U. S. NUCLEAR REGULATORY COMMISSION

SEVENTH WATER REACTOR SAFETY RESEARCH INFORMATION MEETING

NOVEMBER 5-9, 1979

PWR Steam Generator Tube Integrity Program - Surry Reactor Program

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1603 161

STEAM GENERATOR TUBE INTEGRITY PROGRAM

The objective of the Steam Generator Tube Integrity (SGTI) program is to establish validated models, based on experimental data, for prediction of margins-to-failure under burst and collapse pressures of steam generator tubing found to be service degraded by eddy current in-service-inspection. The first phase of the program utilized an extensive matrix of specimens mechanically defected to simulate service induced damage. These specimens were burst or collapse tested at typical steam generator operating temperature. The data were then used to develop mathematical models of remaining tube strength as a function of type and extent of tube defect. Phase two repeated Phase I experiments with a reduced matrix of chemically defected specimens. Phase two data were correlated with the mathematical models developed from Phase I. The chemical defect data, to date, have fit well with the mechanical defect models. The third phase of research is to validate the mathematical models. A feasibility study to acquire a removed from service nuclear steam generator was instigated as a means of fulfilling third phase program specimen requirements. Positive conclusions in the feasibility study led to initiation of the Surry Generator Program. This program includes Phase III of the original SGTI program and involves an expansion into several new task areas.

Steam Generator Tube Integrity Program Accomplishments

Accomplishments this year include manufacture of Inconel 600 tubing specimens chemically defected to simulate wastage, pitting, uniform thinning, and stress corrosion cracking (SCC). An SCC technique was developed that allows formation of SCC with controlled length and depth on a desired tube location. An example of a specimen is shown in Figure 1. All chemically defected specimens, with the exception of those with stress corrosion cracking, were then fully characterized by replication and single and multifrequency eddy current techniques. A substantial effort was made to nondestructively characterize the SCC tubes. This included single and multifrequency eddy current examination, use of a resistivity gauge, UT, visual examinations and X-ray tomography. The later method, a developmental technique, provided the most accurate description of tube cracking. The technique is currently not practical from a hardware standpoint. Multifrequency eddy current examination provided a possibly adequate SCC specimen characterization; however, no confirmatory NDE technique has been identified. There have been examples of large stress corrosion cracks, determined by destructive examination, not detected via eddy current examination. Therefore, the SCC tubes have not yet been destructively tested.

With the exception of the SCC specimens all other chemically defected tubes were burst or collapse tested. The data correlated well with the Phase I mechanical defect data. Figures 2, 3, and 4 are examples of this correlation. The mathematical models of tube strength, based on mechanically defected specimens, were not substantively altered by addition of the chemical defect data. Preliminary indications are that the mathematical model based on EDM notches will correlate well with SCC tube data.

The Phase I and Phase II data were analyzed in terms of the tube strength models. Plots were made of predicted strength vs actual failure strengths and standard deviation bands calculated. Figures 5-10 show these plots.

Surry Generator Program Accomplishments

A feasibility study was submitted to NRC/RSR in March which addressed the physical, financial and institutional aspects of transporting a retired from service nuclear steam generator to Hanford, Washington for nondestructive and destructive examination. The study focused on generators from the Surry and Turkey Point nuclear plants, as these were identified as candidates for early replacement. The Surry generators were indicated as preferrable since they were of a more common series, and are considered to have indications of most defect types. The feasibility study established that it is physically possible to barge a Surry generator to Hanford. Cost estimate ranges for shielding, transporting, and housing the generator were developed. Institutional barriers to transport were identified and evaluated as to potential programmatic impact.

After NRC evaluation of the feasibility study, PNL was requested to examine alternate sites for locating the program. This evaluation included transportation feasibility, available facilities and staff, and overall programmatic costs. After submitting the study, authorization was received to establish contracts for preparation and transport of a generator from Surry, Virginia to Hanford, Washington. Conceptual design of a suitable examination facility was also authorized. The following programmatic tasks have since been accomplished.

1. Handling contract at Surry.
2. Handling contract at Hanford.
3. Carrier contract.
4. Temporary storage site secured at Hanford.
5. Steam Generator Examination Facility site secured at Hanford. Site Environmental Impact Statement prepared.
6. Conceptual design of Steam Generator Examination Facility completed.
7. Marine consultants contract.
8. Resolved ownership and transportation jurisdictional issues.
9. Applied for Department of Transportation permit to transport the generator as a Low Specific Activity (LSA) cargo.
10. Drafted the preliminary program plan.
11. Conducted a radiological assessment of the steam generator.

Active Tasks Include

1. Establish a cooperative permit with VEPCO for work at their Surry site.

2. Shielding contract.

3. Environmental Impact Assessment for transport.

4. Selection of an Architect-Engineer for Facility Title I, II, and III, design.

5. DOT-LSA shipment request.

6. Resolution of Price-Anderson Act Insurance coverage.

7. Establish an industry participation through the Electric Power and Research Institute (EPRI).

Program plans call for transporting a Surry generator to Hanford in early 1980. We will receive the portion of the generator below the transition cone (Figure 11), including the shell, tube sheet and full tube bundle. A cut away view of the generator is depicted in Figure 12. The unit is 44 feet long, 15 feet maximum diameter and weighs 220 tons, prior to sheilding. Figure 13 shows an artist's rendition of the generator within the Steam Generator Examination Facility, as it appears after conceptual design. Figure 14 shows conceptual design dimensional details. The facility is scheduled for completion the second quarter of 1981.

Experimental studies include: Primary and secondary side characterization by existing and developmental NDE techniques. Validation of NDE characterization by selective generator sectioning. Identification and characterization of corrosion, sludge and crud deposits. Statistical mapping of types and locations of defects and deposits. Provision of specimens for tube integrity testing, leak rate determinations, and cleaning/decontamination studies. Test bed verification of long term effects associated with generator cleaning/decontamination.

References

- NUREG-0359 - "Steam Generator Tube Integrity Program", Quarterly Report, January 1 - March 31, 1977.
- NUREG/CR-0277 - "Steam Generator Tube Integrity Program", Annual Progress Report, January 1 - December 31, 1977.
- NUREG/CR-0086 (PNL-2653-1) - "Reactor Safety Research Programs", Quarterly Report, January 1 - March 31, 1978.
- NUREG/CR-0341 (PNL-2653-2) - "Reactor Safety Research Programs", Quarterly Report, April 1 - June 30, 1978.
- NUREG/CR-0546 (PNL-2653-3) - "Reactor Safety Research Programs", Quarterly Report, July 1 - September 30, 1978.
- NUREG/CR-0681 (PNL-2653-4) - "Reactor Safety Research Programs", Quarterly Report, October 1 - December 31, 1978.
- NUREG/CR0855 (PNL-3040-1) - "Reactor Safety Research Programs", Quarterly Report, January 1 - March 31, 1979.
- NUREG/CR-0718 (PNL-2937) - "Steam Generator Tube Integrity Program", Phase I Report, September 1979.

FIGURE 1

1603 166

.875 x .050 UNIFORM THINNING

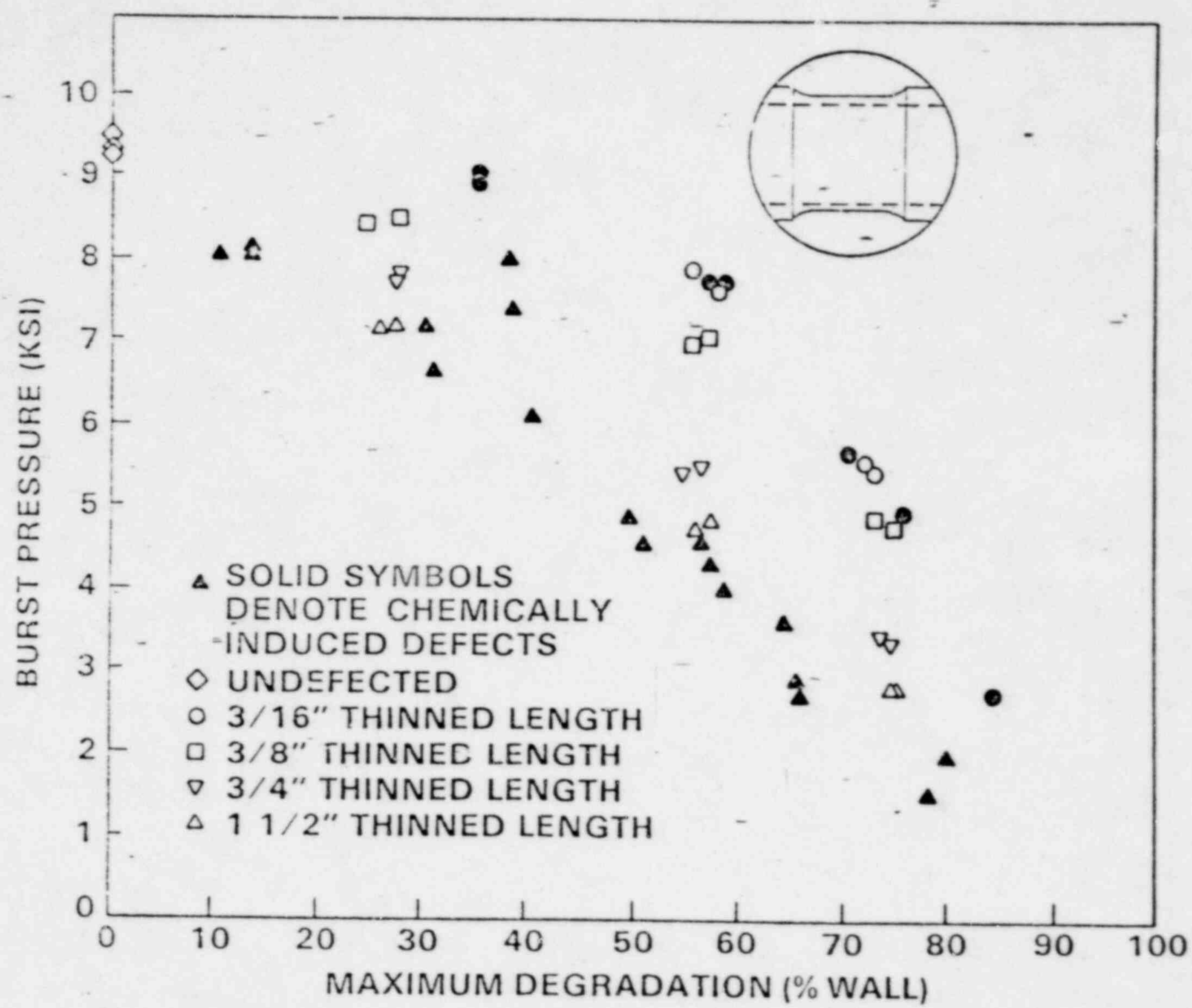


FIGURE 2

1603 167

.875 x .050 ELLIPTICAL WASTAGE

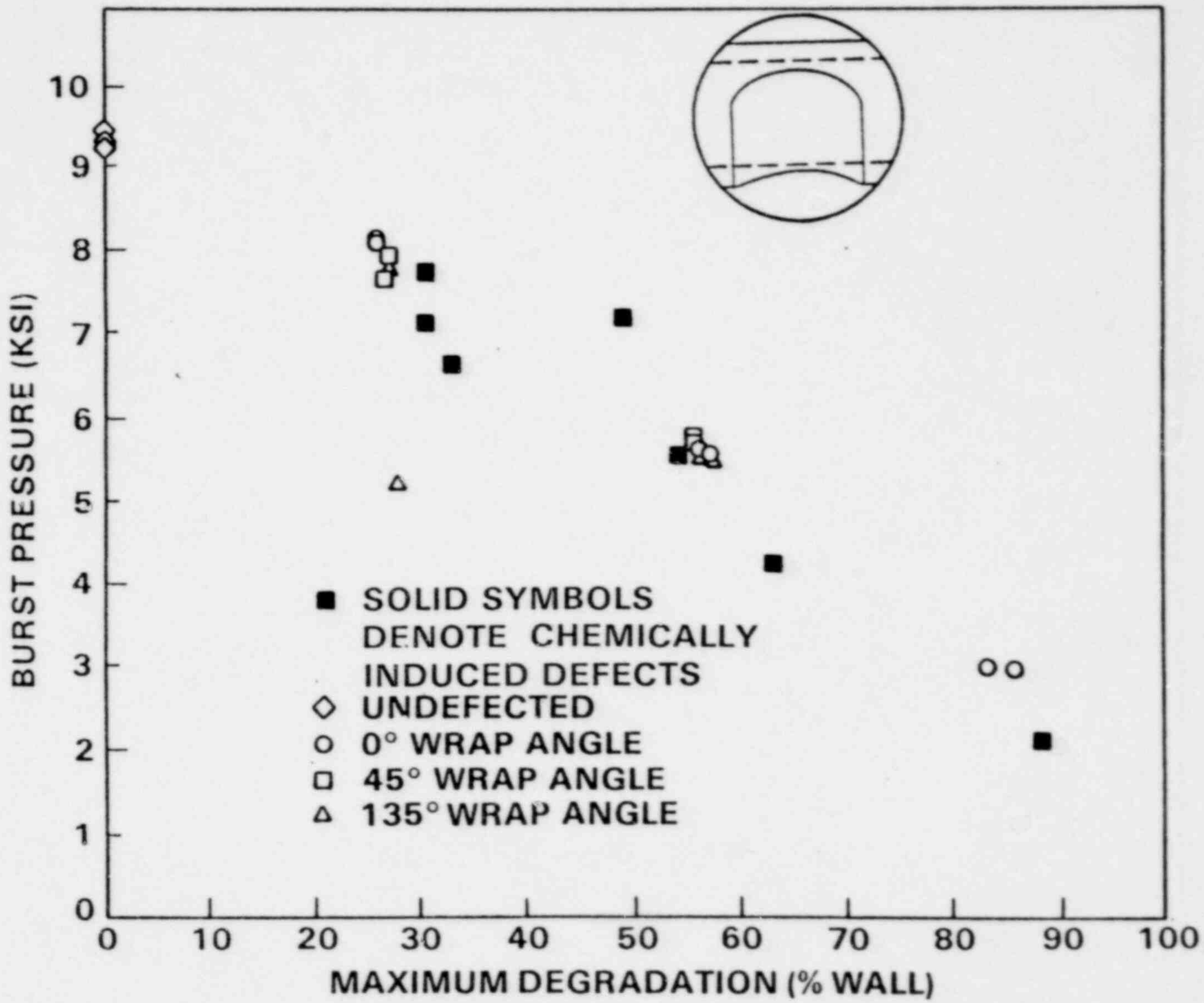


FIGURE 3

1603 168

HEAT B 0.875 IN. X 0.050 M UNIFORM THINNING

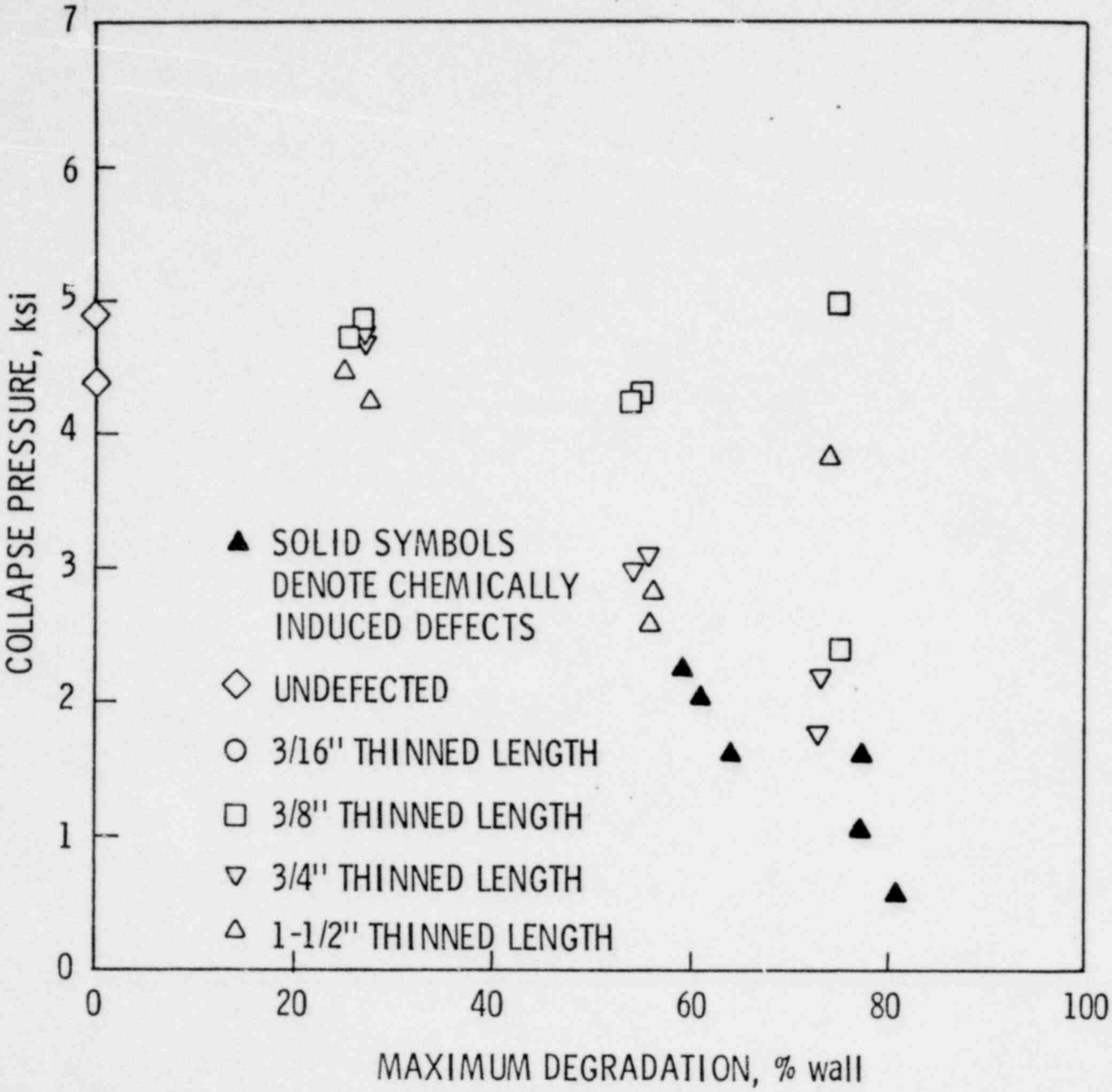
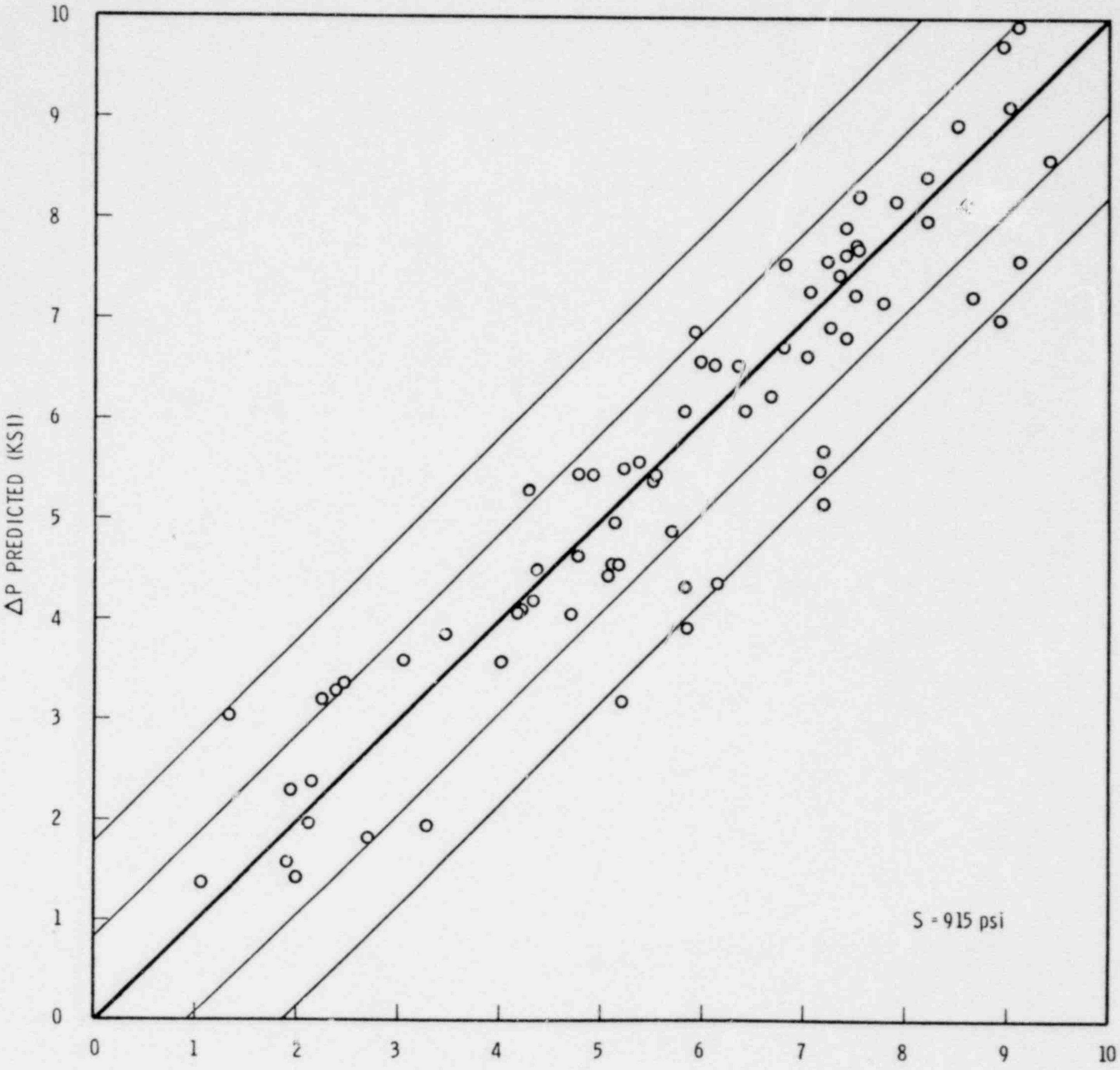


FIGURE 4

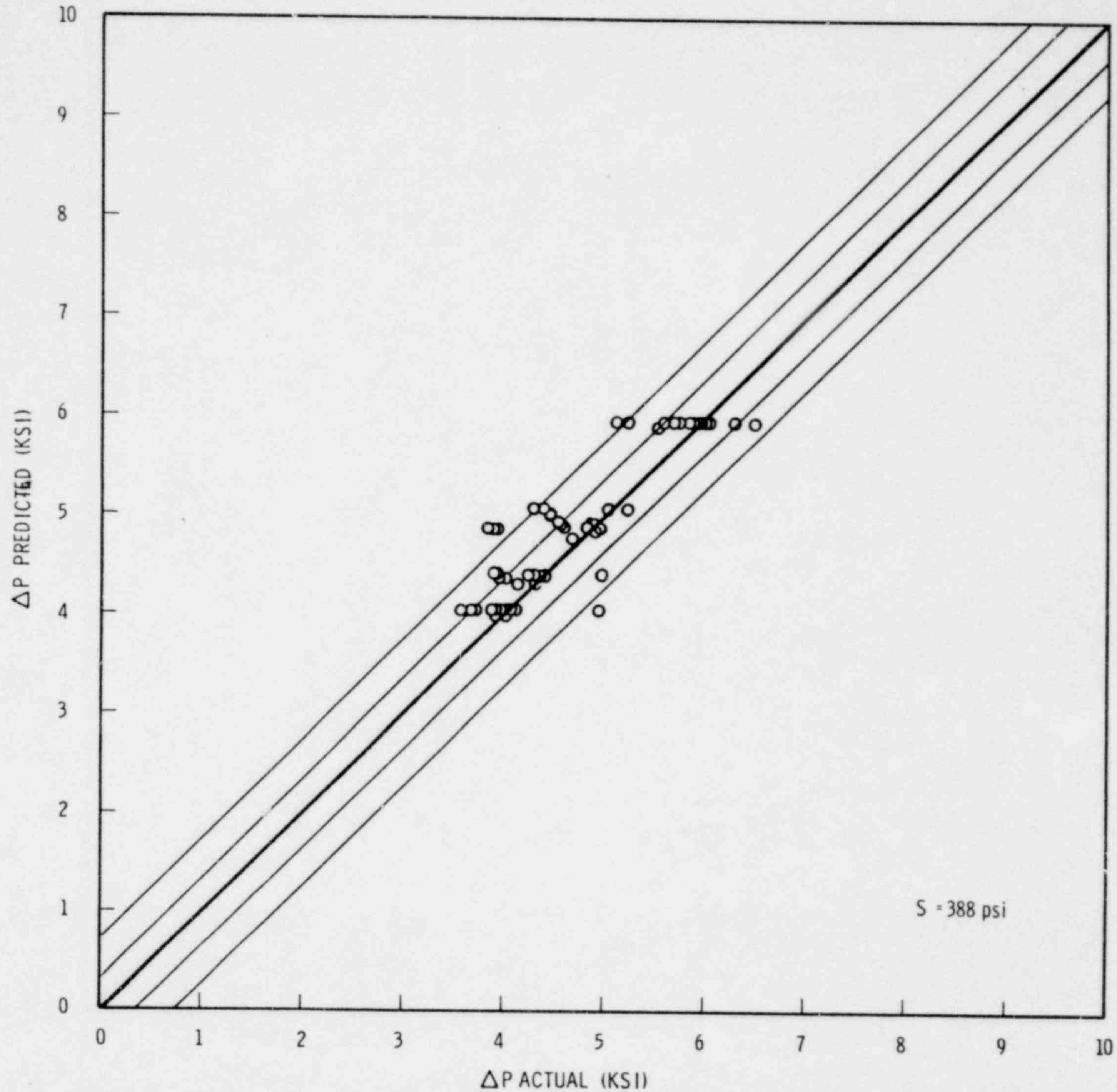
FIGURE 5



EDM SLOTS - BURST

1603 170

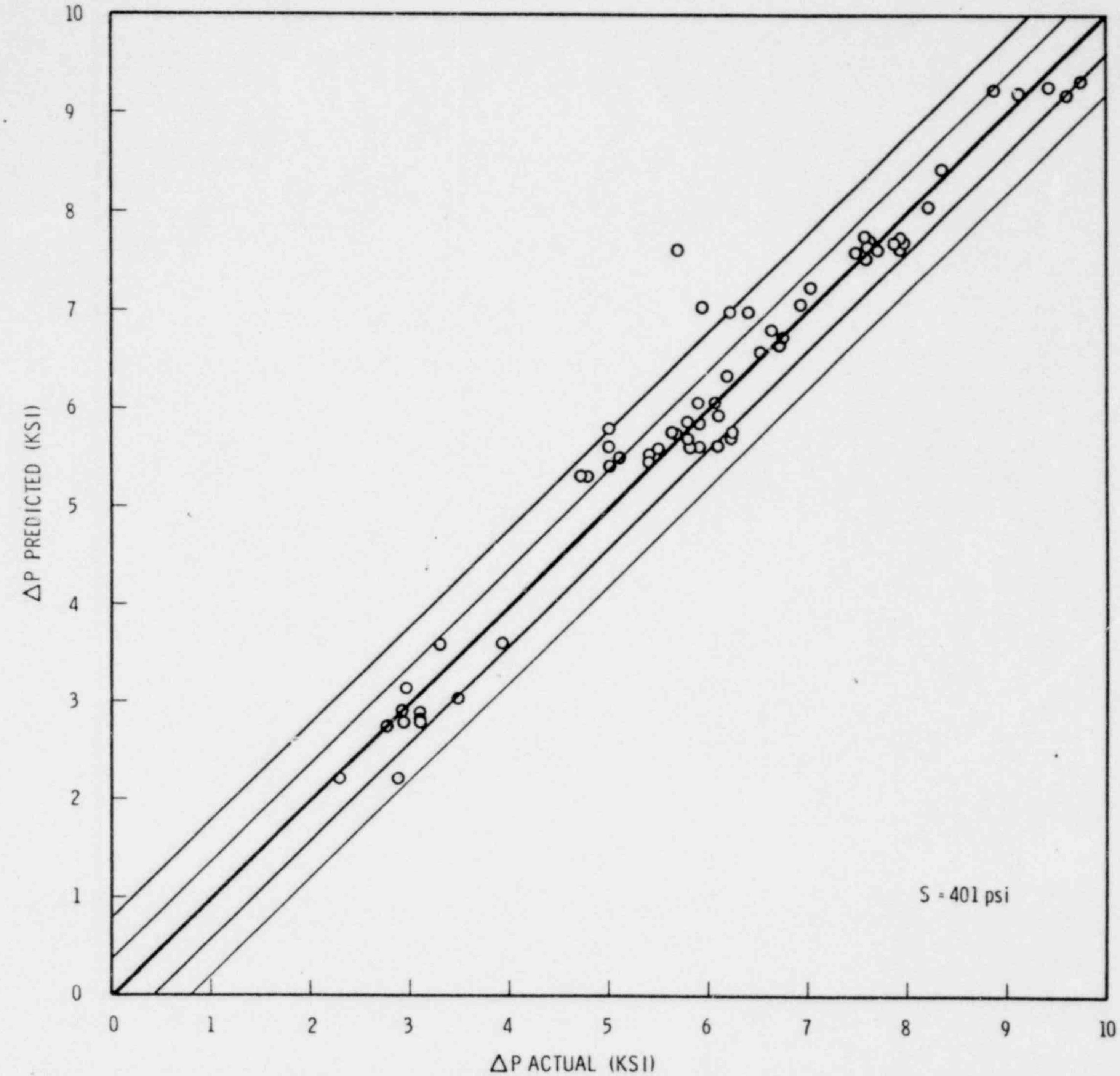
FIGURE 6



EDM SLOTS - COLLAPSE

1603 171

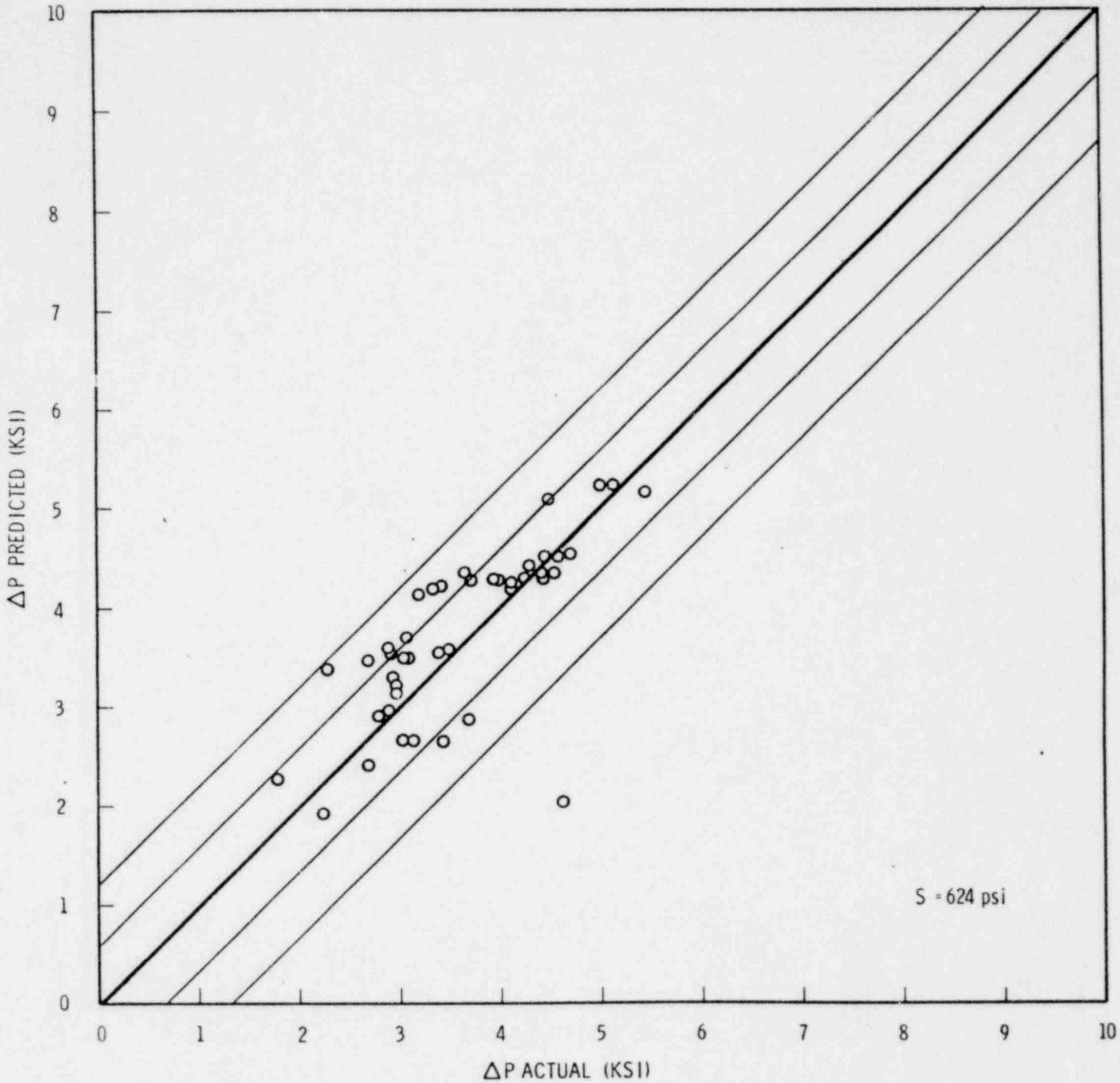
FIGURE 7



ELLIPTICAL WASTAGE - BURST

1603 172

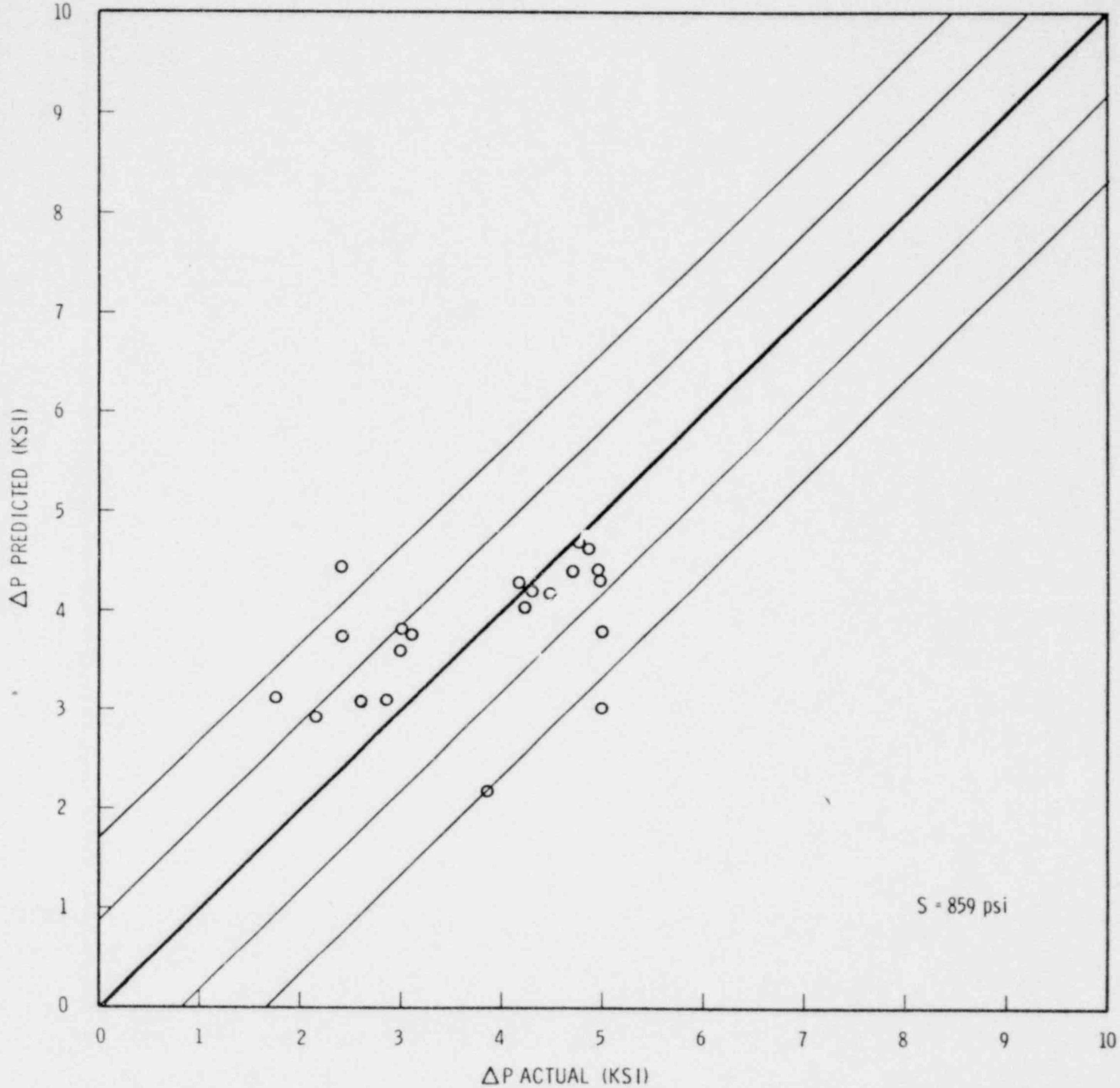
FIGURE 8



ELLIPTICAL WASTAGE - COLLAPSE

1603 173

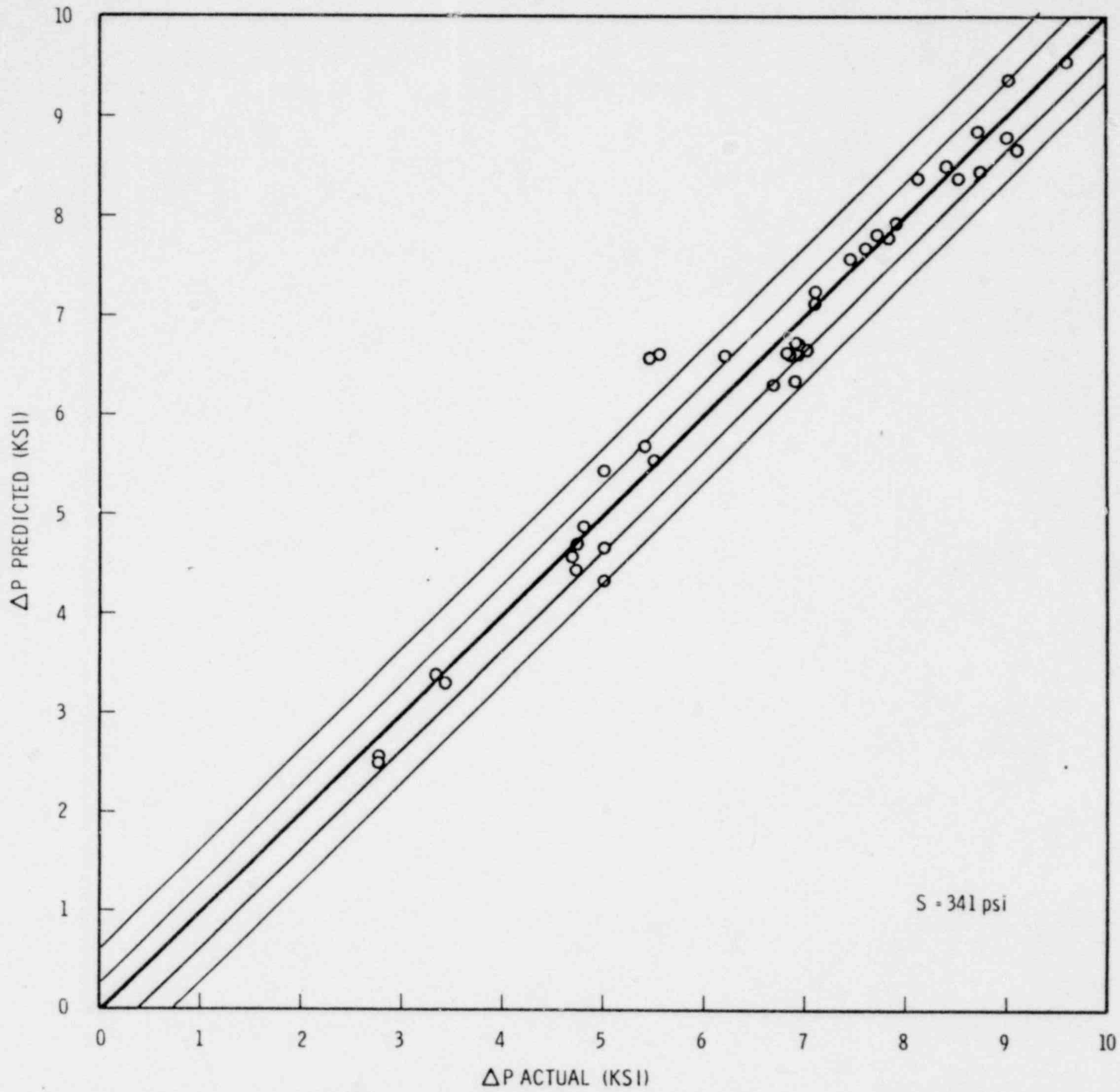
FIGURE 9



UNIFORM THINNING - COLLAPSE

1603 174

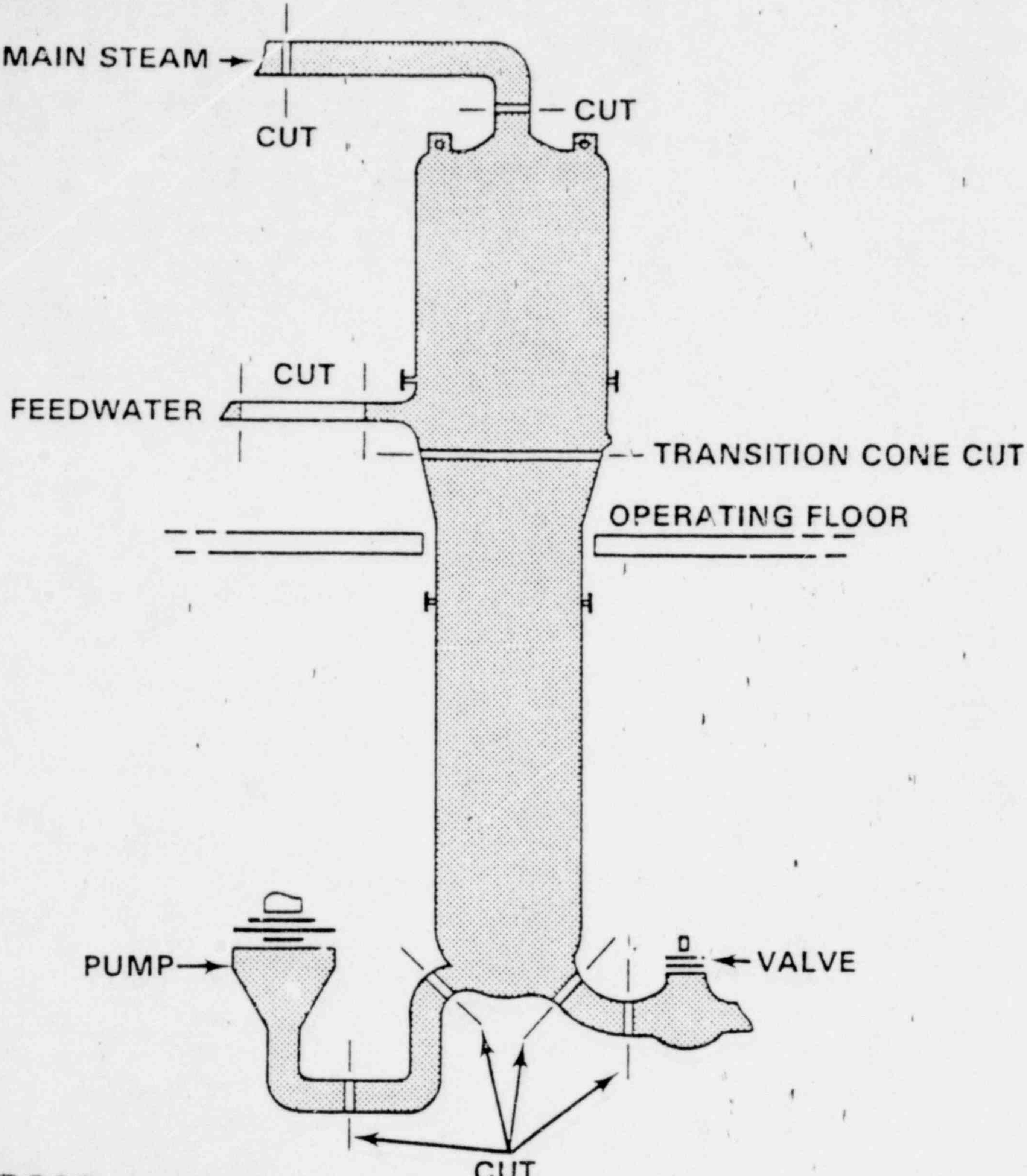
FIGURE 10



UNIFORM THINNING - BURST

1603 175

STEAM GENERATOR CUT LOCATION



POOR ORIGINAL

1603 176

FIGURE 11

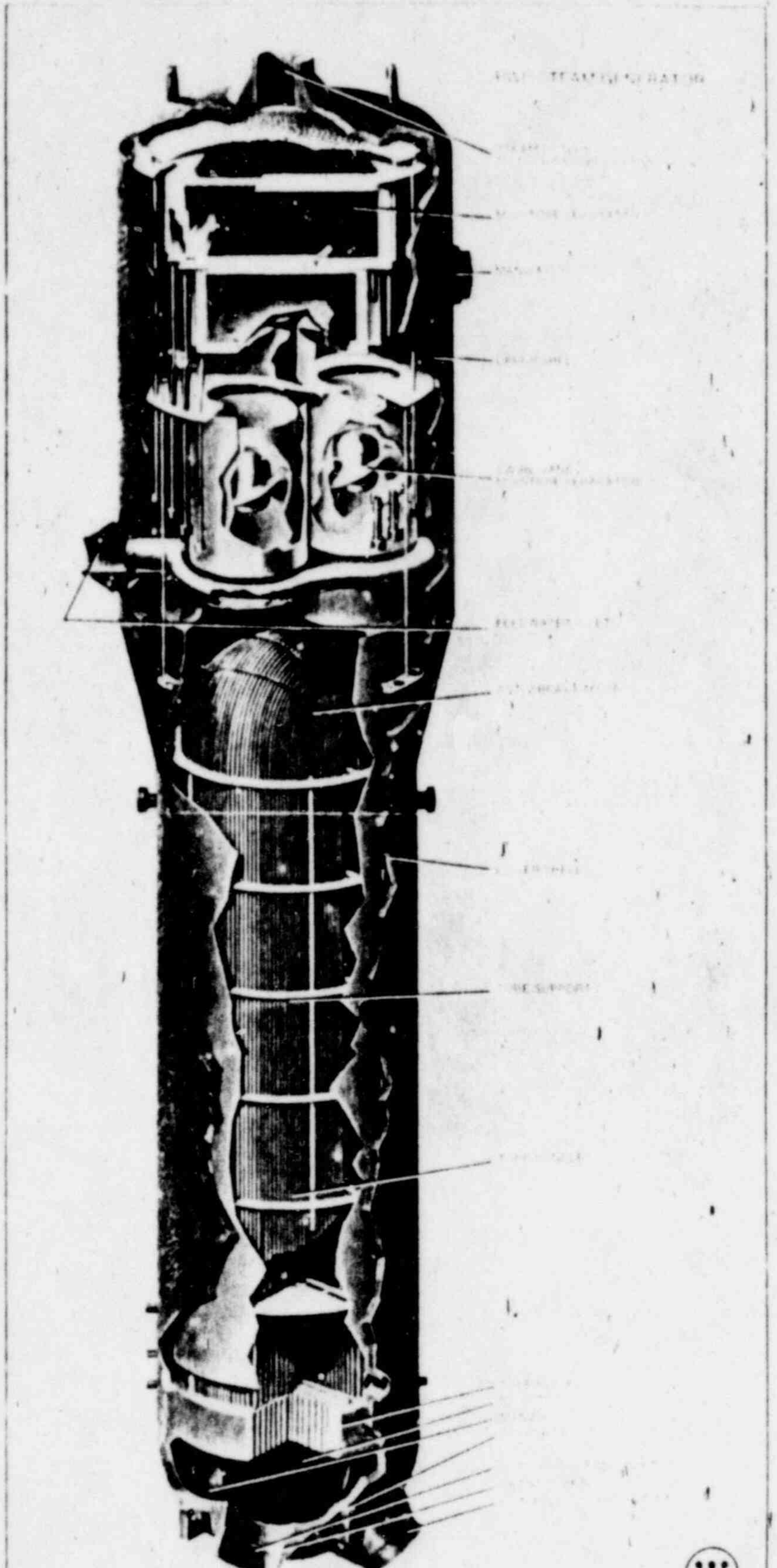


FIGURE 12

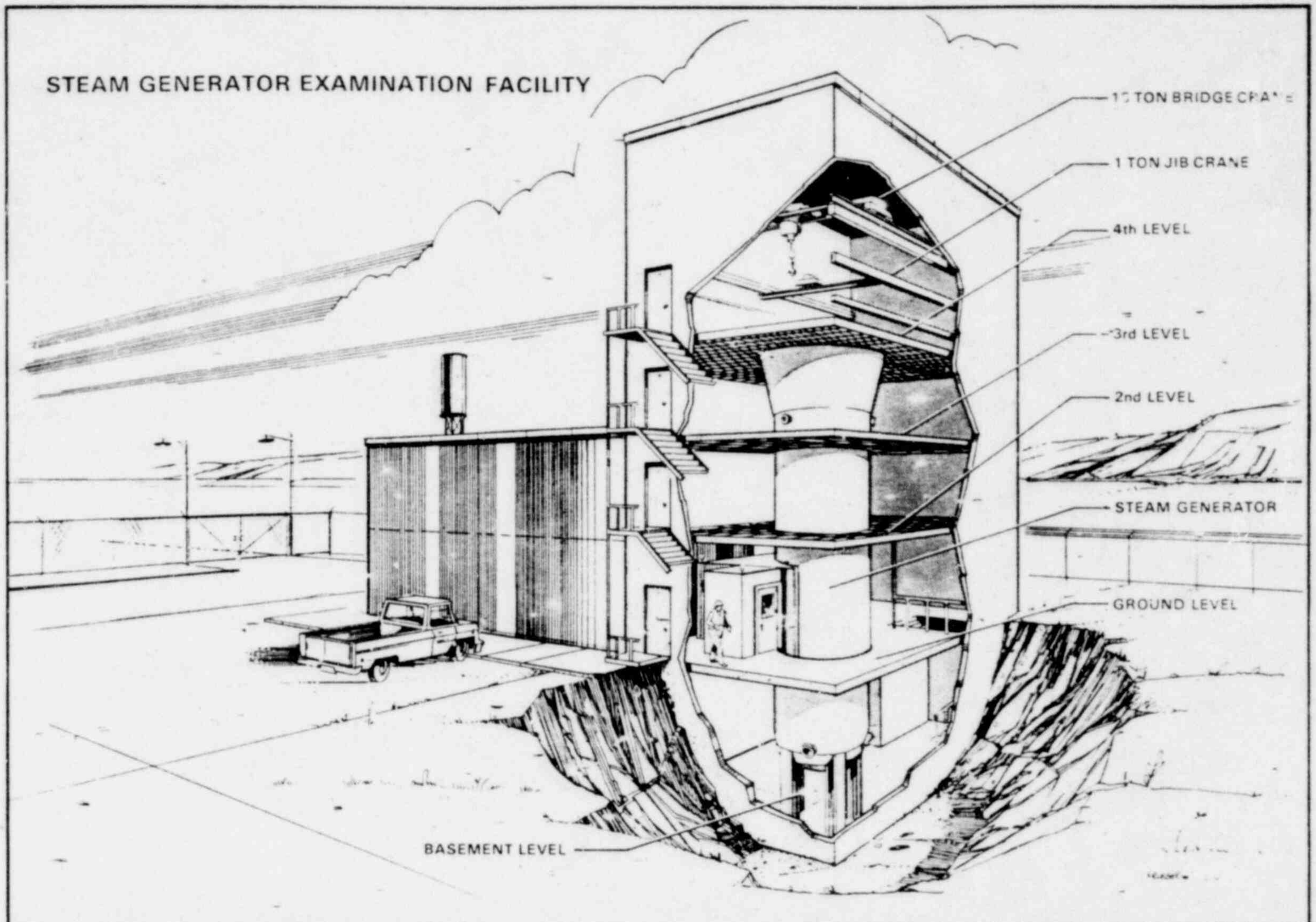

STEAM GENERATOR EXAMINATION FACILITY
TON BRIDGE CRA
1 TON JIB CRANE
4th LEVEL
3rd LEVEL
2nd LEVEL
STEAM GENERATOR
GROUND LEVEL
BASEMENT LEVEL

FIGURE 13

STEAM GENERATOR EXAMINATION FACILITY

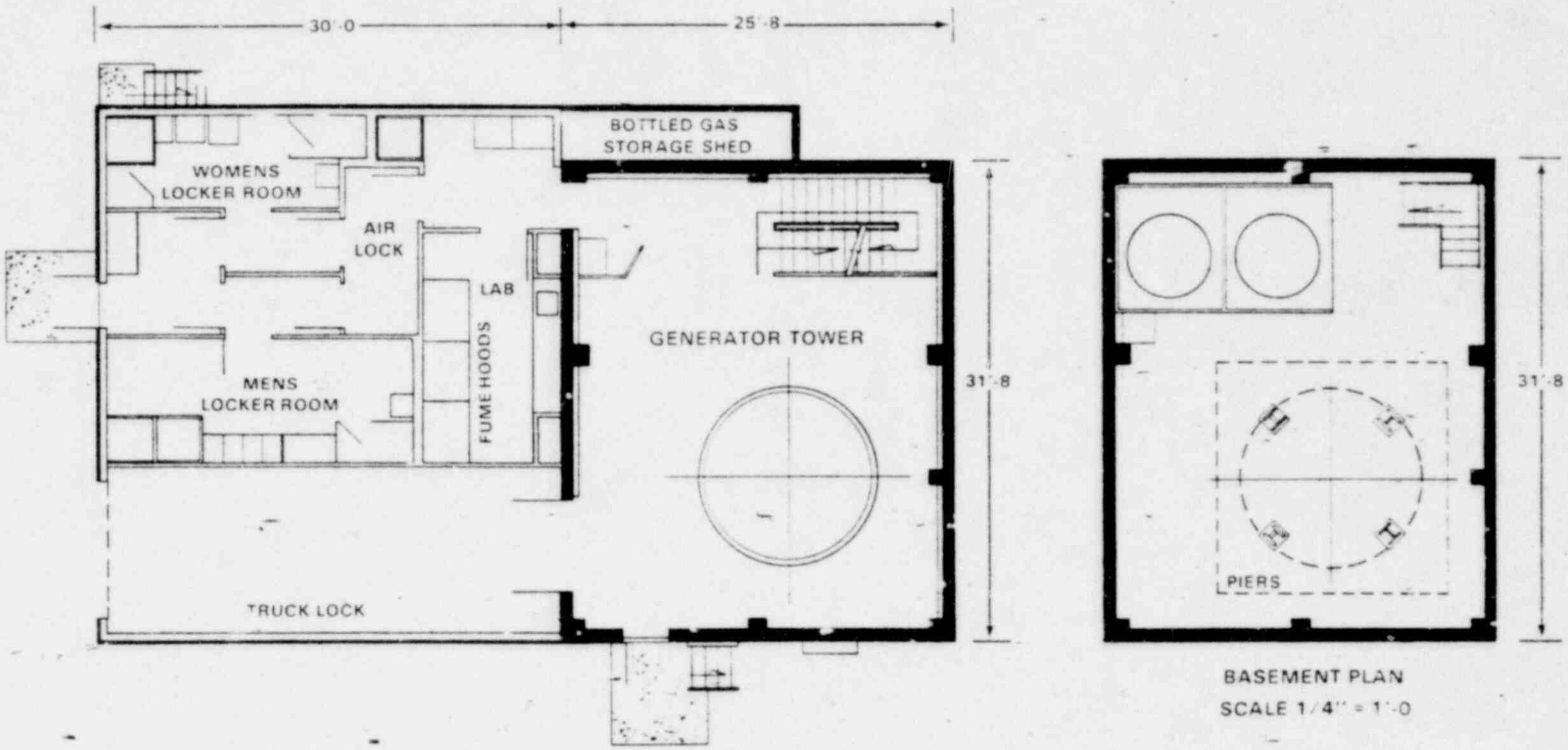


FIGURE 14