Consumers Power Company

General Offices: 212 West Michigan Avenue, Jackson, MI 49201 • (517) 788-0550

September 16, 1983

Atomic Safety & Licensing Board
U S Nuclear Regulatory Commission
Washington, DC 20555

Dear ASLB Members

Attached hereto is a memorandum of a conversation between J E Brunner and Mr John Donnell regarding the alleged Board Order Violation. Note the date of my conversation with Mr Donnell. I have sent a copy of this memorandum to the Region III investigator handling the investigation of the alleged Board Order Violation.

Very truly yours

James E Brunner

J E Brunner

CC OL/OM Service List

To	File
From	JEBrunner, M-1079
Date	September 8, 1983
Subject	JEB CONVERSATION WITH J DONNELL REGARDING BOARD ORDER VIOLATION
CC	MIMiller FCWilliams JAMooney JWCook BWMarguglio

CONSUMERS POWER COMPANY

Internal Correspondence

RECEIVED

SEP 12 1983

MIDLAND PROJECT MANAGEMENT

On September 6, 1983, I reached John Donnell by telephone at the offices of Science Application Incorporated (SAI) in Las Vegas. After identifying myself as an attorney for Consumers Power Company, I told Donnell that we were conducting an investigation in regard to certain work performed on the deep-Q electrical duct bank at the Midland jobsite when he was employed there. I pointed out that the NRC was investigating the same matter.

Donnell stated that NRC had contacted him twice on the subject. He gave the NRC a written statement, although his memory of relevant facts was dim. Donnell felt that he knew nothing of interest to the NRC.

Donnell could not recall the location of the deep-Q duct bank crossing of the freezewall or the work performed at that location. He did not remember talking to anyone on site about this work. According to Donnell, everyone on site knew, in essence, about the April 30, 1982 Board Order, which Donnell understood as requiring Landsman's advance approval of any drilling activities. Donnell did not know of any intentional violations of this requirement. He suggested that I talk to Bob Sevo, who attended all meetings with NRC. Donnell was not aware of any person, including Sevo, who knew that the NRC had prohibited excavation under the deep-Q duct bank.

Donnell offered a few spontaneous comments not relevant to my questions. He pointed out that he departed the site on good terms with the Company. He said that BWM had promised him a recommendation, but added BWM "did him no favors." I did not question him on this. He also said that he had contacted NRC to renew an employment application, which the NRC people apparently misinterpreted as a discrimination complaint.

I thanked Mr Donnell for speaking to me.

Based on the above discussion, I decided not to pursue a trip to Las Vegas to interview Mr Donnell in person, pending release of the NRC's investigation report.

mi0983-0612a100

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'83 JAN 19 A10:53

January 17, 1983

In the Matter of	)	
	)	Docket Nos. 50-329-OM
CONSUMERS POWER COMPANY	)	50-330-OM
	)	50-329-OL
(Midland Plant, Units 1 and 2)	)	50-330-OL

Charles Bechhoefer, Esq.
Atomic Safety & Licensing Board Panel
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dr. Jerry Harbour
Atomic Safety & Licensing Board Panel
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Washington, D. C. 20555

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Dear Administrative Judges:

Enclosed is the first installment of Applicant's prepared testimony for the evidentiary hearings beginning February 14. Pursuant to agreement of the parties and my conversation with Chief Judge Bechhoeffer on Friday, a second installment will be filed on January 24 dealing with Sinclair contention 3 (water hammer) and certain remaining subissues of Stamiris contention 4. My understanding is that the Staff has been granted an extra week, until February 7, to file testimony with respect to the corresponding issues.

One of Applicant's witnesses on Sinclair contention 4 (steam generator corrosion due to pond water chemistry), Cris Hillman, may not be able to be present in Midland during the week of February 14 due to longstanding vacation plans. Rather than asking Mr. Hillman to cancel his vacation, we have arranged for Mr. Bill Beckman, who as Chemistry/Health Physics Superintendent at Midland Plant is Mr. Hillman's boss, to stand in for

Mr. Hillman if necessary. Mr. Beckman's resume is included with Applicant's testimony.

Also included in this package is Applicant's exhibit 29R, which is a redrafted figure showing the locations agreed upon by Applicant and the NRC Staff for Diesel Generator Building crack monitoring, together with an explanation of the frequency and acceptance criteria for such monitoring. This material is provided with the Board's permission merely for the sake of clarity; no substantive changes in the drawing or the explanation of the monitoring program have been made. (See Tr. 11068-72).

Respectfully submitted,

Philip P. Steptoe
One of the Attorneys for
Consumers Power Company

cc Service List

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TESTIMONY OF CRIS HILLMAN

AND TERRY POSTLEWAIT

ON

SINCLAIR CONTENTION 4

My name is Cris Hillman. I am employed by Consumers Power Company as the Plant Chemical Engineer at the Midland Nuclear Plant. In this job, my responsibilities include management and development of an integrated plant chemistry program. I have a BS in Chemical Engineering from Michigan State University and five years experience in chemical engineering in support of nuclear power plant operations at Palisades and Midland. Further information is contained in my resume in Attachement A. I believe as a result of this training and experience, I am qualified to address Sinclair Contention 4.

My name is Terry Postlewait. I am employed by Consumers Power Company as a Staff Engineer in the Design Production Department, Mechanical/Nuclear Section of the Midland Nuclear Plant Project at the Company headquarters in Jackson. In this job, my responsibilities include such activities as the rev[illegible]f mechanical systems design and support of licensing activities. As required, I interface with Bechtel and Consumers Power Company personnel in the resolution of design and construction problems. I have a BS in Mechanical Engineering from the University of Toledo and ten years experience in the design, installation and operation of mechanical equipment. Eight of these years have been with Consumers Power Company, associated with fossil and nuclear power plants. I have been on the Midland Project specifically since April of 1980. Further information is contained in my resume in Attachment B. I believe as a result of this training and experience, I am qualified to address Sinclair Contention 4.

Sinclair Contention 4 states:

"The degradation of steam tube integrity due to corrosion induced wastage, cracking, reduction in tube diameter, and vibration induced cracks is a serious unresolved safety problem at the Midland Nuclear Plant. It is admitted that the chemistry of the cooling water is critical to prevention of steam tube failure, (NUREG-0886). However, the fact that these plants depend on cooling water from the cooling pond increases the likelihood of corrosion and poor water chemistry because the DEIS states that the plant dewatering system will first be discharged to the cooling pond. (DEIS at 5-2). That means that mary wastes, including radioactive materials from leaks and spills on the reactor site, can enter the cooling pond and disrupt the chemistry of the pond. Therefore, due to this contribution of an undetermined amount and quality of ground dewatering inflows to the cooling pond, the NRC's bland assurance that corrosion is unlikely due to the lack of sodium thiosulfate, is unsatisfactory. (NRC Response to Interrogatory 9.j.) In fact, due to the contribution of groundwater, the NRC is not fully aware of the likely constituents of the cooling pond, and the findings required by 10 CFR §§ 50.57(a)(3)(i) and 50.57(a)(6) cannot be made."

I. Introduction

Sinclair Contention 4 is based on the faulty premise that the control of cooling (pond) water chemistry is critical to the prevention of steam generator tube failure (inaccurately deduced from misinterpretation of NUREG 0886). The fact is, NUREG 0886 refers to the control of secondary water chemistry, not cooling water (pond) chemistry, as being a key to minimizing steam generator tube degradation. As can be seen from the simplified sketch of the Midland Plant thermal cycle shown in Attachment C, cooling water from the cooling pond does not flow through the secondary system or the steam generators during normal operation. Regardless of what the cooling water chemistry may be, administrative procedures and design features of the plant are adequate to meet B&W specified secondary water chemistry limits and thus, steam generator tube corrosion will be minimized.

The water normally used in the secondary system is supplied by the Plant Makeup Demineralizer System and does not come, directly or indirectly, from the cooling pond. There are only two circumstances under which cooling water from the cooling pond can be introduced into the secondary system and come into contact with the steam generators. The first is leakage through the condenser. The second is emergency operation of the auxiliary feedwater system, taking water from the pond. These are discussed below.

II. Description of How Cooling (Pond) Water Can Enter the Secondary Cycle

A. Condenser Leaks

Attachment C includes a simplified schematic cross section of a typical condenser. Each Midland Unit utilizes such a condenser to condense the turbine exhaust steam for reuse in the secondary cycle. The condenser is basically a shell and tube type heat exchanger with the turbine exhaust steam being condensed on the shell side and the cooling water being pumped through the tubes. The cooling water flowpath is physically separated from that of the steam by means of the tubes and the tubesheets. Each tube-to-tubesheet joint is made watertight by mechanically expanding the tube into the corresponding hole in the tubesheet.

Cooling water can find its way into the secondary cycle via the condenser if the tube-to-tubesheet joint or the tube itself should develop a leak. Should this occur, the solution is to reroll the tube-to-tubesheet joint or to insert a mechanical plug in each end of the tube. These techniques are standard in the industry and are quite effective.

In-leakage of cooling water to the secondary system is normally indicated by on-line instrumentation. The sample point used to detect a suspected condenser leak is located in the condensate pump discharge piping as noted in Attachment C. The condensate pump discharge sample is continuously monitored for cation conductivity, pH, dissolved oxygen, sodium and silica. A cooling water-to-secondary leak will normally be indicated by an increase in sodium and/or cation conductivity level. Grab samples for cation conductivity and sodium are also taken from the same sample point and analyzed in the laboratory once per shift. This serves as a check of the on-line instrumentation and is used to either confirm or reject the suspected condenser leak.

In addition to the methods and practices described above, each condenser is equipped with a hotwell* sampling system. The system collects condensation and/or leakage from each tubesheet. Samples are then collected and analyzed in the laboratory on an as-needed basis. This system is useful in identifying which individual tube bundle contains the leak.

*The term "hotwell" is standard in the condenser industry and denotes the bottom section of the condenser in which the condensed steam (condensate)is collected prior to being pumped through the demineralizers to the steam generators.

Procedures are now in place that require management personnel be informed of off-normal chemistry conditions which includes suspected condenser leaks. Additionally, Technical Specification 16.6.8.4, Item C, Subsection vii has been proposed which concerns cooling water-to-secondary leakage. This proposed Technical Specification states: "When condenser in-leakage is confirmed, the leak shall be repaired, plugged or isolated within 96 hours."

Once a leaking portion of the condenser is identified, that half of the condenser can be isolated by shutting off one cooling water loop. The specific leaking element (eg, tube or tube-to-tubesheet joint)can then be further identified by means of portable leak detection equipment, and the leak corrected by plugging or rerolling the tube-to-tubesheet joint.

B. Auxiliary Feedwater System

The second path for potentially introducing cooling pond water into the secondary system is by way of the Auxiliary Feedwater (AFW) System. The AFW System, initiated by an Auxiliary Feedwater Actuation Signal (AFWAS), is used to supply water for shutdown to the secondary side of the steam generators in the event main feedwater is lost. During Plant operation, the AFW pumps are aligned to take suction from the condensate storage tank, in the event AFW is needed. Should an AFWAS occur, condensate from the condensate storage tank would be pumped to the secondary side of the steam generators. In the unlikely event that this supply of water to the AFW pump suction should be lost for a specified period of time and an AFWAS be present, suction is automatically transfereed to the service water system, which is a source of cooling pond water. In either of these cases, AFW is used only to shut the plant down, not to continue operating. The frequency of occurrence of the coincidental set of circumstances leading to the use of cooling pond water as a source of AFW is extremely low. The plant can be safely shut down in this scenario of using cooling pond water in the steam generator; prior to restarting the unit, necessary actions, inspections, etc would be performed to ensure integrity of the steam generators.

Note that the water in the condensate storage tank, referred to as "condensate," is a mixture of condensate from the secondary system and demineralized makeup water from the Plant Makeup Demineralizer System and is essentially the same quality as secondary system water. The Plant Makeup Demineralizer System takes its normal suction from the City of Midland water system but can use Dow Chemical Company's demineralized water as a backup source. In either case, the source water is processed through the plant makeup demineralizers to assure proper quality prior to being pumped to the condensate storage tank. The cooling pond is not a source for demineralized or makeup water.

III. Description of Secondary Water Chemistry Control

The secondary system of the plant is a water system which uses ammonia for pH control and hydrazine for oxygen control. The allowable maximum limits of these and other parameters are specified by B&W. The limits to be met by CP Co are in all cases the same or more stringent than the B&W recommendation.

The secondary systems of both Unit 1 and Unit 2 are equipped with full-flow deep bed condensate demineralizers. There are six condensate demineralizers in the system, five in service and one in standby. The demineralizers remove cationic and anionic impurities that exist in the condensate. The demineralizers are located downstream of the condensate pumps and have adequate capacity to purify the feedwater prior to its introduction to the steam generators. Thus, impurities which may enter the secondary system via a condenser leak are adequately removed prior to the condensate being sent to the steam generators.

Conclusions

Cooling pond water quality itself is not relevant to steam generator tube corrosion. This is because the cooling pond water does not flow through the steam generators under normal operating conditions. In the event that condenser in-leakage were to occur, the Midland Plant's design features and procedures are adequate to meet the B&W minimum standards for secondary system water quality and thus, minimize steam generator tube corrosion.

In the unlikely event that cooling pond water were to be introduced into the steam generators by means of emergency actuation of the AFW system, the plant can be safely shut down. Appropriate actions would be taken prior to restarting the unit to ensure the integrity of the steam generators.

Thus, there is reasonable assurance that corrosion of the steam generator tubes does not depend on cooling pond water chemistry; therefore, the NRC can make the findings required by 10 CFR 50.57(a)(3)(i) and 50.57(a)(6).

~~PRIVILEGED AND CONFIDENTIAL~~

ATTACHMENT A

Res..e of Cris Hillman

Education and Training

1977	Bachelor of Science in Chemical Engineering: Michigan State University
1979	AICHE Today Series; Industrial Water Conditioning - 1.4 CEU credits
	Nuclear Steam Supply Technical Training, Babcock & Wilcox - 6 hours
	Mechanalysis Course (Vibration Testing), IRD - 16 hours
1980	Principles of Supervision, Consumers Power Company - 40 hours
1981	Radiochemistry for Supervisors, Babcock & Wilcox - 40 hours
	Human Aspects of Management, Consumers Power Company - 20 hours
1982	Westinghouse PWR Chemistry Course, Westinghouse - 5 weeks

Experience

1977-1978	Graduate Engineer, Palisades Nuclear Plant, Consumers Power Company. Worked on various projects during refueling outage.
1978	Associate Engineer, Palisades Nuclear Plant. Worked for Plant Chemical Engineer (Palisades). Duties included support of demineralizer operations and operator training on makeup demineralizer.
1978-1980	Associate Engineer, Midland Project Testing. Responsible for development and implementation of acceptance test procedures.
1980	Associate Engineer, B C Cobb Steam Plant. Trouble shoot and increase reliability of new demineralizer system.
	Associate Engineer, Midland Project Testing. Responsible for overall preparation and coordination of startup chemistry program including the writing of a startup chemistry manual. Responsible for startup and operation of plant makeup demineralizer system.
1980-Present	Chemical Engineer, Midland Nuclear Plant. Responsible for directing plant chemistry staff activities such as startup chemistry support, budget preparation, chemistry procedure preparation and review, and technical support for chemistry related activities.

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~~PRIVILEGED AND CONFIDENTIAL~~

ATTACHMENT B

Resume of Terry Postlewait

Position	Staff Engineer, Midland Nuclear Plant Project, Design Production Department, Mechanical/Nuclear Section
Education	University of Toledo, 1970, BSME

Experience

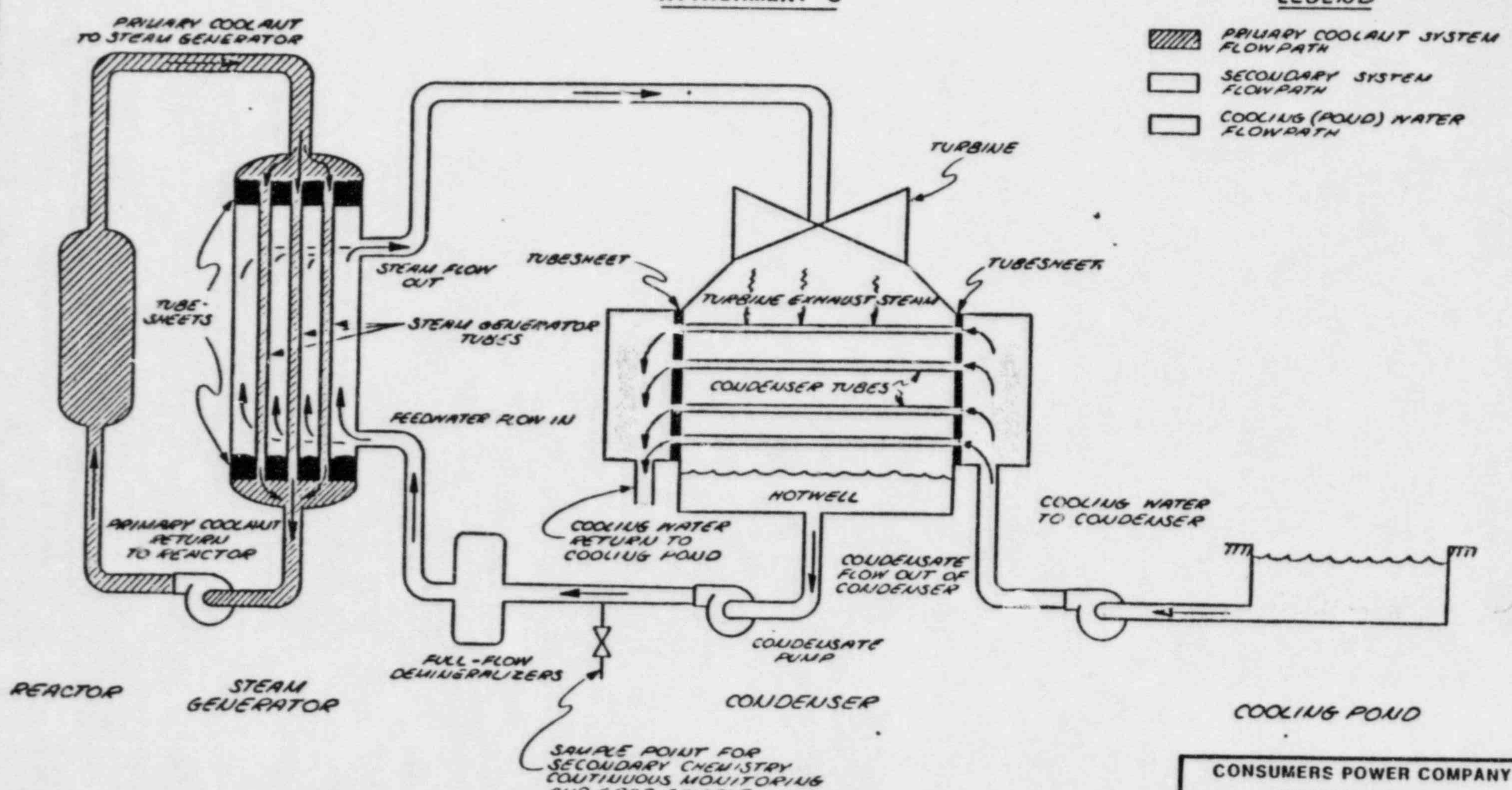
Apr - Present 1980	Joined the Midland Project as a Senior Engineer in the Design Production Department. Duties include assistance to Safety & Licensing Department, review of design of mechanical systems, resolution of problems, commenting on development of specifications, procedures and drawings and as-needed assistance to engineering and field personnel. In June of 1982, promoted to Staff Engineer and involved with additional duties such as coordinating Design Production Department assistance to field activities involving completion/turnover of systems, participation in program to control design changes and assistance to Safety & Licensing Department in developing and administering the Spatial Systems Interaction Program and in efforts to obtain NPDES Permit and finalize the Midland Plant Environmental Statement.
Aug - Apr 1977 1980	Consumers Power Company Senior Engineer - Responsible for reviewing design of new, and modification to existing, power plants. Primarily involved with review of mechanical design of Midland Units 1 & 2. In December 1977, also assumed the duties of Project Engineer for completion of D E Karn Plant, Units 3 & 4 and modification work on Karn Unit 4 cold reheat piping to solve excessive noise and vibration problem.
Feb - Aug 1975 1977	Alyeska Pipeline Service Company Rotating Equipment Engineer - Assigned to the tanker loading terminal for the Trans-Alaskan pipeline. Duties included reviewing mechanical design, monitoring the contractor to ensure proper installation and alignment of rotating equipment, startup problem assistance and field design changes.
1971 - 1975	Consumers Power Company Associate & General Engineer - Duties included review of mechanical design for new nuclear and fossil generating units including specifications, bids and bid evaluations, QA requirements, witnessing performance tests and preoperational test reviews. Was primarily associated with review of mechanical design of D E Karn Plant 3 & 4.

1965 - 1971	Surface Combustion Division, Midland Ross Corporation Technician and Design Engineer - Worked 1965 - 1970 as mechanical lab technician in development of steel and glass pelletizing processes, industrial heat treating furnaces and burners. Upon obtaining my BSME degree in 1970, worked as design engineer responsible for design and drafting on heat treating furnaces.
1965	Johns-Manville Laboratory Technician - Worked in R&D section developing fiberglass products and related manufacturing equipment.
1964 - 1965	Stauffer Chemical Company Chemical Laboratory Technician Performed qualitative analyses for on-line chemical processes.
1963 - 1964	Toledo-Beaver Tools Equipment Operator - Operated lathes, drill presses and mills in the production of pipe cutting and threading tools.

Additional Training

June 1977	Attended training on machinery vibration detection, analysis and balancing given to IRD Mechanalysis, Inc
June - Dec 1978 1982	Attended five courses on Programmatic Quality Assurance Training for the Midland Project
June 1978	Attended Technical Seminar on machinery vibration given by Mechanical Technology, Inc
May 1979	Attended Seminar on piping design given by Teledyne Engineering
Jan 1981	Attended one week training course on the B&W simulator

ATTACHMENT C



CONSUMERS POWER COMPANY MIDLAND PLANT
SIMPLIFIED SKETCH FOR SINCLAIR CONTENTION 4
TKP 1/10/83

RESUME OF WILLIAM BECKMAN

13A.2.6 CHEMISTRY/HEALTH PHYSICS SUPERINTENDENT

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Education and Training

1967:	Bachelor of Science in Chemistry: Fairfield University, Fairfield, Connecticut
1971:	Naval Officer Candidate School, Newport, Rhode Island U.S. Navy - 6 months
1972:	Naval Nuclear Power School, Bainbridge, Maryland - 6 months
	Nuclear Power Training Unit, S1C Prototype, Windsor, Connecticut U.S. Navy - 6 months
1973-1975:	Various Service Schools
1976:	QA Indoctrination Workshop, Consumers Power Company - 3 days
1977:	Radiochemistry for Supervisors, Babcock & Wilcox - 10 days
	Principles of Supervision, Consumers Power Company - 5 days
1978:	Human Aspects of Management, Consumers Power Company - 5 days
1979:	Principles of Data Processing and FORTRAN Programming, Delta College - 4 credits
	Public Presentation Skills Course, Central Michigan University - 30 hours
	Principles of Leadership Effectiveness, Consumers Power Company - 3 days
1980:	Techniques of Supervision, Consumers Power Company - 5 days
	Managerial Economics, Consumers Power Company - 5 days
1981:	Annual Short course on Radiation Protection, University of Michigan - 10 days
	Selected Topics in Reactor Health Physics, HP Society, 1981 summer school, University of Kentucky - 5 days
	Effective Management, Consumers Power Company - 4 days

39

Experience

1967-1971: Senior Sales Engineer, Stero Polymers, Goodyear Chemical Division, Goodyear Tire and Rubber

1971-1972: Attended various Service Schools, U.S. Navy

1972-1973: Qualified Engineering Officer of the Watch on S1C reactor plant, Windsor, Connecticut

1973-1975: Engineering Officer of the Watch, responsible for watch supervision and overall safe operation of S5W reactor plant - 32 months 39

1973-1974: Main Propulsion Assistant and Radiological Controls Officer, USS John C. Calhoun SSBN 630B. Duties included supervision of nuclear plant mechanical maintenance radiation protection, chemistry, and radiochemistry - 24 months

1974-1975: Electrical Officer and Sonar Officer, USS John C. Calhoun SSBN 630B. Duties included supervision of nuclear plant electrical maintenance - 8 months 43

1975-1976: General Engineer, Chemistry Department, Palisades Nuclear Plant (CE PWR), Consumers Power Company. Duties included design and implementation of plant modifications and preparation of chemistry procedures - 9 months

1976: General Office, Palisades Nuclear Plant, coordinated and scheduled refueling outage - 6 months

1976-1977: General Engineer, Midland Nuclear Plant. Duties included design reviews of plant systems with respect to chemistry, environmental, and radiological considerations 39

1977-1979: Chemical Engineer, Midland Nuclear Plant. Responsible for development of the Chemistry/Radiochemistry Department. Duties expanded for 9 months in 1977 to include supervision of the environmental and radiation protection programs

1980-Present: Chemistry/Health Physics Superintendent, Midland Nuclear Plant 43 39

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of)
CONSUMERS POWER COMPANY)
(Midland Plant, Units 1 & 2))

Docket Nos. 50-329 OM
50-330 OM

Docket Nos. 50-329 OL
50-330 OL

TESTIMONY

OF

DR. RICHARD D. WOODS

ON BEHALF OF THE APPLICANT

REGARDING SEISMIC SHAKEDOWN

SETTLEMENT AT THE MIDLAND SITE
(EXCEPT DIESEL GENERATOR BUILDING)

SS: STATE OF MICHIGAN
COUNTY OF WASHTENAW

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of)) CONSUMERS POWER COMPANY) (Midland Plant, Units 1 & 2))	Docket Nos. 50-329 OM 50-330 Docket Nos. 50-329 OL 50-329 OL

AFFIDAVIT OF RICHARD D. WOODS

Richard D. Woods being duly sworn, deposes and says that he is the author of "Testimony of Richard D. Woods concerning Seismic Shakedown Settlement at the Midland Site except Diesel Generator Building," and that such testimony is true and accurate to the best of his knowledge and belief.

Richard D. Woods
RICHARD D. WOODS

Sworn and Subscribed Before Me this 14 Day of January, 1983

Beverly A. Bross
Notary Public
Washtenaw County, Michigan

My Commission Expires BEVERLY A. BROSS, Notary Public WASHTENAW COUNTY - MICHIGAN MY COMMISSION EXPIRES 10-26-85

1.0 BIOGRAPHICAL INFORMATION

This is the testimony of Dr. Richard D. Woods. My detailed resume is attached. The following is a summary of that resume. I received a Bachelor of Science degree in Civil Engineering from Notre Dame University in 1957 and a Master of Science degree from the same school in 1962. I worked for the Air Force Weapons Center, Albuquerque, New Mexico, on the design of blast resistant underground structures for one year and taught in the Civil Engineering Department at Michigan Technological University for one year before going to the University of Michigan for a Ph.D. in Civil Engineering, which I received in 1967. Since then I have been on the faculty of the Department of Civil Engineering at the University of Michigan, advancing to full Professor in 1976. My research interests have been in the field of soil dynamics and earthquake engineering. I have done part-time consulting in the fields of soil dynamics, earthquake engineering, structural vibrations, and general foundation engineering. My clients have included Bechtel, Corning Glass Works, Rockwell International, Eaton Corporation, TAMS, General Motors, Honeywell Inc., Woodward-Clyde Consultants, and Nuclen (Nuclear Brazil). I have directed research associated with dynamic soil properties and foundation vibrations. I am a principal in the foundation consulting firm of Stoll, Evans, Woods, and Assoicates, Ann Arbor, Michigan and am a member of ASCE, ASEE, ASTM, and SSA.

2.0 INTRODUCTION

My testimony is concerned with the evaluation of the potential for shakedown settlement of loose sands in the plant area at Midland (except the Diesel Generator Building). The shakedown settlement was evaluated using a method based on blow count and results of an experimental study on the behavior of sands under seismic loading by Silver and Seed (1969). The maximum ground acceleration was assumed to be 0.19g and 10 cycles of shearing strain reversal were considered. On the basis of my analysis and the proposed remedial measures being taken in the plant area, I have concluded that there is reasonable assurance that the plant area including piping and duct banks will not suffer excessive settlement due to seismic shakedown.

3.0 DISCUSSION

When earthquake excitation is a part of the design loads for a construction site, the potential for shakedown must be evaluated. Shakedown settlement is a phenomenon by which loose, clean cohesionless soils densify due to ground shaking. Soils of this type which have been deposited in a loose condition tend to undergo a redistribution of particle packing when shaken until a condition of minimum potential energy is achieved. The redistribution of particle packing causes a reduction in the bulk volume of the soil, thereby causing a potential for settlement of the ground surface and ..ructures built on the surface or buried in the soil mass.

Whether or not a specific sand formation will undergo shakedown settlement is dependent upon characteristics of the soil and factors associated with the earthquake which causes shaking. Among the soil characteristics which influence the shakedown behavior are: grain size distribution, grain shape and relative density. Uniform grain size, rounded, loose sands are most susceptible to settlement due to shaking. Sands with wider grain size distributions and with more angular individual grains are less susceptible to shakedown settlement. Sands with high initial relative densities are less susceptible to shakedown settlement than sands with low initial relative densities.

Characteristics of the earthquake which influence the potential for and magnitude of shakedown settlement are the maximum ground acceleration and the number of cycles of shearing strain.

Pockets of sand which have a potential for shakedown settlement exist at several locations at the Midland site. Some areas occur under or near Category I structures while others are distributed throughout the plant area where pipelines and duct banks are buried.

4.0 EVALUATION OF SHAKEDOWN SETTLEMENT

Silver and Seed (1969) published the results of an experimental study of the settlement of dry sand subject to seismic loading conditions. The results of this study are appropriate for a conservative evaluation of shakedown potential because sand in the dry state is most susceptible to shakedown settlement. If some moisture occurs in the sand, apparent cohesion is present and this reduces the potential for shakedown. If sufficient water is present in the soil, the danger becomes that of liquefaction potential not shakedown and liquefaction potential has been addressed in other testimony.

To make use of the Silver and Seed (1969) study, the shear stress in the sand pocket under investigation due to the SSE is estimated from an equation based on Seed and Idriss (1971):

$$\tau = 0.65 \frac{a_{max}}{g} \sigma_v \qquad (1)$$

in which:

τ = shear stress

a_{max} = maximum acceleration associated with earthquake

g = acceleration of gravity

σ_v = total vertical stress

Then a trial shear modulus is selected based on an assumed shearing strain and relative density from the curves proposed by Seed and Idriss (1970), Figure 1.

The shear strain is then computed from:

$$\gamma = \frac{\tau}{G} \qquad (2)$$

in which:

γ = shear strain

τ = shear stress

G = shear modulus

Succesive corrections are applied to the trial G until the shear strain for which G was selected and the shear strain from eq (2) are in reasonable agreement. The relative density of the sand pocket is estimated from standard penetration blow counts. Using relative density and the magnitude of shear strain for which agreement was found above, the vertical strain due to 10 cycles of loading is estimated from the Silver and Seed curves, Figure 2.

Shear strain from Figure 2 is then multiplied by the thickness of the deposit to obtain an estimate of the shakedown settlement due to one-dimensional shaking. This settlement is multipled by three to obtain a conservative estimate of three dimensional shaking as suggested by Pyke et al (1975).

The settlement of all pockets occuring along any vertical profile and below any category I structure conduit or pipe are summed up to estimate the local shakedown settlement.

5.0 RESULTS OF SHAKEDOWN SETTLEMENT INVESTIGATION

Sands for which there is a potential for shakedown settlement occur in only five areas for this testimony (one additional area, the diesel generator building, is covered by separate testimony). These areas are shown on Figure 3 and are categorized as : Borated water storage tank area; railroad bay area of the auxiliary building; diesel fuel storage tanks; underground piping areas; and retaining walls area.

5.1 Borated Water Storage Tanks

No potential exists for shakedown settlement under the borated water storage tanks because the soil under these tanks is clay. Furthermore, the sand within the ring foundation has been compacted to a relative density greater than 80% for which no significant shakedown settlement will occur.

5.2 Railroad Bay

Three borings in the railroad bay area of the auxiliary building show pockets of sand. The maximum settlement due to shakedown was estimated to be 0.25 inch. The maximum differential settlement also would be about 0.25 inch because some portions of the same building are founded on till which will not settle due to shakedown.

5.3 Diesel Fuel Storage Tanks

One boring in the diesel fuel storage tank area showed pockets of sand. The maximum shakedown settlement which would occur based on that boring amounts to about 0.10 inch, and relative to a point which does not settle at all amounts to a differential settlement of the same magnitude. These shakedown settlements present no hazard to the diesel fuel storage tanks.

5.4 Underground Piping and Conduits

An inspection of the borings throughout the regions where underground piping and duct banks are buried shows that the worst situation, i.e. thickest sand deposits, occur near the SWPS. Remedial measures are planned for this area which call for removal of loose material to elevation 610 and replacement with suitable material. The potential for shakedown settlement below elevation 610 near the SWPS is small because of limited thickness of loose sand. Category I piping and duct banks in other parts of the site have been evaluated for shakedown settlement by studying the boring logs near and under these lines. By comparison with areas for which shakedown settlement was computed for other structures, it was concluded that the areas under piping and duct banks will experience shakedown settlements of no more than 1/4 inch.

5.5 Retaining Walls

Category I retaining walls are located northeast of the SWPS. Two other non-category I retaining walls are located south of the CWIS. Foundations for these retaining walls are located at elevations 595 and 611. Only loose sand below foundation levels are of concern for shakedown settlement and twelve borings in the region of the retaining walls showed that there is no loose sand under the retaining wall foundations. Shakedown settlement for these structures will be negligible.

6.0 SUMMARY AND CONCLUSION

Limited pockets of loose natural sand and loose fill sand exist in the plant area and under the railroad bay of the auxiliary building. The potential for and magnitude of earthquake shakedown settlement of these sands has been evaluated. An earthquake with a maximum acceleration of 0.19g and 10 cycles of shear strain has been used in this evaluation.

In some areas near the SWPS remedial measures will eliminate the potential for shakedown settlement. For loose sand pockets in other areas, the magnitude of shakedown settlement has been estimated and found to be 1/4 inch or less.

For an SSE of .12g the shakedown settlement would be about 50% of that reported here.

7.0 REFERENCES

1) Pyke, R; Chan, C.K. and Seed, H.B. (1974), "Settlement and Liquefaction of Sands Under Multi-Directional Shaking," Report No. EERC 74-2, Earthquake Engineering Research Center, University of California, Berkeley, February.

2) Seed, H.B. and Idriss, I.M. (1970), "Soil Modulus and Damping Factors for Dynamic Response Analysis," Earthquake Engineering Research Center, University of California, Berkeley, December.

3) Seed, H.B. and Idriss, I.M. (1971), "Simplified Procedure for Evaluating Soil Liquefaction Potential," Journal of the Soil Mechanics and Foundation Division, Proceedings ASCE, Vol. 95, No. SM9, Sept., pp. 1249-1272.

4) Silver, M.L. and Seed, H.B. (1969), "The Behavior of Sands Under Seismic Loading Conditions," Report No. EERC 69-16, Earthquake Engineering Research Center, University of California, Berkely, December.

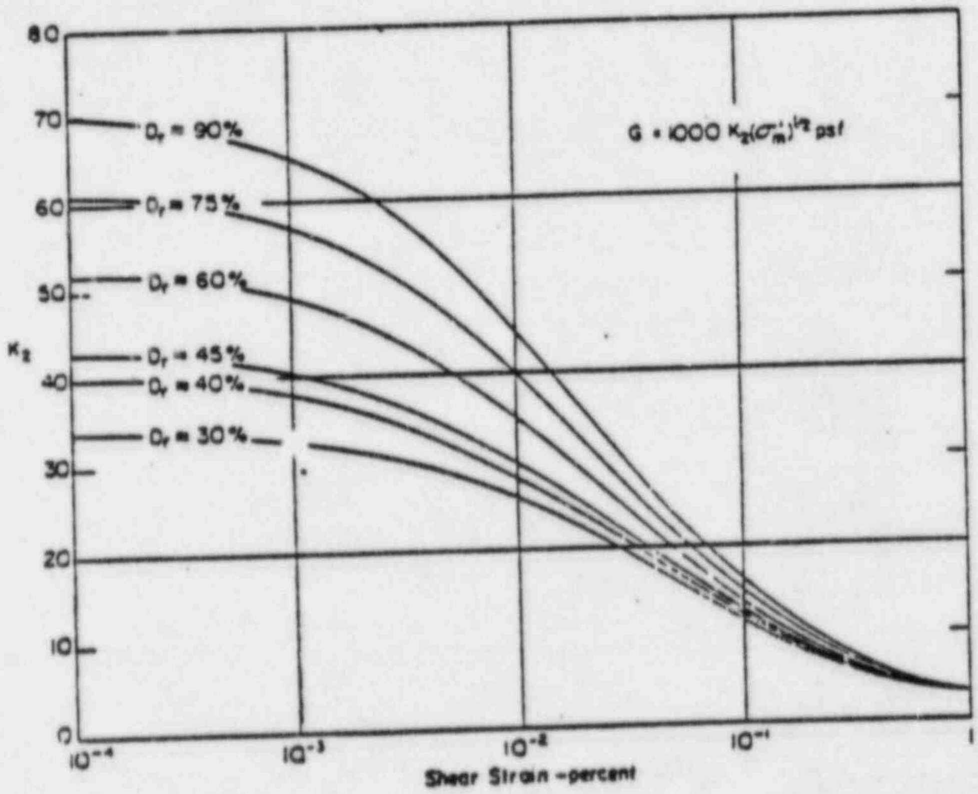


Fig. 1 SHEAR MODULI OF SANDS AT DIFFERENT RELATIVE DENSITIES.
(from Seed and Idriss, 1970)

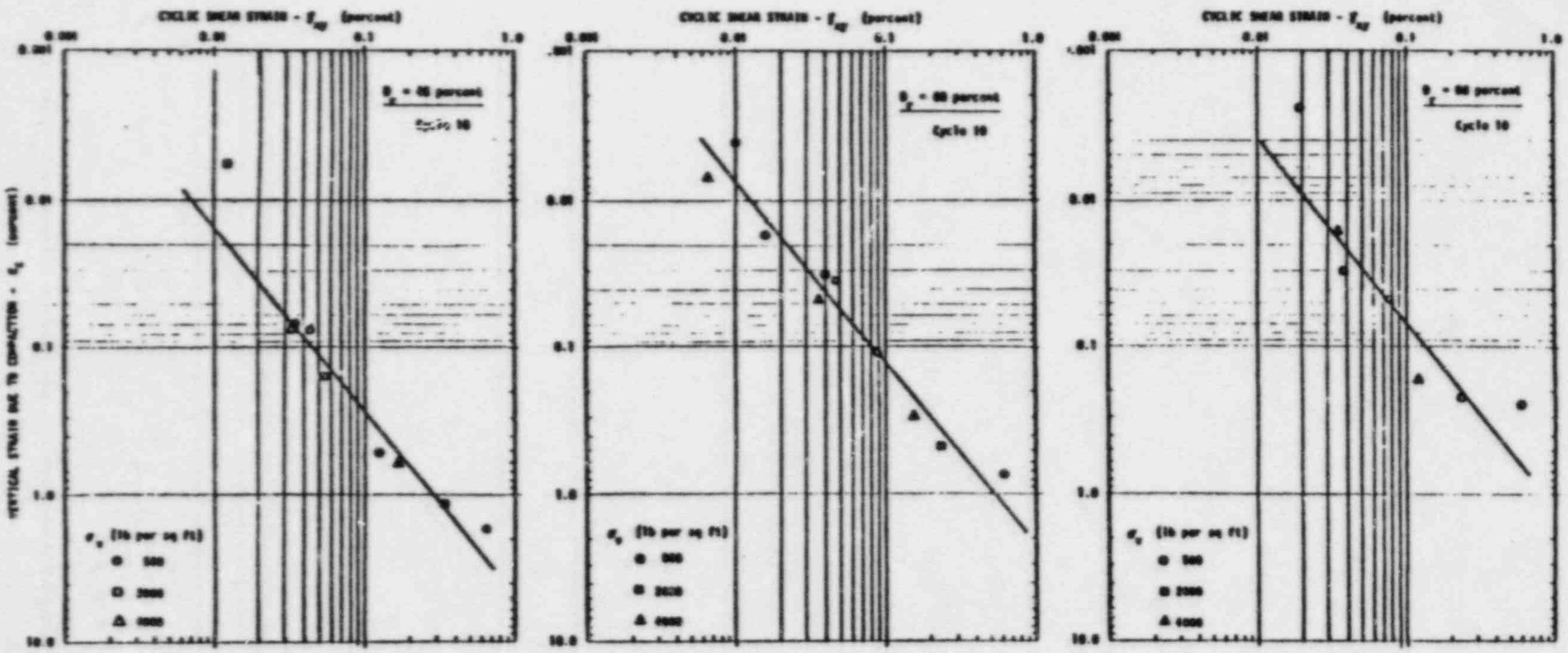
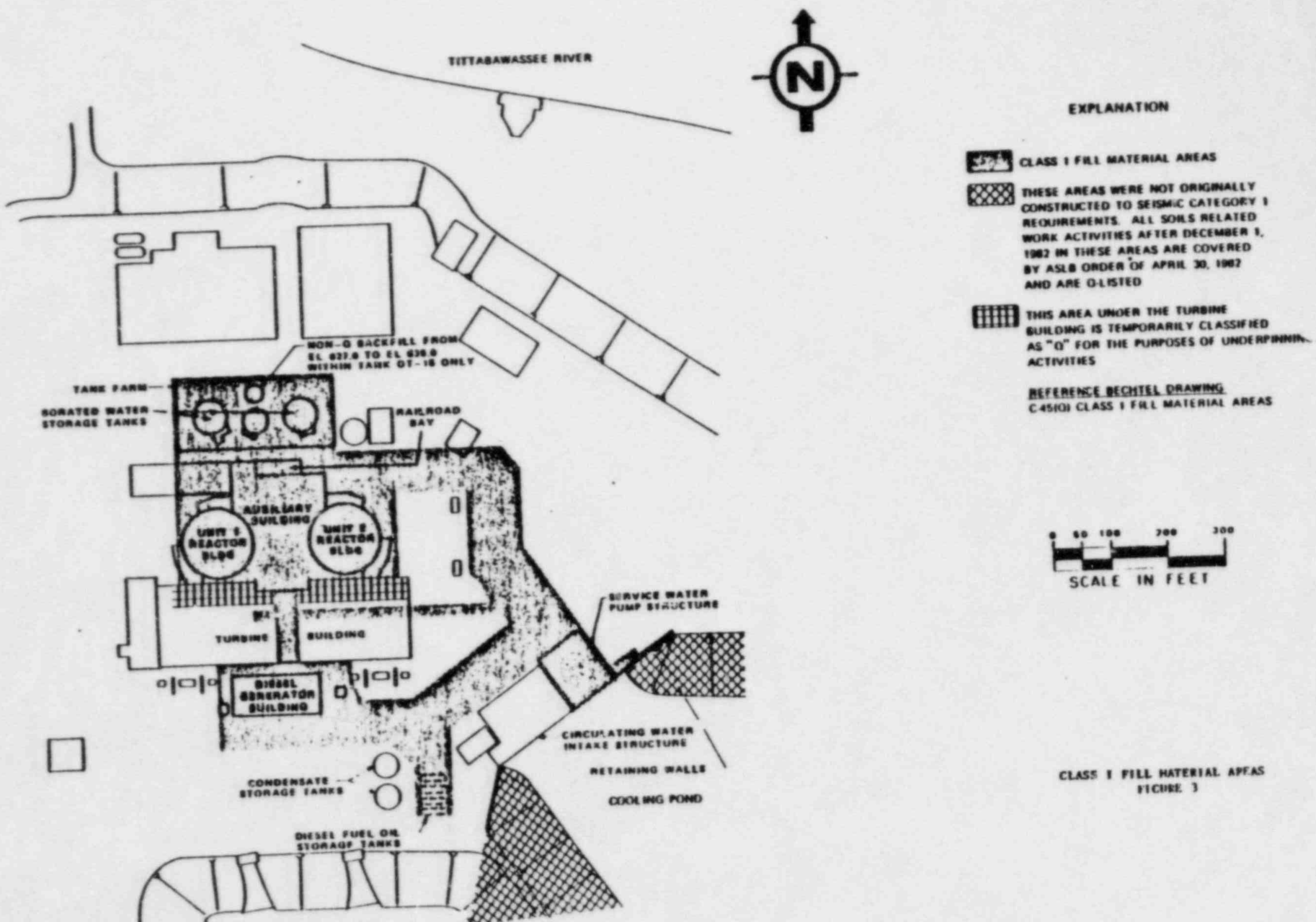


Fig. 2 Effect of Confining Pressure on Settlement in Ten Cycles (from Silver and Seed, 1969)



CLASS I FILL MATERIAL AREAS
FIGURE 3

RICHARD D. WOODS, Ph.D., P.E.
Professor of Civil Engineering
University of Michigan

RÉSUMÉ

RICHARD D. WOODS, Ph.D., P.E.

Professor of Civil Engineering
University of Michigan

August, 1980

Home

700 Mt. Pleasant
Ann Arbor, MI 48103
(313) 769-4352

Office

2322 G. G. Brown Lab
University of Michigan
Ann Arbor, MI 48109
(313) 764-4303

PERSONAL DATA

Age:	45, born U.S. citizen
Physical:	Height 6'; weight 220 lb
Health:	Excellent
Military:	U.S. Marines
Married:	Wife, Dixie Lee (Davis)
	Daughter, Kathleen Ann, age 23
	Daughter, Cecilia Marie, age 15
	Daughter, Karen Teresa, age 12

EDUCATION

High School, J. W. Sexton, Lansing, Michigan, 1953
B.S. Civil Engineering, University of Notre Dame, 1957
M.S. Civil Engineering, University of Notre Dame, 1962
Introductory (non-degree) Course, ASEE-AEC Basic Institute in Nuclear Engineering, North Carolina State College, 1964
Ph.D. Civil Engineering, University of Michigan, 1967

ORGANIZATIONS

American Society of Civil Engineers
American Society for Testing and Materials
American Society for Engineering Education
Chi Epsilon
Society of the Sigma Xi
Seismological Society of America

AWARD

Collingwood Prize of American Society of Civil Engineers, 1969

EMPLOYMENT (Full Time)

1976 to Present	Professor, Civil Engineering, University of Michigan. Courses taught: Basic Soil Mechanics, Field Sampling and Laboratory Testing of Soils, Foundation Engineering, Soil Dynamics, Civil Engineering Dynamics Measurements, Plane Surveying, Statics and Strength of Materials, Reinforced Concrete. Research performed: See separate paragraph below.
1971 to 1976	Associate Professor, Civil Engineering, University of Michigan. Courses taught: Included above.
1967 to 1971	Assistant Professor, Civil Engineering, University of Michigan. Courses taught: Included above.
1965 to 1967	Graduate Student, University of Michigan, supported on NSF Traineeship.
1964	Instructor, Civil Engineering, Michigan Technological University, Houghton, Michigan. Courses taught: Included above.
1963	Project Engineer (GS-11), Air Force Weapons Laboratory, Kirtland, AFB, Albuquerque, N.M. Supervised contracts which were directed at determining engineering properties of soils under dynamic loads.
1960 to 1962	Graduate Student, University of Notre Dame, teaching assistantship, taught surveying camp.
1957 to 1960	Lieutenant, U.S. Marine Corps, Camp Pendleton, California. Six months as platoon leader, movable bridge company. Remainder of service as hydraulic engineering officer preparing evidence for water rights litigation.

EMPLOYMENT (Short Courses and Special Appointments)

1976 Fugro Fellow, University of Florida. On sabbatical leave from University of Michigan. Investigating use of static cone penetrometer with built-in pore pressure transducer to predict liquifaction potential of sands.

1974 Invited Author for Chapter on Soil Dynamics for U.S. Army Corps of Engineers Soils Manual, with F. E. Richart.

1973 Invited Lecturer, Woodward-Clyde Consultants Symposium, Berkeley. Topic: "Seismic Methods to Measure Shear Wave Velocity of Soils and Rock."

1973
1972 Taught Extension Courses (evening), "Applications of Soil Mechanics to Foundation Engineering," 2-10 week lecture series for Commonwealth Associates, Jackson, Michigan.

1972 Visiting Professor, Institute for Soil and Rock Mechanics, University of Karlsruhe, Germany. Taught Soil Dynamics and helped establish soil dynamics laboratory. Research on propagation of Rayleigh Waves in region of obstacles.

1971 Visiting Professor, Indian Institute of Technology, Kanpur, India. Helped establish basic soil dynamics laboratory and field measurements capability.

1971 Invited Lecturer, Earthquake Engineering Seminar, University of Massachusetts, sponsored by National Science Foundation. Lectures on basic vibrations, wave propagation and dynamic soil properties.

1970
1969 Chairman and Principal Lecturer, two 2-day short courses, "Behavior of Soils for the Construction Industry, Continuing Engineering Education Program, College of Engineering, University of Michigan.

1968 Co-Chairman and Lecturer, Two-week short course, "Vibration of Soils and Foundations," Continuing Engineering Education program, College of Engineering, University of Michigan. Lectures on basic vibrations, wave propagation and field and laboratory measurements.

RESEARCH

At University of Michigan

Holographic Interferometry - Investigation of basic wave propagation and surface wave propagation in region of barriers.

Response of Pile Foundations to Dynamic Loads - with F. E. Richart.

Dynamic Properties of Soils - Laboratory and field measurement of compression and shear wave velocity and shear modulus of soils at both low and high amplitudes.

Isolation of Earthwaves by Barriers - Study of effectiveness of trenches and cylindrical holes at screening waves.

Dutch Static Cone Penetrometer - Study of use of penetrometer for identification of soils.

At Michigan Technological University

Mechanics of Slide Dams - Investigation of creation of dams by blasting material from canyon walls

At Notre Dame University

Preliminary Design of Dynamic Direct Shear Device

CONSULTING EXPERIENCE

Areas of Consulting

Vibration Measurements - on machines, in soil, on structures

Measurement of Dynamic Soil Properties, in lab and in field

Stability of Soil Masses (Reserve Mining tailings delta)

Analysis and Design of foundations for dynamic loads

Site Investigations with Dutch, cone penetrometer

Blasting Damage Evaluations

Blasting Code Drafting

Seismic Site Investigations

Principal Clients

Bechtel Power Corporation, Ann Arbor, Michigan

Attorney General, State of Michigan (Reserve Mining Case)

CONSULTING EXPERIENCE--*Continued*

Giffels and Associates, Detroit, Michigan

Smith, Hinchman and Grylls, Detroit, Michigan

City of Rockwood, Michigan

City of Ann Arbor, Michigan

Honeywell Corporation, Minneapolis, Minnesota

Woodward-Clyde Consultants, Orange, California, Oakland, California and Philadelphia, Pennsylvania

Halpert, Neyer Associates, Farmington, Michigan

U. W. Stoll and Associates, Ann Arbor, Michigan

Eaton Brake Division, Detroit, Michigan

Tippetts-Abbett-McCarthy-Stratton, New York (Tarbela Dam)

Site Engineers, Inc., Cherry Hill and Montclair, New Jersey

Corning Glass Works, Corning, N.Y. and three other plants

PUBLICATIONS AND REPORTS

Woods, R. D. (1963), "Preliminary Design of Dynamic-Static Direct Shear Apparatus for Soils and Annotated Bibliographies of Soil Dynamics and Cratering," Air Force Weapons Laboratory, RTD-TDR-63-3050.

Woods, R. D., Reddy, P. D. and Young, G. A. (1964), "Study of the Mechanics of Slide Dams with Distorted Models, Progress Report," Contract 74-0030, Sandia Corporation, Albuquerque.

Woods, R. D. and Richart, F. E., Jr. (1967), "Screening of Elastic Surface Waves by Trenches," *Proceedings Symposium on Wave Propagation and Dynamic Properties of Earth Materials*, Albuquerque, N.M., August.

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Afifi, S. S. and Woods, R. D. (1971), "Long-Term Pressure Effects on Shear Modulus of Soils," *J. SMFD, Proc.* ASCE, Vol. 97, SM 10, Oct., pp. 1445-1460.

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Woods., R. D. and Sagesser, R. (1973), "Holographic Interferometry in Soil Dynamics," *Proceedings of the Eighth International Conference on Soil Mechanics and Foundation Engineering*, Moscow, August, Vol. 1, Part 2, pp. 481-486.

Woods, R. D., Barnett, N. E., and Sagesser, R. (1974), "Holography--A New Tool for Soil Dynamics," *J. GTD, Proc. ASCE*, Vol. 100, No. GT11, Nov., pp. 1231-1247.

Anderson, D. G. and Woods, R. D. (1975), "Comparison of Field and Laboratory Shear Moduli," *Proceedings of Conf. on In Situ Measurement of Soil Properties*, Raleigh, North Carolina, Vol. 1, June, pp. 69-92.

Anderson, D. G. and Woods, R. D. (1976), "Time-Dependent Increase in Shear Modulus of Clay," *J. GTD, Proc. ASCE*, Vol. 102, No. GT5, May.

Woods, R. D. (1976), "Foundation Dynamics," *Applied Mechanics Reviews, Proc. ASME*, Sept.

Woods, R. D. (1977), "Parameters Affecting Dynamic Elastic Properties of Soils," Proceedings of the International Symposium on Dynamical Methods in Soil and Rock Mechanics, Karlsruhe (F.R. Germany), September, Sponsored by NATO Scientific Affairs Division and the Institute of Soil Mechanics and Rock Mechanics, University of Karlsruhe.

Woods, R. D. (1977), " Lumped Parameter Models for Dynamics Footing Response," Karlsruhe (as above).

Woods, R. D. (1977), "Holographic Interferometry to Study Seismic Wave Isolation," Karlsruhe (as above).

Woods, R.D. (1978), "Measurement of Dynamic Soil Properties," Proceedings of the ASCE Geotechnical Engineering Division Specialty Conference, EARTHQUAKE ENGINEERING AND SOIL DYNAMICS, June 19-21, Pasadena, CA., Vol. 1, pp 91-178.

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Allen, N.F., Richart, F.E., Jr., and Woods, R.D. (1980), "Fluid Wave Propagation in Saturated and Nearly Saturated Sands," <u>Journal of Geotechnical Engineering Division</u>, <u>ASCE</u>, Vol. 106, No. GT 3, March, pp 235-254.

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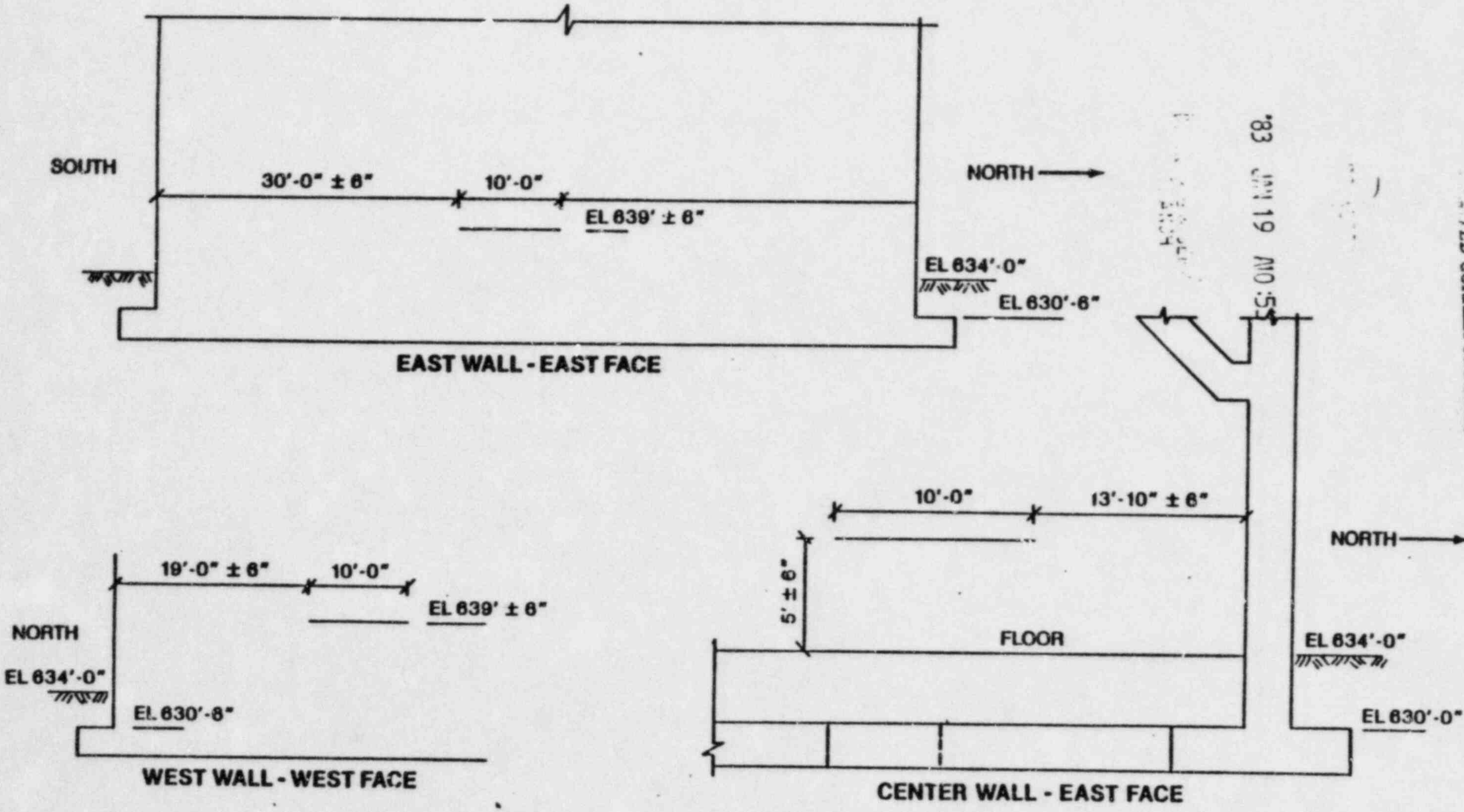
Woods, R.D. and Henke, R. (1981), "Seismic Techniques in the Laboratory," J. GTD Proc. ASCE, Vol. 107, No. GT 10, Oct.

Partos, A., Woods, R.D. and Welsh, J. (1982), "Soil Modification for Relocating Die Forging Operation," International Symposium on Grouting in Geotechnical Engineering, New Orleans, Feb.

Richart, F.E. Jr., and Woods, R.D. (1982), "Foundations for Auto Shredders", Proceedings of International Conference on Soil Dynamics and Earthquake Engineering, Southampton England, July 13-15, Vol. 2, pp.811-824.

EXHIBIT
NO. 29R

MIDLAND NUCLEAR PLANT
DIESEL GENERATOR BUILDING
AREAS FOR CRACK WIDTH MONITORING
DURING THE OPERATION OF THE PLANT



MIDLAND NUCLEAR PLANT

DIESEL GENERATOR BUILDING

AREAS FOR CRACK WIDTH MONITORING

DURING THE OPERATION OF THE PLANT

At the locations indicated by sketch, Applicant Exhibit No 29R, the applicant will monitor widths of cracks along a horizontal line as shown.

This horizontal line will be picked as close as possible to the existing horizontal reinforcing bar in the near face of the wall.

1. <u>Frequency of Monitoring</u>

   Once every year during operation of the power plant for five years and at five year intervals thereafter.

2. <u>Acceptance criteria</u>

   a. Alert Limits:

      1. Any one of the crack monitored reaching a crack width of 50 mils. (0.050 inches)

      2. In 10 feet of gage length, the summation of the increase in crack widths reaching 150 mils. (0.150 inches)

   b. Action Limits:

      1. Any one of the crack monitored reaching 60 mils. (0.060 inches)

      2. In 10 feet of gage length, the summation of increase in crack widths reaching 200 mils. (0.200 inches)

In measuring the widths of the cracks there will be a tolerance limit of (plus) +5 mils. (+0.005 inches)

The definition of Alert and Action Limits are similar to those defined in Staff'sTestimony, SSER 2 Page 2 - 48 under Article No 2.5.4.6.1.2 and testimony of Dr Steve Poulos during SWPS hearing.

FV/mfm

mi0183-3569a112

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket Nos. 50-329-OM
CONSUMERS POWER COMPANY	)	50-330-OM
	)	50-329-OL
(Midland Plant, Units 1 and 2)	)	50-330-OL

TESTIMONY OF B. JOHN GARRICK AND LOUIS S. GIBSON CONCERNING THE ANALYSIS OF CLASS 9 ACCIDENTS IN THE MIDLAND FES

This is the testimony of B. John Garrick and Louis S. Gibson. Dr. Garrick is a principal of Pickard, Lowe and Garrick, Inc. and has been retained by Consumers Power Company as a consultant in the area of risk analysis for the Midland facility. Dr. Garrick's resume outlining his professional and educational qualifications is Attachment 1 to this testimony.

Mr. Gibson is employed by Consumers Power Company as the Section Head of the Nuclear Safety and Analysis Section of the Midland Project Safety and Licensing Department. He is responsible for the nuclear safety analysis for the Midland Plant including accident analysis, transient analysis and probabilistic risk assessment. Mr. Gibson's resume outlining his professional and educational qualifications is Attachment 2 to this testimony.

INTRODUCTION AND SCOPE OF TESTIMONY

The purpose of this testimony is to address Mary Sinclair's Contention 13 (formerly revised new contention 3). This contention asserts that the Midland FES is inadequate because the NRC staff utilized, in assessing the potential environmental risk associated with severe accidents, the results of a rebaselined Reactor Safety Study ("RSS") analysis performed by the NRC rather than the preliminary results of NUREG/CR-2497 "Precursors to Potential Severe Core Damage Accidents: 1969-1979" published by the Nuclear Regulatory Commission (the "Precursor Study").

The assessment of the potential environmental risks resulting from accidents contained in section 5.9.4 of the Midland FES is utilized to satisfy the requirements of the National Environmental Policy Act of 1969 (NEPA) and NRC commission policy (45 FR 40101) for a reasoned consideration of the environmental risks (impacts) attributable to accidents. The results of the FES probabilistic assessment of severe accidents found in section 5.9.4.5(2) are utilized in section 5.9.4.6 as one of three justifications for the conclusion that the potential environmental impacts from accidents at Midland are small and that there are no special or unique radiological circumstances about the Midland site and environs that would warrant special mitigating features for the Midland Plant.

The other two reasons are:

(a) "the fact that considerable experience has been gained with the operation of similar facilities without significant degradation of the environment."

(b) "the fact that in order to obtain a license to operate the Midland facility, Consumers Power must comply with the applicable Commission regulations and requirements." The results of the environmental risk analysis are thereafter used as an input to the summary cost benefit analysis presented in chapter 6 of the FES.

The balance of this testimony is an evaluation of whether the conclusions regarding the potential environmental impacts from accidents at Midland as stated in FES sections 5.9.4.6 and 6.4.3 remain valid in light of the information contained in the Precursor Study.

DESCRIPTION OF PROBABILISTIC RISK ASSESSMENT
AND ITS USE IN NUCLEAR POWER PLANT ACCIDENT ANALYSIS.

Probabilistic risk assessment (PRA), as this term is used in this testimony, is the quantification of the frequency of occurrence of different levels of damage from accidents involving nuclear power plants. In principle, probabilistic risk analysis admits into consideration any scenario that can be conceived involving any number of simultaneous failures and physical processes. Component failure rate distributions are determined. Equipment reliability is calculated. Physical phenomena are evaluated. Finally, the probability of any accident with any number of safety system failures can be calculated along with the associated release of radioactive material. Probabilistic risk assessment is a logical approach to the evaluation of radioactive hazards from nuclear reactors. It attempts to quantify the likelihood of each possible release and, thereby, provides a means for comparing the risk of nuclear reactors with other public hazards and for identifying those components of the nuclear reactor system which most strongly affect that risk. The NRC Staff utilized elements of PRA in Chapter 5 of the FES as one basis for evaluating the environmental effects of severe accidents.

Interest in probabilistic safety analysis has evolved since the 1960s. Analysis techniques were borrowed from statisticians and reliability engineers and developed into detailed tools for predicting failure probabilities for large, complex power plant systems. In 1972, the U.S. Atomic Energy Commission undertook the Reactor Safety Study under Professor N. C. Rasmussen of MIT. This mammoth project (70 man-years and $4 million) took 3 years to complete and was definitely a turning point in the way we think about nuclear safety. It was clearly the most thorough investigation of reactor safety ever conducted and produced an enormous body of technical work that will influence safety analysis and understanding for years to come. It calculated the risk probabilities and consequences from the operation of 100 current design light water reactors in the United States.

The complete report demonstrated that it is possible to methodically analyze results for policymakers and analysts alike. The finished document formed a basis for thorough discussions of risk methodology; i.e., a center for criticism, review and improvement.

Though it is a seminal work, initially the Reactor Safety Study was widely criticized. Between release of a draft report in August, 1974, and the final version in October, 1975, comments were received from 87 organizations and individuals representing government, industry, "public-interest" groups, and universities. Many of these comments had a significant impact on the final report.

Congressional hearings on the Reactor Safety Study were held in 1976, "seeking from experts with disparate views assessments of the validity of the Reactor Safety Study's conclusions and the usefulness of the study as an aid to policymaking. Congress wanted to know how the study has increased our understanding of nuclear safety and how it might be improved upon." The study's directors and authors, representatives of many of the groups who had commented on the study, and other knowledgeable and interested people testified. Many criticized various aspects of the study, particularly its estimates of the uncertainty in specific results, but most reaffirmed that it was a valuable contribution to the understanding of nuclear risks.

The most complete and even-handed review of the Reactor Safety Study was conducted by the Risk Assessment Review Group chaired by Professor H. W. Lewis of the University of California, Santa Barbara. The group was organized by the NRC on July 1, 1977, at the request of Congressman Morris K. Udall, Chairman of the Committee on Interior and Insular Affairs, who had held hearings on the Reactor Safety Study. It was chartered to evaluate the achievements and limitations of that study, the peer comments on the study, and the state-of-the-art of risk assessment methodology and to advise the NRC on the use of such methods in the regulatory process. The Lewis report concluded that the fault tree/event tree methodology was sound. The authors of that report looked carefully into certain statistical questions and identified several areas where in their judgment there was a lack of mathematical rigor. On the other hand, the Lewis group agreed that the lack of mathematical rigor would have little effect on actual calculations.

The Lewis report was a competent technical review of the Reactor Safety Study. It provided constructive suggestions that would enhance future PRAs. The comments favorable to the Reactor Safety Study, particularly in regard to the basic methodology, more than offset the negative criticisms. While the list of criticisms was substantial, the "bottom line" seemed to be that the methodology was sound except in the area of the quantification of the uncertainty of the results. The observation on uncertainty has had a major influence on the methodology employed in current PRAs. It is important that neither the Lewis report nor the NRC disavowed the fault tree/event tree methodology; rather, both find the methodology sound and encourage its further use in the regulatory process.

Of course, the Reactor Safety Study, together with its thorough review, especially the Lewis review, provided an excellent background for further development of the PRA methodology. Contemporary full scope PRAs such as those performed on the specific Zion and Indian Point plants have further advanced the development of PRA techniques.

The result of these advancements is a much greater insight into the components of risk associated with the plants investigated. Perhaps the most important insight provided by the full scope risk studies is that the risk associated with nuclear power plant operation is quantifiable and it appears to be small. It is believed that the major breakthroughs in risk analysis methodology and the ability to identify contributors to risk have already occurred. The idea now is to apply the methods and fine tune the process. Most of the advances of the future should be in the quality of information supporting risk analysis, e.g., a better understanding of the physical processes following the onset of a damaged core.

Among the important observations from the major studies are the following:

* Public risk from nuclear power is less than the financial risk to the owner/operator of the plant. The evidence takes the form of a demonstration that nuclear plants are much more able to cope with a damaged core or even a meltdown than had been perceived. Thus, although the possibility of a meltdown remains an economic risk, the likelihood of a radioactive release threatening the public health is much smaller than had been thought previously.

* Sequences contributing to risk vary depending on the figure of merit adopted. Not only is there a difference between contributors to core melt frequency and to health risk, but there are even differences for different types of health risk.

* The risk studies have moved a long way toward dispelling the "China Syndrome" scenario. The evidence is very strong that basemat melt-through is not a failure mechanism that contributes to risk.

* Full scope PRAs have indicated the importance of a probabilistic treatment of such external events as earthquakes, fires, flood, and high intensity winds. In many cases, the external events are the major contributors to risk by virtue of the large uncertainties associated with their frequencies.

* The emphasis in newer plants on safety system train independence and separation criteria is not necessarily favorable to risk reduction. While such designs favorably impact such rare events as pipe ruptures, large fires, and extensive floodings, they make it more difficult to compensate for more frequently occurring failures. That is, the absence of crossties between systems denies access, for example, to alternate supplies of coolant water. Such limitations often turn out to be more important to risk.

THE ANALYSIS OF SEVERE ACCIDENTS IN THE MIDLAND FINAL ENVIRONMENTAL STATEMENT

The FES for Midland utilizes the RSS to analyze the probabilities of severe accidents. The RSS has been "re-baselined" for this purpose, as described in Appendix E to the FES. Risk estimates for severe accidents, early fatalities and latent cancers are made in the FES, and the overall conclusion of that document is that the environmental costs associated with radiological health impacts from severe accidents is "small". The remainder of this testimony discusses whether studies subsequent to the RSS, particularly the Precursor Study referred to in the contention, invalidate this overall conclusion.

THE "PRECURSOR STUDY"

The Precursor Study published by the U. S. Nuclear Regulatory Commission was in direct response to questions raised by the previously mentioned Lewis group. What the Precursor Study attempts to do is to make a calculation of the frequency of severe core damage (SCD, accidents in nuclear power plants as a whole. It does this by sorting through the Licensee Event Reports (LERs) for the period 1969-1979 and identifying incidents which it calls "precursors for potential severe core damage accidents." It then puts these precursors through a fairly elaborate event tree type calculation procedure and comes up with an SCD frequency of 1.7 to 4.5 $\times 10^{-3}$ per year. This has caused considerable stir, for this number is significantly higher than that calculated in many of the industry's probabilistic risk assessments. In particular, the RSS calculated a point estimate core melt frequency of 6×10^{-5}, a factor of almost 100 less. The key question then is whether the Precursor Study number invalidates the RSS and more generally the process of PRA. To examine this, let us paraphrase the methodology and line of argument of the Precursor Study. The essence of it boils down to the following:

> Up through 1979 we have had 432 years of reactor operation and one SCD accident; namely TMI. We have also had a number of "near misses"; e.g., Browns Ferry and Rancho Seco. We assign each of these near misses a "severity factor," which we get from the event trees. Adding these up we consider that the near misses all together are the equivalent of about one more SCD accident. So we consider that the statistical experience, through 1979, is about two SCD

events in 432 years which gives a frequency of $2/432 = 4.6 \times 10^{-3}$.

The way in which the Precursor Study handled the near misses can be subject to much criticism both on an engineering modeling basis (i.e., the details of the event tree/severity factor work) and on the basis of statistical logic (e.g., whether near misses should be counted at all). We consider much of this criticism to be valid. However, for our present purposes this is not a key issue. What is pertinent is that as of 1979 we experienced one SCD, TMI, in 432 years, whereas, RSS calculated a core melt frequency of one in 20,000 years. The question now is what does this experience tell us about the RSS, about PRA, and about nuclear safety in general.

Evaluating the RSS result, we would point out firstly that counting all free world power reactors, there is today about 1,500 plant years of experience. Thus, our statistical evidence is now 1/1,500 rather than 1/432. Secondly, the RSS result is for a different event than that analyzed in the Precursor Study, core melt rather than severe core damage. Severe core damage is a superset of, and a much more frequent event than, core melt. Thirdly, the RSS result is for one plant, Surrey, and cannot be used to quantify contributors to risk at any other specific plant.

With respect to the PRA process itself, we would note that what a PRA is, basically, is a way of calculating the frequency of compound events from the frequencies of the "elemental" events, which together make up the compound event. The way in which this is done is pure logic and as such is incontestible. Thus, PRA in general, in our view, is not called into question by the Precursor Study. In any particular application of PRA, however, there can, of course, be errors in logic or arithmetic.

With respect to this latter point, it is interesting to note that all three of the events identified as primary contributors to the estimated frequency of severe core damage in the Precursor Study (Three Mile Island, Browns Ferry, and Rancho Seco) involved human errors of commission events, which are inherently difficult to anticipate and predict. At Three Mile Island, cooling systems were mistakenly turned off by an operator; at Browns Ferry the initiating event was a fire accidentally caused by a technician; and at Rancho Seco, a light bulb dropped into a circuit assembly caused the failure of nonnuclear instrumentation. In particular, the Precursor Study finds that about 38 percent of all significant precursors involved human error of some kind. Thus, although its calculations of frequency should not be regarded as gospel, the Precursor Study does do a valuable service in calling attention to the human element in the incidents of the past. Recent policies of the Commission and the industry have put much attention on the human aspect of recator safety. Thus, assessment of risk today would include the substantial design and operational changes brought about by the three top-ranked events of the Precursor Study with a corresponding decrease in calculated risk. Indeed, the foreward to the precursor Study makes just that point.

CONCLUSION

From the foregoing discussion, it is apparent that PRA is an analytical tool which is useful in a variety of contexts. One use is that found in the FES, as a technique which will aid the NRC Staff in reaching a judgment as to the environmental effects of operating the Midland facility. Another use of PRA is to assist utility management in determining the contribution to risk of severe accident scenarios, keeping in mind that all NRC safety regulations have been satisfied. For this latter purpose, a site specific PRA, rather than the generic use of the RSS by the NRC in the Midland FES, must be conducted. Such a study is underway.

In contrast to the Midland site-specific PRA and other studies subsequent to the RSS, the Midland FES uses a generic risk study and point estimates, with a certain amount of "rebaselining", in order to draw the conclusion that the risk to the public, i.e. adverse radiological health effects, from potential accidents is "small". For the reasons given in the preceding sections, we believe that this conclusion is not invalidated by the Precursor Study and will be supported by the more definitive Midland PRA study now being conducted.

In addition, it should be emphasized that the results of the FES risk analysis are but one of the three bases relied on by the Staff in its evaluation of the effects of accidents at Midland. The other two bases for the Staff's conclusion are

(a) "the fact that considerable experience has been gained with the operation of similar facilities without significant degradation of the environment."

(b) "the fact that in order to obtain a license to operate the Midland facility, Consumers Power must comply with the applicable Commission regulations and requirements."

Finally, it is worthy of note that the collective actions taken to improve the safety of nuclear power plants as a result of the investigations of the TMI accident and other events have reduced the risk of severe accidents identified in both the RSS and the Precursor Study. Recently published PRAs that reflect the latest methodology and modifications made in response to the TMI event demonstrate that the risk to the public has been reduced and is sharply lower than was previously believed.

B. JOHN GARRICK

EDUCATION

Ph.D., Engineering, University of California, Los Angeles, 1968.
M.S., Engineering, University of California, Los Angeles, 1962.
B.S., Physics, Brigham Young University, 1952.
U.S. Atomic Energy Commission Grant-in-Aid, Oak Ridge School of Reactor Technology, 1954-1955.

PROFESSIONAL EXPERIENCE

General Summary

A principal of Pickard, Lowe and Garrick, Inc. Consultant in reliability and availability, risk analysis, licensing and safety, management systems, and engineering. Pioneered early use of reliability and risk analysis technology in nuclear and fossil power plants. Served on several design review and safety committees and other task forces related to power plant design and operations. Study director of numerous major risk studies of nuclear power plants including Oyster Creek, Zion, Indian Point, LaSalle, Pilgrim 1, Midland, Browns Ferry, Sequoyah, and Seabrook. Extensive experience with hearings and the general nuclear licensing process. Coordinator and principal lecturer for the annual UCLA short course on power plant reliability. Presented numerous seminars on risk and safety analysis at such institutions as MIT, the University of California, and the United Kingdom's National Centre of Systems Reliability. Served on several accreditation teams evaluating engineering curriculum at different universities. Organized and conducted numerous workshops and training programs on maintenance, reliability, and availability for EPRI, DOE, and many utilities. Author of over 90 papers and reports on reliability and risk, nuclear power, power plant siting, and energy technology.

Adjunct Professor, University of California, Los Angeles; member of several institutional committees including the UCLA Radiation Committee, the Select Review Committee for the Clinch River Breeder Reactor, Design Review Board for the Midland Nuclear Power Plant, Direction and Control System Advisory Committee of the Governor's Emergency Task Force on Earthquake Preparedness, and Boston Edison's Nuclear Safety Review and Audit Committee. Peer reviewer of such national efforts as: (1) PRA Procedures Guide; (2) NRC human reliability research project; and (3) NRC NREP Procedures Guide.

Chronological Summary

1975-Present	Principal, Pickard, Lowe and Garrick, Inc.
1957-1975	Holmes & Narver, Inc. Key Positions: Member of Board of Directors; President, Nuclear & Systems Sciences Group; Sr. Vice President; Vice President, Science & Technology, The Resource Sciences Corporation, Tulsa, Oklahoma (parent company).

1955-1954	Physicist, Hazards Evaluation Branch, U.S. Atomic Energy Commission, Washington, D.C.
1952-1954	Physicist, Phillips Petroleum Company, National Reactor Testing Station, Idaho.

MEMBERSHIPS, LICENSES, AND HONORS

American Nuclear Society.
Fellow, Institute for the Advancement of Engineering.
New York Academy of Sciences.
Registered Professional Engineer, State of California.
Leaders in American Science (Eighth Edition).

Attachment 2

LOUIS S. GIBSON

Position: Senior Staff Engineer - Midland Project

Education:
- Michigan State University, 1974, Masters in Business Administration
- U.S. Navy Training, Nuclear Engineering (12 months) 1964
- University of Notre Dame, 1963, BSEE

Experience: Consumers Power Company:

1980-1983 Section Head - Midland Project - Safety and Analysis Section. Responsible for ensuring proper performance and evaluation of the nuclear safety analysis aspects of the plant design including accident analysis, transient analysis and probabilistic risk assessment. Also responsible for development of conceptual design options for resolution of fluid mechanical and nuclear safety system issues.

1977-1980 Section Head - Reactor and Control Systems. Responsible for design review for new power plant instrument and control systems and nuclear reactor and support systems. Conduct detailed analysis and evaluation of certain critical areas of new plant design and modifications to existing plants. Supervise members of the section in carrying out the above section responsibilities.

1975-1977 Supervisory Engineer - Perform design review for new power plant systems and equipment in the mechanical and instrument and control areas. Have conducted detailed design analysis of certain critical aspects of design of new plants and of modifications to existing plants. Provide advice and assistance to the department head in the area of Quality Assurance.

1972-1975 Administrator of Quality Assurance - Responsible for developing and implementing a program for operational quality assurance for the company's central office and its two nuclear power plants. Served as a member of the Off-Site Safety and Audit Review Board for two operating nuclear plants. Participated in the review of design specifications for new nuclear plants.

1970-1972	General Engineer - Supervised preoperational, hot functional and startup testing of a large PWR nuclear plant. Qualified as Senior Reactor Operator by successfully completing examinations administered by the Atomic Energy Commission; supervised shift operations.
1967-1970	Lieutenant, U.S. Navy - Assigned to a prototype nuclear power plant which was utilized for testing and training of personnel. Certified as senior reactor operator. Responsible for electrical and instrumentation systems at the prototype, including supervision of forty technicians. I later shared responsibility with my civilian counterpart for planning and scheduling the routine repair effort; participated in a major refueling and overhaul of the facility. I also served as a member of the Senior Operator Qualification Board.
1964-1967	Lieutenant, Junior Grade, U.S. Navy - Served as Reactor Control Division Officer, USS Long Beach; responsible for the maintenance, operating and testing of all the nuclear reactor instrumentation and control systems; supervised twenty-five electronic technicians and participated in a major refueling, overhaul and testing of the nuclear plants. I was qualified as senior watchstander on shift.

Additional Training

1973-1974	Graduate level courses - Thermodynamics, Systems Analysis, Michigan State University.
1981	One week training course on B&W Simulator
1981	One week CP Co. course on Effective Management

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the matter of

CONSUMERS POWER COMPANY (Midland Plant, Units 1 and 2)	Docket Nos. 50-329OM 50-330OM 50-329OL 50-330OL

I, B. John Garrick, being first duly sworn, state that my accompanying testimony addressing Mary Sinclair's contention 13 (analysis of Class 9 Accidents in the FES) is true and correct to the best of my knowledge and belief.

B. John Garrick

District of Columbia ss:

Subscribed and sworn to before me this 13th day of January, 1983.

Rita Campbell

Notary Public

My commission expires: 2/14/87

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In The Matter of	)	Docket Nos. 50-329 OM
	)	50-330 OM
CONSUMERS POWER COMPANY	)	
	)	Docket Nos. 50-329 OL
(Midland Plant, Units 1 and 2)	)	50-330 OL

I, Louis S. Gibson, being first duly sworn, state that my accompanying testimony addressing Mary Sinclair's Contention 13 (Analysis of Class 9 Accidents in the FES) is true and correct to the best of my knowledge and belief.

Louis S. Gibson
Louis S. Gibson

Subscribed and sworn to before me this 13th day of January, 1983.

Alva C. Robinson
Notary Public

My commission expires October 1, 1986.

RELATED CORRESPONDENCE

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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In the Matter of	)	
	)	Docket Nos. 50-329-OM
CONSUMERS POWER COMPANY	)	50-330-OM
	)	50-329-OL
(Midland Plant, Units 1 and 2)	)	50-330-OL

CERTIFICATE OF SERVICE

I, Philip P. Steptoe, one of the attorneys for Consumers Power Company, hereby certify that copies of "Testimony of Cris Hillman and Terry Postlewait on Sinclair Contention 4", "Applicant's Exhibit 29R", "Testimony of Richard D. Woods Concerning Seismic Shakedown Settlement at the Midland Site except Diesel Generator Building", "Applicant's Suggestion of Mootness or, in the Alternative, Motion to Close the Record with Respect to Material False Statement", and "Testimony of B. John Garrick and Louis S. Gibson Concerning the Analysis of Class 9 Accidents in the Midland FES" were served upon all persons shown in the attached service list by deposit in the United States mail, first class, this 17th day of January, 1983.

Philip P. Steptoe

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