, University of Dacca
Post Graduate Studies in Physics towards Ph.D., University of Oregon, Eugene OR, and Western Michigan University, Kalamazoo, MI

[redacted]
Project Technical Consultant

Over 20 years experience in the Nuclear Power Industry with ever increasing experience in the areas of engineering and management.

EXPERIENCE: GPU Nuclear Corporation, TMI Nuclear Station, Middletown, Pa.

1989-96 Manager, Engineering Projects/Technical Functions TMI (1989-1996) - Managed 200 projects totaling $20M at TMI and Saxton Nuclear Stations. Managed the Design Engineering function for 90% of these projects. Increased the total dollar value of work by 300% during this period with no increase in staffing. Achieved personnel proficiency and process improvements such that the value of the averaged project increased 200% during this period. Supervised 9 Project/Design Engineers.

Significant projects include:

TMI-1 Power Uprate - Project to raise the plant output by up to 8%. One year, $2M feasibility study on schedule and under budget. Directed overall activities of seventy-five GPUN personnel and several engineering support firms formed into 6 teams.

TMI-1 Security Upgrades - $1M plant upgrade project to protect against terrorist attack by land-based vehicle. Project completed on schedule and within budget and consistent with GPU Nuclear CEO commitments to PA Governor's Office. Briefed PA state officials and local media on implementation. Served as technical advisor to the Nuclear Energy Institute (NEI), Washington, DC for security system design issues.

Natural Draft Cooling Tower Study - Developed and initiated project to evaluate the long term structural integrity of the TMI cooling tower fill system and develop recommendations to optimize the life of these structures valued at $25M.

Expanded business to provide Project Management and Engineering support beyond the local area. Managed Design Engineering support for modifications and studies performed at Oyster Creek, Homer City, Warren and Seneca Generating Stations (western PA and NJ). Provided design engineering support to Parsons Power for security upgrades at 4 nuclear sites operated by Entergy Operations in Arkansas, Louisiana and Mississippi.

Served as alternate Project Engineering member of the TMI Plant Project Integration Team. Scope included the project prioritization and approval functions for the TMI capital and specific O&M budgets valued at $30M per operating cycle.

Facilitated development of Engineering Projects Department Vision Statement. This included initial development at TMI with followon expansion to include Projects Department personnel at both Oyster Creek Nuclear Generating Station and the Parsippany, NJ, Headquarters location.

The result of this effort has been a strengthened management of project resources to improve quality, responsiveness and value.

1981-89 Plant Analysis Manager, TMI-1 - Staffed & directed the TMI-1 Shift Technical Advisor (STA) Program. This program, a lesson learned from the TMI Accident, assigned Engineers to the operating shifts to provide real time technical support to plant operation. Developed training concept and learning objectives for the STA Training Program. The training program is approximately 1 year long, with STA certification provided by a Senior Management Examining Board. This program has been accredited by the Institute for Nuclear Power Operations. Co-facilitated Kepner-Tregoe Problem Analysis & Decision Making module presented in the training program. Supervised 9 Engineers.

Developed, in concert with corporate engineering, the TMI-1 Plant Performance Monitoring Program. Program included evaluation of overall plant, system, and component performance associated with operation of the TMI-1 Nuclear Station. Compared actual performance with that predicted by computer models showing ideal (target) performance level. Identified deviations from expected performance and developed corrective actions to return plant operation to design conditions.

Managed operating experience review program. Reviewed significant events at US nuclear plants to determine applicability of lessons learned to TMI-1. Identified and implemented preventive actions as needed. Interfaced with other US utilities and the Institute of Nuclear Power Operations (INPO).

Developed program to assess TMI-1 performance during unplanned shutdowns. Conducted post shutdown review and presented results to plant and corporate senior management. Focal point for Technical Functions Division concurrence with plant restart following unplanned shutdowns.

1980-89 GPUN representative to the Babcock & Wilcox Owners Group (B&WOG) Transient Assessment Committee (Chairman 1983-84) - Primary architect of Reactor Trip Reduction Program. Lead data collection and evaluation tasks. Chaired Committee meetings of 6 utilities, and reactor system designer, that prioritized actions and developed programmatic approach to reduce the frequency of unplanned shutdowns. Presented program to Executive Committee and awarded funding for implementation. Program contributed to 85% reduction in trip frequency and improved transient response at B&WOG plants.

Chaired followon programs to review plant response for complex transients and recommended actions to improve plant post-trip transient response. Evaluated program implementation at 3 B&WOG utility sites. Team Leader for evaluation at Davis-Besse. Briefed Nuclear Regulatory Commission

(NRC) Advisory Committee on Reactor Safeguards (ACRS) as part of safety review of B&WOG plants.

1979-81 Plant Analysis Engineer, TMI-1 - Developed functional design requirements for TMI-1 computer system software to support operations and maintenance during normal and emergency operating modes. Developed human interface requirements and conceptual design to meet these requirements. Trained operations and maintenance personnel on system design and use.

Project Engineer TMI-1 Control Room Design Review (CRDR) - Coordinated with prime contractor (MPR Associates), human factors consultants, and GPU Nuclear operations, maintenance, and engineering personnel to ensure effective planning, logistical support, and evaluation for the TMI-1 CRDR project. Lead GPU Nuclear interface with Nuclear Regulatory Commission for inspection of re-designed control room. Briefed PA state and congressional elected officials and their staff on technical aspects of design review and design. Briefed local and national media on project and re-design activities.

1974-79 <u>United States Navy</u>

Project Manager, Enlisted Training Programs, Naval Operations, Washington, D.C. Responsible for planning, resource programming and execution monitoring for Advanced and Specialized Skills Training Programs for US Navy. Total scope 1000 training programs with an annual expenditure of $250M.

Division Officer in Engineering and Operations Departments aboard Nuclear Powered Submarine. Certified as Chief Engineer Officer.

<u>EDUCATION</u>: B.S., Civil Engineering, Tulane University, 1974
U.S. Navy Nuclear Training Program, 1975

GPU Executive Development Program - The Wharton School, University of Pennsylvania
Deming Management Methods
Accident/Incident Investigation Workshop (EG&G Services)
Kepner-Tregoe Problem Analysis/Decision Making Course

[redacted]

Safety Analysis Engineer

Experienced in evaluation of normal and emergency offsite radiological consequences using various mathematical models. Experience in thermofluid applications and other safety analyses for major power generating facilities.

EXPERIENCE: Parsons Power (formerly Gilbert/Commonwealth) since 1973

1973 to Present — Continuing Services Project Engineer - Susquehanna Steam Electric Station and R. E. Ginna Project - Responsible for all analysis performed within the Applied Engineering Analysis Department.

Safety Analysis Engineer - Analyzed and evaluated plant design using digital computer techniques in the following areas:

Radiological Analyses

South Carolina Electric & Gas, V.C. Summer Nuclear Station - Performed FSAR Chapter 15 off-site dose assessment at power uprate conditions.

Pennsylvania Power & Light, Susquehanna Steam Electric Station - Performed radiological impact assessment for power uprate.

Evaluated post-accident doses received by control room operators and off-site boundary doses for:

Cleveland Electric Illuminating Company, Perry Nuclear Power Plant, Units 1 & 2
South Carolina Electric & Gas, V.C. Summer Station
Korea Electric Power Company, Ko-Ri, Unit 2

Philadelphia Electric Company, Peach Bottom, Units 2 & 3 - Performed accident analysis of the radwaste building extension for a Safety Evaluation Report.

Rochester Gas & Electric, R. E. Ginna Station - Performed source evaluation and shielding design for all volatile treatment systems.

Evaluated environmental profiles for equipment qualification for:

Cleveland Electric Illuminating Company, Perry Nuclear Power Plant, Unit 1
South Carolina Electric & Gas, V.C. Summer Station
Florida Power Corporation, Crystal River Station, Unit 3

Thermofluid Analyses

South Carolina Electric & Gas, V.C. Summer Nuclear Station - Performed thermal hydraulic assessments for postulated accidents following power uprate.

Pennsylvania Power & Light, Susquehanna Steam Electric Station - Performed thermal hydraulic assessments for postulated accidents following power uprate.

Perry, Unit 1 and Three Mile Island, Unit 1; Crystal River, Unit 3 and Waterford, Unit 3 - Evaluate transient wave acceleration forces within nuclear plant piping systems.

Evaluate steady-state and transient thrust and jet impingement forces for structural plant design for:

Cleveland Electric Illuminating Company, Perry Nuclear Power Plant, Unit 1
South Carolina Electric & Gas, V.C. Summer Station
Florida Power Corporation, Crystal River Station, Unit 3
Rochester Gas & Electric, R. E. Ginna Station

Philadelphia Electric Company, Peach Bottom Atomic Power Station, Units 2 & 3 - Evaluated the hardened vent line size.

Performed steady-state and transient heat transfer analyses in support of system design, station blackout, and equipment qualification documentation for:

Cleveland Electric Illuminating Company, Perry Nuclear Power Plant, Unit 1
South Carolina Electric & Gas, V.C. Summer Station
Florida Power Corporation, Crystal River Station, Unit 3
Pennsylvania Power & Light, Susquehanna Steam Electric Station

Evaluate subcompartment pressure/temperature response and safety equipment thermal response to pipe rupture for:

Cleveland Electric Illuminating Company, Perry Nuclear Power Plant, Unit 1
Florida Power Corporation, Crystal River Station, Unit 3
South Carolina Electric & Gas, V.C. Summer Station
Korea Electric Power Company, Ko-Ri, Unit 2
Electric Utilities of Slovenia and Croatia, Krsko

Evaluate mass and energy release from pipe rupture for:

Cleveland Electric Illuminating Company, Perry Nuclear Power Plant, Unit 1
Korea Electric Power Company, Ko-Ri, Unit 2
Rochester Gas & Electric, R. E. Ginna Station

Performed both steady-state and transient hydraulic analyses for numerous nuclear (PWR/BWR) and non-nuclear systems for:

[redacted] (Continued)

Cleveland Electric Illuminating Company, Perry Nuclear Power Plant, Unit 1
Rochester Gas & Electric, R. E. Ginna Station
Florida Power Corporation, Crystal River Station, Unit 3
South Carolina Electric & Gas, V.C. Summer Station
Public Service Electric & Gas, Hope Creek Generating Station

Florida Power Corporation, Crystal River, Unit 3 - Performed ASME Section XI hydraulic margin assessment analyses for safety related systems.

Other Design Analyses

Electric Power Research Institute - Study evaluating impact on thermodynamic cycle performance when retrofitting the "High Velocity Separator", a moisture removal device, on nuclear power plant turbine cycles.

British Petroleum, Grangemouth - Wrote computer program to simulate the Grangemouth fluid catalytic cracking unit as a training tool.

Western Area Power Administration - Building energy analysis using digital computer code DOE-2.0 for the design of new control complex building.

Florida Power Corporation, Crystal River, Unit 3 - Evaluation of hazard to control room personnel due to toxic gas release.

EDUCATION: B.S., Nuclear Engineering, Pennsylvania State University, 1973
Additional Courses:
Introduction to Environmental Protection, produced by NUS, Combustion Engineering, and The Pennsylvania State University
Two-Phase Fluid Flow, Drexel University, 1978
Fundamentals of Management

REGISTRATION: Professional Engineer - Pennsylvania

SOCIETIES: American Society of Mechanical Engineers

Attachment 4

Millstone Nuclear Power Station, Unit No. 2

Future Work Restrictions, ICAVP Work Location,

and

Financial Independence

March 1997

Millstone Unit No. 2
Parsons Work Restrictions, ICAVP Work Location, and Financial Independence

- Restrictions on Parsons Power from Performing Future Work

  In NNECO's letter to the NRC recommending Parsons Power as the ICAVP contractor for Millstone Unit No. 2 and in the presentation to the NRC on March 18, 1997, NNECO indicated that Parsons Power would be contractually restricted from performing or seeking new work at Millstone for 12 months following completion of the Independent Corrective Action Verification Program (ICAVP). In order to ensure the independence of the ICAVP effort, Parsons Power will be restricted from seeking work at any Northeast Utilities facility for a period of 12 months following completion of the ICAVP at Millstone Unit No. 2.

  Should an individual team member leave the ICAVP project prior to the end of the project, they will still be subject to these conditions until twelve months after the ICAVP project ends. If Parsons is approved by the NRC, NU's list of approved quality suppliers will be revised to reflect this restriction.

- Location of Parsons Power for ICAVP Work

  The Parsons Power Group will conduct the majority of the Millstone Unit No. 2 ICAVP work at its offices (formerly Gilbert/Commonwealth) in Reading, PA. Some work will be conducted locally at or near the Millstone site. Local work will be monitored by the NRC Staff. A staging area for local work has been established in Old Lyme, CT.

- Financial Independence of Parsons Power

  The Parsons Corporation, the parent of Parsons Power Group, Inc., is totally owned by the employees through the PARSONS ESOP. The ESOP does not invest in outside companies. The PARSONS 401K program is administered by the American Express Corporation, and offers individual employees the opportunity to invest in five (5) different mutual funds. The Parsons Corporation matches a portion of the employees contribution to this program, but the employee decides in which mutual funds these company contributions will be placed. No employee of the Parsons Corporation has control of the investment decisions of any of the five funds involved in the 401K program.

CORPORATE OVERVIEW

Parsons Corporation, one of the world's largest international engineering and construction organizations, provides a wide range of services for private industry and government through its operating groups. Our proud heritage of excellence began in 1944, and today Parsons Corporation is the largest 100% employee-owned firm of its kind in the United States.

The following briefly describes Parsons corporate structure and organization.

Our latest annual report, which summarizes the recent activities of the corporation, is provided in Exhibit 1-1.

Through wholly-owned subsidiaries, Parsons provides a wide range of planning, design, engineering, construction, and program management services to clients in government and private industry worldwide, as depicted in Figure 1-1. Our worldwide staff consists of approximately 10,000 managers, engineers, and support personnel.

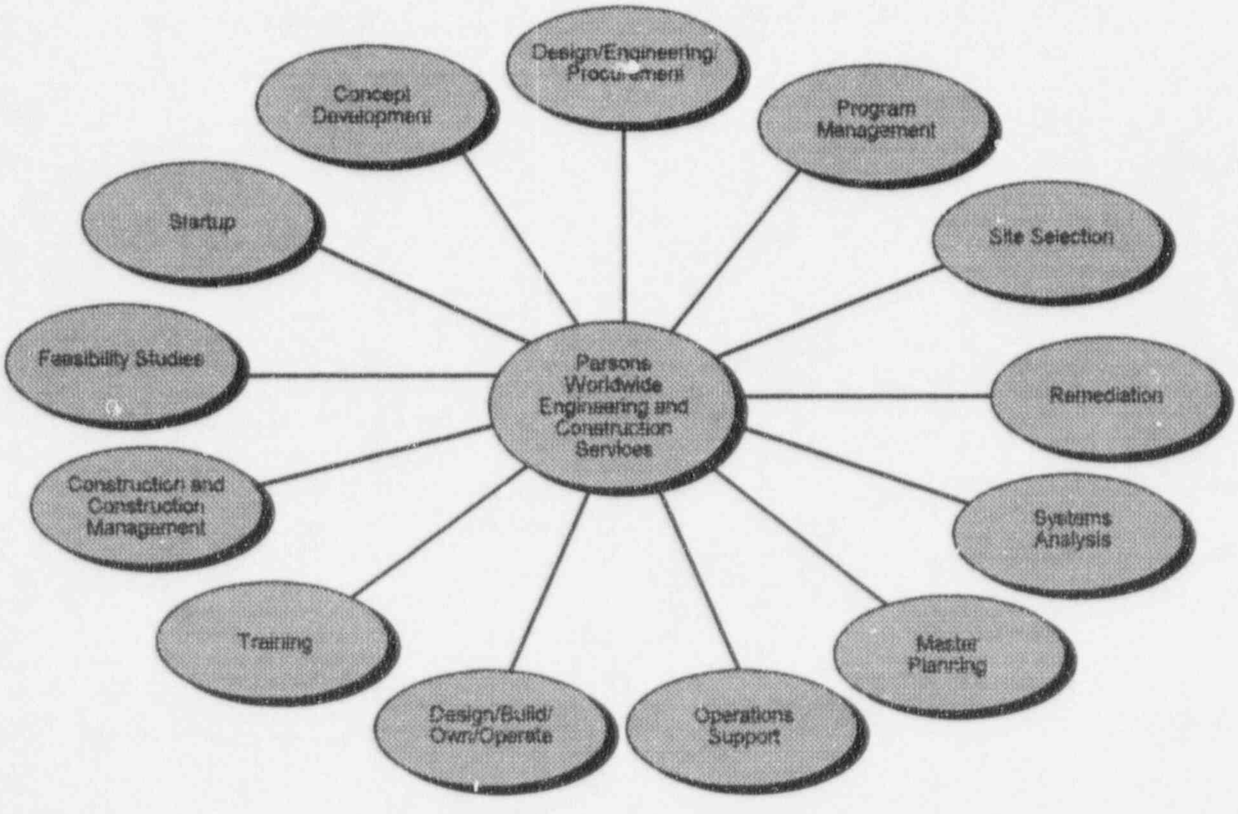


Figure 1-1 - Parsons Worldwide Engineering and Construction Services

Parsons was ranked the top global design firm by *Engineering News Record*, the industry's leading trade publication. The ranking, based on combined domestic and international 1995 billings was announced in the July 22, 1996 issue. ENR also named Parsons the top U.S. design firm for the second year in row.

Parsons Corporation is a recognized leader in the oil and gas, petroleum processing, chemical, power, environmental, water resources, aviation, and pulp and paper industries, as well as infrastructure, government, industrial and community development and ground transportation.

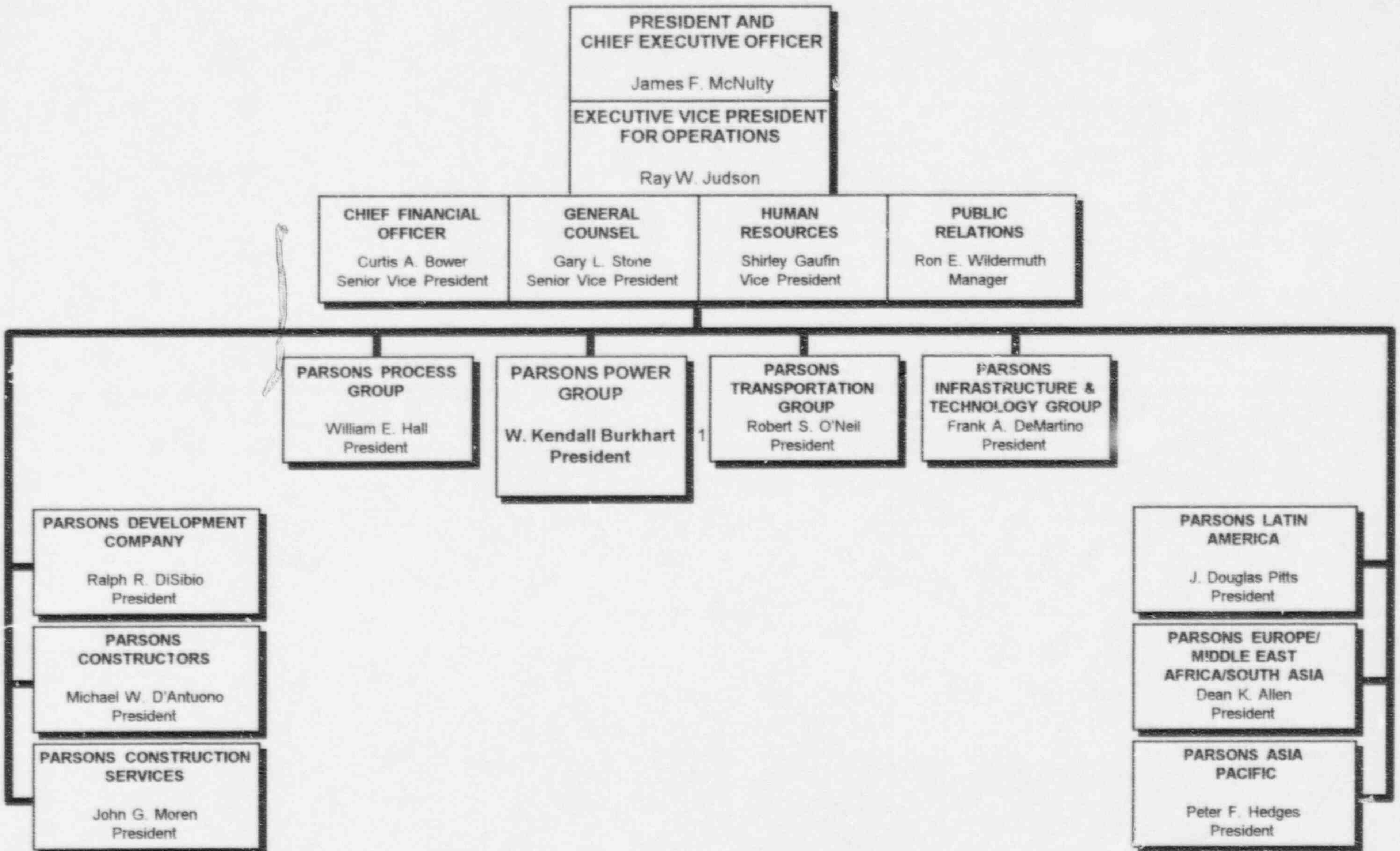
CORPORATE ORGANIZATION

Recently, Parsons Corporation restructured its organization to build upon a historically diversified operating approach, and focus even more sharply on four distinct market sectors, or Global Business Units. These Global Business Units have responsibility for our worldwide project execution, as well as for maintaining state-of-the-art technology and resource capability. Each of these units proudly carries the Parsons name:

- **Parsons Process Group Inc.,** comprising the former Petroleum & Chemical Division of The Ralph M. Parsons Company; Parsons S.I.P. Inc.; and the process industry-related activities of Parsons Limited, Parsons International and Saudi Arabian Parsons Limited.
- **Parsons Infrastructure & Technology Group Inc.,** incorporating the resources of the former Systems Division of The Ralph M. Parsons Company; Parsons Engineering Science, Inc.; Harland Bartholomew & Associates, Inc.; and the industrial units from Parsons Main, Inc. and Gilbert/Commonwealth, Inc.
- **Parsons Power Group Inc.,** representing a combination of the power-related capability of Gilbert/Commonwealth, Inc., and Parsons Main, Inc.
- **Parsons Transportation Group Inc.,** consisting of DeLeuw, Cather & Company; Barton-Aschman Associates, Inc.; and Steinman Boynton Gronquiest & Birdsall.

Parsons overall corporate structure is shown in Figure 1-2.

Parsons Corporation



PARSONS PROCESS GROUP INC.

Parsons Process Group Inc. (PPGI) employs over 2,000 people worldwide and provides a diverse range of services to a global roster of clients in the petroleum and chemical sector. This includes design, engineering, procurement, construction and project management for the petroleum production, refining, sulfur management, oil and gas production, gas processing, chemicals and petrochemicals industries.

PPGI has major full-service design centers in Houston, Texas; Pasadena, California; London, England; and Manila, Philippines.

The following Parsons companies and affiliates are established to perform work in specific countries or regions.

Parsons Engineers, Ltd. (PEL), is headquartered in Kuwait City, Kuwait and provides project management, construction management, engineering, procurement, construction, training and other services to the petroleum, chemical, and oil & gas industries.

Saudi Arabian Parsons Limited (SAPL), is headquartered in Al Khobar, Saudi Arabia, and provides management, design, procurement, construction and program management services for petroleum, chemical, infrastructure, mining and aviation projects in Saudi Arabia.

Parsons International Limited, with offices in Manila, Philippines provides a full range of services for the oil & gas, refining, petrochemical, and infrastructure sectors.

Latinoamericana de Ingeneria, S.A. de C.V.(LATISA), headquartered in Mexico City, Mexico, offers services from feasibility studies through engineering, procurement, and construction supervision for natural resources, industrial and infrastructure projects in Mexico and Latin America.

Parsons de Colombia, with offices in Bogota, Colombia, provides a full range of engineering, procurement and construction services in Colombia and surrounding regions.

Proyeparsons, with offices in Caracas, Venezuela, provides project management, construction management, engineering, procurement, and construction services to a wide range of industries including oil & gas, petroleum refining and petrochemicals.

Parsons Polytech, Inc., a Japanese corporation in consortium with Shimizu Construction Company, provides program management, construction management and construction services in the Pacific Rim.

PARSONS INFRASTRUCTURE AND TECHNOLOGY GROUP INC.

The Parsons Infrastructure and Technology Group Inc. (Parsons I&T), headquartered in Pasadena, California, was formed in 1995 by combining the Systems Division of the Ralph M. Parsons Company and other related subsidiaries. The company, which provides services to clients in government, industry and commerce, consists of the following divisions:

- Aviation
- Federal
- Industrial (Manufacturing)
- Industrial (Environmental)
- Infrastructure/Water Resources

Services are provided to both public and private sectors. Industries served include defense and aerospace, water and sewage treatment, telecommunications, education and medical, communication, power, transportation, environmental and waste management.

Parsons Engineering Science is headquartered in Pasadena, California. Few organizations in the industry can match the environmental experience and diverse capabilities of Parsons ES. The company specializes in a complete spectrum of environmental engineering services including water and waste water treatment, hazardous waste management, nuclear and mixed waste decontamination and decommissioning, water supply, laboratory services, marine waste disposal, solid waste management, and air pollution control.

Harland Bartholomew & Associates, Inc. provides engineering and planning consulting services. This includes urban and regional planning, military master planning, environmental assessment and impact studies, transportation planning, traffic studies, engineering design, site planning, and campus planning.

PARSONS POWER GROUP, INC.

Parsons Power Group Inc. was formed in 1995 from the merger of two Parsons Corporation subsidiaries: Gilbert/Commonwealth, Inc. and Parsons Main, Inc. Gilbert/Commonwealth became a Parsons Corporation subsidiary in July 1995, after serving the power industry for over 90 years. Parsons Main, formerly Charles T. Main, has been part of Parsons Corporation since 1985 and has been serving the power industry for over 100 years.

Parsons Power Group Inc. provides consulting services, design, engineering, procurement, project management, construction and construction management to clients throughout the world.

Industries or facilities served include electric power generating plants, cogeneration plants, hydroelectric facilities, other types of independent power generation, power transmission and distribution systems, industrial and process plants, laboratory facilities, commercial buildings, municipal buildings, pulp, paper and forest industries, printing and publishing facilities, and environmental and hazardous materials projects.

Parsons Power Inc. has the leading edge expertise in various technologies, including fluidized bed boilers, fuel cells, coal gasification, high and low temperature gas cleanup and environmental.

PARSONS TRANSPORTATION GROUP INC.

Parsons Transportation Group, Inc. was formed in 1995 by the consolidation of De Leuw, Cather Co., Barton-Aschman Associates, Inc. and Steinman, three former subsidiaries of the Parsons Corporation. The company is a leader in the international transportation business and provides comprehensive planning, management, design and construction support services for project from concept through construction and operations.

PARSONS CONSTRUCTORS INC.

Parsons Constructors Inc., (PCI), headquartered in Pasadena, California, is a Parsons Corporation subsidiary. The Company provides construction services to other Parsons companies as well as to government and private industry. Services provided by PCI include direct hire plant construction, construction management and supervision, quality assurance/quality control, field inspection and material supervision, safety management, labor relations and labor negotiations, planning, scheduling, and logistics support, and constructability assessment.

PARSONS CONSTRUCTION SERVICES, INC.

Parsons Construction Services, Inc. is a Parsons Corporation subsidiary, based in Houston, Texas. The Company provides construction services on a merit shop basis for Parsons and other companies on refining, petrochemical, industrial development, and public works projects.

PARSONS DEVELOPMENT COMPANY

Parsons Development Company is headquartered in Washington, D.C., a center of international financing and lending institutions and multinational banking. The Company is dedicated exclusively to project development and assists clients around the globe with innovative financing for various types of projects, including infrastructure, power generation, industrial facilities, transportation systems, and water supply and treatment.

THE PARSON CORPORATION FINANCIALS

Parsons Corporation and all of its subsidiary companies, including Parsons Power Group Inc., are privately held under an Employee Stock Ownership Plan (ESOP), the organization's financial information is not publicly released. Although the organization's financial information is not made available for subsidiary companies or publicly released, the following audited financial information is provided:

1. Average Annual Sales During the Past Five Years $1,479,000.00
2. Estimated Billable Sales this Year $1,300,000.00