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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

FEB 5 1982

Docket Nos. 50-329
and 50-330 OM, OL

APPLICANT: Consumers Power Company

FACILITY: Midland Plant, Units 1 and 2

SUBJECT: SUMMARY OF OCTOBER 6-7,1981 MEETING ON UNDERGROUND PIPING

On October 6 and 7, 1981, the NRC staff met in Bethesda, Maryland with Consumers Power Company, Bechtel, and consultants to discuss underground piping in inadequately compacted plant fill at the Midland site.

A summary of this meeting is provided by Enclosure 1.

Darl Hood

Darl S. Hood, Project Manager
Licensing Branch No. 4
Division of Licensing

Enclosure:
As stated

cc: See next page

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FEB 18 1982

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CONSUMERS
POWER
COMPANY

Internal
Correspondence

To File 0485.16

From GSKeeley, P-14-113B G S Keeley

Date October 23, 1981

Subject MIDLAND PROJECT - UNDERGROUND PIPING MEETING WITH - STAFF ON OCTOBER 6 AND 7, 1981 - FILE 0485.16 SERIAL 14704

CC
JWCook, P-26-336B (w/o att)
AJBoos, Bechtel-AA (w/o att)
JEBrunner, M-1079 (w/att)
WJCloutier, P-24-611 (w/att)
Roger Huston, Washington (4 copies w/att)
DFLewis, Bechtel-AA (w/att)
MIMiller, IL&B (w/att)
DESibbald, Midland (w/att)
DMBudzik/TJSullivan, P-24-624A (w/o)

I. Introduction - G S Keeley (CP Co)

The meeting is intended to provide an update for the NRC Staff regarding activities related to underground piping at Midland. A previous meeting on this subject was held May 5, 1981. This meeting addressed actions taken since the earlier discussion in January 1981 when results of profiles taken in 1979 were discussed as well as stress calculations resulting from these profiles.

It is Consumers Power Company's belief, based on the work done to date, that the piping in its present configuration does not present a safety problem. CP Co's approach includes proposed acceptance criteria intended to show that the piping is capable of performing its intended function over the plant's design life. This performance-based acceptance criteria is similar to that recently accepted in a board decision on North Anna.

The specific discussions principally concern the Service Water Piping. Previous activities included a profile of one line in each trench (1979). A reprofiling and ovality check of the B Train Service Water Supply and return lines was completed on September 23, 1981. The techniques used for this reprofiling allowed for a more accurate measurement (± 1/16 inch). Reprofiling and ovality measurements on the A Train are scheduled to start the week of October 12 and should be completed by November 15 for turnover to Consumers Testing.

We will also discuss the problem of modeling since we have difficulty interpreting profile readings as being due to 100% settlement that has occurred since installation.

W J Cloutier (CP Co) indicated that telephone conferences were held between CP Co, ETEC and NRC on August 10 and 25, 1981. In the first of these conferences, it was noted that CP Co's intent was to show the piping is not in distress and adequate for use as a Class 2 safety grade system.

II. Intent of Current Efforts W J Cloutier (CP Co)

It was noted that Standard Review Plan Section 3.9.3 allows alternatives to an acceptance based on evaluation of stress calculations provided dimensional stability and functional capability can be maintained. Upon review of this position, NRC MEB personnel responded in the second telephone conference that the principal concern is assuring system functionality. Discussed during the telecon was using a hydro, sizing pig and performance (functional) tests to determine functionality. It was reported that the current availability of the piping (system being open) had prompted efforts to obtain ovality measurements as a more accurate indication of the current condition of the piping, rather than passing a sizing pig through the piping. The acceptance criteria to be used to assure functionality throughout life was addressed in this meeting.

Soil Settlement is a long term, noncyclic process. The concern, therefore, is to demonstrate that settlement loading will not cause pipe collapse reducing the flow area to below that required for functionality. The effect of settlement loading on pipe is principally a bending action and thus measurement of out-of-roundness (ovality) was chosen as an appropriate indicator of pipe distress. A criteria of 8% is being used for acceptance; this value is based on ASME codes for installation and fabrication (NC3642 and NC4223.2) and is widely used throughout industry (ASME B31.1, B31.2 and B31.3).

Proposed Continuing Testing Program - D F Lewis (Bechtel)

There was a discussion on the construction hydro test.

Flow verification test - A full flow verification test will be conducted annually. A requirement to perform this test will be proposed for inclusion in the Technical Specifications (Assuming NRC acceptance of this approach). The continuing monitoring program will include a trending evaluation of this test data to detect any decreases in flow even though acceptance criteria are met. The proposed testing is expected to be performed during plant operations.

This type of testing will not explicitly show that no pipe deformation is occurring; rather, it demonstrates that deformation sufficient to reduce the flow below that necessary is not occurring. It was noted that deformation considerably greater than the 8% ovality acceptance criteria being used would be required to cause any appreciable decrease in flow. Slides were presented (see attached) on location of flow measurement devices.

D Gupta and A Cappucci (NRC) questioned the appropriateness of this type of testing. Their concern is that small deformations go undetected. It is not apparent that pipe deformation could not progress so far by the time any flow effect is noted that collapse might be imminent. Such collapse might then occur between testing periods and go undetected for some period.

In Service Inspection - ISI will initially be based on ASME Section XI 1980 Edition with Addenda through winter 1980. ISI inspections present an additional check on functionability of this piping (see attachment).

(A correction to the slide on acceptance criteria was noted; the entry reading 0.5 gpm should read 0-5 gpm.)

III. Analytical Difficulties - W J Cloutier (CP Co)

There have been difficulties in analyzing the piping to determine stresses. The problem is not the computer codes, it is the availability and reliability of input data. Field data is input by placing artificial rigid restraints at locations measured; this has resulted in artificially high bending and stresses being calculated at these locations.

Measurement inaccuracies also affect these results. In 1979, profiling was done to ± 1/4 inch accuracy with measurements every 10 feet. A parametric study over a 20 foot span using worst case measurement errors (1/2 inch deflection) yields a calculated stress of 55 ksi. The current reprofiling is being done to ± 1/16 inch; this helps the problem of "artificial" calculated stresses but current measuring techniques intensify the effect of local discontinuities. Fitup and installation differences ("discontinuities") result in very high calculated stresses unless the curve is "smoothed."

SMA has performed calculations (results on attached slide) to determine the soil loading which would have been required to cause the observed deformations if settlement were the only deformation mechanism. This study showed soil loadings necessary to be as much as three times the conservative estimate of the soil capacity. The limited information available about presettlement, as-built conditions thus is shown to provide an unrealistic calculational solution. H Singh (COE) questioned the assumptions used in this analysis; specifically that of a uniform soil spring constant. It was explained that the analysis showed that in order to force the pipe into its present condition the soils could not apply enough force to do this.

D Hood (NRC) questioned whether the nonsafety grade piping was installed and fit up to the same requirements. CP Co and Bechtel personnel present were not sure this was the case and committed to check this point and inform Mr Hood of the answer. (A subsequent check indicates that nonsafety grade pipe was installed per ASME B31.1 which requires the same alignment tolerances as safety grade.) The QCIs for safety grade piping showed that the pipe was installed per the spec with no actual measurements on the QCI. It was pointed out that fit up measurements are made prior to welding and that distortion occurs during the welding process. Hood asked why we don't remove the pipe, surcharge the soil, then replace the pipe at proper elevation. We said we don't believe we have a problem with the pipe that warrants this.

Basis for Acceptance Criteria - J Tsacoyeanes (TES)

Previous calculations were done to 3 S_c. Some members of the working group on design codes felt there would be no real problem involved in exceeding this. There is reasonable assurance that the pipe would function and not fail if stressed beyond this limit since it is based on a fatique concern which is not present in this case. Settlement is a strain limited or deflection controlled problem and does not have a continuous force to drive the pipe to failure once a maximum bending stress is reached. A theoretical calculation using BOSOR indicates no pipe failure with a 50% increase in stress; such a calculation assumes unrestricted deformation whereas the real case includes restrictions on pipe movement caused by the soil. The uncertainties involved with predicting failure based on stresses, combined with the difficulty of calculating stresses from field measurements, thus led to a conclusion that an acceptance criteria on deformation was more applicable.

The 8% limit used is based on fabrication codes as noted above. It was noted also that the existence of ovality on out-of-roundness does not in itself imply a structural failure of the pipe.

IV. Measurement Techniques - D Sibbald (CP Co)

Profiling and ovality measurement has been completed for the B Service Water Train. This involved cleaning the interior surface and marking it at a minimum of 5 foot increments for measurement. Measurements at some locations, particularly in elbows, were as close as 1.5 ft. Measurements were also taken 2-1/2 inches on either side of pipe welds.

The Pipe Evaluation Profile Measurement System developed by SWRI for this effort was described (see attachments). The device uses a pressure transducer moved within the pipe and positioned on the pipe bottom (as determined using a bubble level on the transducer). The measurement is of the differential pressure between a reference water column and a column ending at the transducer. The system used in 1979 was similar but involved a visual measurement rather than sensed dp. (In 1979 the pipe was not completely drained leading to possible additional uncertainties in the preciseness of locating the pipe bottom.)

The 20" condensate piping to be profiled will be measured by a similar method utilizing a "crawler" being developed by SWRI. This will basically be a fully automated version of the technique used on the SWS piping measured to date. Piping 26" or larger in diameter will continue to be measured using personnel in the pipe.

Ovality is measured at the same locations as elevation and using another SWRI instrument. The device uses rotating arms to obtain both maximum and minimum diameters. Their azimuthal orientation is also recorded along with the azimuthal location of the longitudinal fabrication weld. Fittings were measured using the same measurement arm, however, this required removing it from the rolling platform (dolly) which was used in straight pipe sections for accurate positioning.

The preliminary (reviews not yet completed) results of a portion of the 1981 measurements were reviewed (drawings provided to NRC Staff). The 1979 data was plotted on the same drawings for reference purposes. Ovality measurements were also presented (see attachments). They generally were less than 2% compared to a required manufacturing tolerance in straight pipe of approximately 1%. (Approx 1.76% in fittings.) The ovality measurements have not yet been plotted but will be shown along with the profile data in future plots.

The Staff expressed concern regarding the unavailability of stresses calculated from this data. CP Co agreed to provide such calculations.

V. Overburden Loads - D F Lewis (Bechtel)

A question has been raised regarding overburden loads where live loads could be present at the surface. It was noted that this issue was addressed in Question 34 of CP Co's 50.54(f) responses. Mr Lewis pointed out that the fuel oil line at approximately 2-1/2 ft depth is a small diameter line; some SWS piping is at approximately 5-1/2 ft depth but most piping is below 6 ft obviating major concern for live load overburdens.

VI. Other lines - W J Cloutier

Fuel oil lines to the diesel generators were installed after the building surcharge. They were installed on unistruts imbedded in concrete and their actual elevations were measured. CP Co concludes that this treatment implies no settlement concern with these lines. J Kane (NRC) questioned this conclusion since no survey data exists since the original measurements in 1980; since no calculation of stresses assuming worst case settlement has been made, this conclusion may be inappropriate.

The 8" and 10" lines near the east side diesel generator building which have not been rebedded previously will be rebedded. (OHBC 27, 2HBC311, 2HBC310) since this effort is more straightforward than data collection would be on these lines.

A sizing pig will be used to detect deformation in the remaining 8" lines which will not be rebedded. (8"-1HBC-310, 8"-1HBC-311, 8"-2HBC-82, 8"-2HBC-81.)

Lines associated with the BWST will be rebedded from the valve pit to the dike area. The service water system pipes will be repositioned at the SWPS where it enters the structure. It was noted that a question remains open regarding the rattle space at this penetration. This problem will be corrected as part of the SWPS underpinning. (The write-up on the history of this issue has been provided to the NRC subsequent to the meeting.)

VII. Summary

The data on installed profiles and ovality measurements indicate that the SWS piping is not presently in distress. Plans for a post-construction hydrostatic test, periodic flow monitoring and the required ISI program will demonstrate continued functionability and provide adequate assurance of safety.

The Staff and the Corps of Engineers questioned the problems posed by seismic considerations. They requested that a stress analysis due to seismic events considering post-settlement piping conditions be documented. Concern was raised that a seismic input could lead to a pipe failure due to a prestressed condition which might go undetected by the proposed testing regimen. CP Co responded by stating that the ASME Code equations for combining stresses do not require settlement stresses to be combined with seismic stresses. The staff restated their concern was principally with the effect of the present and future profile curvature on the seismic analysis.

Meeting Continuation - October 7, 1981

This meeting was reconvened briefly on October 7, 1981 to permit the NRC Staff to provide comments on the October 6, 1981 meeting after their in-house caucus with their Branch Chief (Bosnack). The Staff indicated the following:

1. A quantitative evaluation is needed demonstrating that a safe shutdown earthquake will not rupture the pipe and how to separate settlement from installed conditions.

2. Appendix A of 10 CFR 100 requires that it be demonstrated an OBE will not impact operation.

3. Quantification of stresses sufficient to permit Staff acceptance is lacking.

4. A seismic margin analysis will also be required.

5. The scope of NRC concern is all safety Class 1 buried piping. The primary concern is the SWS piping. Some Staff personnel believe the data presented indicates this piping is presently overstressed. Others believe the ovality shows no problem. Input is still needed relating pipe ovality to a predicted pipe failure.

6. Seismic and settlement loadings cannot be decoupled.

7. The piping must meet code and must be shown to meet functional requirements. If enough good data is available, use of the $3 S_c$ stress limit could possibly be waived. Likewise if we met $3 S_c$ as piping is now, then would have a better argument of future acceptability of pipe.

The major concern remaining is the effect of earthquakes and whether a margin to seismically-induced failure can be established from ovality measurements. The staff asked, and we agreed to provide results of BOSOR as to where buckling takes place.

If the ovality reduction which will be measurable by flow verification can be defined and it can be demonstrated that such a reduction is not a concern during an SSE, this issue could likely be resolved. There has to be more technical justification on this.

In conclusion, the Staff noted that reprofiling was done externally at Summer Plant with stress calculations showing 1/2 code allowable.

When questioned whether the Staff would reconsider curve fitting as an approach, Mark Hartsman indicated he would talk to ETEC and let us know.

NRC MEETING AGENDA

I. Introduction

   A. Meeting Purpose
   B. Previous Activities and Meetings
   C. Schedule and Activities
   D. Recent Telecons

II. Proposed Demonstration Solution

   A. Acceptance Criteria

      1. Ovality Measurements
      2. Construction Hydro
      3. Periodic Verify of Acceptable Flow
      4. Inservice Inspection

III. Limitations of Analytical Solution

   A. Difficulty in Truly Modeling the Problem.
   B. SMA Study on Soils Forces Required
   C. No as Built Dimensions of Installed Conditions.
   D. QCI Requirements
   E. Basis of Acceptance Criteria

IV. Preliminary 1981 Measurements Results

   A. SRI Measurement Techniques

      1. Profiling
      2. Out of Roundness

   B. Data Presentation

      1. Profiles for 1981 Data Compared with 1979 Data
      2. Ovality Measurements Results

V. Miscellaneous Concerns

   A. Overburden loads - 50.54(f) Question 34
   B. Fuel oil lines
   C. Rebedding and Realignment

      1. 10"-OHBC-27, 8"-2HBC-311, 8"-2HBC-310
      2. 36" Service Water Header Fix for Adequate Rattle Space

   D. Sizing Pig Operation

      1. 8"-1HBC-310, 8"-1HBC-311, 8"-2HBC-81, 8"-2HBC-82

   E. BWST Lines

VI. Summary

ATTENDANCE 10/6/81

D. F. LEWIS	BECHTEL
D. E. Sibbald	CPCo.
J. C. Tsacoyeanes	TES
D. M. BUDZIK	CPCO
F. C. Cherny	NRC/DE/MEB
Mark Hartzman	NRC/DE/MEB
A. J. CAPPUCCI	NRC/DE/MEB
W. P. Chen	ETEC
H. L. BRAMMER	NRC/DE/MEB
Dan Hood	LB#4/DL/NRR
BILL CLOUTIER	CPCo
TED SULLIVAN	NRC/ASB
Roger Huston	Consumers Power
James Brunner	″
Joseph Kane	NRC, DE, HGEB
Hari Narain Singh	US Army Corps of Engineers Chicago
DINESH GUPTA	NRC, DE, HGEB
Gil Keeley	CPCo.
~~W. Cloutier~~	~~CPCo~~

CONSTRUCTION HYDRO TEST

ASME III NC-6221 NC6129

- TEST PRESSURE - 1.25 X SYSTEM DESIGN PRESSURE
- HOLD INTERVAL - 1 HOUR, INACCESSIBLE WELD JOINTS
- TEST PUMPS LEAKAGE - MONITOR FLOW FOR FUTURE LEAKAGE CRITERIA

FLOW VERIFICATION

- ENSURE ABILITY OF BURIED PIPING TO MAINTAIN FLOWS REQUIRED FOR SAFETY FUNCTIONS
- ESTABLISH PUMP AND SYSTEM LINEUPS TO OBTAIN KNOWN CONFIGURATION THAT PROVIDE REQUIRED FLOWS
- UTILIZE INSTALLED INSTRUMENTATION TO VERIFY REQUIRED FLOW IN EACH BURIED LINE
- ONCE PER YEAR
- TO BE INCLUDED IN TECHNICAL SPECIFICATIONS

MINIMUM REQUIRED FLOWS

Line	Description	Required Flow (gpm)
8''-1HBC-310	DG 1A Supply	1,600
8''-2HBC-81	DG 2A Supply	1,600
8''-1HBC-81	DG 1B Supply	1,600
8''-2HBC-310	DG 2B Supply	1,600
8''-1HBC-311	DG 1A Return	1,600
8''-2HBC-82	DG 2A Return	1,600
8''-1HBC-82	DG 1B Return	1,600
8''-2HBC-311	DG 2B Return	1,600
10''-0HBC-27	DG 1B/2B Supply	3,200
10''-0HBC-28	DG 1B/2B Return	3,200
26''-0HBC-53	DG 1A/2A + TB Supply	9,225
26''-0HBC-54	DG 1A/2A + TB Return	9,225
26''-0HBC-55	DG 1B/2B + TB Supply	9,225
26''-0HBC-56	DG 1B/2B + TB Return	9,225
26''-0HBC-15	Aux Bldg A Supply	15,894
26''-0HBC-16	Aux Bldg A Return	15,894
26''-0HBC-19	Aux Bldg B Supply	15,894
26''-0HBC-20	Aux Bldg B Return	15,894
36''-0HBC-15	A Supply	25,119
36''-0HBC-16	A Return	25,119
36''-0HBC-19	B Supply	25,119
36''-0HBC-20	B Return	25,119

Required flows are based on FSAR tables 9.2-1 and 9.2-2. Worst-case values for each line were determined from the six operation modes and the ESF mode in those tables. Turbine building flows are based on potential flow under accident conditions (Mode 6).

FLOW MEASUREMENT

Line	Description	Flow Element	Location
8''-1HBC-310	DG 1A Supply	1 FE 1841	Cooler Outlet
8''-2HBC-81	DG 2A Supply	2FE 1851	Cooler Outlet
8''-1HBC-81	DG 1B Supply	1FE 1846	Cooler Outlet
8''-2HBC-310	DG 2B Supply	2FE 1855	Cooler Outlet
8''-1HBC-311	DG 1A Return	1FE 1841	Cooler Outlet
8''-2HBC-82	DG 2A Return	2FE 1851	Cooler Outlet
8''-1HBC-82	DG 1B Return	1FE 1846	Cooler Outlet
3''-2HBC-311	DG 2B Return	2FE 1855	Cooler Outlet
10''-0HBC-27	DG 1B/2B Supply	1FE 1846 + 2FE 1855	Cooler Outlet Cooler Outlet
10''-0HBC-28	DG 1B/2B Return	1FE 1846 + 2FE 1855	Cooler Outlet Cooler Outlet
26''-0HBC-53	DG 1A/2A + TB1 Supply	1FE 1876	Supply Line - Metering Pit
26''-0HBC-54	DG 1A/2A + TB1 Return	1FE 1876	Supply Line - Metering Pit
26''-0HBC-55	DG 1B/2B + TB2 Supply	2FE 1876	Supply Line - Metering Pit
26''-0HBC-56	DG 1B/2B + TB2 Return	2FE 1876	Supply Line - Metering Pit
26''-0HBC-15	Aux Bldg A Supply	0FE 1995A + 1FE 1914A + 1FE 1990A + 2FE 1990A	Aux Bldg A - Supply Line Booster Pump Discharge Chiller Outlet Chiller Outlet
26''-0HBC-16	Aux Bldg A Return	0FE 1995A + 1FE 1914A + 1FE 1990A + 2FE 1990A	Aux Bldg A - Supply Line Booster Pump Discharge Chiller Outlet Chiller Outlet
26''-0HBC-19	Aux Bldg B Supply	0FE 1995B	Aux Bldg B - Return Line
26''-0HBC-20	Aux Bldg B Return	0FE 1995B	Aux Bldg B - Return Line
36''-0HBC-15	A Supply	1FE 1876 + 0FE 1995A + 1FE 1914A + 2FE 1990A 2FE 1990A	Supply Line - Metering Pit Aux Bldg A - Supply Line Booster Pump Discharge Chiller Outlet Chiller Outlet
36''-0HBC-16	A Return	1FE 1876 + 0FE 1995A + 1FE 1914A + 1FE 1990A + 2FE 1990A	Supply Line - Metering Pit Aux Bldg A - Supply Line Booster Pump Discharge Chiller Outlet Chiller Outlet
36''-0HBC-19	B Supply	2FE 1876 + 0FE 1995B	Supply Line - Metering Pit Aux Bldg B - Return Line
36''-0HBC-20	B Return	2FE 1876 + 0FE 1995B	Supply Line - Metering Pit Aux Bldg B - Return Line

(This list confirms capability to measure flows in buried service water system piping using installed instrumentation. In some areas, additional measurement devices are installed that may be considered preferable alternatives.)

INSERVICE INSPECTION

- ENSURE PRESSURE BOUNDARY INTEGRITY
- ASME XI - 1980 EDITION, THROUGH WINTER 1980 ADDENDA
- INSERVICE TESTS WITH LEAKAGE TESTS
- HYDROSTATIC TESTS WITH LEAKAGE TESTS

INSERVICE INSPECTION (cont'd)

- ONE UNIT AT POWER DURING TEST
- TEST DURATION WITHIN TECHNICAL SPECIFICATION LIMITS
- RAPID RESTRORATION POSSIBLE

INSERVICE TESTS - LEAKAGE TESTS

- EACH INSPECTION PERIOD: 3, 7, 10, 13, 17...YEARS
- NOMINAL SYSTEM OPERATING PRESSURE: 57 PSIG
- ISOLATE BURIED PIPING
- PRESSURIZE WITH TEST PUMP
- MAINTAIN PRESSURE 4 HOURS
- MEASURE FLOW

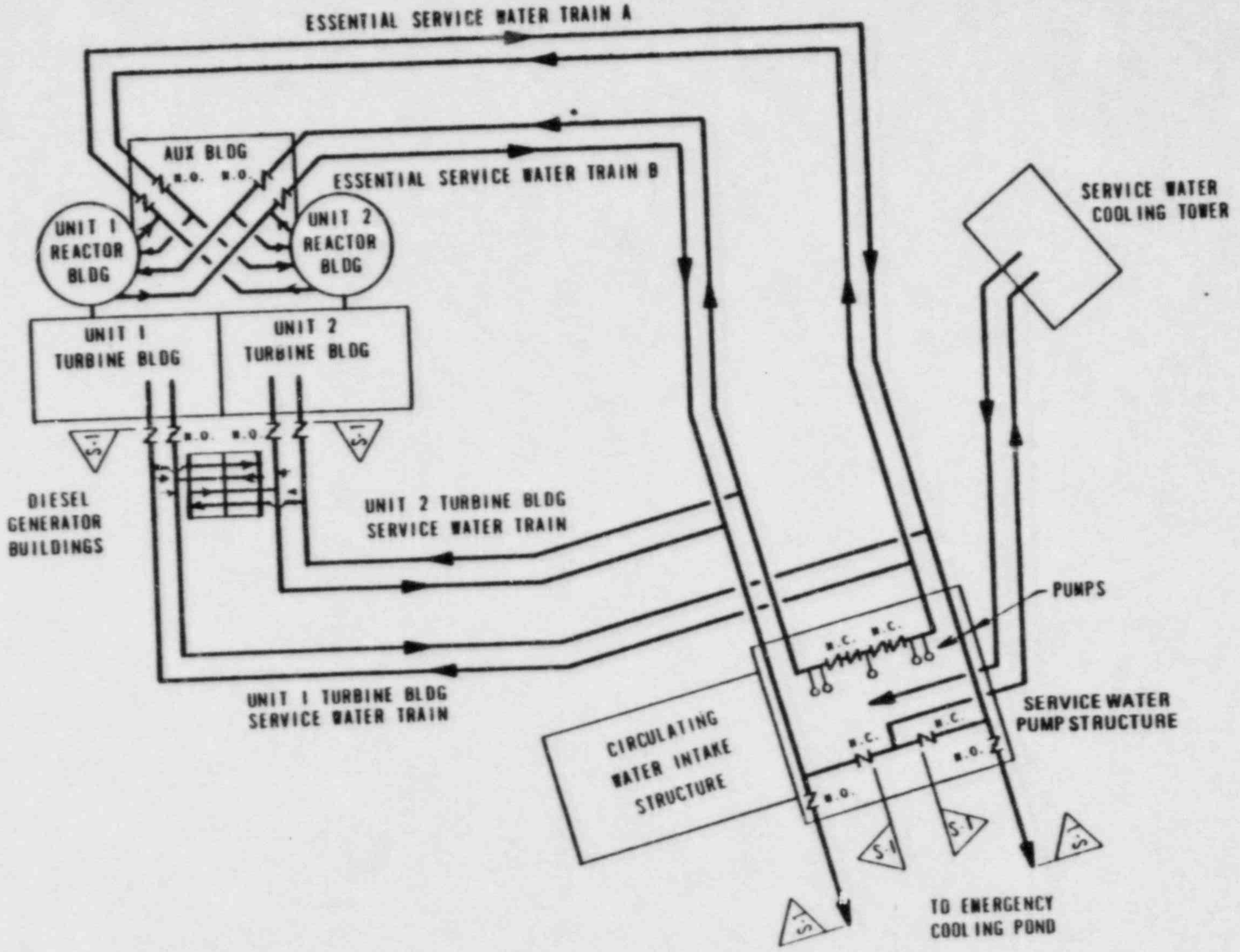
HYDROSTATIC TESTS - LEAKAGE TESTS

- EACH INSPECTION INTERVAL: ONCE EACH 10 YEARS
- 1.10 × DESIGN PRESSURE: 115.5 PSIG
- ISOLATE BURIED PIPING
- PRESSURIZE WITH TEST PUMP
- MAINTAIN PRESSURE 4 HOURS
- MEASURE FLOW

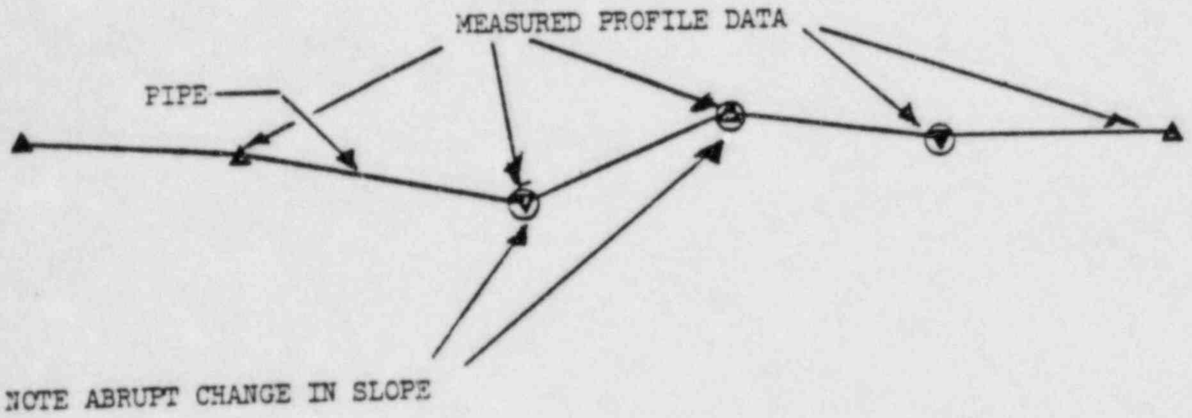
LEAKAGE TEST ACCEPTANCE CRITERIA

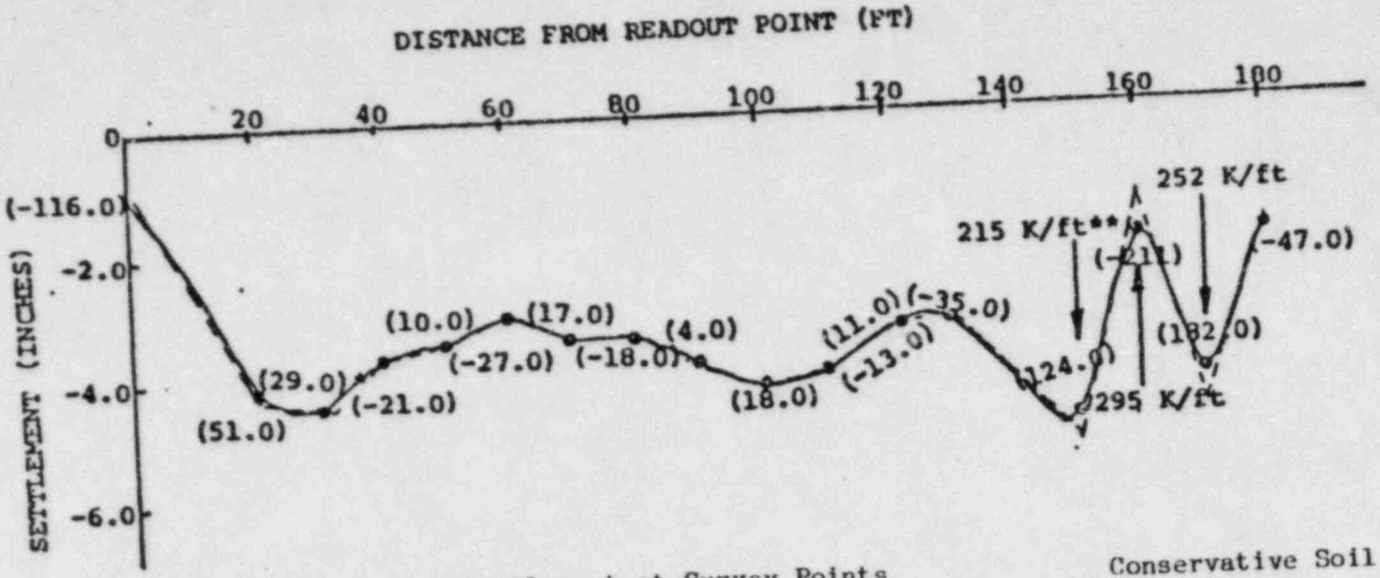
- SMALL ENOUGH TO DETECT PRESSURE BOUNDARY FAILURE
- LARGE ENOUGH TO ACCOMMODATE ANTICIPATED BOUNDARY VALVE LEAKAGE
- 0-5 ~~0.5~~ GPM
- RESULTS IN INSIGNIFICANT FLOW LOSS
- TO BE REVIEWED FOLLOWING PRESERVICE TESTS

SCHEMATIC DIAGRAM SERVICE WATER SYSTEM



SOIL SETTLEMENT PROFILE





● Indicates Pipe Settlement at Survey Points

—— Pipe Displacement Profile

--- Soil Settlement Profile

* Pipe bending stress in ksi at measurement point (typical)

** Soil spring forces (typical)

Conservative Soil Capacity Estimates

Uplift = 10 K/Ft
Bearing = 75 K/Ft
Lateral = 28 K/Ft

LINEAR ELASTIC ANALYSIS RESULTS FOR UPPER BOUND SOIL PROPERTIES

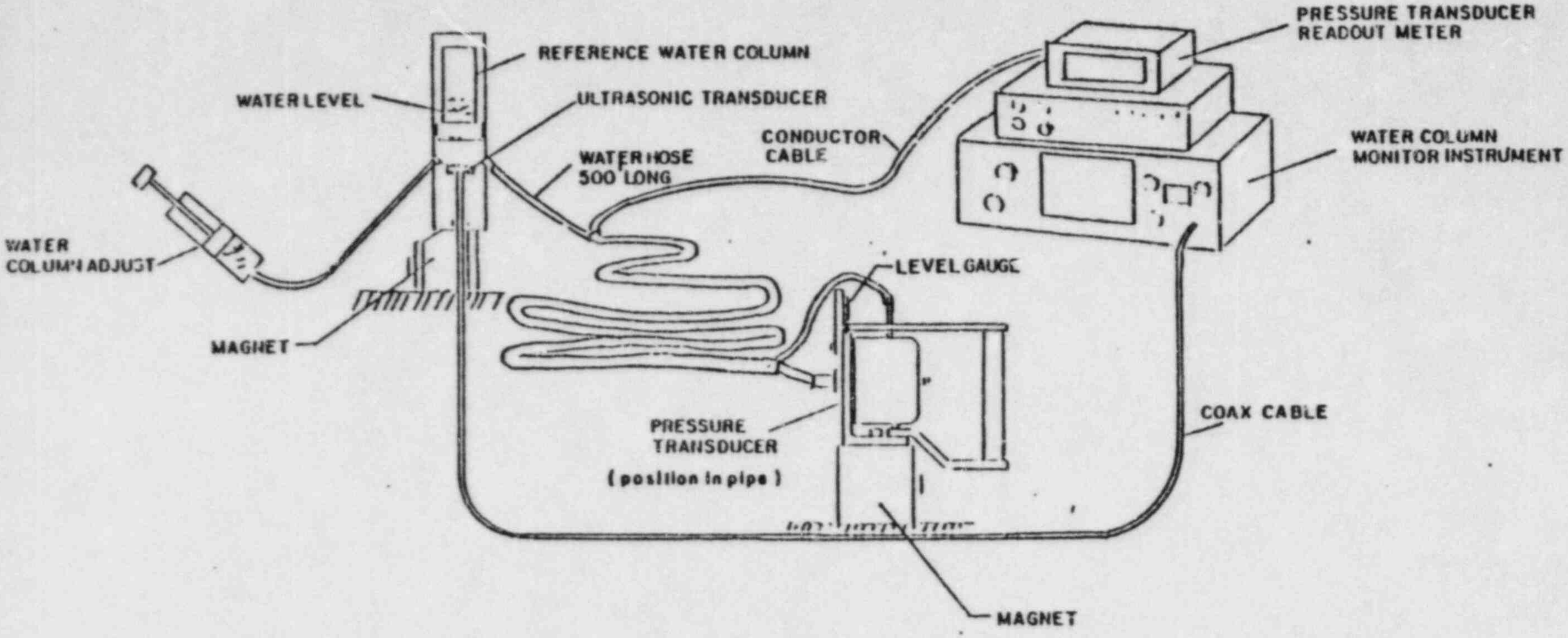
BASIS FOR ACCEPTANCE CRITERIA

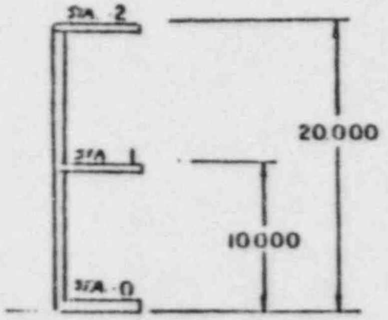
LIMITS ON STRESS:

- $3S_c$ (NC-3652.3) - SECONDARY STRESS
- BASED ON BUCKLING - BOSOR
- REFLECT LOAD-CONTROLLED SITUATION

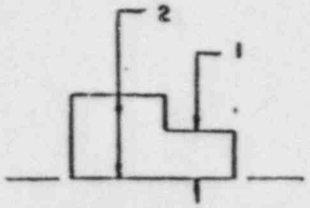
LIMITS ON DEFORMATION:

- MEASURED BY OVALITY
- CODE LIMIT 8% (NC-3642, NC-4223.2)



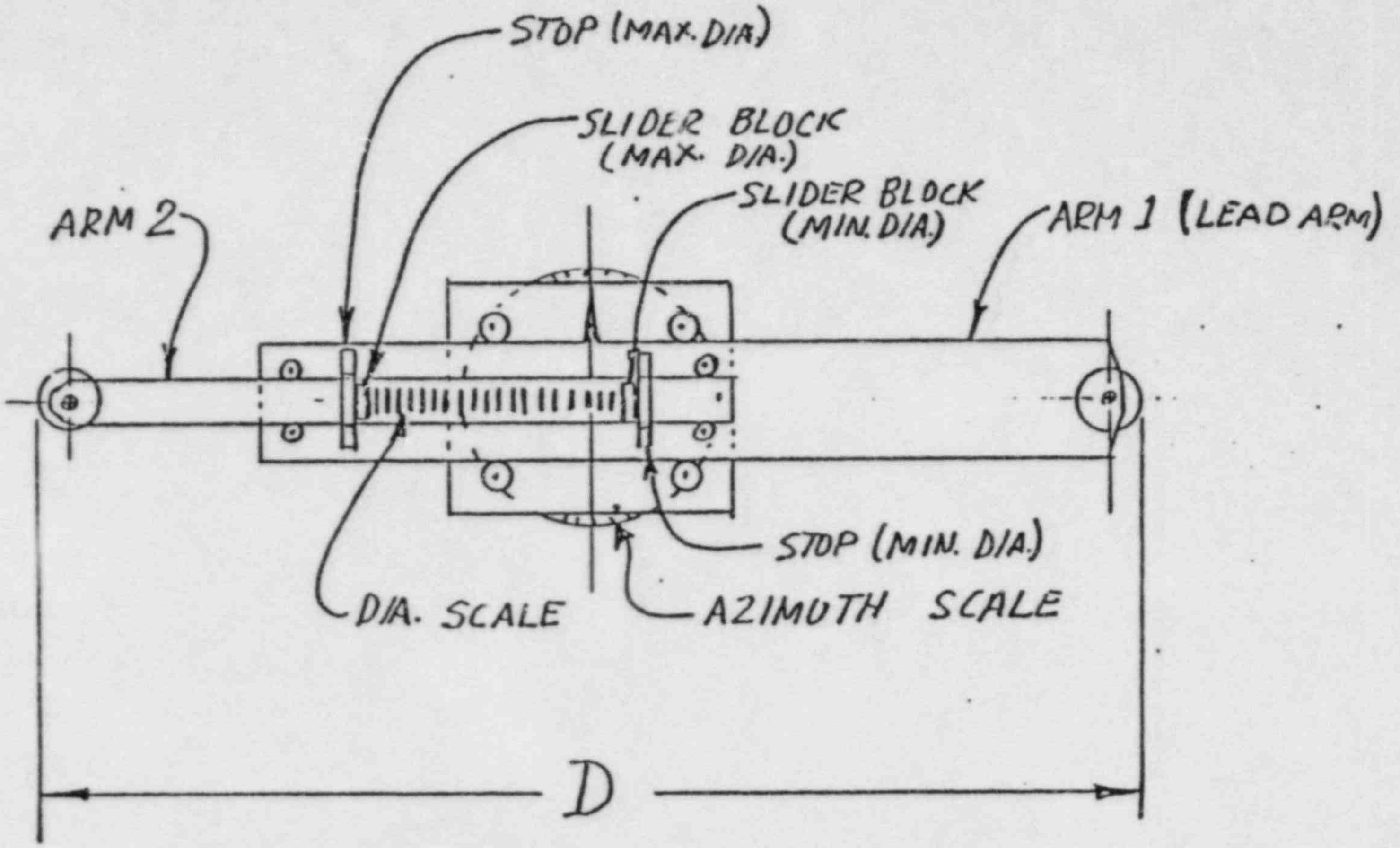


REFERENCE CALIBRATION BLOCK FOR HEIGHT



REFERENCE CALIBRATION BLOCK FOR THICKNESS

SCHEMATIC- PIPE ELEVATION PROFILE MEASURMENT SYSTEM



SKETCH - SwRI OUT-OF-ROUNDNESS MEASUREMENT INSTRUMENT

WJC

OUT OF ROUNDNESS

$\% = 100 \frac{DMAX - DMIN}{Do}$

PIPELINE: SERVICE WATER FITTINGS

Do = Average I.D. = 25.25"
Do = 64.135cm
DMAX = Maxinum I.D.
DMIN = Minimum I.D.

Pipe Position	% Ovalness	Pipe Position	% Ovalness	Pipe Position	% Ovalness
26"-OHBC-56					
13A	1.87				
13B	1.40				
13C	1.56				
12D	1.56				
21D	0.78				
22A	1.09				
22B	0.9				
22C	0.9				
26"-OHBC-55					
38D	1.09				
39A	1.40				
39B	0.9				
39C	0.47				
47D	1.56				
48A	1.87				
48B	1.25				
48C	2.03				
26"-OHBC-20					
95A	1.72				
94C	1.40				
94B	1.72				
94A	1.72				
86A	0.9				
85D	1.09				
85C	0.9				
85B	1.09				
85A	0.6				
26"-OHBC-19					
134A	1.56				
133C	1.09				
133B	1.56				
133A	2.03				
124A	1.72				
123D	1.56				
123C	1.72				
123B	1.09				
123A	1.40				

WJC 9/20/81

OUT OF ROUNDNESS

$$\% = 100 \frac{DMAX - DMIN}{Do}$$

PIPELINE: 26/36"-OHBC-20

Do = Average I.D. = 25.25"
Do = 64.135cm
DMAX = Maxinum I.D.
DMIN = Minimum I.D.
Do = 35.25 = 89.535cm

Pipe Position	% Ovalness	Pipe Position	% Ovalness	Pipe Position	% Ovalness
74C	1.72	98A	0.9	90B	0.9
70A	1.09	97D	0.9	90A	0.6
70B	1.09	97C	0.9	89D	0.78
70C	1.25	97B	0.9	89C	0.9
70D	1.09	97A	0.78	89B	0.78
71A	1.40	96D	0.6	89A	0.9
71B	1.87	96C	1.09	88D	0.78
71C	1.56	96B	0.9	88C	0.78
71D	1.56	96A	0.9	88B	0.78
72A	0.6	95D	0.78	88A	1.4
72B	0.78	95C	0.6	87D	0.9
72C	1.25	95B	0.6	87C	0.9
72D	0.9	93D	3.12	87B	0.9
73A	0.9	93C	1.87	87A	0.9
73B	0.78	93B	1.09	86D	0.78
73C	0.78	93A	0.78	86C	1.09
73D	0.78	92D	0.78	86B	0.9
74A	0.6	92C	1.09	84D	0.6
74B	0.78	92B	1.09	84C	0.6
100D	0.6	92A	1.09	84B	0.9
100C	1.40	91D	0.6	84A	0.16
100B	1.40	91C	1.87	83D	0.78
100A	1.40	91B	1.25	83C	0.9
99D	1.25	91A	1.72	83B	1.25
99C	1.56	90D	1.56	83A	1.25
99B	0.9	90C	1.40	76C	0.78
99A	1.25	80A	0.6	76B	0.47
98D	0.9	79D	1.09	76A	0.6
98C	0.78	79C	0.9	75D	0.78
98B	0.78	79B	0.9	75C	0.6
82D	1.25	79A	0.9	75B	0.9
82C	0.78	78D	0.6	75A	1.09
82B	0.9	78C	0.9	103A	1.79
82A	0.78	78B	1.09	103C	0.78
81D	0.9	78A	0.9	103D	0.34
81C	0.16	77D	1.25	104A	0.45
81B	0.47	77C	1.09	104B	0.67
81A	0.78	77B	0.78	104C	0.78
80D	0.78	77A	0.47	104D	1.12
80C	1.25	76D	0.78	105A	1.12
80B	1.09			105B	1.23

OUT OF ROUNDNESS

Pipeline: 26/36" OHBC-20 (cont'd)

Pipe Position	% Ovalness	Pipe Position	% Ovalness	Pipe Position	% Ovalness
105C	1.90				
105D	2.90				
106A	2.79				
106B	2.12				
106C	1.56				
106D	1.45				
107A	1.23				
107B	1.45				
107C	1.45				

WJC

OUT OF ROUNDNESS

$$\% = 100\ \frac{DMAX - DMIN}{Do}$$

PIPELINE: 26-OHBC-56

Do = Average I.D. = 25.25"
Do = 64.135cm
DMAX = Maxinum I.D.
DMIN = Minimum I.D.

Pipe Position	% Ovalness	Pipe Position	% Ovalness	Pipe Position	% Ovalness
1A	2.49	11D	0.78		
1B	0.60	12A	0.9		
1C	0.78	12B	0.9		
1D	0.78	12C	0.9		
2A	0.9	14A	1.87		
2B	0.47	14B	1.40		
2C	0.9	14C	1.40		
2D	1.09	14D	0.6		
3A	1.40	15A	0.9		
3B	0.90	15B	1.09		
3C	0.6	15C	0.9		
3D	0.78	15D	0.78		
4A	1.09	16A	0.78		
4B	1.25	16B	0.9		
4C	1.40	16C	0.9		
4D	0.78	16D	1.09		
5A	0.9	17A	1.09		
5B	1.09	17B	0.6		
5C	1.09	17C	0.6		
5D	0.78	17D	0.9		
6A	0.9	18A	0.78		
6B	0.78	18B	0.78		
6C	0.9	18C	1.40		
6D	0.6	18D	0.78		
7A	0.78	19A	0.3		
7B	1.25	19B	0.6		
7C	1.09	19C	0.47		
7D	0.47	19D	0.47		
8A	0.9	20A	0.6		
8B	0.9	20B	0.78		
8C	1.09	20C	0.6		
8D	0.78	20D	1.09		
9A	0.9	21A	0.78		
9B	1.40	21B	0.47		
9C	1.40	21C	0.47		
9D	0.9	23B	0.6		
10A	0.9	23C	0.6		
10B	0.9	24A	1.09		
10C	0.9	24B	0.47		
11A	0.9	24C	0.6		
11B	0.78	24D	0.78		
11C	0.78				

WJC

OUT OF ROUNDNESS

$$\% = 100\,\frac{DMAX - DMIN}{Do}$$

PIPELINE: 26-OHBC-55

Do = Average I.D. = 25.25"
Do = 64.135cm
DMAX = Maxinum I.D.
DMIN = Minimum I.D.

Pipe Position	% Ovalness	Pipe Position	% Ovalness	Pipe Position	% Ovalness
25A	0.78	37B	1.40		
25B	1.25	37C	1.72		
25C	0.78	37D	0.3		
25D	0.78	38A	0.6		
26A	0.48	38B	0.6		
26B	0.6	38C	0.78		
26C	0.6	40A	0.9		
26D	0.6	40B	0.9		
27A	0.3	40C	0.6		
28A	0.3	40D	0.6		
29A	0.48	41A	0.78		
29B	0.60	41B	0.6		
29C	0.48	41C	0.78		
29D	0.60	41D	0.6		
30A	1.09	42A	0.6		
30B	0.6	42B	0.78		
30C	0.48	42C	0.78		
30D	1.40	42D	0.9		
31A	1.40	43A	0.78		
31B	0.9	43B	0.78		
31C	0.9	43C	0.6		
31D	1.09	43D	0.47		
32A	1.25	44A	0.78		
32B	0.9	44B	1.09		
32C	0.6	44C	1.09		
32D	0.6	44D	0.9		
33A	0.48	45A	0.78		
33B	1.09	45B	0.9		
33C	0.78	45C	1.09		
33D	0.78				
34A	0.9	45D	1.56		
34B	1.56	46A	0.9		
34C	1.09	46B	0.78		
34D	1.09	46C	0.6		
35A	1.09	47A	0.3		
35B	1.25	47B	0.78		
35C	1.25	47C	1.09		
35D	0.6	49A	1.40		
36A	0.78	49B	1.40		
36B	0.9	49D	1.25		
36C	1.09	50A	0.78		
36D	0.47	50B	1.09		
37A	0.6	50C	0.6		
		50D	1.56		

WJC 9/20/81

OUT OF ROUNDNESS

$$\% = 100\,\frac{DMAX - DMIN}{Do}$$

PIPELINE: 26/36"OHBC-19

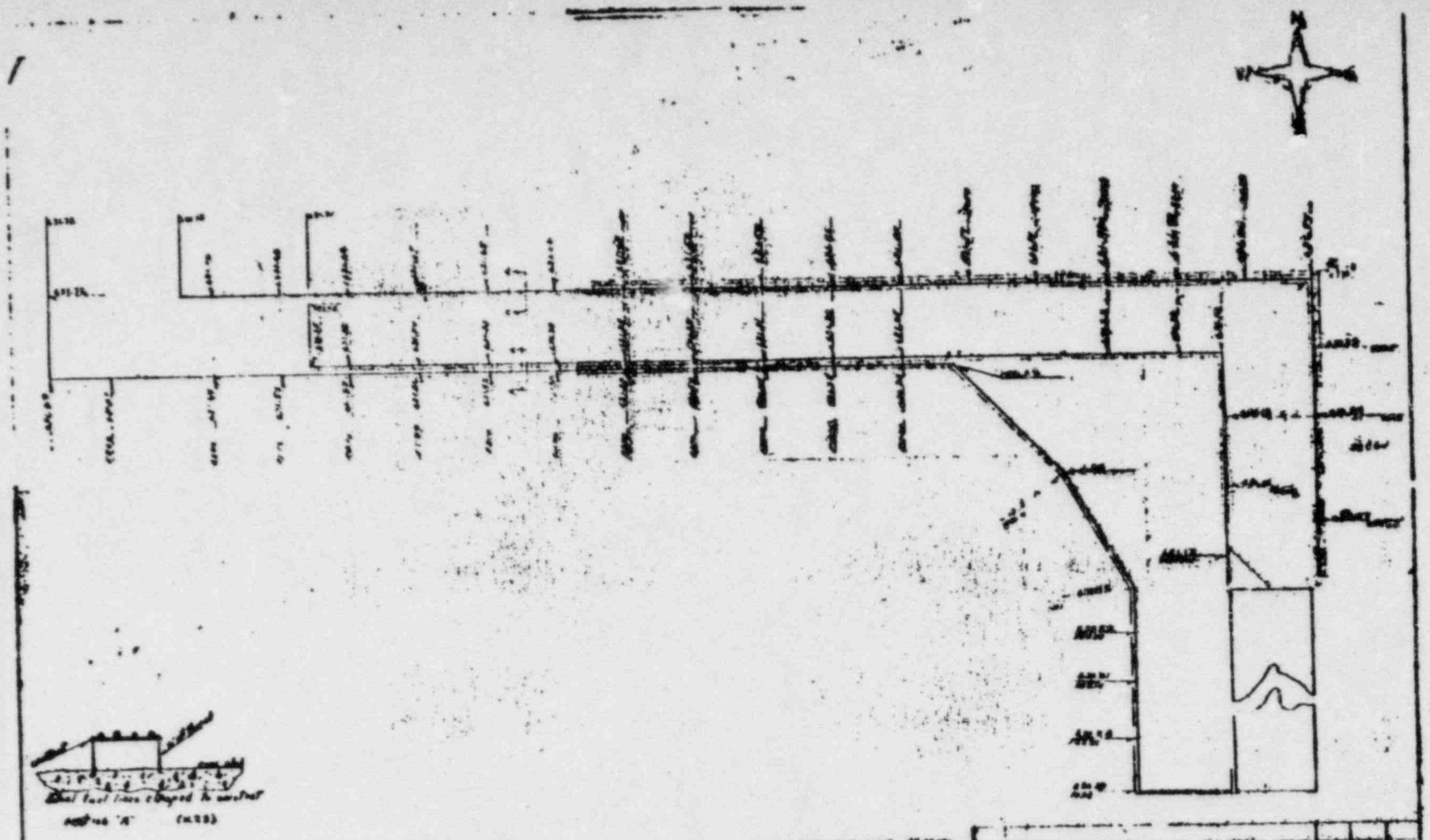
Do = Average I.D. = 25.25"
Do = 64.135cm
Do = 35.25 = 89.535cm
DMAX = Maxinum I.D.
DMIN = Minimum I.D.

Pipe Position	% Ovalness	Pipe Position	% Ovalness	Pipe Position	% Ovalness
108A	0.6	125A	1.09	113B	0.6
108B	0.3	124D	1.09	113A	1.09
108C	0.78	124C	1.09	139D	0.78
108D	0.3	124B	1.72	139C	1.25
109A	0.48	122D	0.6	139B	0.9
109B	0.16	122C	0.9	139A	0.78
109C	0.3	122B	1.09	138D	0.9
109D	0.16	122A	0.78	138C	0.6
110A	0.3	121D	0.6	138B	0.9
110B	0	121C	0.78	138A	0.9
110C	0.6	121B	0.9	137D	1.25
110D	0	121A	1.4	137C	1.72
111A	0.9	120D	0.9	137B	1.87
111B	0.6	120C	1.25	137A	1.40
111C	0.16	120B	0.78	136D	1.25
111D	0.16	120A	0.9	136C	1.09
112A	0.48	119D	0.9	136B	0.48
112B	0.3	119C	1.72	136A	1.09
112C	0.48	119B	1.87	135D	0.9
130D	1.25	119A	1.72	135C	1.72
130C	1.56	118D	1.40	135B	1.56
130B	1.56	118C	1.25	135A	1.87
130A	1.56	118B	1.72	134D	1.25
129D	0.9	118A	1.09	134C	1.40
129C	0.78	117D	1.09	134B	1.40
129B	0.78	117C	1.40	132D	1.87
129A	0.78	117B	1.09	132C	0.9
128D	0.78	117A	0.9	132B	1.25
128C	0.6	116D	0.6	132A	1.72
128B	0.78	116C	0.6	131C	0.9
128A	0.9	116B	0.9	131B	0.9
127D	0.78	116A	1.09	131A	0.78
127C	1.40	115D	1.09	142A	0.89
127B	1.72	115C	1.25	142B	1.45
127A	1.25	115B	0.9	142C	1.79
126D	1.56	115A	0.3	142D	0.89
126C	1.25	114D	0.3	143A	1.01
126B	0.6	114C	0.3	143B	1.56
126A	0.78	114B	0.9	143C	1.79
125D	0.6	114A	0.9	143D	1.23
125C	1.40	113D	0.9	144A	1.23
125B	1.40	113C	0.6	144B	1.34

OUT OF ROUNDNESS

PIPELINE: 26/36" OHBC - 19 (Cont'd)

Pipe Position	% Ovalness	Pipe Position	% Ovalness	Pipe Position	% Ovalness
144C	2.12				
144D	2.12				
145B	2.35				
145B	2.01				
145C	1.90				
146A	1.80				
146C	1.12				



0 Revised to reflect As Built Condition

Scale 1"=20'

BECHTEL POWER CORP
MIDLAND, MICHIGAN

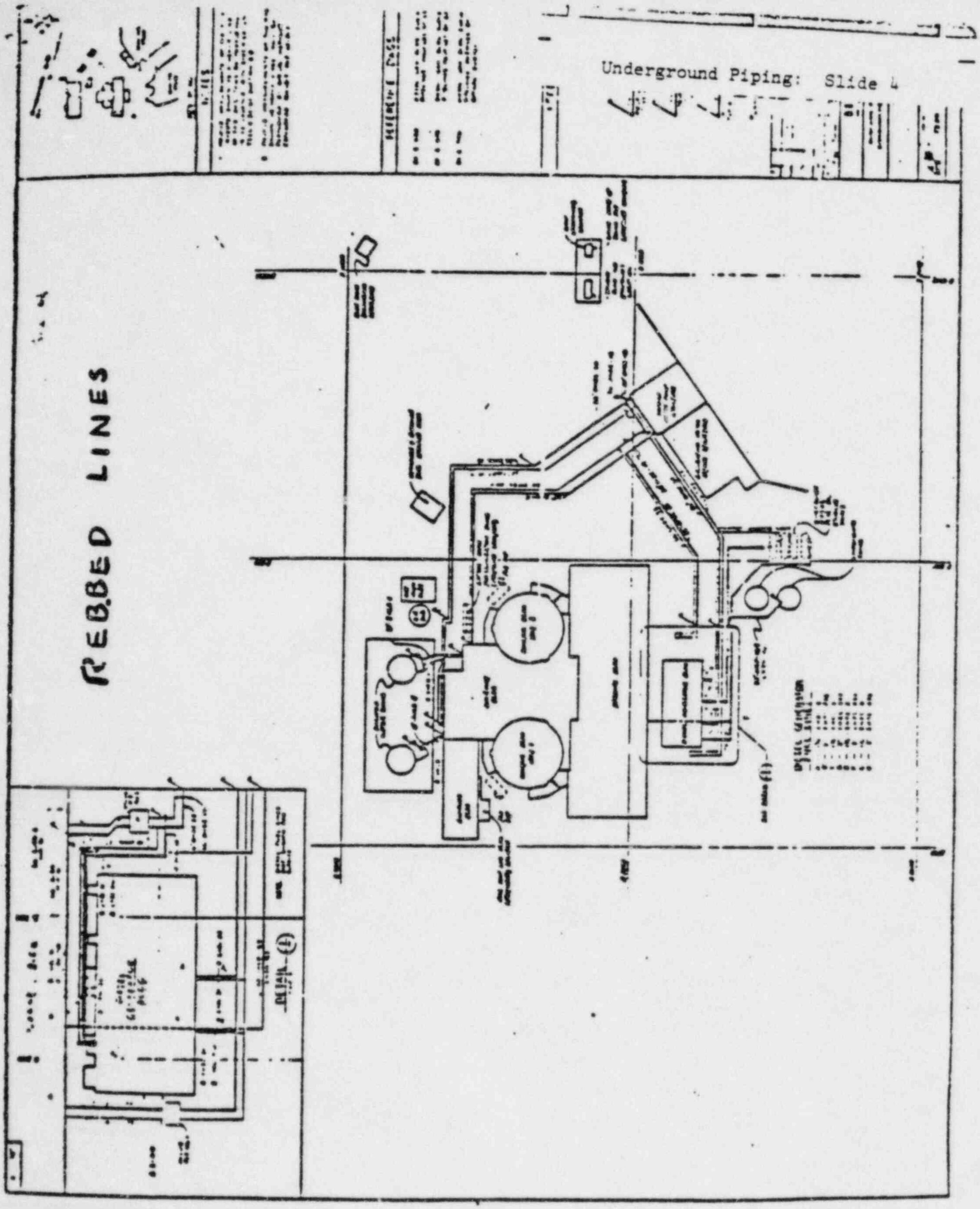
CONSUMERS POWER COMPANY
MIDLAND PLANT, UNITS 1 & 2

Top Line Elevations of Diesel Fuel Lines

7220 FSK-MPY-138 Q 0

UNCONTROLLED
NOT TO BE USED
FOR CONSTRUCTION

Underground Piping: Slide 4



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

January 29, 1982

Docket Nos: 50-329
and 50-330 OM, OL

APPLICANT: Consumers Power Company

FACILITY: Midland Plant, Units 1 and 2

SUBJECT: SUMMARY OF JANUARY 12, 1982 MEETING ON QA ORGANIZATIONAL CHANGES AND UNDERPINNING QA

On January 12, 1982 NRC met in Glen Ellyn, Illinois with Consumers Power Company to discuss; (1) changes in the quality assurance organization for Midland Plant, Units 1 and 2 and, (2) the quality program for underpinning of the Auxilairy Building area and the Service Water Pump Structures. Meeting attendees are listed by Enclosure 1.

QA Organizational Change

In November 1981, Consumers implemented certain changes in the Midland Project Quality Assurance Department (MPQAD). The changes were identified in a December 1981 letter to the ASLB and were discussed during the December 1981 session of the OM-OL hearing. The hearing discussions revealed that information provided the NRC on these changes was very limited and the early assessment by the NRC raised concerns regarding the acceptability of these changes. The changes were subsequently discussed in Consumers letter of December 23, 1981. The meeting on January 12, 1982, included a review of the information from the December 23 letter.

Mr. B. Marguglio described the changes in the QA organization using several viewgraph slides (Enclosure 2) during his presentation. Slides 3 and 4 show the previous and new organization for the Midland Project Quality Assurance Department (MPQAD). The principal change is that three QA sections (Fluid Mechanical, Civil and Electrical I&C) no longer report through the superintendent of site project QA to Mr. Walt Bird, the MPQAD manager; rather they directly report to the combined B. Marguglio (MPQAD director) and W. Bird (MPQAD manager) arrangement, along with several other sections.

At the conclusion of the presentation and several questions, Mr. Keppler stated he was concerned about how much Messrs. Marguglio and Bird may be diluted with other work, and that the presentation failed to provide any convincing evidence that the change represents an enhancement of the previous organization. After a brief caucus, Mr. J. Cook returned to announce that the position of superintendent of site project QA would be reinstated after that position can be filled, and the three sections as before would report through this position to

FEB 18 1982

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5 PP

Mr. Marguglio. Mr. Keppler replied that such an organization would represent a further enhancement to the previous MPQAD which he had found acceptable, and would meet the Staff's criteria for establishing depth in an organization.

Mr. Cook stated that this change would be documented by letter shortly and an implementation date will be provided. The responsibilities of Mr. Bird with respect to HVAC will also be addressed. Mr. Cook also announced that due to reasons of health, Mr. Gil Keeley was being replaced by Mr. Jim Mooney.

QA Plan for Underpinning

Mr. W. Bird reviewed the general Quality Plan and the quality plans for the activities associated with the underpinning of the service water pump structure and auxiliary building. Viewgraph slides used during the presentation are provided by Enclosure 3. The presentation consisted of a review of the information in Consumer's letter of January 7, 1982.

Darl Hood

Darl S. Hood, Project Manager
Licensing Branch No. 4
Division of Licensing

Enclosures:
As stated

cc: See next page

MIDLAND

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Geotechnical Engineers, Inc.
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1017 Main Street
Winchester, Massachusetts 01890

ENCLOSURE 1

ATTENDENCE SHEET

CPCo - NRC MEETING

W. R. Bird	CPCo
B. W. Marguglio	CPCo
J. G. Bloom	Isham, Lincoln & Beak
J. Cook	CPCo
D. C. Boyd	NRC
R. J. Cook	NRC
W. D. Paton	NRC
D. Hood	NRC
M. Wilcove	NRC
G. Gallagher	NRC
R. Landsman	NRC
C. Noseline	NRC
L. Spessard	NRC
J. Keppler	NRC
D. E. Horn	CPCo
R. E. Sevo	Bechtel

ENCLOSURE 2

MIDLAND PROJECT QA ORGANIZATIONAL CHANGE

PRESENTATION TO
REGION III AND NRR QA BRANCH

GLEN ELLYN, ILLINOIS
JANUARY 12, 1982

B W MARGUGLIO
CONSUMERS POWER COMPANY

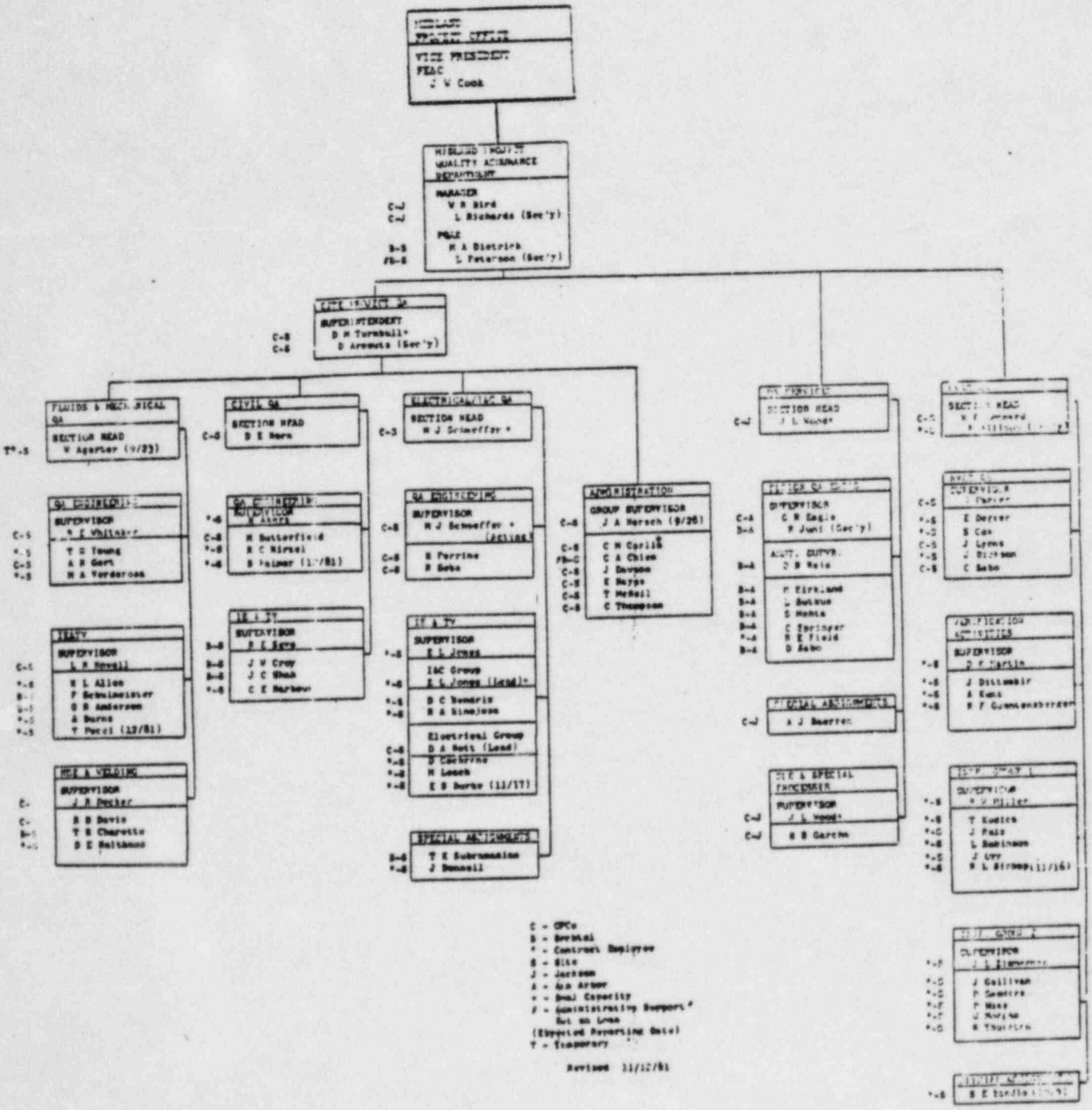
~~8203010270 XA~~
15 pp.

OUTLINE OF PRESENTATION

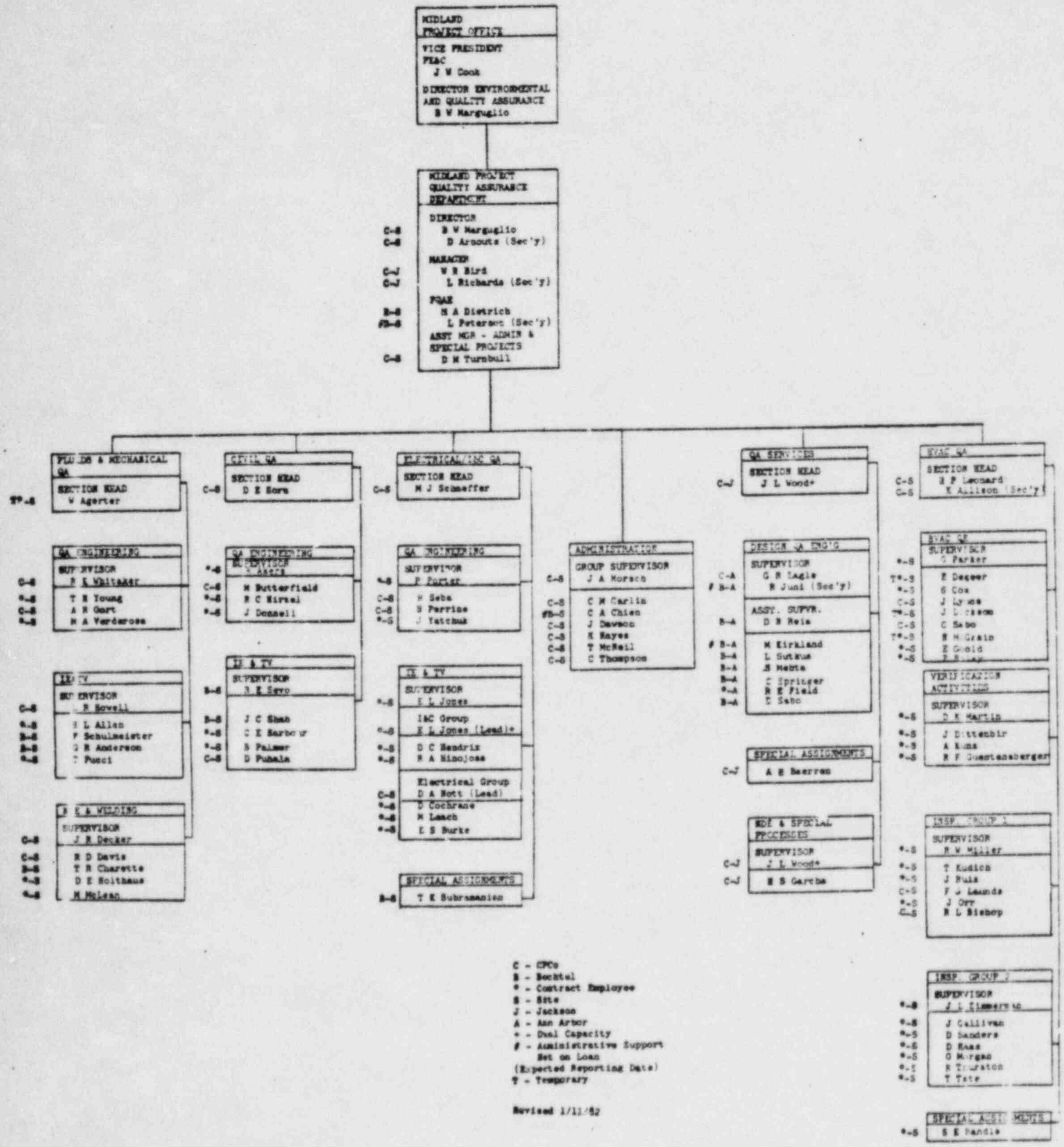
- PURPOSES OF THE CHANGE
- DESCRIPTION OF THE CHANGE
- RESPONSES TO NRC QUESTIONS/CONCERNS
- OTHER BENEFITS FROM THE CHANGE
- DISCUSSION
- NRC POSITION

PURPOSES OF THE CHANGE

- ADD SENIOR EXPERIENCED QA MANAGEMENT
- ACCOMMODATE THE GROWTH IN THE NUMBER OF QA PERSONNEL LOCATED AT THE SITE
- FULLY ADDRESS THE QA NEEDS OF THE JOB IN ITS FINAL STAGES
- UPGRADE LEADERSHIP AT THE SITE



Previous Organization



MIDLAND PROJECT OFFICE
VICE PRESIDENT PMAC
J W Cook
DIRECTOR ENVIRONMENTAL AND QUALITY ASSURANCE
B W Marguglio

MIDLAND PROJECT QUALITY ASSURANCE DEPARTMENT
DIRECTOR
C-S B W Marguglio
C-S D Arnouts (Sec'y)
MANAGER
C-J W R Bird
C-J L Richards (Sec'y)
PQAE
B-S H A Dietrich
#B-S L Peterson (Sec'y)
ASST MGR - ADMIN & SPECIAL PROJECTS
C-S D M Turnbull

FLUIDS & MECHANICAL QA
SECTION HEAD
T*-S W Agerter

QA ENGINEERING
SUPERVISOR
C-S P E Whitaker
*-S T E Young
C-S A R Gort
*-S H A Verderose

IE & TV
SUPERVISOR
C-S R Bovell
*-S L Allen
B-S F Schulmeister
B-S G R Anderson
*-S T Pucci

E & WELDING
SUPERVISOR
C-S J R Decker
C-S R D Davis
B-S T R Charette
*-S D E Holthaus
*-S M McLean

CIVIL QA
SECTION HEAD
C-S D E Horn

QA ENGINEERING
SUPERVISOR
*-S K Akers
C-S M Butterfield
*-S R C Hirzel
*-S J Donnell

IE & TV
SUPERVISOR
B-S R E Sevo
B-S J C Shah
*-S C E Barbour
*-S B Palmer
C-S D Puhala

ELECTRICAL/I&C QA
SECTION HEAD
C-S M J Schaeffer

QA ENGINEERING
SUPERVISOR
*-S P Porter
C-S H Seba
C-S B Perrine
*-S J Yatchak

IE & TV
SUPERVISOR
*-S E L Jones
I&C Group
*-S E L Jones (Lead)+
*-S D C Hendrix
*-S R A Hinojosa
Electrical Group
C-S D A Bott (Lead)
*-S D Cochrane
*-S M Leach
*-S E S Burke

SPECIAL ASSIGNMENTS
B-S T K Subramanian

ADMINISTRATION
GROUP SUPERVISOR
C-S J A Horsch
C-S C M Carlin
#B-S C A Chien
C-S J Dawson
C-S K Hayes
C-S T McNeil
C-S C Thompson

QA SERVICES
SECTION HEAD
C-J J L Wood+

DESIGN QA ENG'G
SUPERVISOR
C-A G R Eagle
B-A R Juni (Sec'y)
ASST. SUPVR.
B-A D R Reis
B-A M Kirkland
B-A L Sutkus
B-A S Mehta
B-A C Springer
*-A R E Field
B-A E Sabo

SPECIAL ASSIGNMENTS
C-J A E Beerren

NDE & SPECIAL PROCESSES
SUPERVISOR
C-J J L Wood+
C-J E S Gartha

HVAC QA
SECTION HEAD
C-S E F Leonard
C-S K Allison (Sec'y)

HVAC QC
SUPERVISOR
*-S G Parker
T*-S E Degeer
*-S G Cox
C-S J Lyons
T*-S J [illegible]
C-S C Sabo
T*-S R McGrain
*-S E Gould
*-S [illegible]

VERIFICATION ACTIVITIES
SUPERVISOR
*-S D K Martin
*-S J Dittenbir
*-S A Kuns
*-S R F Guestensberger

INSP. GROUP 1
SUPERVISOR
*-S R W Miller
*-S T Kudich
*-S J Ruiz
C-S F J Launds
*-S J Orr
C-S R L Bishop

INSP. GROUP 2
SUPERVISOR
*-S J L Zimmerman
*-S J Gallivan
*-S D Sanders
*-S D Ross
*-S G Morgan
*-S R Thurston
*-S T Tate

SPECIAL ASSIGNMENTS
*-S S E Randle

C - CPCo
B - Bechtel
* - Contract Employee
S - Site
J - Jackson
A - Ann Arbor
\+ - Dual Capacity
\# - Administrative Support
Not on Loan
(Expected Reporting Date)
T - Temporary

Revised 1/11/82

New Organization

JWC SPECIFICATIONS FOR BWM ASSIGNMENT

- DIRECT LINE RESPONSIBILITY FOR MPQAD
- THREE FULL DAYS AT SITE--MINIMUM
- CONTINUE TO OVERSEE PREVIOUSLY ASSIGNED FUNCTIONS, BUT WITH DELEGATION

DELEGATION

- BWM IS SENIOR QA PERSON
- WRB IS BWM's DEPUTY
- BOTH BWM AND WRB HAVE LINE RESPONSIBILITY AND AUTHORITY
- TO MORE EFFECTIVELY MANAGE QA:
    - ON A DAY-TO-DAY BASIS, THE HVAC SECTION AND THE QUALITY ENGINEERING SERVICES SECTION WILL REPORT TO WRB.
    - ON A DAY-TO-DAY BASIS, THE OTHER SECTION HEADS AND THE ASSISTANT MANAGER-ADMINISTRATION AND SPECIAL PROJECTS WILL REPORT TO BWM.
    - ON A DAY-TO-DAY BASIS, THE PQAE WILL COMMUNICATE AND INTERFACE WITH EITHER WRB OR BWM, DEPENDING UPON THE ABOVE-NOTED DELEGATION OF SUPERVISION.

(CONTINUED)

DELEGATION
(continued)

- IN ADDITION, ON A DAY-TO-DAY BASIS, WRB WILL CONTINUE TO SUPERVISE ALL ACTIVITIES ASSOCIATED WITH 50.55(e) AND PART 21 REPORTS (ie, DETERMINING REPORTABILITY, PREPARING REPORTS AND FOLLOWING-UP FOR PROBLEM RESOLUTION).
- IN ADDITION, ON A DAY-TO-DAY BASIS, WRB WILL CONTINUE TO SUPERVISE THE REMEDIAL SOILS WORK.
- IT IS INCUMBENT UPON EACH SECTION HEAD, THE PQAE AND THE ASSISTANT MANAGER TO NOTIFY EITHER WRB OR BWM OF ANY SIGNIFICANT ITEMS IN ACCORDANCE WITH THE ABOVE-NOTED DELEGATION OF SUPERVISION.

FULL-TIME MANAGEMENT

- SITE TIME SHALL BE WHATEVER IS REQUIRED TO DO THE JOB
- MIDLAND PROJECT BUSINESS AT ANN ARBOR, AND JACKSON
- MANAGING EVEN WHEN AWAY FROM MIDLAND--MANAGING FULL TIME
- DELEGATING OTHER FUNCTIONS--EXCEPT FOR ENVIRONMENTAL, SAME AS ORIGINAL RESPONSIBILITIES

LINES OF COMMUNICATION

- SAME DEGREE OF INVOLVEMENT FOR JWC
- SHORTER LINES OF COMMUNICATION FROM SITE QA SECTION HEADS TO JWC
- EQUAL BWM AND WRB ACCESS TO JWC

ORGANIZATIONAL AUTHORITY

- BWM IS SINGLY ACCOUNTABLE
- BWM HAS FULL-LINE AUTHORITY
- ASSIGNING DAY-TO-DAY SUPERVISION IS NOT DELEGATING AWAY FINAL RESPONSIBILITY AND AUTHORITY

OTHER BENEFITS

- ADDITIONAL SENIOR EXPERIENCED QA MANAGEMENT
- CONCENTRATED/SPECIALIZED EFFORT
- ADDITIONAL MANAGER
- ADDITIONAL SITE PRESENCE--WRB CONTINUES TO SPEND SAME AMOUNT OF TIME AT SITE, EVEN WITH BWM's PRESENCE AT SITE

CONCLUSION

- STRONGER QA ORGANIZATION

QUALITY PROGRAM
FOR
UNDERPINNING
ACTIVITIES

ENCLOSURE 3

QUALITY PLAN FOR UNDERPINNING ACTIVITIES

PURPOSE

PRESENT QUALITY PLANS, FOR THE UNDERPINNING ACTIVITIES TO HIGHLIGHT

- ORGANIZATIONS INVOLVED, SPECIFIC RESPONSIBILITIES AND THEIR INTERFACING
- THOSE UNIQUE ACTIVITIES OR REQUIREMENTS THAT GO BEYOND THE ESTABLISHED QUALITY PROGRAMS
- COMPREHENSIVE TOTAL QUALITY INVOLVEMENT AND CONTROLS ON THE QUALITY RELATED ACTIVITIES

PROVIDE A STATUS ON:

- STAFFING OF THE QUALITY ORGANIZATIONS
- IMPLEMENTATION OF THE QUALITY PLAN

PROVIDE AN OPPORTUNITY FOR FACE TO FACE COMMUNICATION ON THE UNDERPINNING QUALITY PROGRAM

OUTLINE OF THE PRESENTATION

CPCO AND BECHTEL ORGANIZATIONS

SUBCONTRACTOR AND CONSULTANT ORGANIZATIONS

QUALITY PLAN CONTENT

DESIGN CONTROL FOR UNDERPINNING ACTIVITIES

DESIGN DOCUMENT INTERFACE FLOW CHART

PROCEDURE REVIEW APPROVAL/FLOW CHART

QUALITY RELATED ACTIVITIES LIST

SUBCONTRACTOR REQUIRED "Q" PROCEDURES

STAFFING OF QUALITY ORGANIZATIONS

ADDITIONAL QUALITY PROGRAM DOCUMENTS REQUIRED TO SUPPORT THE UNDERPINNING WORK

SUMMARY AND CONCLUSION

CPCO AND BECHTEL ORGANIZATIONAL ELEMENTS

THE EXISTING COMPANY ORGANIZATIONS AS PROVIDED BY ORGANIZATIONAL CHARTS AND DESCRIPTIONS IN THE TOPICAL REPORTS AND LOWER TIER DOCUMENTS REMAIN FULLY APPLICABLE

ORGANIZATIONS INVOLVED IN THE UNDERPINNING

- CPCO PROJECT MANAGEMENT
- CPCO DESIGN PRODUCTION
- CPCO SITE MANAGEMENT
- BECHTEL PROJECT MANAGEMENT
- BECHTEL PROJECT ENGINEERING
- BECHTEL PROJECT GEOTECHNICAL ENGINEER
- BECHTEL CONSTRUCTION (REMEDIAL SOILS GROUP)
- GEOTECH SERVICES
- RESIDENT GEOTECHNICAL ENGINEER
- BECHTEL QUALITY CONTROL (QC)
- MIDLAND PROJECT QUALITY ASSURANCE DEPARTMENT (MPQAD)

THE QUALITY PLAN FOR UNDERPINNING ACTIVITIES PROVIDES A BRIEF SCOPE STATEMENT FOR EACH ORGANIZATION AS RELATED TO THE UNDERPINNING ACTIVITY

ORGANIZATIONS

SUBCONTRACTORS AND CONSULTANTS

SUBCONTRACTORS/CONSULTANTS	SCOPE OF DUTIES
MUESER, RUTLEDGE, JOHNSON AND DESIMONE	DESIGN INPUT FOR THE UNDERPINNING OF THE SERVICE WATER PUMP STRUCTURE UNDER A TECHNICAL SERVICE AGREEMENT ALSO, CONSULTANT FOR THE UNDERPINNING OF THE AUXILIARY BUILDING UNDER A TECHNICAL SERVICE AGREEMENT
SPENCER, WHITE AND PRENTIS, INC (PROPOSED)	SUBCONTRACTOR FOR THE UNDERPINNING OF THE SERVICE WATER PUMP STRUCTURE
MERGENTIME CORP/HANSON ENGINEERS, INC	JOINT VENTURE TO PROVIDE DESIGN INPUT FOR THE UNDERPINNING OF THE AUXILIARY BUILDING UNDER A TECHNICAL SERVICE AGREEMENT
MERGENTIME CONST CORP	SUBCONTRACTOR FOR THE UNDERPINNING OF THE AUXILIARY BUILDING

ORGANIZATIONS

SUBCONTRACTORS AND CONSULTANTS
(CONT)

SUBCONTRACTOR/CONSULTANTS	SCOPE OF DUTIES
WISS, JANNEY, ELSTNER AND ASSOCIATES, INC	PROVIDE THE DESIGN FOR THE SETTLEMENT MONITORING EQUIPMENT, PROCURES THE MONITORING EQUIPMENT, INSPECTS THE INSTALLATION OF THE MONITORING EQUIPMENT, AND PROVIDE DATA TO PROJECT ENGINEERING
U S TESTING COMPANY, INC	SUBCONTRACTOR FOR TESTING CONCRETE PRODUCTION MATERIALS (CEMENT, FLYASH, WATER, AGGREGATES), SOILS, CONCRETE, GROUT, FINES MONITORING OF SOIL PARTICLES, TENSILE TESTING OF REINFORCING STEEL AND REINFORCING SPLICES.

REMEDIAL SOILS WORK QUALITY PROGRAM

- CPCo QUALITY ASSURANCE PROGRAM MANUAL FOR NUCLEAR POWER PLANTS
  - Volume I - Policies (Topical CPC-1-A)
  - Volume II - Procedures for Design and Construction
- BQ-TOP-1, REVISION 1A
  - Bechtel Nuclear Quality Assurance Manual

QUALITY PLAN CONTENT

PROVIDES ORGANIZATIONAL RESPONSIBILITIES AND RELATIONSHIPS

ESTABLISHES A SPECIFIC Q-LIST OF DESIGNATED QUALITY ACTIVITIES

PROVIDES A NARRATIVE OF THE MAJOR PROGRAM ELEMENTS

PROVIDES UNIQUE QUALITY PROGRAMMATIC CONTROLS WHICH ARE NOT IN THE STANDARD EXISTING PROJECT QUALITY PROGRAMS

PROVIDES ADDITIONAL DEFINITION TO THE QUALITY REQUIREMENTS IN THE TECHNICAL SPECIFICATIONS

PROVIDES A LIST OF THE SPECIFIC SAFETY RELATED (Q) PROCEDURES THE SUBCONTRACTOR MUST PROVIDE FOR PROJECT REVIEW, APPROVAL AND RELEASE

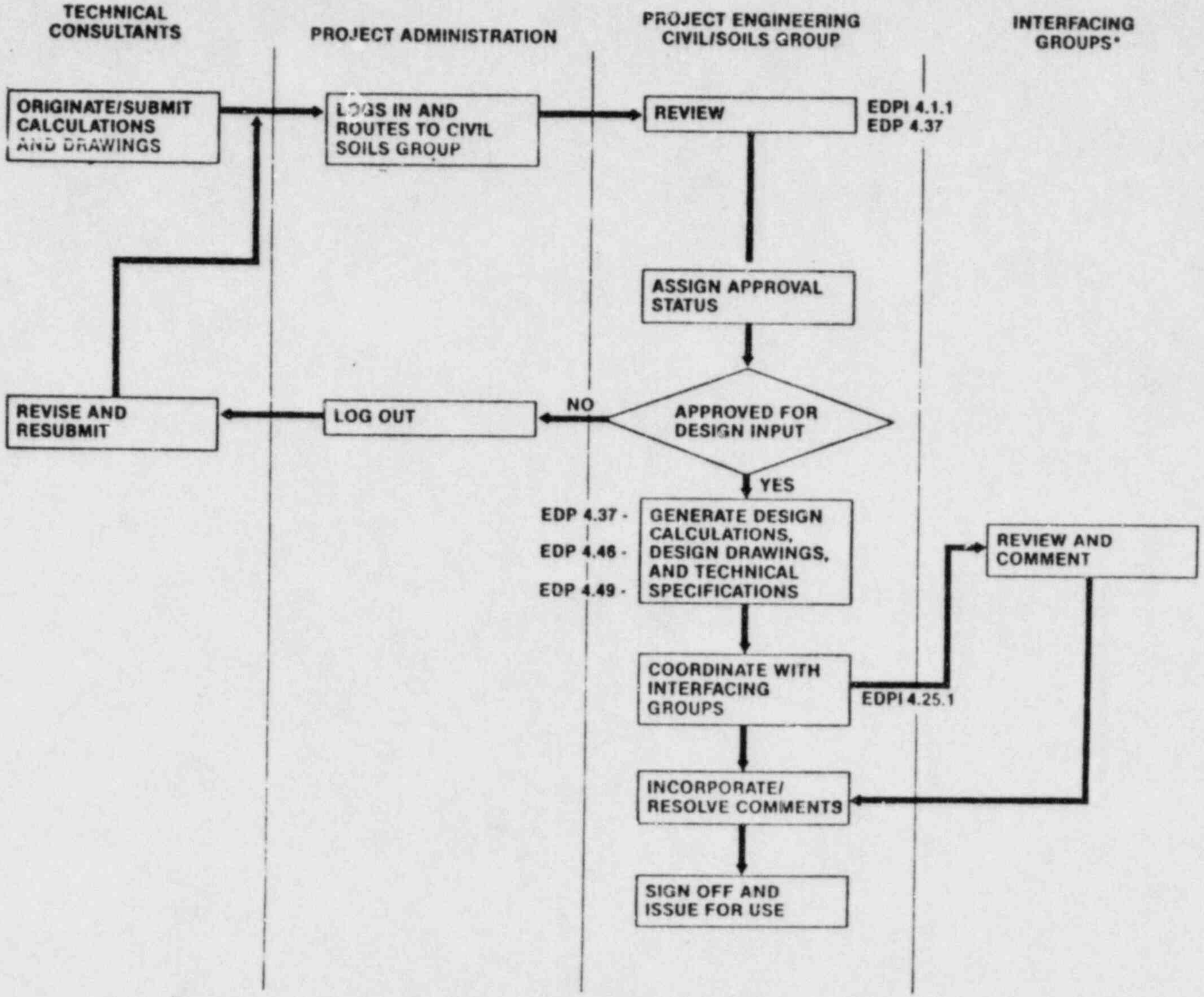
DESIGN CONTROL FOR UNDERPINNING ACTIVITIES

QUALITY PLAN FOR UNDERPINNING ACTIVITIES PROVIDES A DETAILED DESCRIPTION OF THE DESIGN CONTROL PROCESS AND REFERENCES THE DETAIL PROCEDURES CONTROLLING THE BECHTEL AND CPCO DEPARTMENT PROCEDURES

QUALITY PLAN INCORPORATED IN EACH SPECIFICATION PROVIDES THE DETAIL FLOW PROCESS FOR PREPARATION REVIEW AND RELEASE OF DESIGN DOCUMENTS

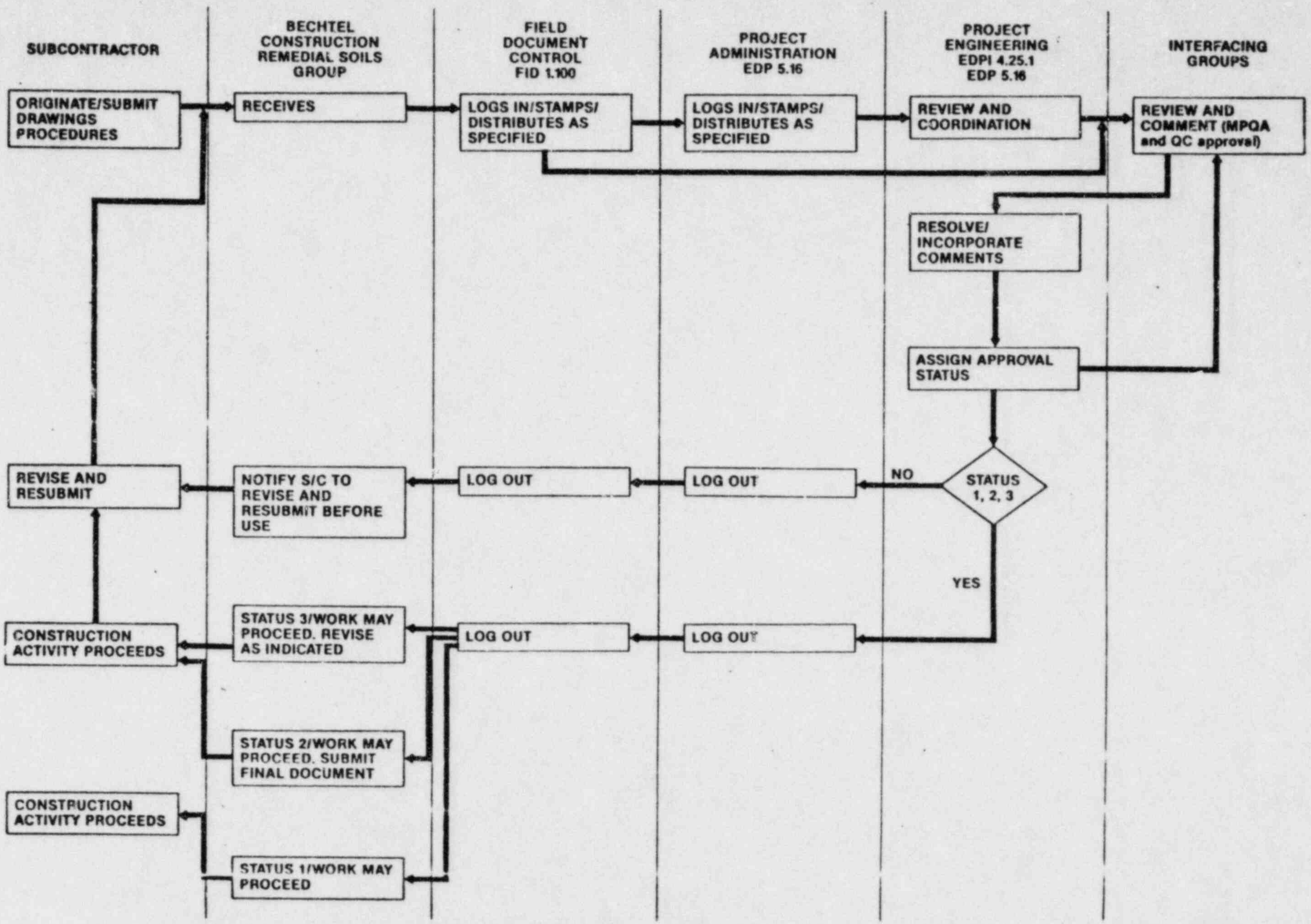
UNDERPINNING SUBCONTRACTOR(S) WILL BE REQUIRED TO HAVE A PROCEDURE TO CONTROL THE PROJECT ISSUED DESIGN DOCUMENTS AND PROCEDURES

DESIGN DOCUMENT INTERFACE FLOWCHART



*INTERFACING GROUPS (as defined by EDPI 4.25.1 or approved alternate)
- DISCIPLINE ENGINEERING GROUPS
- CHIEF ENGINEER (per EDP 4.34)
- GEOTECHNICAL SERVICES
- CONSULTANTS
- QUALITY ENGINEERING (drawings and specifications)
- MPQA (drawings and specifications)

PROCEDURE REVIEW/APPROVAL FLOWCHART



9A

Procedures To Be Submitted By The Subcontractor	Organization Responsible For Procedure Review & Approval					
	Proj Eng	Resident Geotech	Bechtel Construction RSG	Bechtel Quality Control	MPQAD	Technical Consultant
Procedure for general underpinning - This procedure shall include the overall concept of the work involved, including the interface of all the operations listed below.	X	0	0	X	X	0
Procedure for load transfer.	X	0	0	X	X	0
Procedure for placement of lean concrete backfill in shafts and tunnel.	X		0	X	X	
Procedure for installation of (including mixing) and pressure grouting.	X		0	X	X	
Procedure for placement of pier concrete.	X		0	X	X	
Procedure for acquiring and maintaining calibration of jacks and gages.	X		0	X	X	
Procedure for mechanical splicing of reinforcement.	X		0	X	X	
Procedure for threading of reinforcing steel.	X		0	X	X	
Procedure for installation of anchor bolts and rock anchors.	X		0	X	X	
Procedure for installation of compressible material.	X		0	X	X	
Procedure for placing reinforcement including bending steel reinforcement (hot and cold).	X		0	X	X	
Procedure for core drilling.	X		0	X	X	

LEGEND

REVIEW & APPROVAL - X

REVIEW & COMMENT - 0
as applicable

9 B

Procedures To Be Submitted By The Subcontractor	Proj Eng	Resident Geotech	Bechtel Construction RSG	Bechtel Quality Control	MPQAD	Technical Consultant
	Organization Responsible For Procedure Review & Approval					
Procedure for concrete repairs.	X		0	X	X	
Procedure for excavation "Q" structures and the installation of lagging.	X	0	0	X	X	
Procedure for protection of underground utilities	X		0	X	X	
Procedure for preparing, submitting, and revising Q procedures.	X		0	X	X	
Procedure for handling, storing, and controlling Contractor-furnished materials.	X		0	X	X	
Procedure for design document control.	X		0	0	X	
Procedures for interface and coordination between the Subcontractor and the Contractor for activities covered by the QA Program.	X	0	0	0	X	
Procedure for construction of temporary supports including grillage.	X		0	X	X	0
Procedure for welding.	X		0	X	X	
Procedure for certifying subcontractor personnel specifically for AWS welding and mechanical splices.	X		0	X	X	
Procedure for Training Program of subcontractor personnel for the Q-Procedures covering the subcontractor scope of work.	X		0	X	X	

LEGEND

REVIEW & APPROVAL - X

REVIEW & COMMENT - 0
as applicable

QUALITY RELATED (Q-LISTED ACTIVITIES)

1. DOCUMENT SUBMITTAL, INTERFACE AND CONTROL ①
2. PROCURING Q-LISTED ITEMS AND MATERIALS
3. STORAGE, HANDLING AND CONTROL OF Q-LISTED MATERIALS ①
4. FURNISHING AND INSTALLATION OF LAGGING AND BRACING UNDER "Q" STRUCTURES ①
5. EXCAVATION LIMITS, CONTROL AND SEQUENCE UNDER "Q" STRUCTURES ①
6. CRACK MAPPING AND EVALUATION
7. CALIBRATION, MAINTENANCE, CONTROL AND INSTALLATION OF GAGES AND SETTLEMENT MONITORING INSTRUMENTATION
8. MONITORING OF BUILDING MOVEMENT INSTRUMENTATION AND PIER PRESSURE GAGES
9. FINES MONITORING OF DEWATERING WELLS IN "Q" AREAS
10. LOCATION AND PROTECTION OF "Q" UTILITIES ①
11. GEOTECHNICAL ACCEPTANCE OF SUBGRADE
12. FABRICATION OF STEEL GRILLAGE FOR TEMPORARY SUPPORTS FOR "Q" STRUCTURES ② ①
13. FABRICATIONS AND INSTALLATION OF TEMPORARY SUPPORTS FOR "Q" STRUCTURES ② ①
14. WELDING OF TEMPORARY AND PERMANENT SUPPORTS FOR "Q" STRUCTURES ② ①

① SUBCONTRACTOR HAS TO HAVE PROCEDURES

② APPLY ONLY TO AUXILIARY BUILDING UNDERPINNING

QUALITY RELATED (Q-LISTED ACTIVITIES)
(CONTINUED)

15. FABRICATION AND INSTALLATION OF REINFORCING STEEL ①
16. CERTIFICATION OF PERSONNEL PERFORMING SPLICES ①
17. THREADING OF REINFORCING STEEL AND INSTALLATION OF MECHANICAL SPLICES ①
18. DRILLING IN "Q" STRUCTURES FOR THE INSTALLATION OF ANCHOR BOLTS, ROCK ANCHORS AND DEWATERING WELLS ①
19. INSTALLATION ① AND INSPECTION OF ANCHOR BOLTS AND ROCK ANCHORS
20. COMPRESSIBLE MATERIAL CONFIGURATION AND INSTALLATION ①
21. TESTING OF REINFORCING STEEL AND MECHANICAL SPLICES
22. INSTALLATION ① INSPECTION AND TESTING OF STRUCTURAL CONCRETE, LEAN CONCRETE, GROUT AND DRYPACK
23. REPAIR OF CONCRETE IN "Q" STRUCTURES ①
24. CALIBRATING, MAINTAINING, INSTALLING AND CONTROLLING OF HYDRAULIC JACKS AND PRESSURE GAGES ①
25. LOAD TRANSFER ACTIVITIES ①
26. BACKFILLING ① AND ACCEPTANCE TESTING FOR ACCESS SHAFTS AND TUNNELS IN "Q" AREAS

① SUBCONTRACTOR HAS TO HAVE PROCEDURES

② APPLY ONLY TO AUXILIARY BUILDING UNDERPINNING

SUBCONTRACTOR REQUIRED "Q" PROCEDURES

LIST IS TAKEN DIRECTLY FROM THE QUALITY PLAN FOR SPECIFICATION C-195

PROCEDURE LIST

PROCEDURE FOR GENERAL UNDERPINNING - THIS PROCEDURE SHALL INCLUDE THE OVERALL CONCEPT OF THE WORK INVOLVED, INCLUDING THE INTERFACE OF ALL THE OPERATIONS LISTED BELOW

PROCEDURE FOR LOAD TRANSFER

PROCEDURE FOR PLACEMENT OF LEAN CONCRETE BACKFILL IN SHAFTS AND TUNNELS

PROCEDURE FOR INSTALLATION OF (INCLUDING MIXING) AND PRESSURE GROUTING

PROCEDURE FOR PLACEMENT OF PIER CONCRETE

PROCEDURE FOR ACQUIRING AND MAINTAINING CALIBRATION OF JACKS AND GAGES

PROCEDURE FOR MECHANICAL SPLICING OF REINFORCEMENT

PROCEDURE FOR THREADING OF REINFORCING STEEL

PROCEDURE FOR INSTALLATION OF ANCHOR BOLTS AND ROCK ANCHORS

PROCEDURE FOR INSTALLATION OF COMPRESSIBLE MATERIAL

SUBCONTRACTOR REQUIRED "Q" PROCEDURES (CONTINUED)

PROCEDURE FOR PLACING REINFORCEMENT INCLUDING BENDING STEEL REINFORCEMENT (HOT AND COLD)

PROCEDURE FOR CORE DRILLING

PROCEDURE FOR CONCRETE REPAIRS

PROCEDURE FOR EXCAVATION "Q" STRUCTURES AND THE INSTALLATION OF LAGGING

PROCEDURE FOR PROTECTION OF UNDERGROUND UTILITIES

PROCEDURE FOR PREPARING, SUBMITTING AND REVISING Q PROCEDURES

PROCEDURE FOR HANDLING, STORING, AND CONTROLLING CONTRACTOR-FURNISHED MATERIALS

PROCEDURE FOR DESIGN DOCUMENT CONTROL

PROCEDURES FOR INTERFACE AND COORDINATION BETWEEN THE SUBCONTRACTOR AND THE CONTRACTOR FOR ACTIVITIES COVERED BY THE QA PROGRAM

PROCEDURE FOR CONSTRUCTION OF TEMPORARY SUPPORTS INCLUDING GRILLAGE

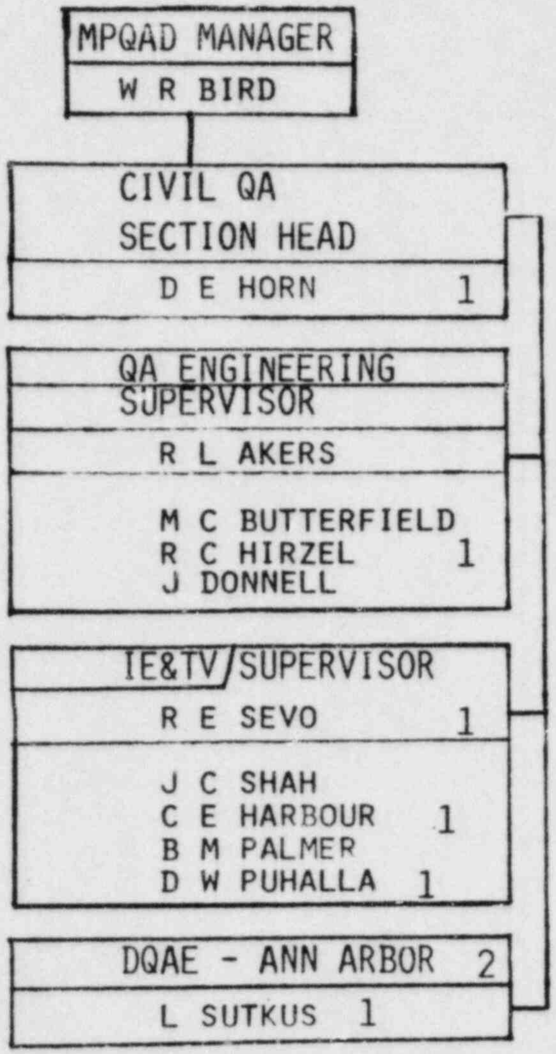
PROCEDURE FOR WELDING

PROCEDURE FOR CERTIFYING SUBCONTRACTOR PERSONNEL SPECIFICALLY FOR AWS WELDING AND MECHANICAL SPLICES

PROCEDURE FOR TRAINING PROGRAM OF SUBCONTRACTOR PERSONNEL FOR THE Q-PROCEDURES COVERING THE SUBCONTRACTORS SCOPE OF WORK

ORGANIZATION CHART OF MPQAD IN SUPPORT OF UNDERPINNING

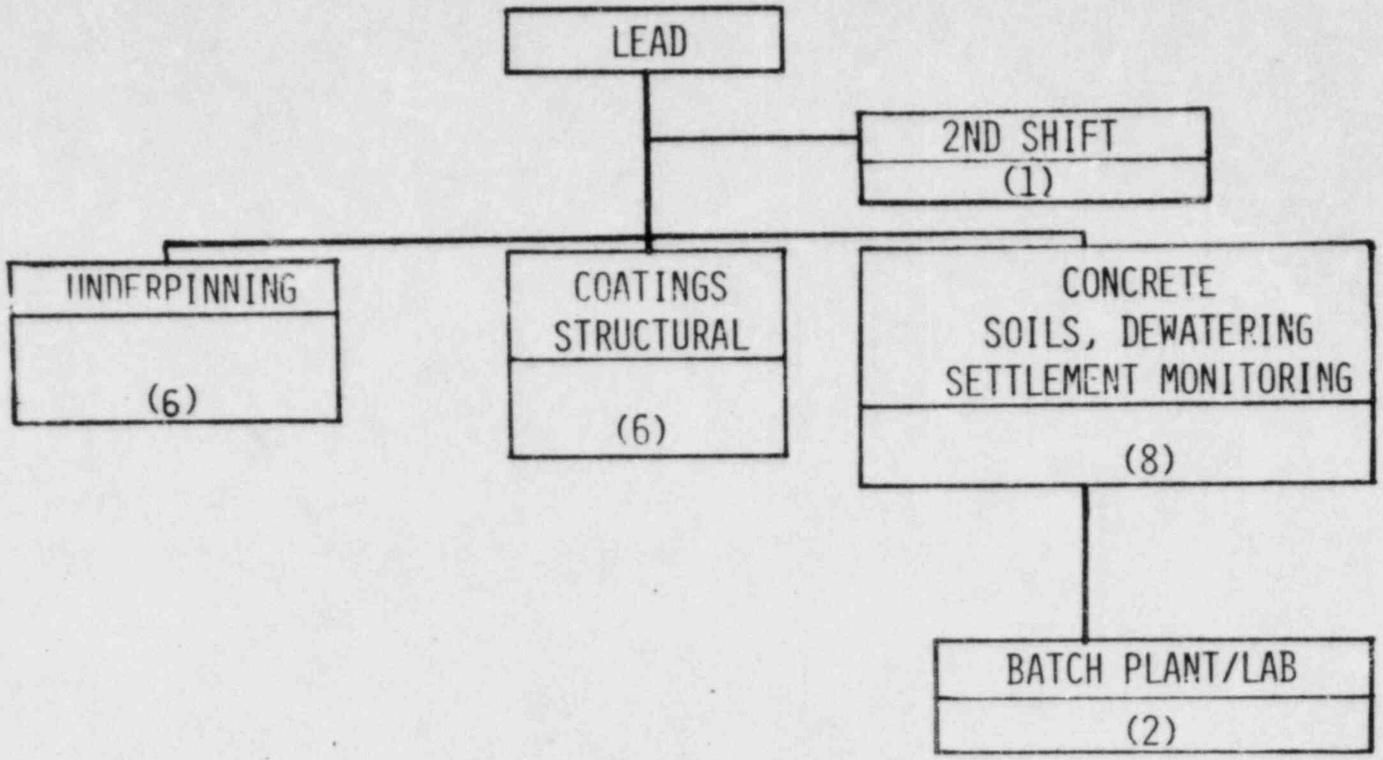
MIDLAND PROJECT OFFICE



1 THOSE INDIVIDUALS WHOSE PRIMARY RESPONSIBILITIES AND TIME ARE FOR SUPPORT OF THE UNDERPINNING WORK

2 ADMINISTRATIVELY UNDER QUALITY ENGINEERING SERVICES SECTION

BECHTEL QUALITY CONTROL CIVIL DISCIPLINE



LEAD

2ND SHIFT
(1)

UNDERPINNING
(6)

COATINGS
STRUCTURAL
(6)

CONCRETE
SOILS, DEWATERING
SETTLEMENT MONITORING
(8)

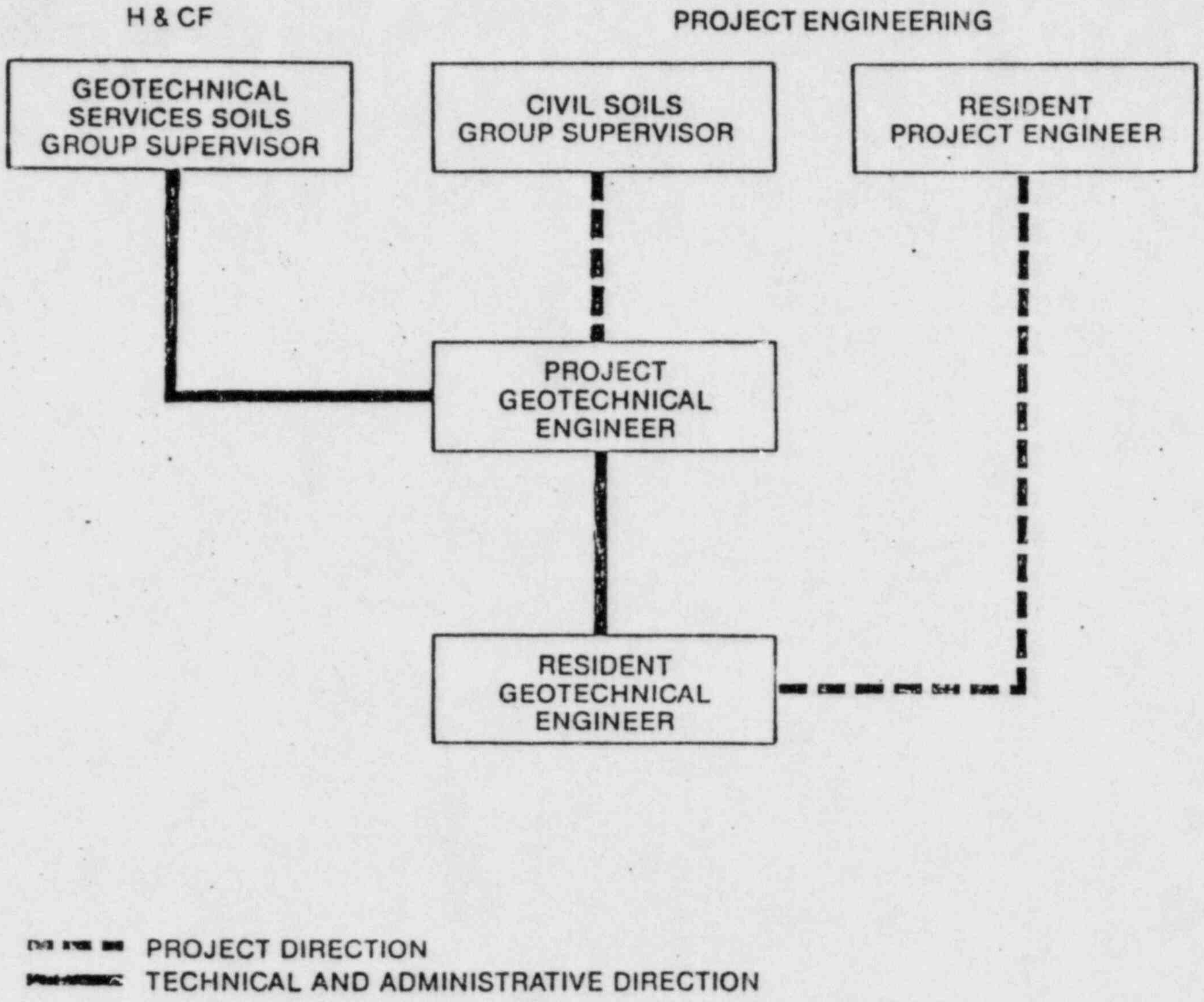
BATCH PLANT/LAB
(2)

NUMBERS IN THE BLOCKS SHOW THE NUMBER OF QUALITY CONTROL ENGINEERS ASSIGNED AS OF JANUARY, 1982

PRESENT STAFF AS SHOWN IS ADEQUATE TO COVER NEAR FUTURE SCOPE OF WORK

CERTIFICATION FOR SPECIFIC UNDERPINNING QUALITY CONTROL INSTRUCTIONS IS ACTIVITY PENDING

GEOTECHNICAL SUPPORT



QUALITY PROGRAM DOCUMENTS

QUALITY PROGRAM DOCUMENTS THAT WILL BE REVISED OR PREPARED TO IMPLEMENT PROGRAM CHANGES IN RESPONSE TO THE QUALITY PLANS

EDPI - 4.25.1 DESIGN INTERFACE CONTROL
(OR APPROVED ALTERNATE)

EDPI - 2.14.8 RESIDENT GEOTECHNICAL ENGINEER FOR MIDLAND REMEDIAL UNDERPINNING OPERATIONS

EDP - 5.16 SUPPLIER DOCUMENT CONTROL

FPD - 1.000 DESIGN DOCUMENT AND CORRESPONDENCE CONTROL
(OR APPROVED ALTERNATE)

SPECIFICATION C-198 - QUALITY PLAN FOR SETTLEMENT MONITORING AND INSTRUMENTATION

FINALIZE INDOCTRINATION AND PROGRAMMATIC TRAINING OF SUBCONTRACTOR PERSONNEL

SUMMARY

REVIEWED THE MAJOR ELEMENTS OF THE QUALITY PLANS

PROVIDED THE STATUS OF IMPLEMENTATION OF THESE PLANS

EMPHASIZED THE UNIQUE ASPECTS OF THESE ACTIVITIES AND THE WAYS THE QUALITY PROGRAM RESPONDS TO THESE ASPECTS

Consumers Power Company

James W Cook
Vice President - Projects, Engineering and Construction

General Offices: 1945 West Parnall Road, Jackson, MI 49201 • (517) 788-0453

January 25, 1982

PRINCIPAL STAFF			
DIR			
D/D			
A/D			
[illegible]			
[illegible]			
DEP&OS		File	

Landsman

Harold R Denton, Director
Office of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Washington, DC 20555

MIDLAND PROJECT
MIDLAND DOCKET NOS 50-329, 50-330
EVALUATION REPORT FOR THE FEEDWATER ISOLATION VALVE PITS
FILE 0485.16 SERIAL 15493
ENCLOSURES: (1) EVALUATION OF FEEDWATER ISOLATION VALVE PITS AT MIDLAND PLANT
(2) FEEDWATER ISOLATION VALVE PIT CRACK MONITORING PROGRAM

On December 10, 1981 and January 11, 1982, meetings were held with the Staff and its consultants to discuss concrete cracks in the auxiliary building, the service water pump structure, the diesel generator buildings and the feedwater isolation valve pits. During the January 11, 1982 meeting, Consumers Power agreed to provide the NRC with an evaluation of the significance of concrete cracks relative to the design strength of the feedwater isolation valve pit structures.

In response to this commitment, we are providing the enclosed report (Enclosure 1) entitled "Evaluation of Feedwater Isolation Valve Pits at Midland Plant" by Messrs W G Corley and A E Fiorato of Construction Technology Laboratories, a Division of the Portland Cement Association. This report presents an evaluation of the significance of cracks observed in the feedwater isolation valve pit structures. The information, measurements and test data presented in Enclosure 1 lends further support to our conclusion that: (1) cracks in an adequately reinforced concrete member do not prevent the member from developing its expected strength, and (2) cracks in the feedwater isolation pits are the result of restrained volumetric changes which occurred during the curing and drying of concrete and are not due to structural distress. In addition, a program for monitoring structural integrity during the implementation of remedial measures is outlined.

During the underpinning operation, cracks in the feedwater isolation valve pits will be monitored and recorded by mapping at the time of specific construction milestones. These construction milestones, at which time crack mapping will be performed, are identified in Enclosure 2. The frequency of

JAN 28 1982

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crack monitoring identified in this enclosure is based upon our discussions with the Staff and its consultants during the recent January 19, 1982 audit held in Ann Arbor, and this crack monitoring program incorporates the Staff's concerns.

Based upon the information contained in Enclosure 1, we conclude that the present cracks in the feedwater isolation valve pit structures are of no structural significance, and any changes in their condition during the underpinning operations will be monitored and, if necessary, evaluated.

JAMooney
J A Mooney
Executive Manager
Midland Project Office

For J W Cook

JWC/RLT/dsb

CC Atomic Safety and Licensing Appeal Board, w/o
CBechhoefer, ASLB, w/o
MMCherry, Esq, w/o
FPCowan, ASLB, w/o
RJCook, Midland Resident Inspector, w/o
RSDecker, ASLB, w/o
SGadler, w/o
JHarbour, ASLB, w/o
GHarstead, Harstead Engineering, w/a
DSHood, NRC, w/a (2)
DFJudd, B&W, w/o
JDKane, NRC, w/a
FJKelley, Esq, w/o
RBLandsman, NRC Region III, w/a
WHMarshall, Esq, w/o
JPMatra, Naval Surface Weapons Center, w/a
WOtto, Army Corps of Engineers, w/a
WDPaton, Esq, w/o
SJPoulos, Geotechnical Engineering, w/a
FRinaldi, NRC, w/a
HSingh, Army Corps of Engineers, w/a
BStamiris, w/o

ENCLOSURE 2
FEEDWATER ISOLATION VALVE PIT CRACK MONITORING PROGRAM

During the underpinning operation, cracks in the feedwater isolation valve pit structures will be monitored by mapping at the time of the following construction milestones:

1. Prior to extending the access shaft below Elevation 609' for the purpose of taking baseline measurements.
2. During the tunneling to Pier W 9 (ie, Pier N on Figure 8 of Enclosure 1.)
3. After completion of tunneling to Pier W 9.
4. After completion of all excavation under the feedwater isolation valve pits.
5. At two-month maximum intervals after completion of the excavation under the feedwater isolation valve pits, or at increased intervals if settlement becomes significant.
6. Prior to jacking of the permanent underpinning.
7. After jacking of the permanent underpinning.
8. After any rejacking of the temporary support system.

ENCLOSURE 1

Report to

CONSUMERS POWER COMPANY
Jackson, Michigan

EVALUATION OF FEEDWATER ISOLATION VALVE PITS AT MIDLAND PLANT

by

W. G. Corley
A. E. Fiorato

Submitted by

CONSTRUCTION TECHNOLOGY LABORATORIES
A Division of the Portland Cement Association
5420 Old Orchard Road
Skokie, Illinois 60077

January 1982

8201290408

TABLE OF CONTENTS

EVALUATION OF FEEDWATER ISOLATION VALVE PITS
AT MIDLAND PLANT

by

W. G. Corley and A. E. Fiorato*

INTRODUCTION

This report presents an evaluation of the significance of cracks observed in the Feedwater Isolation Valve Pits located at Midland Nuclear Power Plant Units 1 and 2. Observed cracks in these structures are described and significance of the cracks with regard to future load carrying capacity is discussed. In addition, a program for monitoring structural integrity during implementation of remedial measures is described. Remedial measures are being undertaken to underpin selected structures.

DESCRIPTION OF STRUCTURES

A site plan for the Midland Plant is shown in Fig. 1.(1)** Feedwater Isolation Valve Pits are located at the ends of Electrical Penetration Areas for Reactor Building Units 1 and 2. These penetration areas are located on either side of the Auxiliary Building Control Tower. The plan of the Auxiliary Building, shown in Fig. 2,(1) gives the location of the Feedwater Isolation Valve Pits. As can be seen in the figure, the pits are bounded by the Electrical Penetration Area, the

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**Superscript numbers in parentheses refer to references listed at the end of this report.

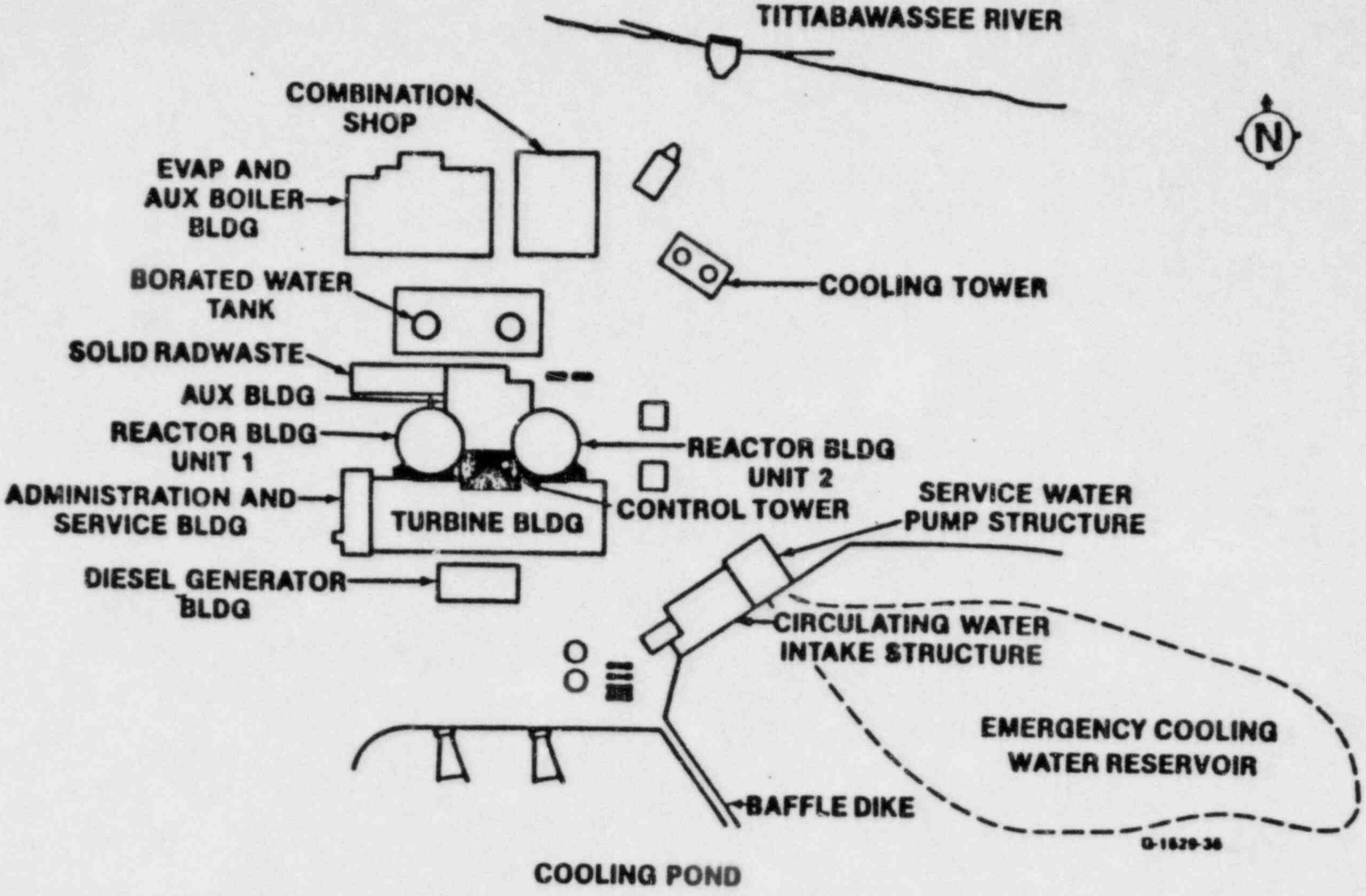


FIG. 1 SITE PLAN

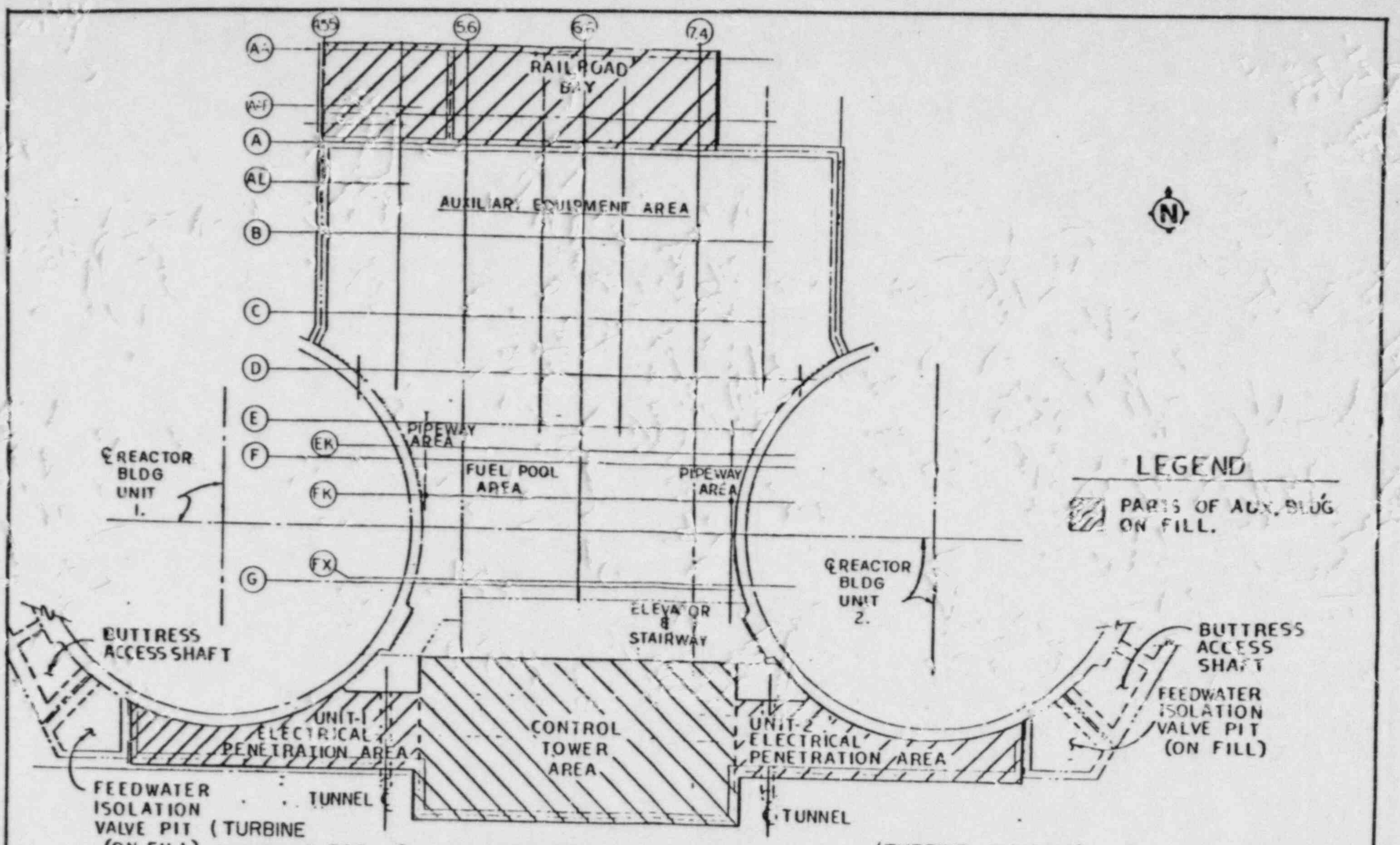


FIG. 2 **AUXILIARY BUILDING PLAN**

Reactor Building, a Buttress Access Shaft, and the Turbine Building.

The function of the Feedwater Isolation Valve Pits is to enclose Seismic Category I feedwater pipe isolation valves. Each pit is C-shaped with the open end toward the containment building. The pits are structurally isolated from surrounding structures, are constructed of reinforced concrete, and are supported on backfill soil.

Figures 3, 4, and 5 show the general reinforcement arrangements for the walls, floor, and roof of the Feedwater Isolation Valve Pits. These figures are based on Bechtel Construction Drawing C-429, Revision 4, 10/1/79. Additional reinforcement details are given on Drawing C-429 as well as Drawing C-442, Revision 1, 4/6/77.

Feedwater Isolation Valve Pit walls adjacent to the Buttress Access Shaft and the Electrical Penetration Area are 2-ft 6-in. thick. Vertical reinforcement in these walls is No. 10 bars spaced at 12 in. on centers at each face. Horizontal reinforcement consists of No. 11 bars spaced at 12 in. on centers at each face. Concrete compressive strength is specified at 5000 psi for the entire structure.

The Feedwater Isolation Valve Pit wall adjacent to the Turbine Building is 3-ft 6-in. thick. Vertical and horizontal reinforcement in this wall consists of No. 11 bars spaced at 12 in. on centers at each face.

The "exposed" wall of the Feedwater Isolation Valve Pit is 3-ft 6-in. thick. This wall runs between the Buttress Access

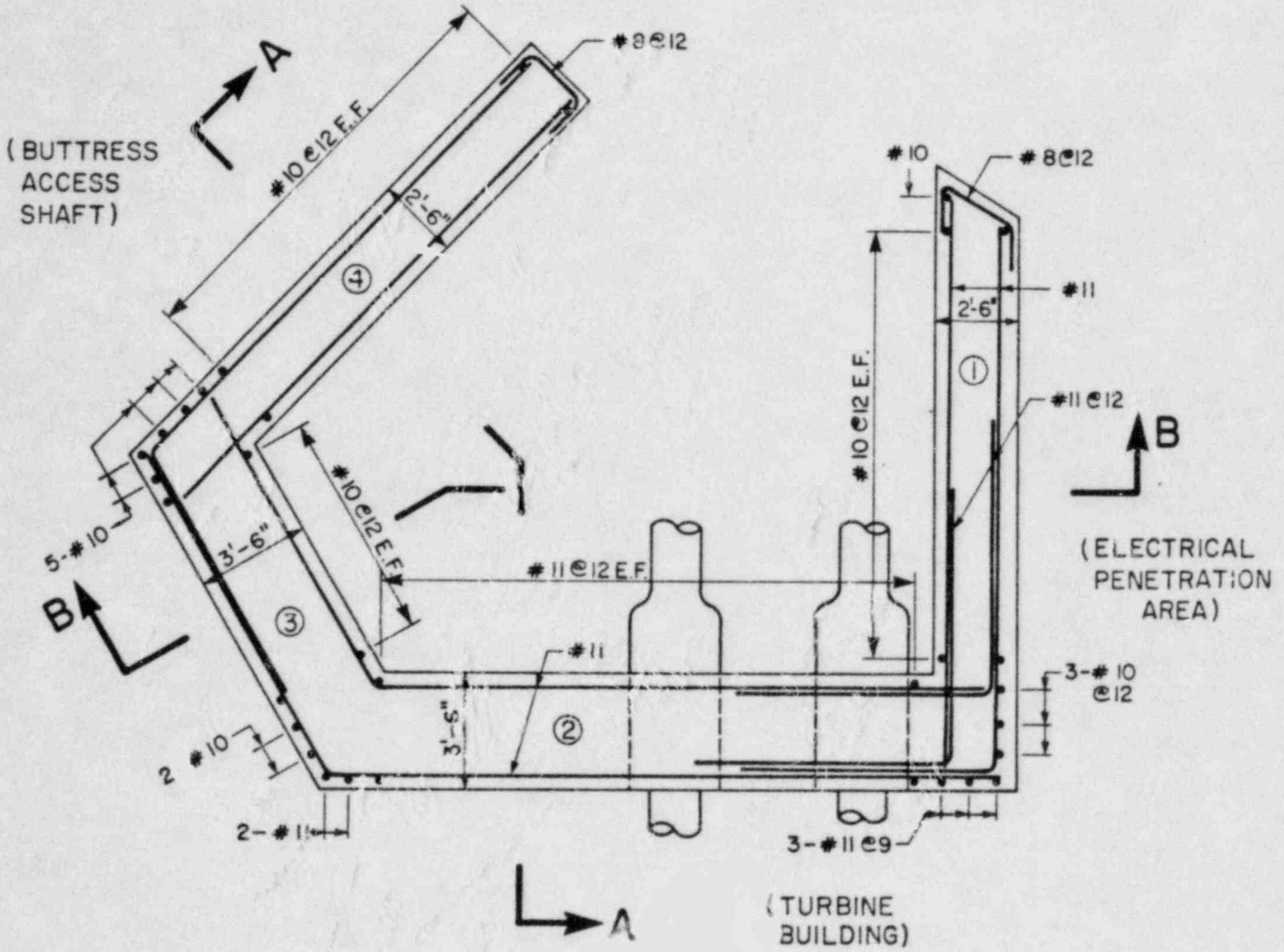


Fig. 3 Reinforcement in Feedwater Isolation Valve Pit Walls - Plan View

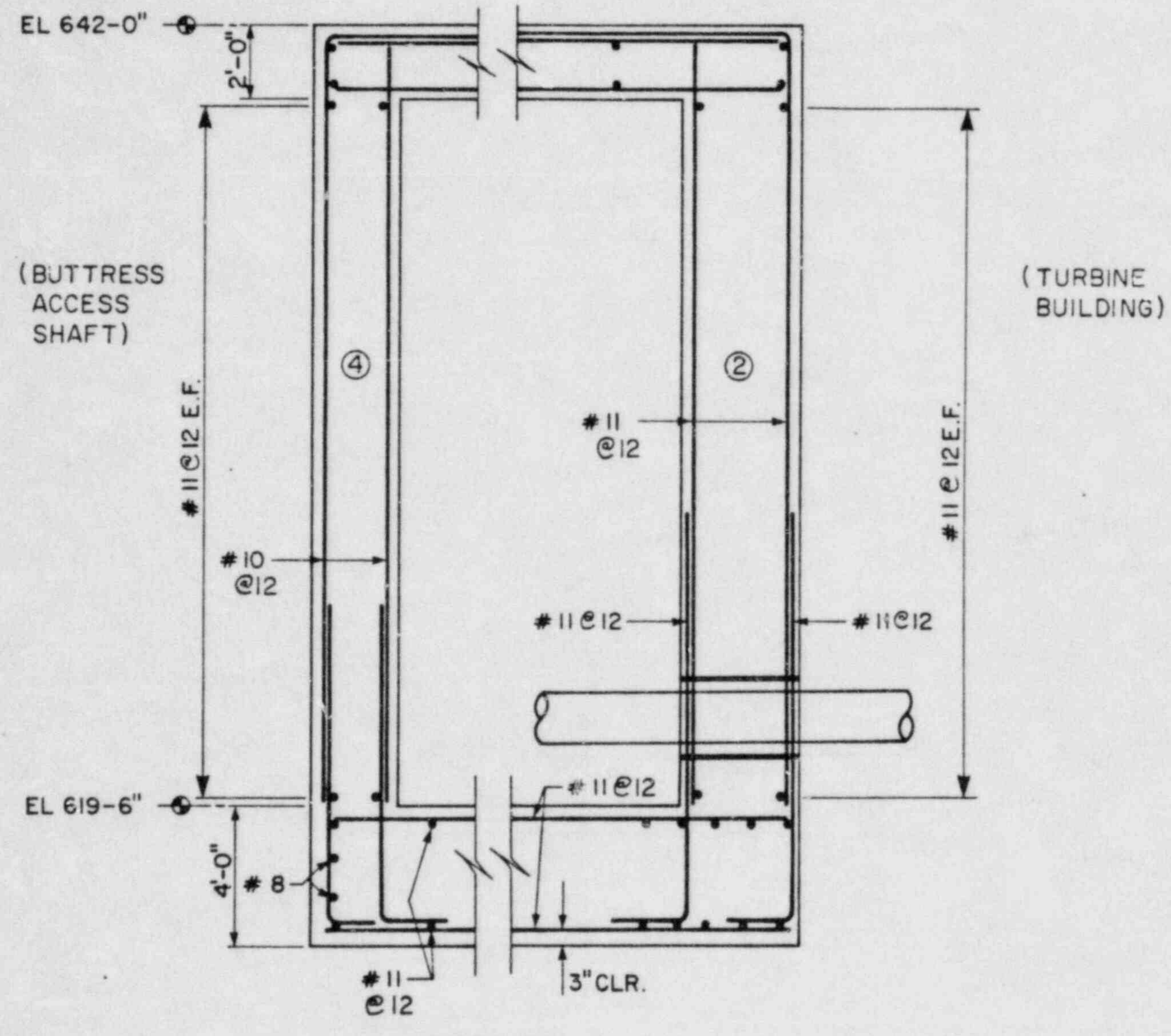


Fig. 4 Reinforcement in Feedwater Isolation Valve Pit Walls 2 and 4 - Vertical Section

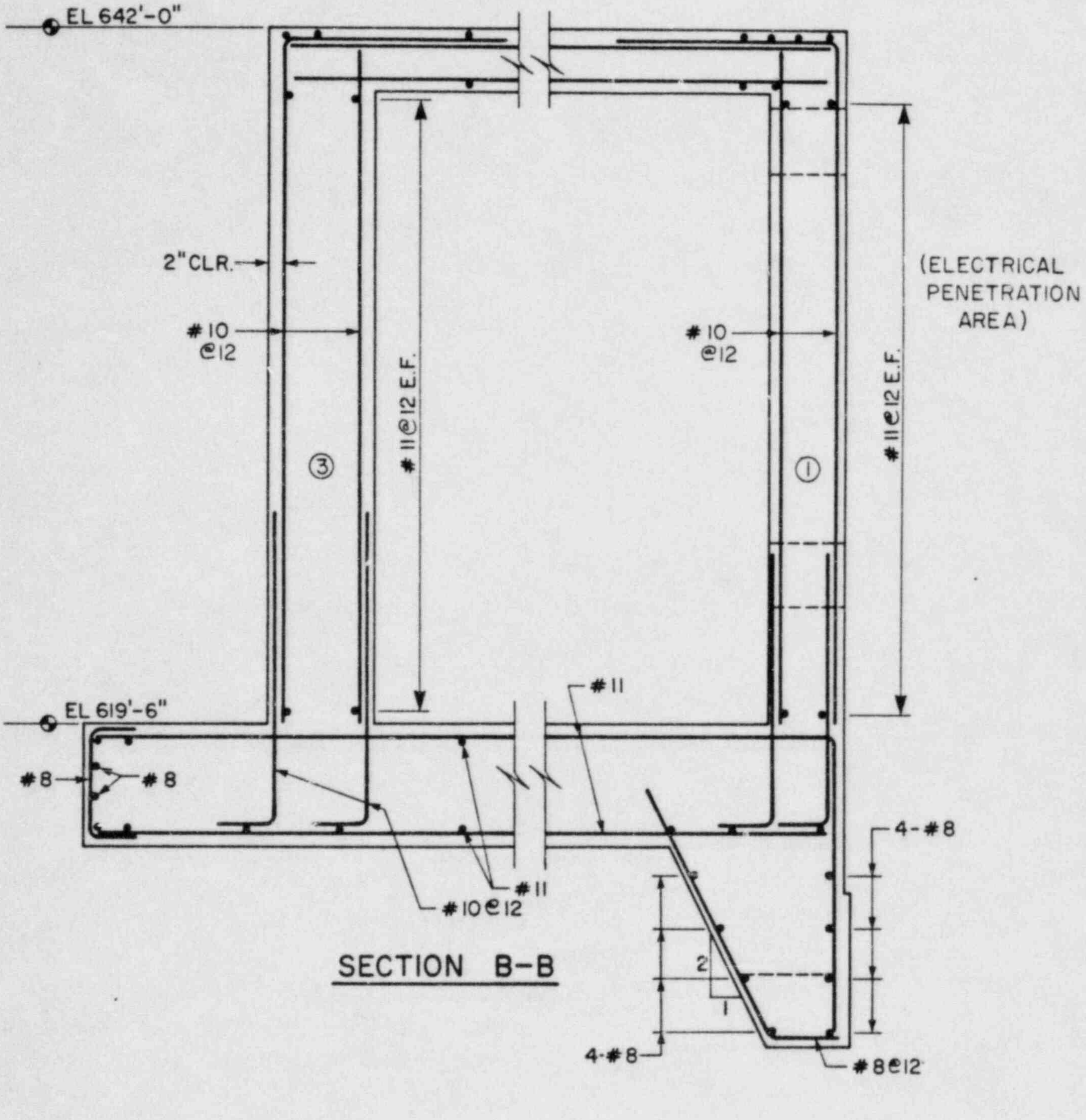


Fig. 5 Reinforcement in Feedwater Isolation Valve Pit Walls 1 and 3 - Vertical Section

Shaft and the Turbine Building. Vertical reinforcement consists of No. 10 bars at 12 in. on centers at each face. Horizontal reinforcement consists of No. 11 bars at 12 in. on centers at each face.

The roof of the Feedwater Isolation Valve Pits is 2-ft thick. Bottom reinforcement in the roof slab is No. 8 bars spaced at 12 in. on centers in each direction. Top reinforcement is made up from No. 10 or No. 11 vertical wall bars bent at 90° into the slab. This steel is supplemented by No. 8 bars spaced at 12 in. on centers.

The floor slab of the Feedwater Isolation Valve Pits is 4-ft thick. Primary reinforcement consists of No. 11 bars spaced at 12 in. on centers in each direction at top and bottom of the slab. Dowel bars for vertical reinforcement are also anchored in the base slab. The floor slab is thickened along the wall adjacent to the Electrical Penetration Area.

EVALUATION OF CRACKING

On January 12, 1982, personnel of the Construction Technology Laboratories inspected the Feedwater Isolation Valve Pits, Units 1 and 2 (west and east units). The inspection included a visual survey of interior wall, floor, and roof surfaces. Except for a small portion of one wall in each valve pit, exterior surfaces were not accessible for inspection.

In addition to visual observation, widths of selected cracks were measured using a 50 power crack microscope with a manufacturer's rated sensitivity of 0.001 in. Approximate crack locations were measured using commercial quality steel tape measures. Because of difficult access to many wall areas, "exact" crack locations could not always be obtained. However, the accuracy of the measurements is well within that required to draw conclusions based on the results.

Weather on the day of the site visit was cold with temperatures ranging from approximately 15 to 20°F. Sky conditions were mostly cloudy with intermittent snow flurries.

Feedwater Isolation Valve Pit Unit 1 (West Unit)

Although access was not ideal because of congested construction scaffolding and piping, most wall areas in Unit 1 could be inspected. Some areas were blocked by temporary supports put in place prior to start of remedial foundation work. Natural light into the pit through the top hatch was blocked by construction scaffolding. Therefore, primary light for inspection was provided by portable electric lights and hand held flashlights.

Interior wall and roof surfaces in Unit 1 were covered with a glossy clear coating. This coating was sufficiently transparent to permit observation of formed surfaces. Most formed wall surfaces contained craze cracks which are fine random cracks that commonly occur as a result of surface drying of concrete. Craze cracks were also observed on interior roof surfaces. Because the floor was covered with construction equipment, dirt and debris, there was only limited access for visual inspection. The clear coating observed on walls and roof was not seen on floor surfaces.

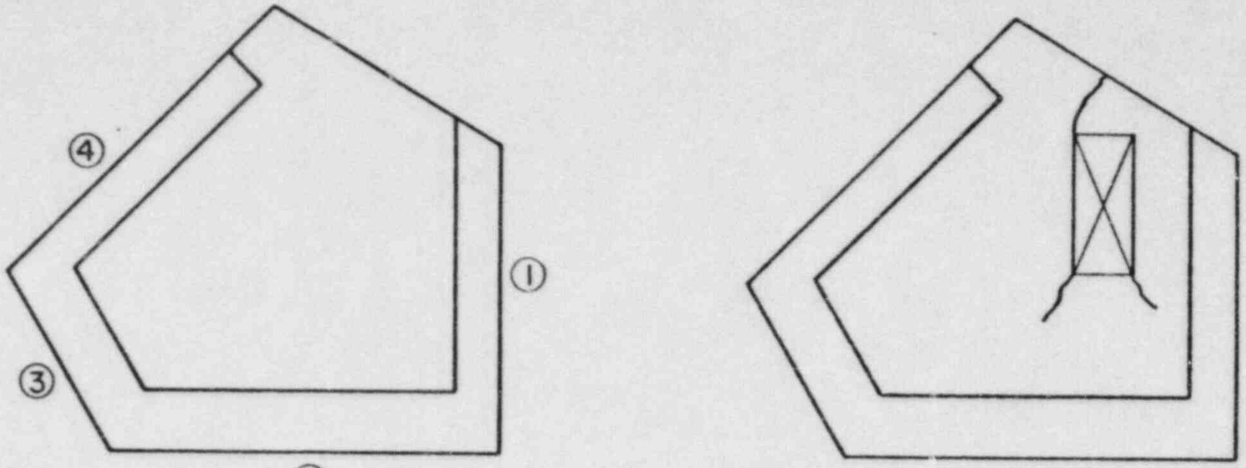
Figure 6 shows cracks mapped on interior floor and roof surfaces in Unit 1. Primary access to all areas was from construction scaffolding located in the unit. Upper portions of the wall adjacent to the Buttress Access Shaft (Wall 4) and parts of the exposed wall (Wall 3) were inspected from a ladder.

Cracks observed in Unit 1, shown in Fig. 6, are indicative of cracking that occurs as a result of restrained volume changes. Maximum measured crack width was 0.006 in. Vertical cracks in walls near the floor are attributed to volume changes caused by temperature and shrinkage of wall concrete combined with the restraining effect of the floor slab. Cracks observed around the wall penetration and in the roof around the hatch opening are indicative of types of volume change cracking that often occur at discontinuities in concrete members. The horizontal crack in Wall 3 did not penetrate through the clear coating.

Feedwater Isolation Valve Pit Unit 2 (East Unit)

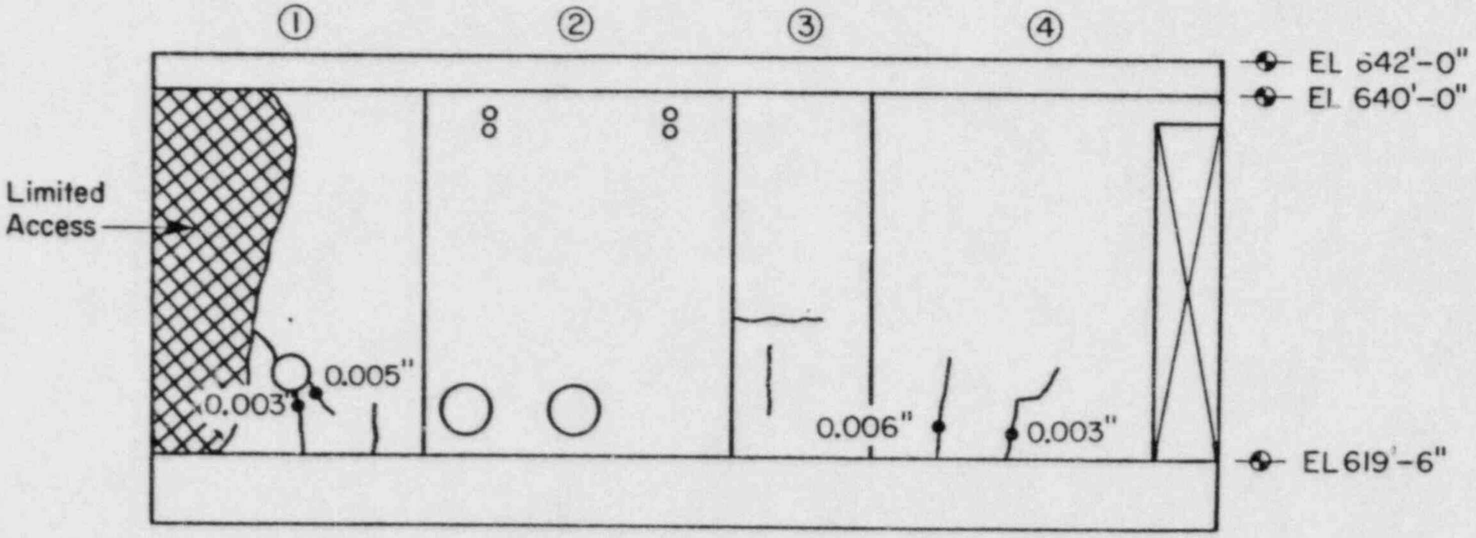
Lighting conditions for inspection of Unit 2 were essentially the same as those encountered in Unit 1. Primary lighting was provided by portable electric lights and hand held flashlights. Since construction scaffolding was not available in all areas of Unit 2, access to most walls above eye level was obtained using ladders.

As was the case in Unit 1, all interior wall and ceiling surfaces were covered with a glossy clear coating. Some crazing was observed on all surfaces of the walls and the roof. Although the floor area in Unit 2 was covered with some



(a) Plan @ EL 619'-6"

(b) Plan @ EL 640'-0"



(c) Interior of Walls

Fig.6 Feedwater Isolation Valve Pit - Unit 1 (West Unit) debris and dirt it was more accessible for inspection than that in Unit 1. No clear coating was visible on the floor surface, nor were any cracks seen.

Figure 7 shows cracks mapped on interior wall and roof surfaces of Feedwater Isolation Valve Pit Unit 2. Maximum measured crack width was 0.007 in. As was the case for Unit 1, observed cracks are attributed to restrained volume changes. Wall cracks were observed near penetrations. A vertical crack was seen at the intersection of Walls 2 and 3. Vertical cracks were also observed in Wall 1. The horizontal crack seen in Wall 3 did not reflect through the clear coating.

SIGNIFICANCE OF CRACKS

Cracks observed on January 12, 1982 in Feedwater Isolation Valve Pit Units 1 and 2 are attributed to volume changes that occur in concrete during curing and subsequent drying. No evidence of structural distress was observed.

As a measure of significance of observed cracks relative to future integrity of the structure,* the tensile stress that uncracked concrete is assumed to carry was compared to available tensile capacity provided by structural reinforcement crossing the cracks. Available structural reinforcement was determined from Bechtel Drawings No. C-429, Revision 4, 10/1/79 and C-442, Revision 1, 4/6/77.

Table 1 summarizes results of this comparison for members in which cracks were observed. In the calculations, concrete

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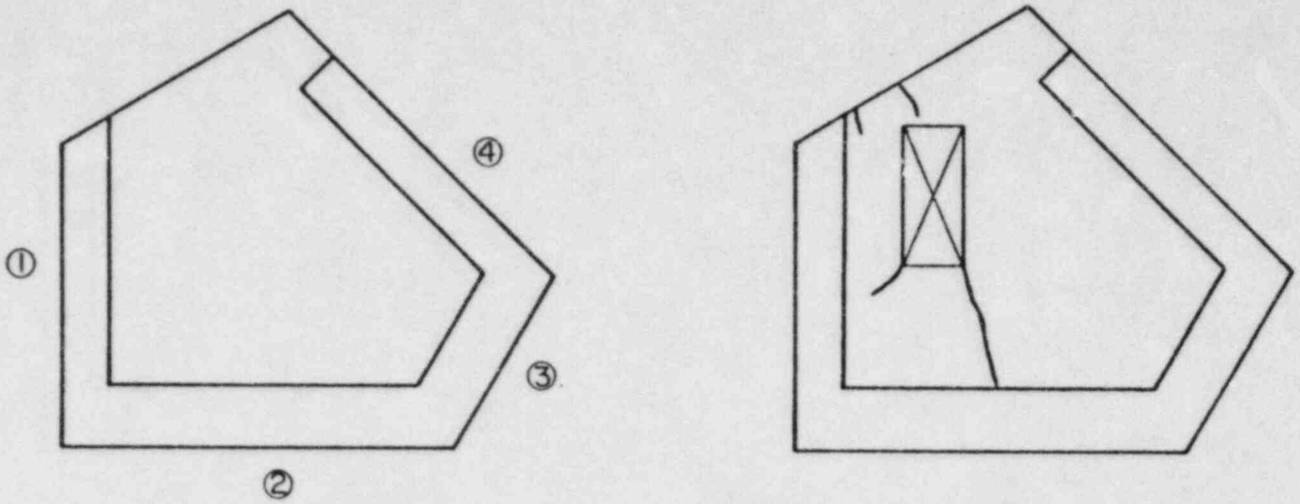
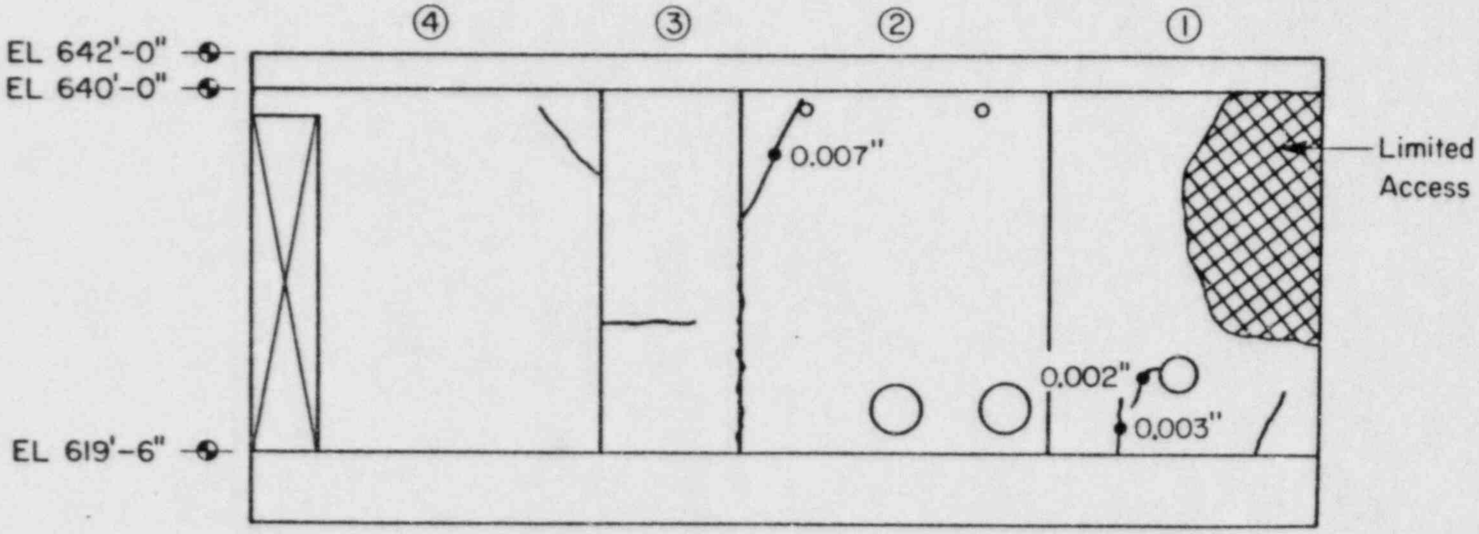
*A general discussion of strength of cracked reinforced concrete members is given in Appendix A.



(a) Plan @ EL 619'-6"

(b) Plan @ EL 640'-0"



(c) Interior of Walls

Fig. 7 Feedwater Isolation Valve Pit - Unit 2 (East Unit)

TABLE 1 - AVAILABLE "MEMBRANE CAPACITY" FOR FEEDWATER ISOLATION VALVE PITS

Element No.	Location	$4\sqrt{f'_c}\,A_g$ (kips)	$A_s f_y$ (kips)*
Wall 1	Wall Adjacent to Electrical Penetration Area	101.8	152.4
Wall 2	Wall Adjacent to Turbine Building	142.6	187.2
Wall 3	"Exposed" Wall	142.6	152.4
Wall 4	Wall Adjacent to Buttress Access Shaft	101.8	152.4
Roof	Roof	81.5	94.8

*Minimum value when different reinforcement areas used in orthogonal directions.

is assumed to carry a principal tensile stress of $4\sqrt{f'_c}$ where f'_c = specified concrete compressive strength. This assumption is consistent with Section 11.4.2.2 of the ACI Building Code.(2) For vertical and horizontal directions, where cracks were observed in the walls and roof, resistance of reinforcement was calculated as $A_s f_y$, where A_s = area of reinforcement and f_y = specified yield stress of reinforcement. If resistance provided by reinforcement crossing the crack exceeds $4\sqrt{f'_c}$, there is sufficient reinforcement to carry the stress attributed to the concrete. As indicated in Table 1, resistance provided by available reinforcement in the walls and roofs of the Feedwater Isolation Valve Pits exceeds tensile stress assumed to be carried by the concrete.

RECOMMENDED PROGRAM FOR MONITORING STRUCTURAL INTEGRITY DURING IMPLEMENTATION OF REMEDIAL MEASURES

As part of remedial measures to eliminate the possibility of unsatisfactory foundation conditions, selected areas of the Auxiliary Building will be underpinned.(1) Figure 8 shows the underpinning construction sequence plan as outlined in public hearing testimony from Midland Plant Units 1 and 2.(1) The underpinning plan includes construction of access shafts immediately east and west of the two Feedwater Isolation Valve Pits and adjacent to the Turbine Building. The location of the west access shaft is shown in Fig. 8. The east access shaft will be symmetrically located.

During construction of shafts and subsequent access tunnels, it will be necessary to monitor movements of existing structures

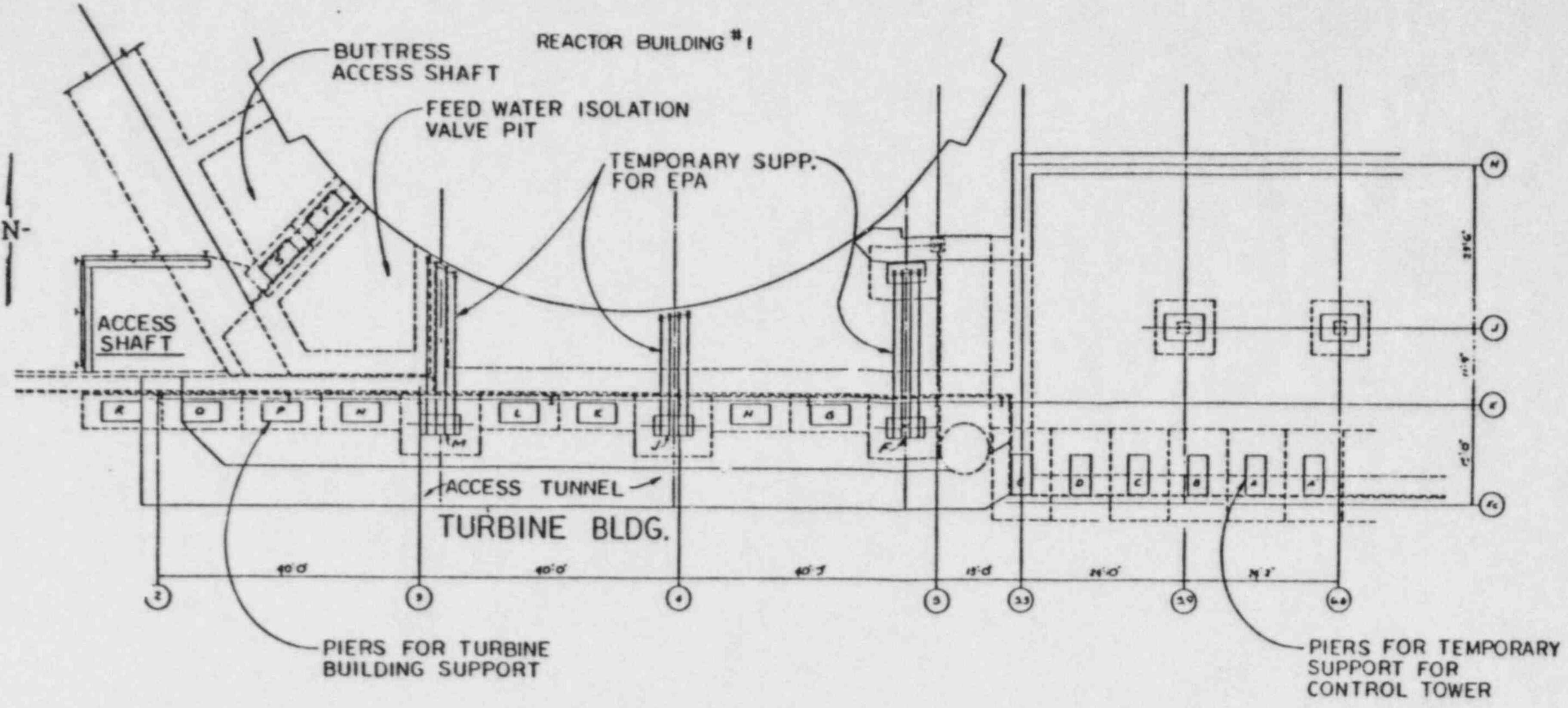


FIG. 8 **UNDERPINNING CONSTRUCTION SEQUENCE PLAN**

that may be affected by underpinning operations. Feedwater Isolation Valve Pit Units 1 and 2 should be monitored.

Figure 9 shows temporary supports that have been constructed for the Feedwater Isolation Valve Pits.(1) These supports will remain during underpinning operations. The temporary supports are used to hang the Feedwater Isolation Valve Pits from the Buttress Access Shaft and the Turbine Building walls. Temporary supports were in place at the time of the inspection on January 12, 1982.

During underpinning operations, structural integrity of the Feedwater Isolation Valve Pits should be monitored by continuous measurement of structural displacements and by regular visual inspection for cracking.

Displacement Monitoring

A continuous time history of displacements of the Feedwater Isolation Valve Pits should be maintained during underpinning operations. It is recommended that readings be taken on a daily basis with a maximum interval of one week. Additional readings should be taken at selected construction milestones.

Displacement measurements will be made to monitor both absolute movement and relative distortions of structural elements. Figure 10 shows approximate locations of recommended displacement measurement points. As a minimum, vertical displacements of the base slab of the structure should be measured at each of these points. Relative horizontal displacements between the Feedwater Isolation Valve Pits and adjacent structures may also be measured. Displacement measurements of the

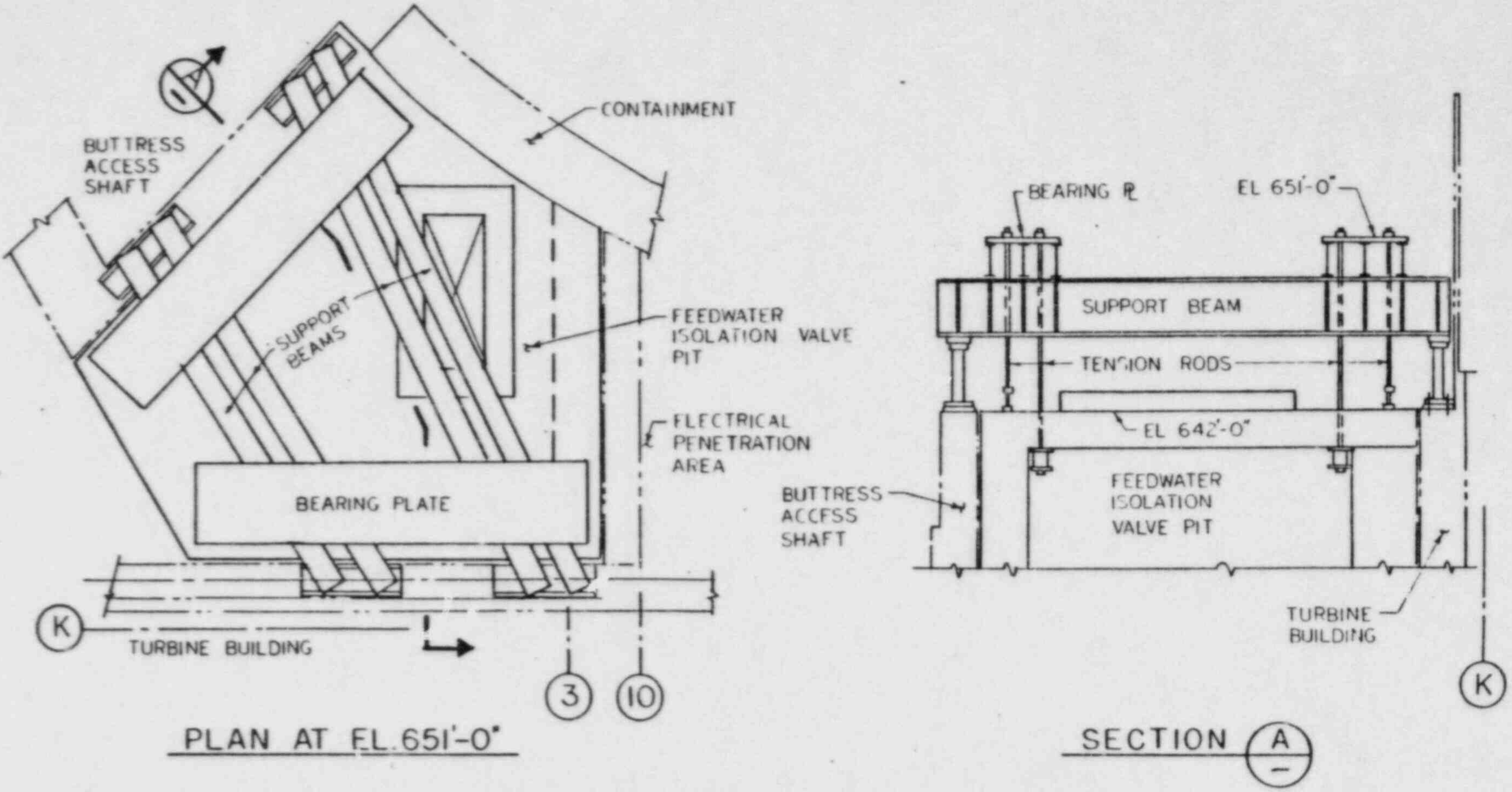


FIG. 9 **TEMPORARY SUPPORT FOR FEEDWATER ISOLATION VALVE PIT**

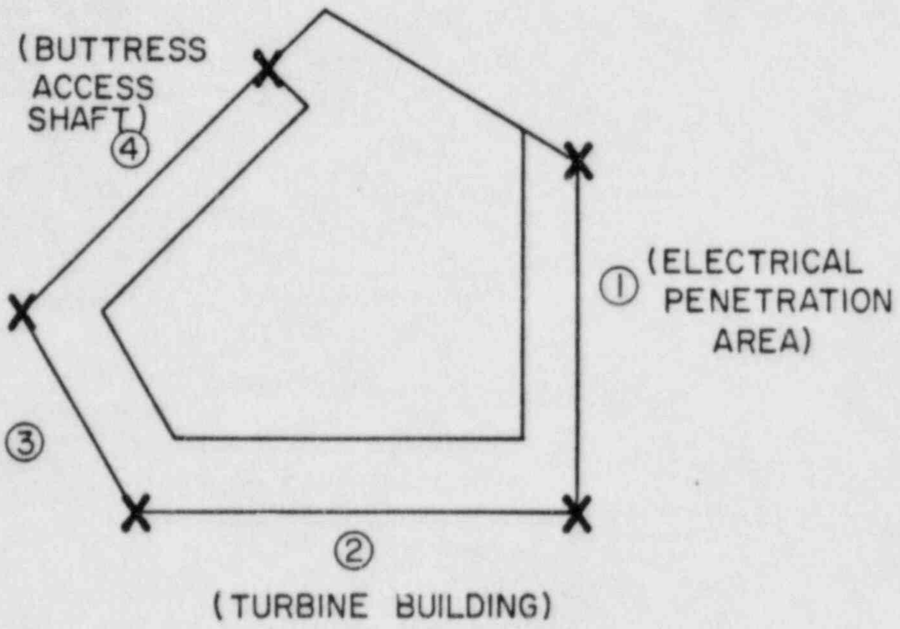


Fig. 10 Displacement Measurement Points on Feedwater Isolation Valve Pits

base slab can be supplemented with measurements at the roof level.

Displacement measurements should be recorded as a function of time for the duration of underpinning operations. Significant construction milestones should be marked at appropriate time intervals. Prior to start of underpinning, limiting distortion criteria should be selected so that critical deformation limits of the structure are not exceeded. In this way, the distortion versus time plot will provide a warning of impending structural distress. If distortion limits are reached, construction should be stopped until remedial measures are evaluated.

It is also recommended that the time history of distortions be submitted on a regular basis to a consultant familiar with reinforced concrete behavior and design. The consultant could then provide recommendations on trends observed in the data. Prior to start of construction and distortion monitoring, the consultant should review details of the monitoring plan.

Crack Monitoring

As a supplement to the displacement monitoring program, periodic visual inspections of the Feedwater Isolation Valve Pits should be made to determine if new cracking has developed or if existing cracks have changed in width or length. Crack inspections should be conducted on a continuing basis by qualified personnel. In addition, a consultant knowledgeable in reinforced concrete design and behavior should inspect the valve pits at significant construction milestones. Personnel who monitor cracking should be instructed in crack mapping techniques by the consultant prior to start of operations.

The following criteria should be used for evaluation of observed crack widths:

1. If a new crack develops that is wider than 0.010 in., a consultant should evaluate significance of the new cracking. Within two hours after observation of the crack, the consultant should provide a verbal report recommending whether construction should stop or continue. The verbal report should be confirmed with a written report within five days.
2. If any crack exceeds 0.030 in. in width, a consultant should evaluate significance of the cracking. Within two hours after observation of the crack, the consultant should provide a verbal report recommending whether construction should stop or continue. The verbal report should be confirmed with a written report within five days.
3. If development of yield strain in the reinforcement is inferred from any observed crack, construction should be stopped immediately. Individual criteria will be recommended by the consultant for each structure. If criteria are exceeded, a consultant should evaluate significance of the cracking. Within two hours after observation of the crack, the consultant should provide a verbal report recommending whether construction should continue. The verbal report should be confirmed by a written report within five days.

The following criteria should be used in evaluation of significance of cracks that develop in the Feedwater Isolation Valve Pits:

1. Geometry of member
2. Amount and distribution of reinforcement in the member
3. Material properties of the member
4. Function of the member
5. Magnitude and distribution of loads on the member
6. Construction technique
7. Sequence of construction
8. Crack location and distribution
9. Crack size
10. Interaction of multiple cracks.

Basically these criteria define a procedure that requires the function and load carrying mechanism of the member or structure to first be defined. Then the influence of cracks on the path of load distribution is determined. In this way, the cause of cracking is defined and the influence of cracking on future load capacity of the structure can be evaluated.

In evaluating cracks in reinforced concrete structures, it is not sufficient to base conclusions on a single criteria such as crack width. The overall crack pattern including location and direction of cracks, length and width of cracks, and interrelationship between multiple cracks must be considered. The pattern of cracking provides significant clues with regard to causes of cracks and their effects on future performance.

SUMMARY AND CONCLUSIONS

This report presents an evaluation of the significance of cracking observed in the Feedwater Isolation Valve Pits located at Midland Plant Units 1 and 2. Cracks observed in these structures by Construction Technology Laboratories' personnel on January 12, 1982 are attributed to restrained volumetric changes that occur during curing and drying of concrete. No indications of structural distress were observed during the site visit. Calculations based on section geometry indicate that structural reinforcement provided in the walls and roofs provides a capacity in excess of the tensile cracking stress attributed to the concrete.

A program for monitoring structural integrity of the Feedwater Isolation Valve Pits during implementation of remedial measures to underpin the structure is also outlined. It is recommended that measured displacements be used as the primary means of monitoring behavior of the structures. It is also recommended that continuous displacement measurements be supplemented with visual inspections to monitor cracking in the structures. Displacement and crack monitoring should be reviewed by a consultant knowledgeable in reinforced concrete behavior and design.

REFERENCES

1. "Testimony of Edmund M. Burke, W. Gene Corley, James P. Gould, Theodore E. Johnson, and Mete Sozen, on Behalf of the Applicant Regarding Remedial Measures for the Midland Plant Auxiliary Building and Feedwater Isolation Valve Pits," United States of America Nuclear Regulatory Commission, Atomic Safety and Licensing Board, Public Hearing Testimony, Docket Nos. 50-329OM, 50-330OM, 50-329OL, and 50-330OL, Vol. 1-Text and Vol. 2-Figures.

2. ACI Committee 318, "Building Code Requirements for Reinforced Concrete (ACI 318-77)," American Concrete Institute, Detroit, 1977.

APPENDIX A

STRENGTH OF CRACKED REINFORCED CONCRETE MEMBERS

APPENDIX A

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APPENDIX A

STRENGTH OF CRACKED REINFORCED CONCRETE MEMBERS

by

A. E. Fiorato and W. G. Corley*

INTRODUCTION

Cracking is an inherent characteristic of reinforced concrete structures. The existence of cracks is not necessarily indicative of structural distress. The objective of this report is to clarify the relationship between cracking and strength of reinforced concrete members. The relationship will be demonstrated by examining the response of selected structural members that have been loaded to destruction in the laboratory. To provide a cross-section of data, results from tests on structural walls, beams, and containment elements will be considered.

TESTS OF STRUCTURAL WALLS

Reinforced concrete structural walls are commonly used as lateral load resisting elements in buildings. Both "low-rise" walls, which act as deep beams, and "high-rise" walls, which undergo significant flexural yielding, have been tested in the laboratory.

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Tests of "Low-Rise" Structural Walls

Figure 1 shows the test setup used to apply reversing loads to eight specimens representing "low-rise" structural walls with boundary elements.(1)*

Principal variables in this test program included amount of flexural reinforcement, amount of horizontal wall reinforcement, amount of vertical wall reinforcement, and height-to-horizontal length ratio of the wall. Flexural reinforcement was varied from 1.8 to 6.4% of the boundary element area. Horizontal and vertical wall reinforcement were varied from 0 to 0.5% of the wall area. Height-to-horizontal length ratio of the wall was varied from 1:4 to 1:1. The test program was designed to determine effects of load reversals. Data obtained also provided information on the relationship between cracking and strength.

Principal test results for the eight walls are shown in Table 1. For all specimens, except B5-4, the maximum nominal shear stress in the wall exceeded the stress at first observed shear cracking by a factor of at least 2.4. For Specimen B5-4, which contained no vertical reinforcement in the diaphram, the maximum nominal shear stress exceeded the stress at first shear cracking by a factor of 1.5. The ratio of maximum nominal shear force to first shear cracking even exceeded 2.5 for Specimen B4-3 which contained no horizontal reinforcment. For each of the "low-rise" walls tested, measured capacity exceeded

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*The superscript numbers in parentheses refer to references listed at the end of this report. A copy of each reference is attached.

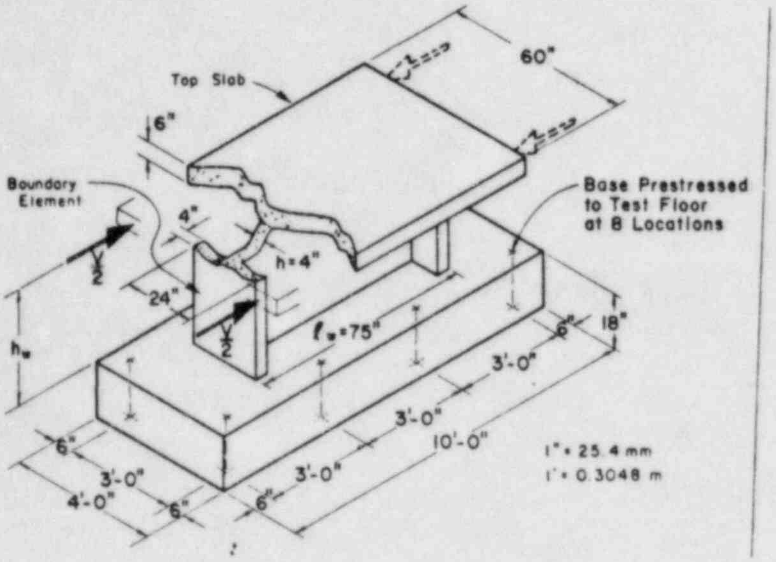


Fig. 1 - Setup for Tests of "Low Rise" Walls (1)

TABLE 1 - Principal Test Results (1)

Specimen	Variable(1)	First Shear Cracking				Ultimate Load				End of Test	
		Shear stress v_{cr}, psi	$\frac{v_{cr}}{\sqrt{f'_c}}$	Deflection $\Delta\ell$, in.	$\frac{\Delta\ell}{h_w}$	Shear stress v_u, psi	$\frac{v_u}{\sqrt{f'_c}}$	Deflection $\Delta\ell$, in.	$\frac{\Delta\ell}{h_w}$	Shear stress v_m, psi	$\frac{v_m}{\sqrt{f'_c}}$
B1-1	ρ = 1.8%(2)	420	6.5	0.027	0.00072	1,010	15.5	0.23	0.0061	280	4.4
B2-1	ρ = 6.4%(2)	240	4.9	0.016	0.00043	767	15.8	0.26	0.0069	270	5.5
B3-2	Control	330	5.2	not measured		881	14.1	0.21	0.0056	190	3.0
B3-2R	Repair	190	3.3	0.020	0.00053	676	11.5	0.49	0.0130	230	4.0
B4-3	ρ_h = 0	320	6.1	0.015	0.00040	810	15.4	0.20	0.0053	160	3.0
B5-4	ρ_n = 0	330	5.2	0.012	0.00032	538	8.3	0.20	0.0053	280	4.3
B6-4	ρ_n = 0.25%	280	5.0	0.013	0.00035	686	12.3	0.23	0.0061	190	3.5
B7-5	h_w/ℓ_w = 1/4	330	5.4	0.006	0.00032	906	14.8	0.16	0.0085	350	5.7
B8-5	h_w/ℓ_w = 1	200	3.5	0.027	0.00036	704	12.1	0.42	0.0056	150	2.6

(1) Except as indicated below, all specimens had the following characteristics:
h_w/ℓ_w = 1/2, ρ_h = 0.5%, ρ_n = 0.5%, ρ = 4.1%.

(2) Specimens subjected to static loading. All other specimens subjected to load reversals.

Note: 1 in. = 25.4 mm; 1,000 psi = 70.3 kg per square centimeter that calculated by American Concrete Institute Building Code Requirements for Reinforced Concrete.

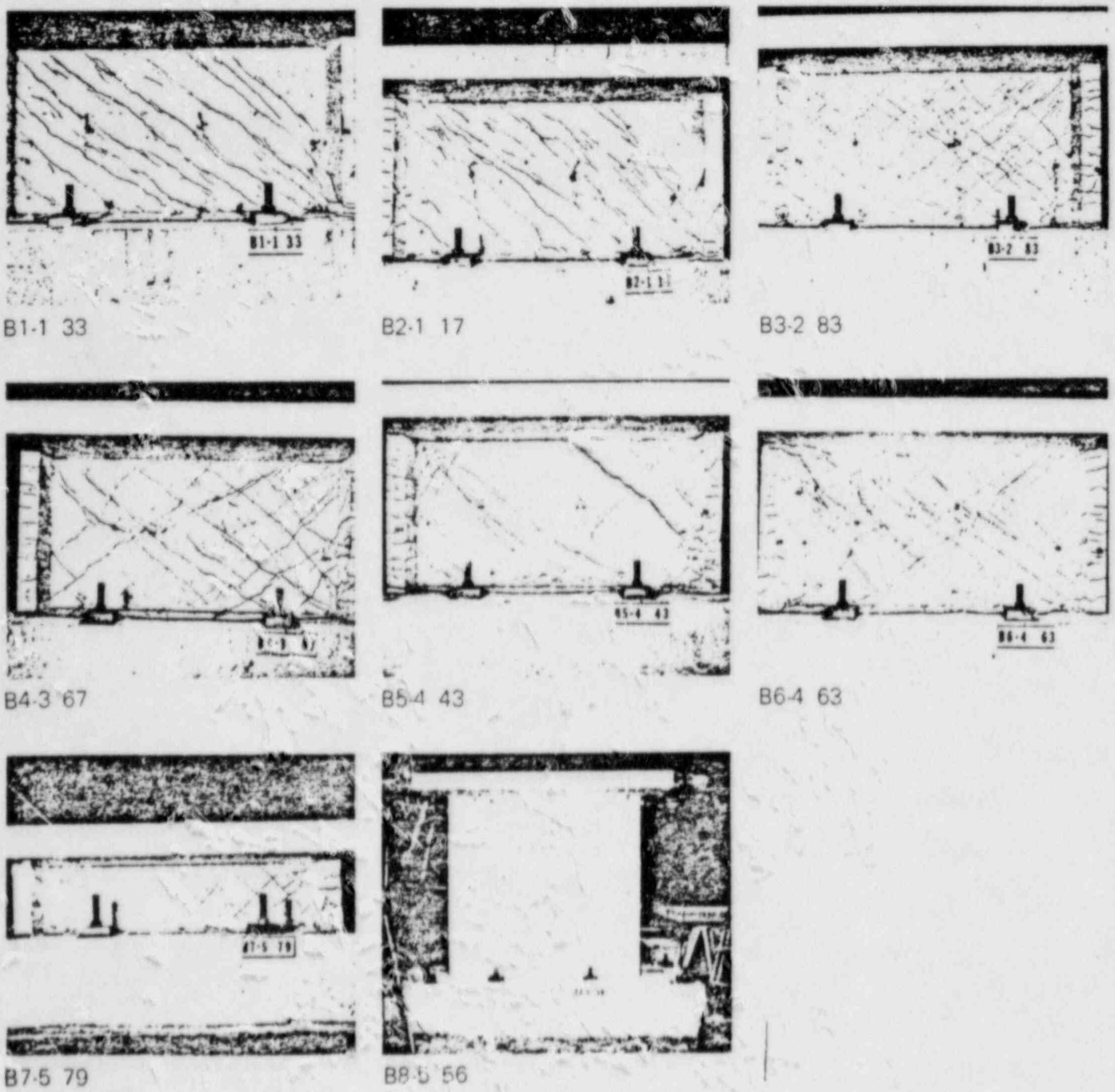
Figure 2 shows crack patterns in the "low-rise" walls at the ultimate load levels listed in Table 1. The inclined cracks are indicative of shear stresses that predominate in short cantilever members. It is apparent that the presence of cracks does not necessarily indicate loss of structural capacity. Even with the extensive cracking shown in Fig. 2, the walls were carrying maximum applied loads. For a particular section geometry and applied loading, structural capacity is a function of the amount and distribution of reinforcement.

There was no evidence that reversing loads caused residual stresses that reduced strength of the walls. Additional data on these tests are given in Reference 1.

Tests of "High-Rise" Structural Walls

Tests reported in References 2, 3, and 4 were conducted to obtain data on strength and deformation capacity of structural walls subjected to significant numbers of inelastic load reversals. Effects of load history, section shape, vertical and horizontal reinforcement, confinement reinforcement, moment-to-shear ratio, axial compressive stress, and concrete strength were considered.

Figure 3 shows the setup used for tests of "high-rise" walls. The walls were tested as vertical cantilever members with forces applied through the top slab. The behavior of one of the test specimens is described in detail in the following



B1-1 33

B2-1 17

B3-2 83

B4-3 67

B5-4 43

B6-4 63

B7-5 79

B8-5 56

Fig. 2 "Low-Rise" Wall Test Specimens at Ultimate Load (1)

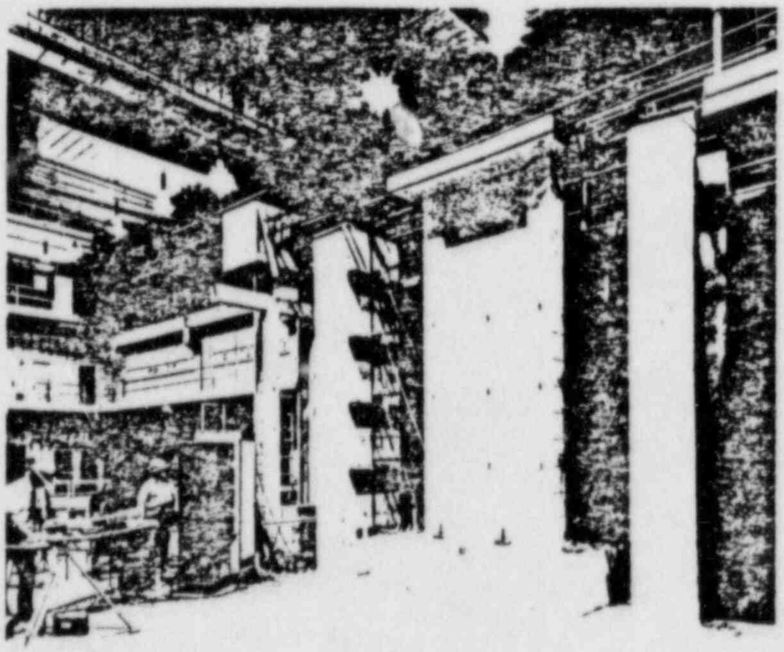


Fig. 3 Setup for Tests of "High-Rise" Walls

paragraphs. This behavior illustrates the influence of cracks that developed during the tests. Additional data on other specimens can be obtained in References 2, 3, and 4.

Figure 4 shows the measured load vs deflection relationship for Specimen B3. This was a barbell shaped specimen which represented a wall with column boundary elements at each end. As can be seen in Fig. 4, the wall was subjected to increasing levels of load reversals. The test consisted of 42 complete load cycles.

Initial cracking was observed in the fourth cycle at a load of 28 kips. First yielding in the vertical flexural reinforcement occurred in Cycle 10 at a load of 45 kips. Maximum measured crack widths were 0.012 in. in the tension boundary element and 0.025 in. across a diagonal crack in the web.

Figure 5 is a photograph of Specimen B3 at Load Stage 112. This load stage, which is marked on Fig. 4, represents a point in the test when the specimen was unloaded. There were no applied in-plane horizontal forces. Figure 5 shows the intersecting pattern of cracks in the lower six feet of the wall after the first 21 load cycles.

From Load Stage 112, loads were increased in a positive direction until Load Stage 117 was reached. Figure 6 shows the condition of the specimen at Load Stage 117. At Load Stage 117, maximum measured crack width in the tension boundary element was 0.07 in. and maximum measured crack width in the wall web was approximately 0.16 in. It should be noted that, at this load stage, the wall had been pushed to a lateral deflection of more than three times its yield deflection.

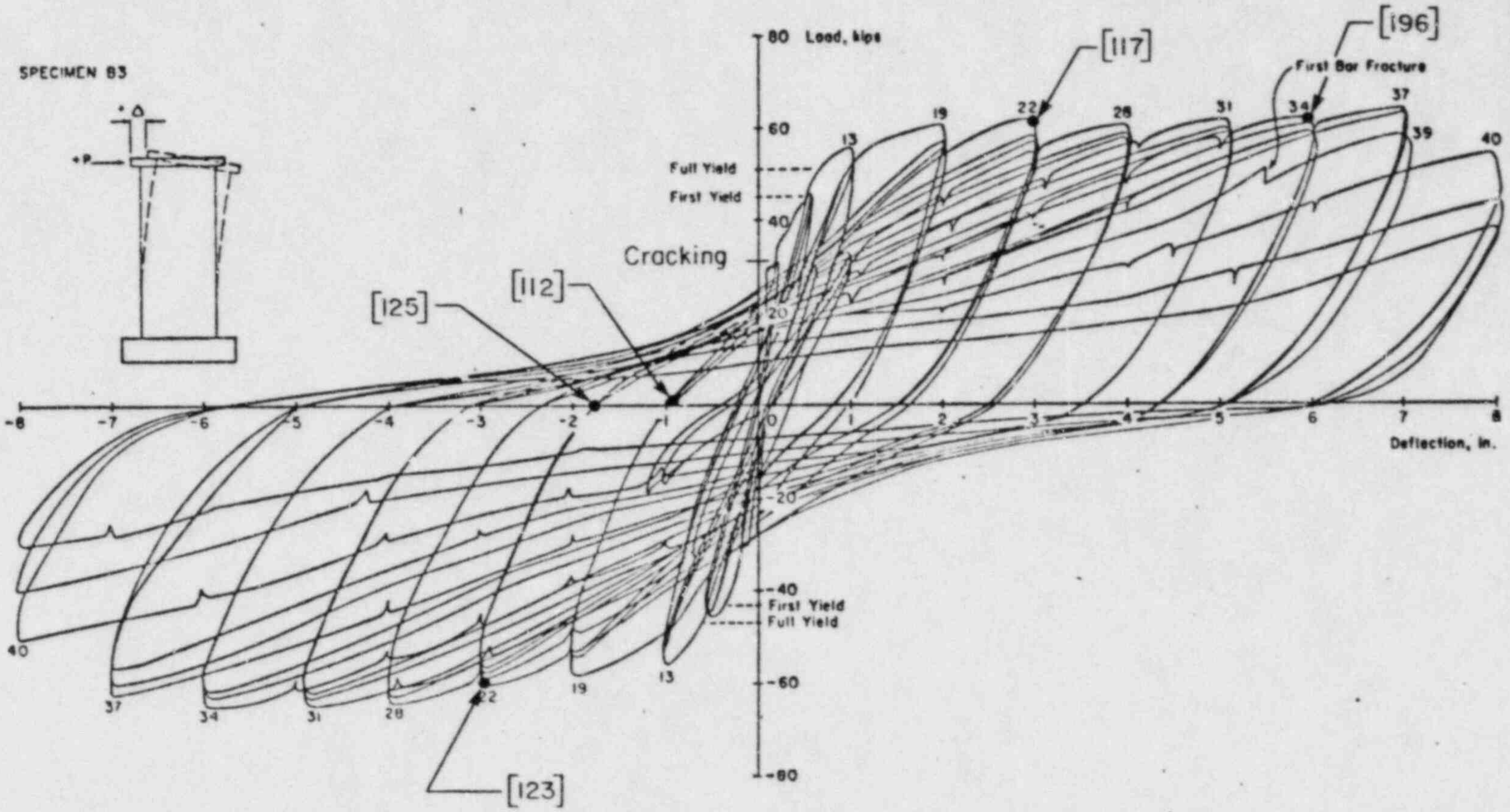


Fig. 4 Load-Deflection Relationship for Specimen B3

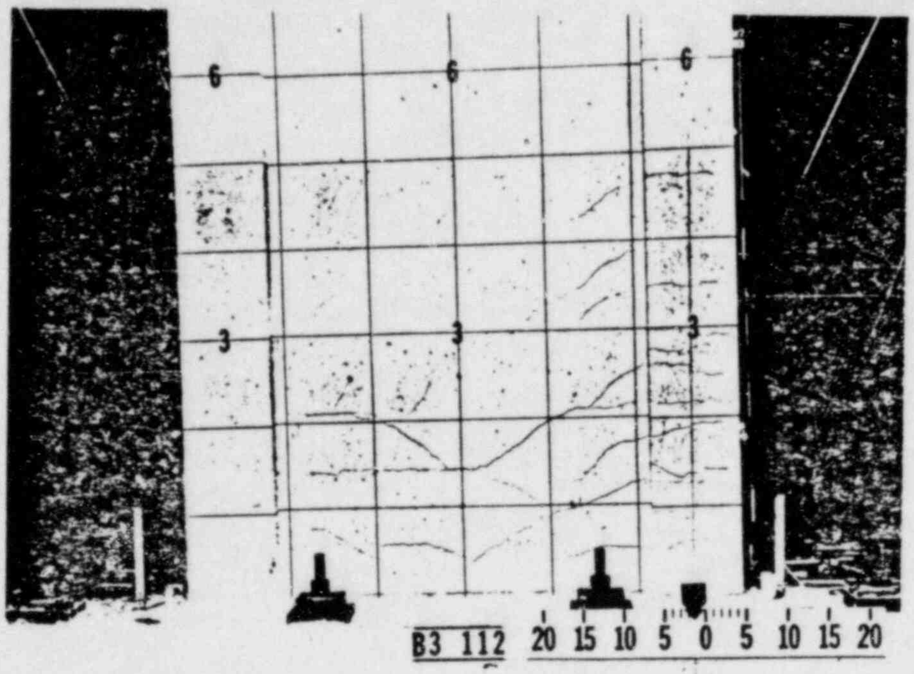


Fig. 5 Specimen B3 at Load Stage 112

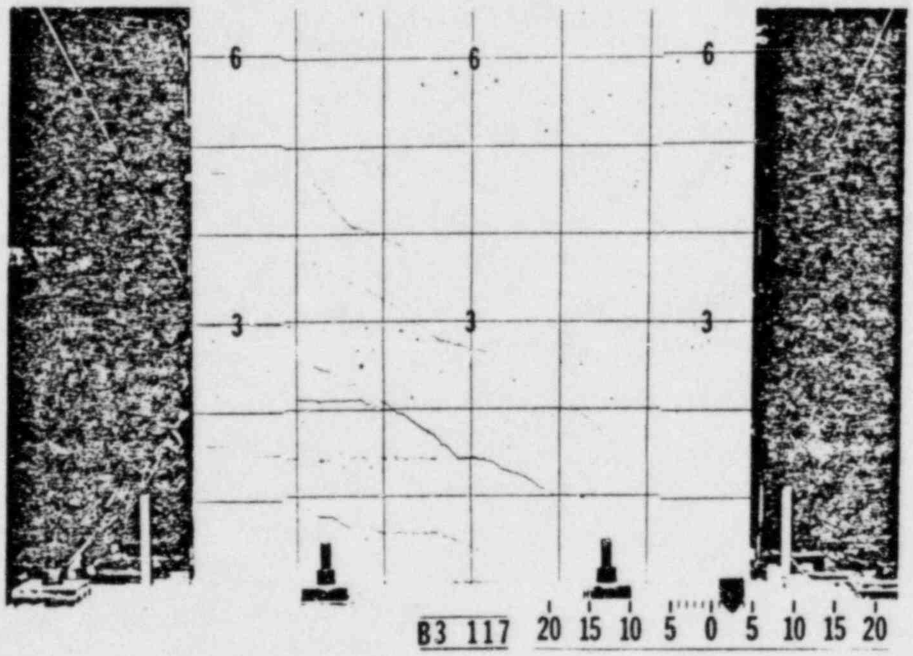


Fig. 6 Specimen B3 at Load Stage 117

After Load Stage 117 was reached, the wall was unloaded and pushed in the opposite direction until Load Stage 123 was reached. Figure 7 shows the condition of Specimen B3 at Load Stage 123. At this load stage, the maximum crack width measured in the tension column was approximately 0.07 in. and the maximum measured crack width in the wall web was 0.16 in. When the wall was again unloaded, to Load Stage 125, the crack pattern shown in Fig. 8 resulted. It is clearly evident from the behavior of Specimen B3 (and from other specimens tested) that the presence of cracks did not prevent the walls from maintaining their structural integrity and developing their nominal strength.

Figure 9 shows Specimen B3 at Load Stage 196. This load stage is also indicated in Fig. 4. The cracking pattern in Fig. 9 is indicative of severe distress in the member, yet at this stage the wall carried its maximum load which corresponded to approximately $3.1\sqrt{f'_c}$. For purposes of comparison, the design strength this member calculated in accordance with the American Concrete Institute Building Code is $2.3\sqrt{f'_c}$.

A question that occurs in evaluating cracked reinforced concrete structures is whether residual stresses associated with the occurrence of cracks influence strength of the member. It is evident from the behavior of Specimen B3 that internally balanced residual stresses, such as those existing when the specimen was unloaded, did not influence strength.

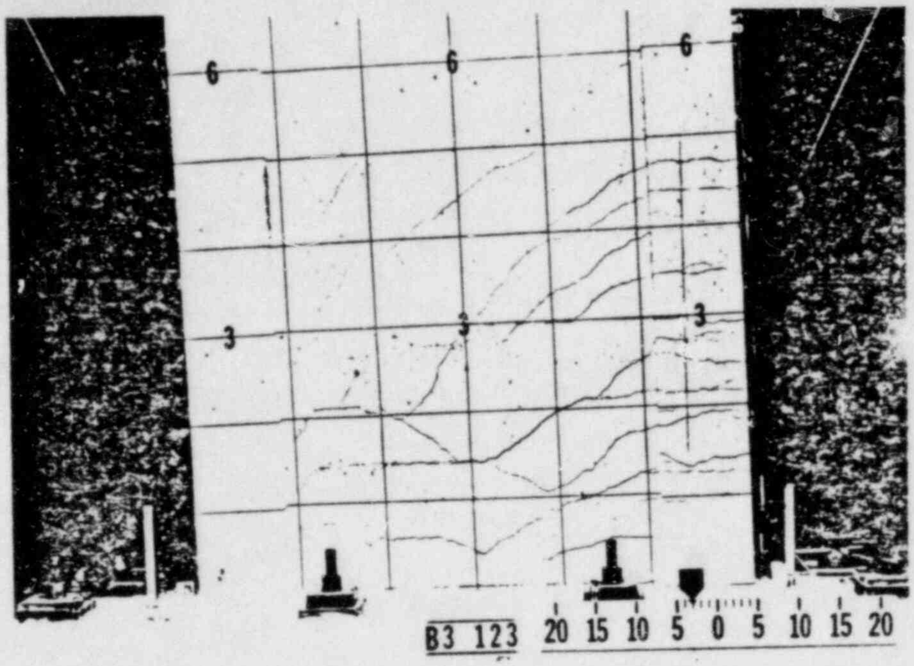


Fig. 7 Specimen B3 at Load Stage 123

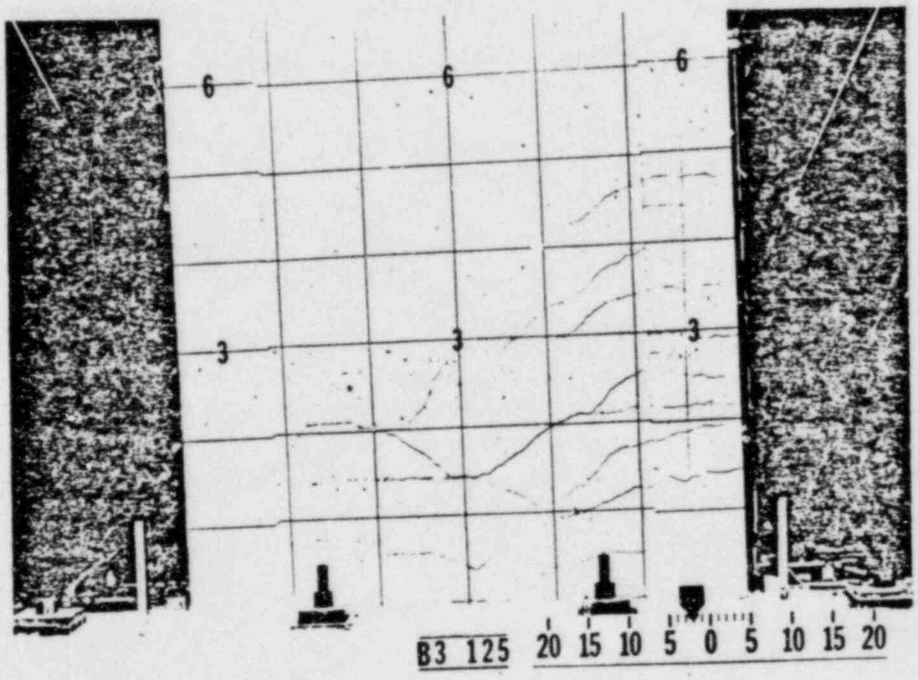


Fig. 8 Specimen B3 at Load Stage 125

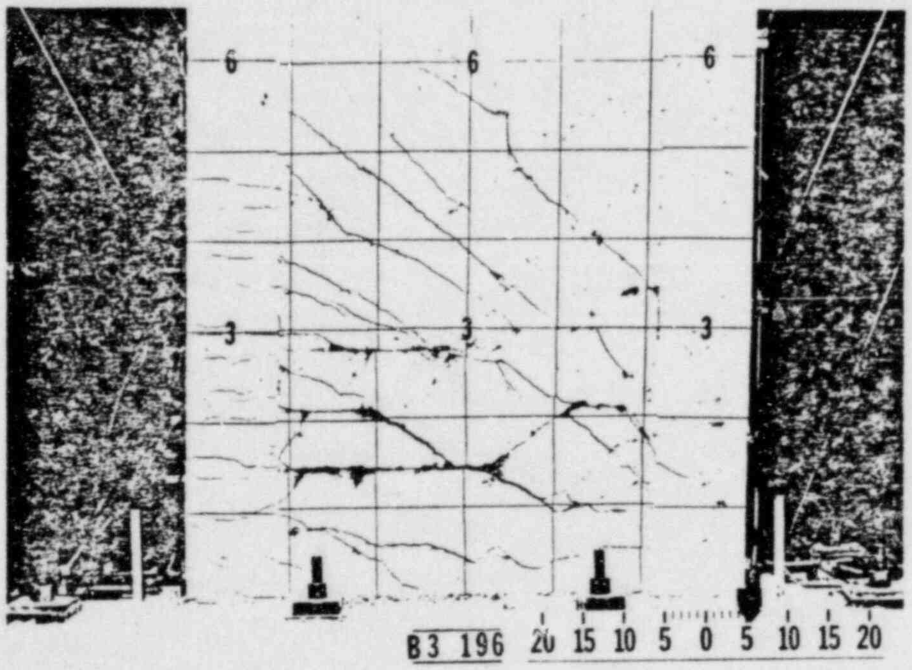


Fig. 9 Specimen B3 at Load Stage 196

TESTS OF BEAMS

Background data on strength of cracked reinforced concrete members can also be obtained from tests on reinforced concrete beams. Data from tests reported by Scribner and Wight are shown in Figs. 10 and 11.(5)

Figure 10 shows the load vs displacement curve for a reinforced concrete beam element that contained positive and negative steel. The beam was subjected to increasing levels of fully reversed load cycles. Yielding occurred in the first load cycle as indicated in Fig. 10.

Figure 11 illustrates crack patterns that developed during the first inelastic loading and during subsequent load reversals. As increasing numbers of load cycles were applied, the entire beam moment at the face of the column was carried by a force couple between the top and bottom layers of longitudinal steel. Thus, applied moments were primarily resisted by the positive and negative longitudinal reinforcement.

Under load reversals a complete crack plane, labeled A-B-C in Fig. 11, formed through the beam. This crack plane did not prevent the beam from transferring load. During the final stages of the test, increasing numbers of inelastic load reversals caused concrete near the face of the column to abrade and eventually disintegrate. This resulted in a "slip plane" along the beam at the face of the column. The significance of such a slip plane is related to the number of inelastic load reversals and the level of shear stress on the beam. The existence of

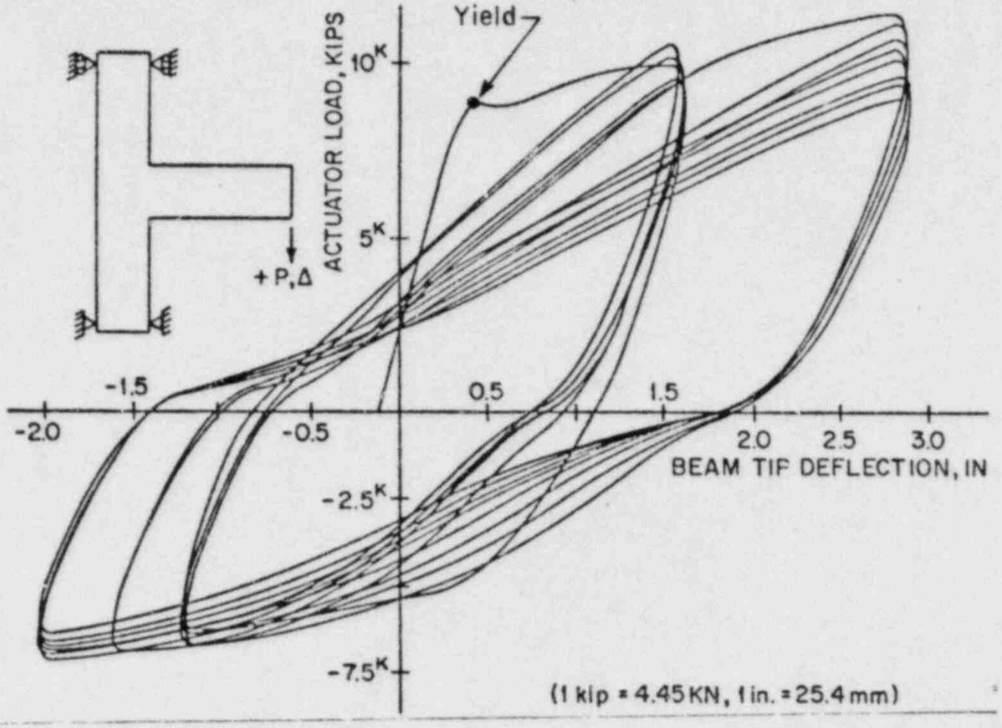
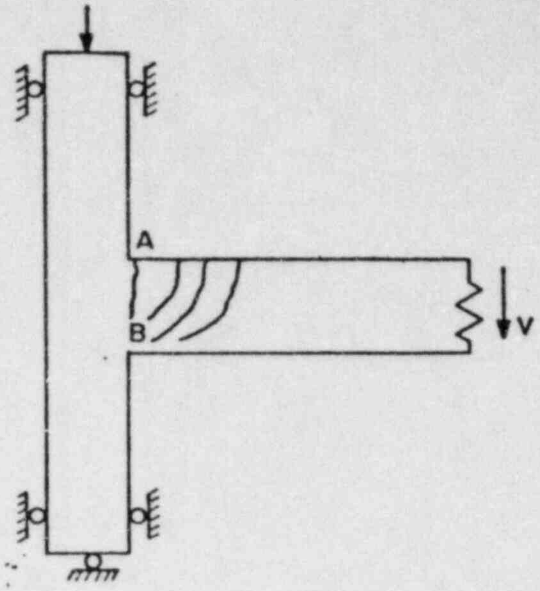
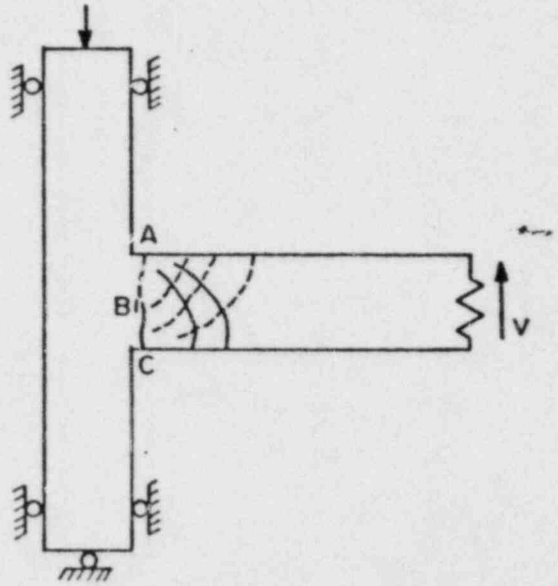


Fig. 10 Load vs Displacement Curve - Specimen 1 (After Ref. 5)



Formation of Cracks during First Inelastic Loading



Additional Cracks Formed during Load Reversal

Fig. 11 Crack Pattern (After Ref. 5)

the crack plane did not become significant until repeated numbers of inelastic cycles were applied.

Additional data on beam tests can be obtained from References 6 and 7. In addition, tests of beam-column joints reported in Reference 8 also provide useful information.

Results shown in Fig. 10 indicate that beams can transfer flexural and shear loads even with the presence of cracks through their entire depth. Tests conducted at the University of Washington have shown that the effectiveness of web reinforcement in resisting shear in reinforced concrete beams is not affected by axial force in the beam.(9) These tests were conducted on beams subjected to combined axial tension, bending, and shear. Results indicated that effectiveness of web reinforcement is not reduced by the presence of axial tension. In the tests, applied axial load was sufficient to cause cracking prior to the application of transverse load. For all beams with web reinforcement, measured load capacity of the precracked beams exceeded values calculated in accordance with the American Concrete Institute Building Code.

TESTS OF CONTAINMENT ELEMENTS

Another series of tests that can be used to demonstrate the strength of cracked reinforced concrete members is reported in an experimental program to investigate shear transfer in cracked containments without diagonal reinforcement.(10) The test setup was designed and constructed to simulate boundary conditions of a wall element of a pressurized containment subjected to tangential shear stresses. Forces on an element in a containment wall are illustrated in Fig. 12. Figures 13 and 14 show the test setup used for the experiments. The experimental program included monotonic and reversing load tests on large-scale specimens subjected to biaxial tension and shear. Specimens were 5-ft square and 2-ft thick with No. 14 and No. 18 reinforcement.

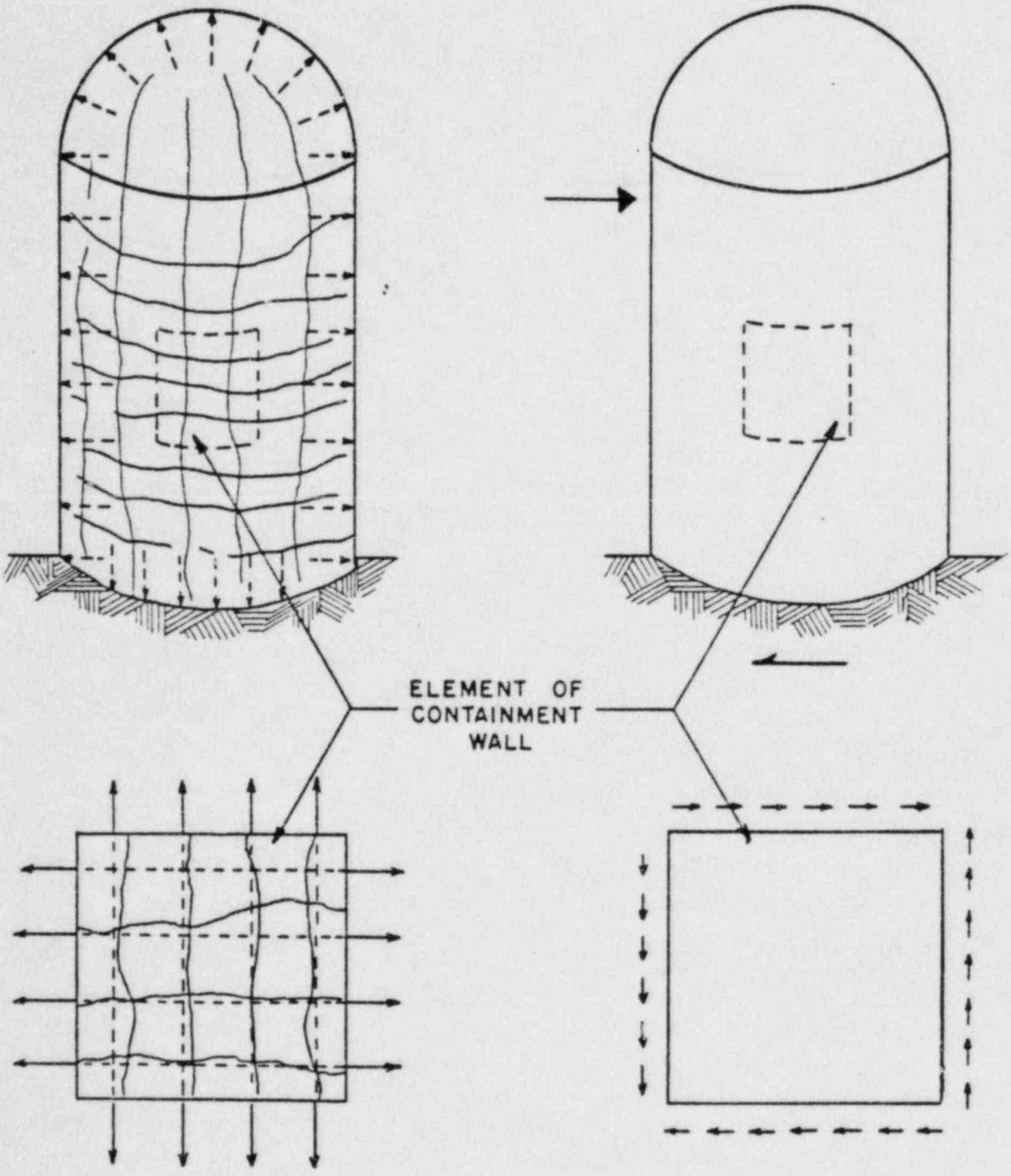
This discussion includes a description of one of the test specimens. Additional data are available in Reference 10.

Figure 15 shows the crack pattern observed in Specimen MB1 after reinforcement in the element was loaded to obtain a tension stress of 54 ksi in the steel. This stress corresponds to 90% of the yield stress of the reinforcement. Crack width measurements made on the specimen after biaxial tension was applied indicated a maximum width of approximately 0.036 in.

Figures 16 and 17 show the crack pattern and nominal shear stress vs shear distortion relationship for Specimen MB1. Shear forces were applied while constant biaxial tension was maintained. It is evident from Fig. 17 that the reinforced concrete element was capable of transferring shear forces even though it was traversed by biaxial tension cracks through the complete thickness.

SUMMARY AND CONCLUSIONS

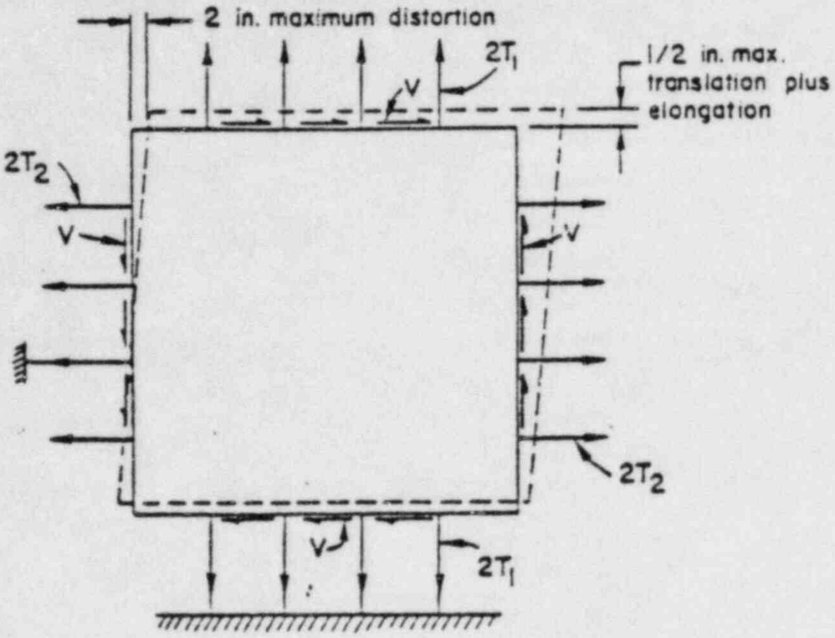
Test data presented in this report demonstrate that cracks in an adequately reinforced concrete member do not prevent the member from developing its expected strength. Adequate reinforcement for the test specimens was determined in accordance with current code provisions. Data presented also indicate the



a) Biaxial Tension Due to Internal Pressurization

b) Shear Forces Due to Lateral Load

Fig. 12 Forces on Element in Containment Wall (10)



$T_1 = 0$ to 280 kips
sustained tension each #18 bar

$T_2 = 0$ to 160 kips
sustained tension each #14 bar

$V = 0$ to 210 kips
reversing shear applied at 3 locations each face

Fig. 13 Loading System Capabilities (10)

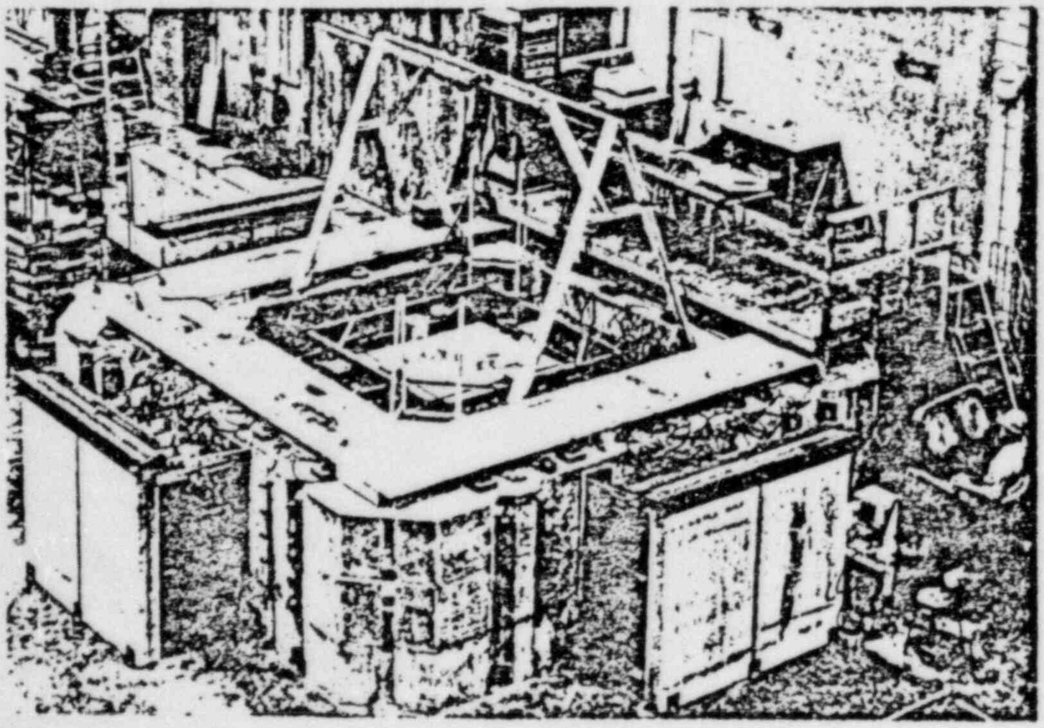
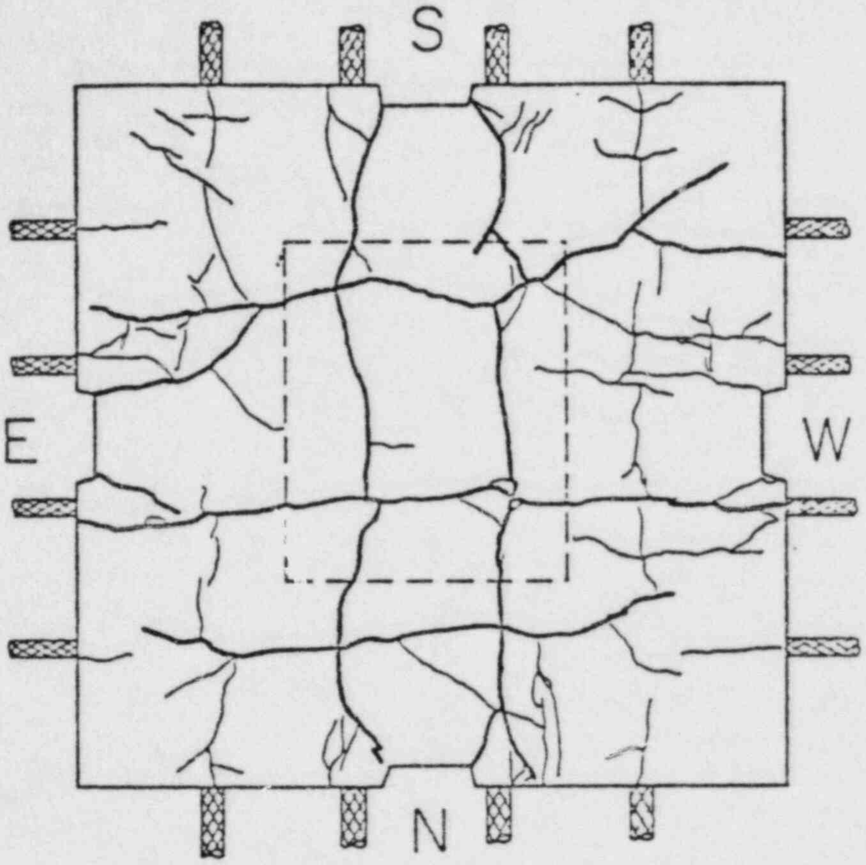


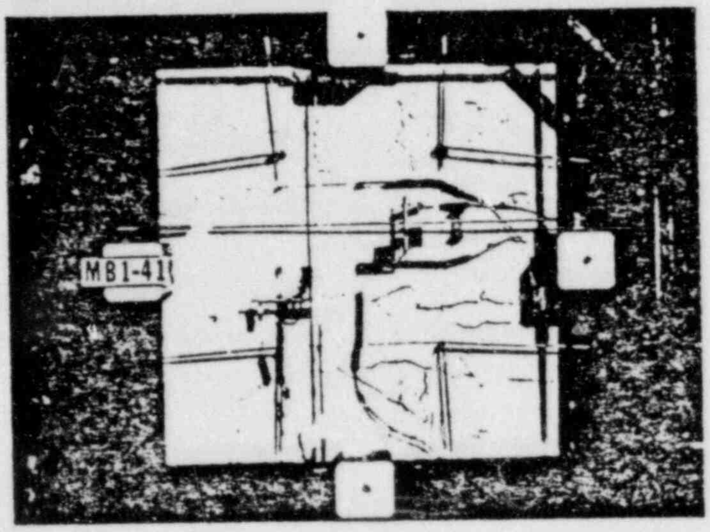
Fig. 14 Test Setup for Containment Element (10)



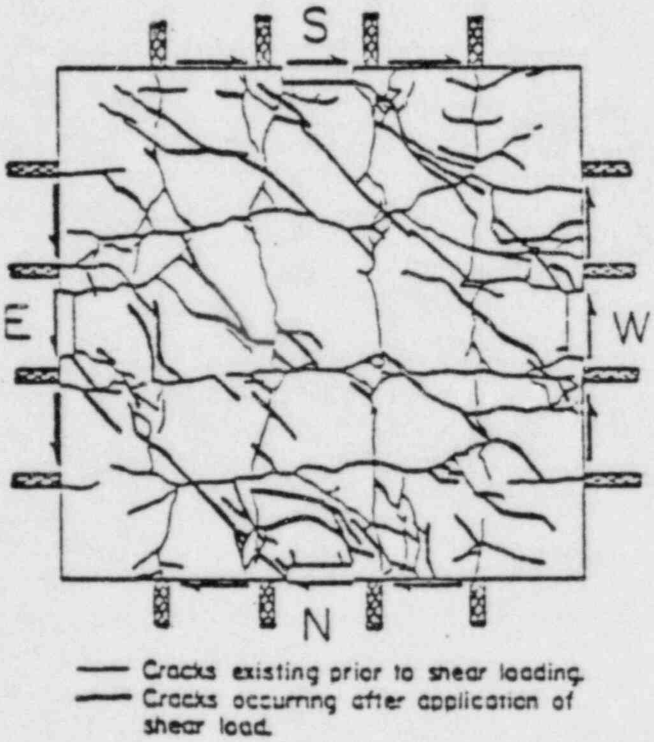
━━ Cracks considered to Penetrate the Full Thickness of the Specimen.

── Cracks considered to Penetrate only the Cover Layer.

Fig. 15 Crack Pattern After Biaxial Tension of 54 ksi in Containment Element Specimen MB1 (10)



a) Just Prior to Loss of Shear Capacity



b) Crack Pattern Just Prior to Maximum Shear Load

Fig. 16 Crack Pattern in Specimen MB1 (10)

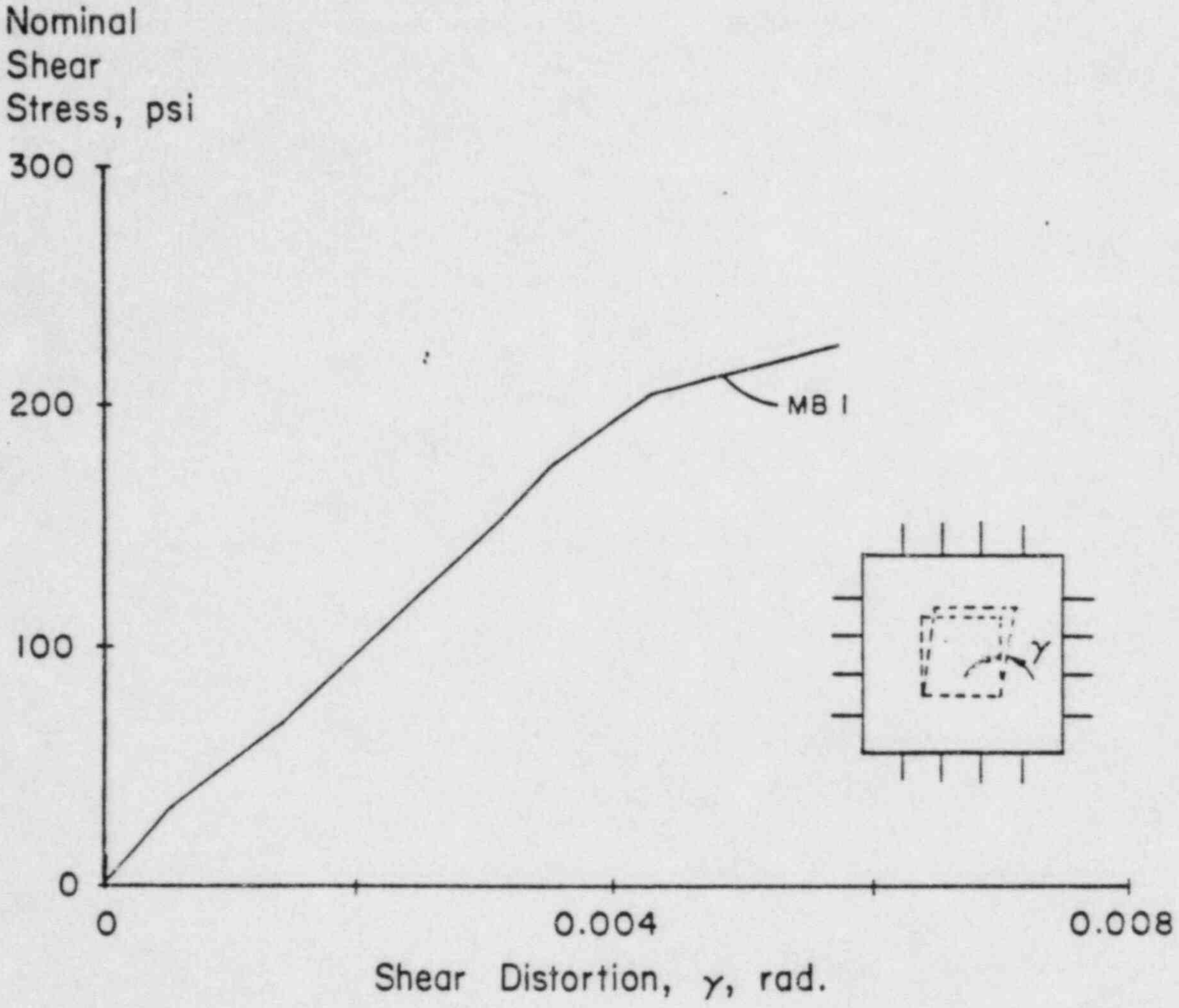


Fig. 17 Nominal Shear Stress versus Shear Distortions for Containment Element Specimen MB1 (After Ref. 10)

level or severity of cracking associated with severe stress in reinforced concrete members. Obviously the presence of cracks in a reinforced concrete structure cannot be summarily dismissed as insignificant. The pattern of cracking and crack widths should be evaluated to determine their significance. However, the mere presence of a crack does not necessarily indicate that the integrity of the structure is in jeopardy, or that its load-carrying capacity has been reduced.

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