SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

PRESSURIZED THERMAL SHOCK EVALUATION

FLORIDA POWER AND LIGHT COMPANY

ST. LUCIE UNITS 1 AND 2

DOCKET NOS. 50-335 AND 50-389

1.0 INTRODUCTION

By letter dated May 14, 1996, the licensee submitted a pressurized thermal shock (PTS) evaluation for St. Lucie Units 1 and 2. In addition, proprietary and non-proprietary copies of the Combustion Engineering Owner's Group (CEOG) report CEN-405-P, Revision 2, "Application of Reactor Vessel Surveillance Data for Embrittlement Management" were enclosed for NRC review and approval.

By teleconference conducted on August 27, 1996, the NRC staff suggested that the licensee submit new proprietary and non-proprietary reports since data extracted from the power reactor embrittlement database (PR-EDB) are non-proprietary. New proprietary and non-proprietary versions of CEN-405-P (designated Revision 3) were submitted by letter dated September 23, 1996. Additional information was provided by letters dated January 14 and May 16, 1997. The January 14, 1997 letter changed the requested approval date from April 1, 1997 to April 1, 1998 due to scheduling outage changes.

It should be noted that CEN-405-P, Revision 1 was originally submitted to the NRC on December 6, 1991. On January 29, 1992, the staff issued a request for additional information (RAI). CEN-405-P, Revision 2 incorporated changes made as a result of the RAI, and was submitted for review and approval on August 6, 1993. Review of the topical report was given very low priority due to staff resources. Revision 2 was resubmitted as an attachment to the St. Lucie PTS evaluation on May 14, 1996, and therefore, had a higher priority for review.

The PTS rule adopted on July 23, 1985 and revised on May 15, 1991, and December 19, 1995 established screening criteria that are a measure of a

Attachment

limiting level of reactor vessel material embrittlement beyond which operation cannot continue without further plant-specific evaluation. The screening criteria are given in terms of reference temperature, RT_{PTS}. The screening criteria are 270°F for plates and axial welds and 300°F for circumferential welds. The RT_{PTS} is defined as:

$$RT_{PTS} = RT_{NDT(U)} + \Delta RT_{PTS} + M$$

where: (a) $RT_{NDT(U)}$ is the initial reference temperature, (b) ΔRT_{PTS} is the mean value in the adjustment in reference temperature caused by irradiation; and (c) M is the margin to be added to cover uncertainties in the initial reference temperature, copper and nickel contents, fluence, and calculational procedures.

The initial reference temperature is the measured unirradiated value as defined in the American Society of Mechanical Engineers (ASME) Code, Paragraph NB-2331. If measured values are unavailable for the heat of material of interest, generic values may be used. The generic values are based on the data for materials of all heats that were made by the same vendor using similar processes. The generic values of initial reference temperature for welds are defined in the PTS rule.

The ΔRT_{PTS} depends upon the amount of neutron irradiation and the amounts of copper and nickel in the material and is calculated as the product of a fluence factor and a chemistry factor (CF). The fluence factor is calculated from the best estimate neutron fluence at the clad-weld-metal interface on the inside surface of the vessel at the location where the material receives the highest fluence at the end of the period of evaluation. The CF may be determined using credible surveillance data or from the CF tables in the PTS rule. The CFs in the tables are dependent upon the best-estimate values of the amount of copper and nickel in the material. The term "best-estimate" is not well defined statistically, but has normally been interpreted as the mean of the measured values.

The revised PTS rule contains criteria for determining whether surveillance data are credible. The rule also contains the procedure for calculating the vessel weld CF from the adjusted or measured values of ΔRT_{PTS}. Specifically, the rule states that if there is clear evidence that the copper and nickel content of the surveillance weld differs from that of the vessel weld, the measured values of ΔRT_{PTS} should be adjusted by multiplying them by the ratio

of the CF of the vessel weld to that of the surveillance weld. The CF is calculated by multiplying each adjusted or measured value of ΔRT_{PTS} by its corresponding fluence factor, summing the products, and dividing by the sum of the squares of the fluence factors. The resulting CF will give the relationship of ΔRT_{PTS} to fluence that fits the plant surveillance data in such a way as to minimize the sum of the squares of the errors.

The margin term is intended to account for variability in initial reference temperature and the adjustment in reference temperature caused by irradiation. The value of the margin term is dependent upon whether the initial reference temperature was a measured or generic value and whether the adjustment in reference temperature was determined from credible surveillance data or from the CF tables in the PTS rule.

2.0 DISCUSSION

St. Lucie Unit 1

The St. Lucie Unit 1 (SL-1) reactor vessel beltline includes the intermediate shell plates C-7-1, C-7-2 and C-7-3, heats A4567-1, B9427-1 and A4567-2 respectively; lower shell plates C-8-1, C-8-2 and C-8-3, heats C5935-1, C5935-2 and C5935-3 respectively; intermediate shell axial welds 2-203 A,B,C, heats A8746/34B009; intermediate to lower shell girth welds 9-203, heat 90136 and the material with the greatest amount of embrittlement (limiting material) is the lower shell axial welds 3-203 A,B,C. The axial weld was fabricated by Combustion Engineering (CE)

using the submerged arc weld process with weld wire heat 305424 and Linde 1092 flux, lot number 3889.

Surveillance data for the limiting material are not available in the SL-1 surveillance program, however, the data are available in the Beaver Valley Unit 1 (BV-1) surveillance program. The BV-1 vessel and the surveillance weld were fabricated by CE and designed by Westinghouse (W). The surveillance weld was fabricated using the submerged arc weld process with weld wire heat 305424 and Linde 1092 flux, lot number 3889 which is the same process that was used to fabricate the SL-1 lower shell axial welds 3-203 A,B,C (the limiting material). In addition, the BV-1 and SL-1 vessels were both fabricated during the same period by CE in Chattanooga, Tennessee.

The staff evaluated the applicability of the BV-1 surveillance data to the

SL-1 vessel in terms of similarity of the irradiation environments. The staff reviewed the additional information that was provided by letter dated January 14, 1997, which included the displacement rate (dpa/sec) and flux values for the last surveillance capsules removed from both BV-1 and SL-1.

The time weighted average BV-1 and SL-1 cold leg inlet temperatures are 544.7°F and 546.7°F, respectively. Since the BV-1 surveillance capsules were irradiated at a similar, but slightly lower cold leg temperature as compared to the SL-1 cold leg temperature, the BV-1 surveillance data do not require any temperature correction for use.

In addition, comparison of the ratio of displacement rate to flux, or the damage ratio, is an indication of differences in the energy distribution of neutrons at the surveillance capsule locations. When comparing the damage ratios of the SL-1 vessel at the critical weld location and the BV-1 and SL-1 surveillance capsules, the irradiation behaviors are similar within 9%. Therefore, in terms of irradiation environment, the BV-1 surveillance data are appropriately applicable to the SL-1 reactor vessel data.

In addition, the licensee provided a statistical analysis in support of the conclusion that no significant bias exists between surveillance data from CE and W designed vessels that were fabricated in the CE Chattanooga facility. The staff completed an independent statistical analysis to verify the licensee's conclusions. The results of the staff's analysis are detailed in the statistical analysis section of this SER. Therefore, based on statistical analysis, the BV-1 surveillance weld is considered to be representative of the SL-1 lower shell axial seam welds 3-203 A,B,C.

St. Lucie Unit 2

The St. Lucie Unit 2 (SL-2) reactor vessel beltline includes the intermediate shell plates M-605-1 and M-605-3, heats A-8490-2 and A-8490-1 respectively; lower shell plates M-4116-1, M-4116-2 and M-4116-3, heats B-8307-2, A-3131-1 and A3131-2 respectively; intermediate shell axial welds 101-124 A,B,C and 101-124C, heats 83642 and 83637 respectively; intermediate to lower shell girth welds 101-171, heats 3P7317 and 83637 respectively; and lower shell axial welds 101-142 A,B,C. The material with the greatest amount of embrittlement (limiting material) is the intermediate shell plate M-605-2, heat B-3416-2. It should be noted that the SL-2 reactor vessel has low copper and nickel content, and the limiting plate has an RT_{PTS} value that is 110°F below the screening criterion of 270°F.

Sufficient surveillance capsule data are not yet available for SL-2, so projections of RT_{PTS} at expiration-of-license (EOL) were made based on initial chemistry values and the projection methodology of 10 CFR 50.61, "Fracture Toughness Requirements for Protection Against Pressurized Thermal Shock Events".

3.0 Statistical Analysis for St. Lucie Unit 1

As mentioned, CEN-405-P, Revisions 1 and 2 had previously been submitted to the NRC in 1991 and 1993 respectively. Discrepancies between the licensee's database and the data that the staff identified were outlined in the January 29, 1992 staff RAI. The main source of the staff's data was the Oak Ridge National Laboratory (ORNL) Report NUREG/CR 4816,"PR-EDB: Power Reactor Embrittlement Database, Version 2". The licensee also utilized data from the ORNL report except in cases where data had been omitted, or incorrect data were identified. Missing values were corrected when additional sources of the data were available. When incorrect data values were identified, each case was evaluated using original source documents to determine the appropriate value. Therefore, the licensee's current database represents updated values, and the data were utilized in the statistical analysis.

For completeness, analyses were done for both the licensee's reported values (designated as "CEOG data" in the figures and tables), and the values that were outlined in the staff's 1992 RAI (designated as "NRC data" in Table 2) in order to compare the results.

The staff performed the statistical Mann-Whitney Test of Independence on the data provided in Tables A-1 and A-2 of the CEOG Report CEN-405-P, Revision 3, "Application of Reactor Vessel Surveillance Data For Embrittlement Management, September 1996." The Mann-Whitney Test is a non-parametric test in which the data from two populations are combined and arranged in ascending order. The U statistics are determined for each sample population. Each member of a given population is assigned the number of members from the other population which precede it in the ordered list. The U statistic is the summation of the numbers assigned to the members of a given population. The Z statistic, also known as the standardized sampling error, is generated from 1) the calculated U value, 2) the product of the number of members in each population divided by two (e.g. $n_1n_2/2$), and 3) the standard deviation of the U statistic.

Table 1 lists data including the predicted minus actual (P-A) values of the increase in the nil ductility transition temperature caused by neutron irradiation (ΔRT_{NDT}). The data are from plate and weld surveillance material that was irradiated in CE and W designed, CE fabricated vessels. The P-A values for the CE and W data were the parameters used for the staff's and the licensee's statistical analyses. Additional data with regard to plate orientation are also provided. Figure 1 shows a schematic of the method used to separate the data according to 1) material type (plate or weld), 2) vessel designer (CE or W), 3) orientation (LT or TL - plates only), and 4) data set (CEOG or NRC) for the statistical analyses.

Mann-Whitney tests were performed on CEOG plate data based on vessel designer and plate orientation. CEOG weld data were subjected to the Mann-Whitney test with population differentiation based on vessel designer. NRC values for both plates and welds were also tested. A total of six (6) tests were performed on the data.

The null hypothesis tested was that there is no difference between the two population distributions that were tested in each permutation. The null hypothesis was accepted in each case based on the stated decision criteria given in Table 2. The table summarizes the results of the Mann-Whitney statistical tests.

Figures 2-7, 9 and 10 present the histograms of the CEOG CE and W plate and weld data. These figures indicate the frequency of a given value as well as the normal probability distribution based on the calculated mean and standard deviation. Figures 8 and 11 present the combined CEOG CE fabricated, CE and W designed plate and weld data, respectively.

Based on the statistical analysis, the staff concluded that there is no significant difference or bias between the CE fabricated, CE and W designed surveillance data. Therefore, surveillance data from CE fabricated, CE and W designed vessels will, on average, be representative of each other for vessels fabricated in the CE Chattanooga facility.

4.0 Initial Reference Temperature

As part of the PTS evaluation, the staff reviewed the basis for the initial reference temperature values for all SL-1 and 2 beltline materials. The results of the review are discussed below.

St. Lucie Unit 1

The limiting weld in the SL-1 reactor vessel beltline was fabricated from the same heat of weld wire (305424) as the BV-1 surveillance weld and welds in the LaSalle 1 (LS-1) reactor vessel beltline. A full Charpy curve was produced as part of the initial property testing for the BV-1 surveillance program. In addition, three Charpy tests were performed at +10°F for weld heat 305424 with the same Linde 1092 flux used to fabricate the SL-1 and LS-1 vessel beltline welds. The three Charpy test data results of 82, 87, and 92 ft-lbs at +10°F were reported for both the SL-1 and LS-1 vessel beltline welds. Initially, the licensee only used the BV-1 data to conclude that the $RT_{NDT(U)}$ value for the limiting weld is drop weight controlled. The staff verified that the drop weight temperature remains controlling with the inclusion of Charpy data from SL-1 and LS-1. The resulting initial reference temperature value for the limiting axial welds is -60°F.

St. Lucie Unit 2

The licensee used a plant specific initial reference temperature value of +10°F for the limiting plate.

The licensee also reported a plant specific $RT_{NDT(U)}$ value of -80°F for the intermediate shell axial welds 101-124 A,B,C in the SL-2 reactor vessel. These welds were fabricated using weld wire heat 83642. Beaver Valley 2 reported a value of -30°F for a weld that was also fabricated from heat 83642. The original submittal stated that an $RT_{NDT(U)}$ value of -80°F would be used for the SL-2 weld. The justification was that these welds are not the limiting material, and the RT_{PTS} value is significantly below the screening criterion.

Since there is such a large difference in the two values, the staff issued a request for additional information (RAI) by letter dated March 13, 1997. In response to the RAI, the licensee committed to use the generic value of -56°F with a larger margin term instead of the non-conservative value of -80°F for calculation of the RT_{PTS} value.

5.0 Best-estimate Chemical Composition of the Limiting Material

St. Lucie Unit 1

The licensee's best-estimate values of the amount of copper and nickel in the limiting weld for SL-1 are 0.28% and 0.63%, respectively. Linear interpolation of the CFs in Table 1 of the PTS rule indicates that the chemistry factor is 191.65°F for welds with these amounts of copper and

nickel. The best estimate values of copper and nickel are mean values of weld deposit data from the CE weld metal qualification (WMQ) test and the BV-1 surveillance weld.

St. Lucie Unit 2

The licensee's best-estimate values of the amount of copper and nickel in the limiting plate for SL-2 are 0.13% and 0.62%, respectively. Linear interpolation of the CFs in Table 1 of the PTS rule indicates that the chemistry factor is 91.5°F for plates with these amounts of copper and nickel. The best estimate values of copper and nickel are mean values from the plate certification test.

6.0 Best-estimate Chemical Composition of the Beaver Valley 1 Surveillance Weld

The licensee's best-estimate of the amount of copper and nickel in the BV-1 surveillance weld are 0.26% and 0.62%, respectively. Linear interpolation of the CFs in Table 1 of the PTS rule indicates that the chemistry factor is 183.2°F for welds with these amounts of copper and nickel. The best-estimate of the amount of copper and nickel in the surveillance weld is the mean value of the measurements of these elements from the surveillance weld itself.

7.0 Evaluation of Surveillance Data

The licensee determined the CF for the SL-1 vessel weld using: (a) the BV-1 surveillance data, (b) the ratio procedure that is recommended in 10 CFR 50.61 when the chemistry of the surveillance weld is different than the vessel weld, and (c) the calculational procedures that are recommended in 10 CFR 50.61. The best-estimate chemistry of the SL-1 vessel weld is 0.28% copper and 0.63% nickel. The best-estimate chemistry of the BV-1 surveillance weld is 0.26% copper and 0.62% nickel. The licensee's estimate of the ratio of the CF of the vessel weld to the CF of the surveillance weld was 1.046. The CF calculated by the licensee was 200.15°F.

The staff determined the CF for the vessel weld using its best-estimate chemistry for the vessel weld (0.28% copper and 0.63% nickel) and the surveillance weld that was discussed above. The ratio of the CF of the vessel weld to the CF of the surveillance weld was 1.046. The CF calculated by the staff was 200.1°F.

Credibility Criterion (C) in section (c)(2)(i) of 10 CFR 50.61 indicates that the scatter of the measured ΔRT_{PTS} values must be less than 17°F for base metal and 28°F for welds. The licensee determined that the scatter for the BV-1 surveillance weld data is less than 28°F. Evaluation of this criterion was the basis for the licensee's determination that the BV-1 weld surveillance data met the credibility criteria in 10 CFR 50.61. The licensee proposed that the calculated CF from the surveillance data (200.15°F) be used in determination of ΔRT_{PTS} and RT_{PTS}.

The staff independently evaluated the scatter of the measured ΔRT_{PTS}, and determined that the weld surveillance data satisfy Criterion (C) in section (c)(2)(i) of 10 CFR 50.61. Hence, the surveillance data are credible and should be used to determine the CF for the vessel weld.

8.0 Margin Value

St. Lucie Unit 1

The licensee calculated the margin value in accordance with the methodology in 10 CFR 50.61. A standard deviation of zero was used for the initial reference temperature ($RT_{NDT(U)}$) since, as discussed in section 4, the $RT_{NDT(U)}$ is a measured value. 10 CFR 50.61 recommends that the standard deviation for the adjustment in reference temperature be reduced by half if surveillance data are credible. Therefore, a standard deviation of 14°F was used since the surveillance data for the weld were found to be credible. The licensee calculated a margin value of 28°F. This value is acceptable since it was calculated in accordance with the methodology in 10 CFR 50.61.

St. Lucie Unit 2

The licensee calculated the margin value in accordance with the methodology in 10 CFR 50.61. A standard deviation of zero was used for the initial reference temperature ($RT_{NDT(U)}$) since the $RT_{NDT(U)}$ is a measured value. A standard deviation of 17°F was used for the adjustment in reference temperature for the plate. The licensee calculated a margin value of 34°F. This value is acceptable since it was calculated in accordance with the methodology in 10 CFR 50.61.

9.0 Projected RT_{PTS} Value at EOL

St. Lucie Unit 1

The RT_{PTS} value calculated by the licensee at EOL is 213°F. The RT_{PTS} value calculated by the staff for SL-1 is 212.6°F. The staff's value is calculated using (a) a measured value of the initial reference temperature, (b) best-estimate values of copper and nickel for the vessel and surveillance welds, (c) a CF calculated from BV-1 surveillance data and adjusted to account for the difference between the best-estimate chemistry of the SL-1 vessel and BV-1 surveillance weld, (d) an EOL neutron fluence of 2.27E19n/cm^2, and (e) a margin value of 28°F. The slight difference between the staff's and the licensee's RT_{PTS} values is due to round off error. (213°F calculated by the licensee and 212.6°F calculated by the staff).

Using the BV-1 weld surveillance data for the SL-1 PTS evaluation, indicates that the reactor pressure vessel would be below the PTS screening criteria at the expiration of its license.

St. Lucie Unit 2

The RT_{PTS} value calculated by the licensee at EOL is 160°F. The RT_{PTS} value calculated by the staff for SL-2 is 160.3°F. The staff's value is calculated using (a) a measured value of the initial reference temperature, (b) best-estimate values of copper and nickel for the vessel plate, (c) a CF determined from the CF table for plates in 10 CFR 50.61, (d) an EOL neutron fluence of 2.76E19n/cm^2, and (e) a margin value of 34°F. The slight difference between the staff's and the licensee's RT_{PTS} values is due to round off error. (160°F calculated by the licensee and 160.3°F calculated by the staff).

The SL-2 reactor pressure vessel PTS evaluation indicates that the reactor pressure vessel would be below the PTS screening criteria at the expiration of its license.

10.0 CEOG report CEN-405-P, Revision 3

As mentioned, the CEOG submitted report CEN-405-P, Revision 3 "Application of Reactor Vessel Surveillance Data for Embrittlement Management" for review and approval as part of their St. Lucie PTS submittal. The report presents two approaches for CE owners to apply Regulatory Position 2.1 of Regulatory Guide (RG) 1.99, Revision 2 when the limiting material of the vessel is not in the

surveillance program, and the surveillance data meet the remaining four RG credibility criteria. The integrated surveillance approach would use limiting material data from another CE fabricated host vessel after determining the similarity of that vessel to the subject vessel (i.e. similarity of irradiation environment). The margin reduction approach would use the plant specific surveillance data to reduce the margin to be added to the predicted shift.

The current PTS rule incorporates the five surveillance data credibility criteria of RG 1.99, Revision 2. The first credibility criterion states that "Materials in the capsules should be those most likely to be controlling with regard to radiation embrittlement according to the recommendations of [RG 1.99, Revision 2]." The licensee's approach proposes that the credibility of the surveillance data be determined using only four of the criteria. Application of the margin reduction approach would require an exemption from the PTS rule.

The integrated surveillance approach, would be allowed by the PTS rule. In order to apply this approach a licensee would need to confirm that the material in the host surveillance program is equivalent to the controlling material in their vessel. This method involves several plant specific considerations. Therefore, approval of a generic topical report for a method that would need to be reviewed on a case-by-case basis could lead to situations where licensees may not be able to effectively reference the report. Therefore, the staff denies approval of generic topical report CEN-405-P, Revision 3.

11.0 CONCLUSION

a) The BV-1 weld surveillance data meet the credibility criteria in 10 CFR 50.61. The weld data was determined to be acceptable for use in the SL-1 PTS evaluation by comparison of the irradiation environments and by statistical analysis.

b) Specifically, since the BV-1 weld surveillance data meet the credibility criteria of 10 CFR 50.61, the data were used to determine the CF for the limiting SL-1 vessel weld.

c) The licensee's and staff's calculated values of RT_{PTS} for SL-1 at expiration of license (213°F) is well below the 270°F screening criterion specified in 10 CFR 50.61 for axial welds.

d) The licensee's and staff's calculated values of RT_{PTS} for SL-2 at expiration of license (160°F) is well below the 300°F screening criterion specified in 10 CFR 50.61 for plates.

e) Since the conclusions in c) and d) are dependent upon the available chemistry and surveillance data, they are subject to change when new data become available. It should also be noted that the licensee for SL-1 must track and assess any changes in the BV-1 data that would effect the SL-1 PTS evaluation. The staff reserves the right to request a written assessment of the impact of changes (if any) to the SL-1 PTS evaluation that result from changes in the BV-1 data.

f) The staff denies approval of CEOG report CEN-405-P, Revision 3 "Application of Reactor Vessel Surveillance Data for Embrittlement Management" since 1) application of the margin reduction approach would require an exemption from the PTS rule, and 2) application of the integrated surveillance approach would need to be reviewed on a case-by-case basis.

References

1. Regulatory Guide 1.99, Radiation Embrittlement of Reactor Vessel Materials, Revision 2, May 1988

2. Code of Federal Regulations, Title 10, Part 50, Section 50.61, "Fracture Toughness Requirements for Protection Against Pressurized Thermal Shock Events"

3. ASME Boiler and Pressure Vessel Code, Section III, Appendix G for Nuclear Power Plant Components, Division 1, "Protection Against Nonductile Failure"

4. May 16, 1997, Letter from J. A. Stall to USNRC Document Control Desk, Subject: St. Lucie Units 1 and 2 Request for Additional Information - Response 10 CFR 50.61 - Pressurized Thermal Shock Evaluation.

5. January 14, 1997, Letter from J. A. Stall to USNRC Document Control Desk Subject: St. Lucie Units 1 and 2 Request for Additional Information (RAI) - Response 10 CFR 50.61 - Pressurized Thermal Shock Evaluation

6. September 23, 1996 Letter from J. A. Stall to USNRC Document Control Desk, Subject: St. Lucie Units 1 and 2 10 CFR 50.61 - Evaluation of Pressurized Thermal Shock of Reactor Vessel Beltline Materials - Supplement

7. November 15, 1993, Letter from D. A. Sager to USNRC Document Control Desk, Subject: Forwards Response to Request for Additional Information Re: Generic Letter, 92-01, Revision 1, Including New Mean Chemistry Values for Unit 1 Lower Longitudinal Welds."

8. August 6, 1993, Letter from R. F. Burski to USNRC Document Control Desk Subject: C-E Owners Group Submittal of CEN-405-P, Revision 2 "Application of Reactor Vessel Surveillance Data for Embrittlement Management." (Enclosure II was formal response to NRC staff request for additional information)

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10. Parsons R., 1978, *Statistical Analysis*, Second Edition, Harper & Row, Publishers, New York, NY.

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TABLE 1 (PAGE 1 OF 4)

Plate or Weld	Designer	Plant	Capsule ID	Heat ID	Orientation (From PR-EBD)	Cu%	Ni%	Fluence (E18 n/cm^2)	Flux (E10 n/cm^2sec)	Predicted Shift (°F)	P-A (°F)
P	CE	ANO-2	W-97	PAN201	LT	0.08	0.60	3.41	6.39	21	15
P	CE	ANO-2	W-97	PAN201	TL	0.08	0.60	3.41	6.24	50	-14
P	CE	CC1	W-263	PCC103	LT	0.12	0.64	6.00	6.47	60	12
P	CE	CC1	W-263	SHSS01	LT	0.18	0.66	5.90	6.36	88	29
P	CE	CC2	W-263	PCC202	LT	0.14	0.66	8.06	5.58	84	12
P	CE	CC2	W-263	SHSS01	LT	0.18	0.66	8.14	5.64	128	1
P	CE	FT. CAL	W-225	PFC101	LT	0.10	0.48	5.83	5.60	60	-5
P	CE	FT. CAL	W-225	SHSS01	LT	0.18	0.66	5.83	5.60	124	-8
P	CE	FT. CAL	W-265	PFC101	LT	0.10	0.48	8.30	4.78	74	-12
P	CE	FT. CAL	W-265	PFC101	TL	0.10	0.48	8.70	5.01	70	-8
P	CE	MILSTON 2	W-97	PML201	LT	0.14	0.61	3.75	3.96	70	3
P	CE	MILSTON 2	W-97	PML201	TL	0.14	0.61	3.67	3.87	96	-24
P	CE	MAINE Y	A-25	PMY01	LT	0.15	0.59	17.60	43.00	120	7
P	CE	MAINE Y	A-25	SHSS01	LT	0.18	0.66	17.60	43.00	150	8
P	CE	MAINE Y	A-35	PMY01	LT	0.15	0.59	77.30	61.40	185	-22
P	CE	MAINE Y	A-35	PMY01	TL	0.15	0.59	77.30	61.40	195	-32
P	CE	MAINE Y	W-263	PMY01	LT	0.15	0.59	5.67	4.70	97	-4
P	CE	MAINE Y	W-263	PMY01	TL	0.15	0.59	5.67	4.70	93	0
P	CE	PALISAD	A-240	PPAL01	LT	0.25	0.53	60.60	62.00	205	34
P	CE	PALISAD	A-240	PPAL01	TL	0.25	0.53	60.60	62.00	205	34
P	CE	PALISAD	W-290	PPAL01	LT	0.25	0.53	11.00	7.01	175	-5
P	CE	PALISAD	W-290	PPAL01	TL	0.25	0.53	11.30	7.20	155	17
P	CE	ST. LUC 1	W-97	PSL101	LT	0.15	0.57	5.40	3.67	68	22
P	CE	ST. LUC 1	W-97	PSL101	TL	0.15	0.57	5.40	3.67	70	20
P	CE	ST. LUC 2	W-83	PSL201	LT	0.11	0.61	1.62	4.60	35	3
P	CE	ST. LUC 2	W-83	PSL201	TL	0.11	0.61	1.63	4.63	21	18
P	CE	SONGS 2	W-97	PS0201	LT	0.10	0.60	5.07	4.80	55	-2
P	CE	SONGS 2	W-97	PS0201	TL	0.10	0.60	5.07	4.80	35	18
P	W	BV 1	U	PBV101	LT	0.20	0.54	6.54	5.79	120	6
P	W	BV 1	U	PBV101	TL	0.20	0.54	6.54	5.79	135	-9
P	W	BV 1	V	PBV101	LT	0.20	0.54	2.91	7.92	130	-35
P	W	BV 1	V	PBV101	TL	0.20	0.54	2.91	7.92	140	-45
P	W	BV 1	W	PBV101	LT	0.20	0.54	9.49	5.11	150	-9
P	W	BV 1	W	PBV101	TL	0.20	0.54	9.49	5.11	185	-44
P	W	COOK 1	T	PCK101	LT	0.14	0.49	2.71	6.79	60	2
P	W	COOK 1	T	PCK101	TL	0.14	0.49	2.71	6.79	70	-8
P	W	COOK 1	T	SHSS02	LT	0.14	0.68	2.71	6.79	60	6

(TABLE 1 CONTINUED)

P	W	COOK 1	Y	PCK101	LT	0.14	0.49	13.40	8.59	105	-1
P	W	COOK 1	Y	PCK101	TL	0.14	0.49	10.60	6.80	115	-17
P	W	COOK 1	Y	SHSS02	LT	0.14	0.68	12.00	7.69	110	-3
P	W	CALLA 1	U	PCL101	LT	0.07	0.59	3.27	12.10	0	30
P	W	CALLA 1	U	PCL101	TL	0.07	0.59	3.27	12.10	30	0
P	W	HAD NEC	A	SASTM	LT	0.20	0.18	3.16	6.04	85	-17
P	W	HAD NEC	D	SASTM	LT	0.20	0.18	22.20	6.68	140	-18
P	W	HAD NEC	F	SASTM	LT	0.20	0.18	6.06	7.92	80	6
P	W	HAD NEC	H	SASTM	LT	0.20	0.18	20.00	8.37	127	-8
P	W	DIAB 1	S	PDC103	LT	0.077	0.46	2.98	7.51	0	33
P	W	DIAB 1	S	SSHS02	LT	0.14	0.68	2.98	7.51	66	2
P	W	DIAB 2	U	PDC201	LT	0.15	0.67	3.51	11.20	65	15
P	W	DIAB 2	U	PDC201	TL	0.15	0.67	3.51	11.20	73	7
P	W	FARLEY 1	U	PFA101	LT	0.14	0.55	16.50	17.30	115	-3
P	W	FARLEY 1	U	PFA101	TL	0.14	0.55	16.60	17.30	90	22
P	W	FARLEY 1	X	PFA101	LT	0.14	0.55	28.30	14.70	135	-10
P	W	FARLEY 1	X	PFA101	TL	0.14	0.55	28.30	14.70	105	20
P	W	FARLEY 1	Y	PFA101	LT	0.14	0.55	5.83	16.30	85	-2
P	W	FARLEY 1	Y	PFA101	TL	0.14	0.55	5.83	16.30	55	28
P	W	FARLEY 2	U	PFA201	LT	0.20	0.60	5.61	16.20	103	22
P	W	FARLEY 2	U	PFA201	TL	0.20	0.60	5.61	16.20	133	-8
P	W	FARLEY 2	W	PFA201	LT	0.20	0.60	15.40	12.50	165	2
P	W	FARLEY 2	W	PFA201	TL	0.20	0.60	15.40	12.50	165	2
P	W	ROBIN 2	S	PHB201	LT	0.12	0.20	3.91	9.29	30	20
P	W	ROBIN 2	S	PHB202	LT	0.10	0.20	3.91	9.29	20	23
P	W	ROBIN 2	S	PHB203	LT	0.09	0.20	3.91	9.29	15	24
P	W	ROBIN 2	S	SASTM	LT	0.20	0.18	3.91	9.29	70	4
P	W	ROBIN 2	T	PHB203	LT	0.09	0.20	41.10	18.10	75	-3
P	W	ROBIN 2	T	SASTM	LT	0.20	0.18	41.10	18.10	150	-14
P	W	ROBIN 2	V	PHB202	LT	0.10	0.20	7.24	6.90	45	8
P	W	ROBIN 2	V	SASTM	LT	0.20	0.18	7.24	6.90	70	21
P	W	IP 2	Y	PIP203	LT	0.14	0.57	4.72	6.40	145	-67
P	W	IP 2	Y	SASTM	LT	0.20	0.18	4.72	6.40	70	9
P	W	IP 3	T	PIP301	LT	0.18	0.50	3.23	7.67	89	-2
P	W	IP 3	T	PIP304	LT	0.24	0.52	3.23	7.67	137	-26
P	W	IP 3	T	PIP304	TL	0.24	0.52	3.23	7.67	118	-7
P	W	IP 3	Y	PIP304	TL	0.24	0.52	8.05	8.15	150	1
P	W	IP 3	Y	SHSS02	LT	0.14	0.68	8.05	8.15	140	-44
P	W	IP 3	Z	PIP303	LT	0.19	0.49	10.70	6.11	150	-17
P	W	IP 3	Z	PIP304	LT	0.24	0.52	10.70	6.11	170	-6
P	W	IP 3	Z	PIP304	TL	0.24	0.52	10.70	6.11	155	9
P	W	KEWAUN	R	SHSS02	LT	0.14	0.68	20.70	14.50	140	-18

(TABLE 1 CONTINUED)

P	W	KEWAUN	V	SHSS02	LT	0.14	0.68	6.41	15.80	95	-6
P	W	MCG 1	U	PMC101	LT	0.09	0.60	4.14	14.20	45	-3
P	W	MCG 1	U	PMC101	TL	0.09	0.60	4.14	14.20	50	-8
P	W	MCG 1	X	PMC101	LT	0.09	0.60	13.80	10.10	45	16
P	W	MCG 1	X	PMC101	TL	0.09	0.60	13.80	10.10	65	-4
P	W	SALEM 1	T	PSA101	LT	0.22	0.53	2.84	8.29	100	0
P	W	SALEM 1	T	PSA102	LT	0.23	0.54	2.84	8.29	100	4
P	W	SALEM 1	T	PSA103	LT	0.22	0.52	2.84	8.29	75	24
P	W	SALEM 1	T	SHSS02	LT	0.14	0.68	2.84	8.29	60	7
P	W	SALEM 1	Y	PSA103	LT	0.22	0.52	8.91	8.33	110	36
P	W	SALEM 1	Y	SHSS02	LT	0.14	0.68	8.91	8.33	125	-26
P	W	SALEM 2	T	PSA201	LT	0.10	0.61	2.56	6.99	50	-9
P	W	SALEM 2	T	PSA201	TL	0.10	0.61	2.56	6.99	70	-2[illegible]
P	W	SONGS 1	A	PSO103	LT	0.18	0.20	28.60	49.10	100	18
P	W	SONGS 1	A	SASTM	LT	0.20	0.18	28.60	49.10	120	8
P	W	SONGS 1	D	PSO101	LT	0.17	0.20	56.20	63.30	140	-15
P	W	SONGS 1	D	PSO102	LT	0.18	0.20	56.20	63.30	110	21
P	W	SONGS 1	D	PSO103	LT	0.18	0.20	56.20	63.30	130	1
P	W	SONGS 1	D	SASTM	LT	0.20	0.18	56.20	63.30	150	-8
P	W	SONGS 1	F	PSO102	LT	0.18	0.20	57.30	23.50	120	11
P	W	SONGS 1	F	SASTM	LT	0.20	0.18	57.30	23.50	130	13
P	W	WOLF 1	U	PWC101	LT	0.07	0.62	3.39	12.00	30	1
P	W	WOLF 1	U	PWC101	TL	0.07	0.62	3.39	12.00	25	6
W	CE	ANO-2	W-97	WAN20		0.04	0.08	3.34	6.26	10	12
W	CE	CC 1	W-263	WCC101		0.24	0.18	6.10	6.58	59	44
W	CE	CC 2	W-263	WCC201		0.20	0.04	7.97	5.52	69	15
W	CE	FT. CAL	W-225	WFC101		0.35	0.60	5.83	5.60	205	-25
W	CE	FT. CAL	W-265	WFC101		0.35	0.60	8.00	4.61	221	-22
W	CE	MILLSTON 2	W-97	WML201		0.30	0.06	3.77	3.98	76	23
W	CE	MAINE Y	A-25	WMY01		0.36	0.78	17.60	43.00	270	1[illegible]
W	CE	MAINE Y	A-35	WMY01		0.36	0.78	77.30	61.40	345	13
W	CE	MAINE Y	W-263	WMY01		0.36	0.78	5.67	4.70	222	-18
W	CE	PALISAD	A-240	WPAL101		0.22	1.27	60.60	62.00	350	33
W	CE	PALISAD	W-290	WPAL101		0.22	1.27	10.30	6.56	290	-22
W	CE	ST. LUC 1	W-97	WSL101		0.23	0.11	5.30	3.60	74	16
W	CE	ST. LUC 2	W-83	WSL201		0.05	0.07	1.62	4.60	0	17
W	CE	SONGS 2	W-97	WSO201		0.03	0.12	5.07	4.80	15	10
W	W	BV 1	U	WBV101		0.26	0.62	6.54	5.79	155	6
W	W	BV 1	V	WBV101		0.26	0.62	2.91	7.92	150	-29
W	W	BV 1	W	WBV101		0.26	0.62	9.49	5.11	185	-5
W	W	COOK 1	T	WCK101		0.27	0.74	2.71	6.79	80	53
W	W	COOK 1	Y	WCK101		0.27	0.74	10.60	6.80	200	9

(TABLE 1 CONTINUED)

W	W	CALLA 1	U	WCL101	0.06	0.07	3.27	12.10	70	-46
W	W	HAD NEC	A	WCTY01	0.22	0.05	3.16	6.04	95	-27
W	W	HAD NEC	D	WCTY01	0.22	0.05	22.20	6.68	110	10
W	W	DIAB 1	S	WDC101	0.21	0.98	2.98	7.51	110	41
W	W	DIAB 2	U	WDC201	0.22	0.83	3.51	11.20	174	-28
W	W	FARLEY 1	U	WFA101	0.14	0.19	16.50	17.30	80	9
W	W	FARLEY 1	X	WFA101	0.14	0.19	28.30	14.70	100	0
W	W	FARLEY 1	Y	WFA101	0.14	0.19	5.83	16.30	80	-14
W	W	FARLEY 2	U	WFA201	0.03	0.90	5.61	16.20	10	24
W	W	FARLEY 2	W	WFA201	0.03	0.90	15.40	12.50	10	36
W	W	ROBIN 2	T	WHB201	0.34	0.66	41.10	18.10	285	11
W	W	ROBIN 2	V	WHB201	0.34	0.66	7.24	6.90	175	22
W	W	IP 2	Y	WIP201	0.23	1.06	5.89	7.99	195	1[illegible]
W	W	IP 3	T	WIP301	0.15	1.02	3.23	7.67	143	-11
W	W	IP 3	Y	WIP301	0.15	1.02	8.05	8.15	180	0
W	W	IP 3	Z	WIP301	0.15	1.02	10.70	6.11	220	-24
W	W	KEWAUN	R	WKWE01	0.20	0.77	20.70	14.50	235	-9
W	W	KEWAUN	V	WKWE01	0.20	0.77	6.41	15.80	175	-10
W	W	MCG 1	U	WMC101	0.21	0.88	4.14	14.20	160	-1
W	W	MCG1	X	WMC101	0.21	0.88	13.80	10.10	165	64
W	W	SALEM 1	Y	WSA101	0.16	1.26	8.91	8.33	165	43
W	W	SALEM 2	T	WSA201	0.23	0.71	2.56	6.99	155	-37
W	W	SONGS 1	A	WSO101	0.19	0.20	28.60	49.10	80	48
W	W	SONGS 1	F	WSO101	0.19	0.20	57.30	23.50	145	-6
W	W	WOLF 1	U	WWC101	0.04	0.09	3.39	12.00	20	3

(TABLE 1 CONTINUED)

SCHEMATIC OF THE METHOD USED TO SEPARATE SURVEILLANCE DATA FROM CE FABRICATED, CE AND W DESIGNED PLANTS FOR STATISTICAL ANALYSIS

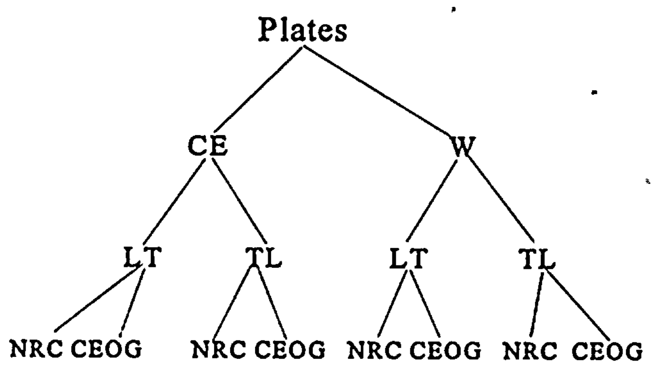

FIGURE 1

TABLE 2 - SUMMARY OF RESULTS FROM MANN-WHITNEY STATISTICAL TEST

POPULATION TESTED	DECISION CRITERIA FOR Z STATISTIC *	RESULTING Z STATISTIC
CEOG DATA FOR CE AND W DESIGNED PLATES	$-1.96 \leq Z \leq 1.96$	1.05
CEOG DATA FOR CE AND W DESIGNED PLATES-ORIENTATION ANALYSIS (LT AND TL)	$-1.96 \leq Z \leq 1.96$	0.83
NRC DATA FOR CE AND W DESIGNED PLATES	$-1.96 \leq Z \leq 1.96$	1.60
NRC DATA FOR CE AND W DESIGNED PLATES-ORIENTATION ANALYSIS (LT AND TL)	$-1.96 \leq Z \leq 1.96$	0.83
CEOG DATA FOR CE AND W DESIGNED WELDS	$-1.96 \leq Z \leq 1.96$	0.88
NRC DATA FOR CE AND W DESIGNED WELDS	$-1.96 \leq Z \leq 1.96$	1.06

* A two tailed test, employing a critical probability (α) of 0.05 results in an acceptable Z range of $-1.96 \leq Z \leq 1.96$. Therefore, the null hypothesis was accepted for each case since the Z statistic was in the acceptable range.

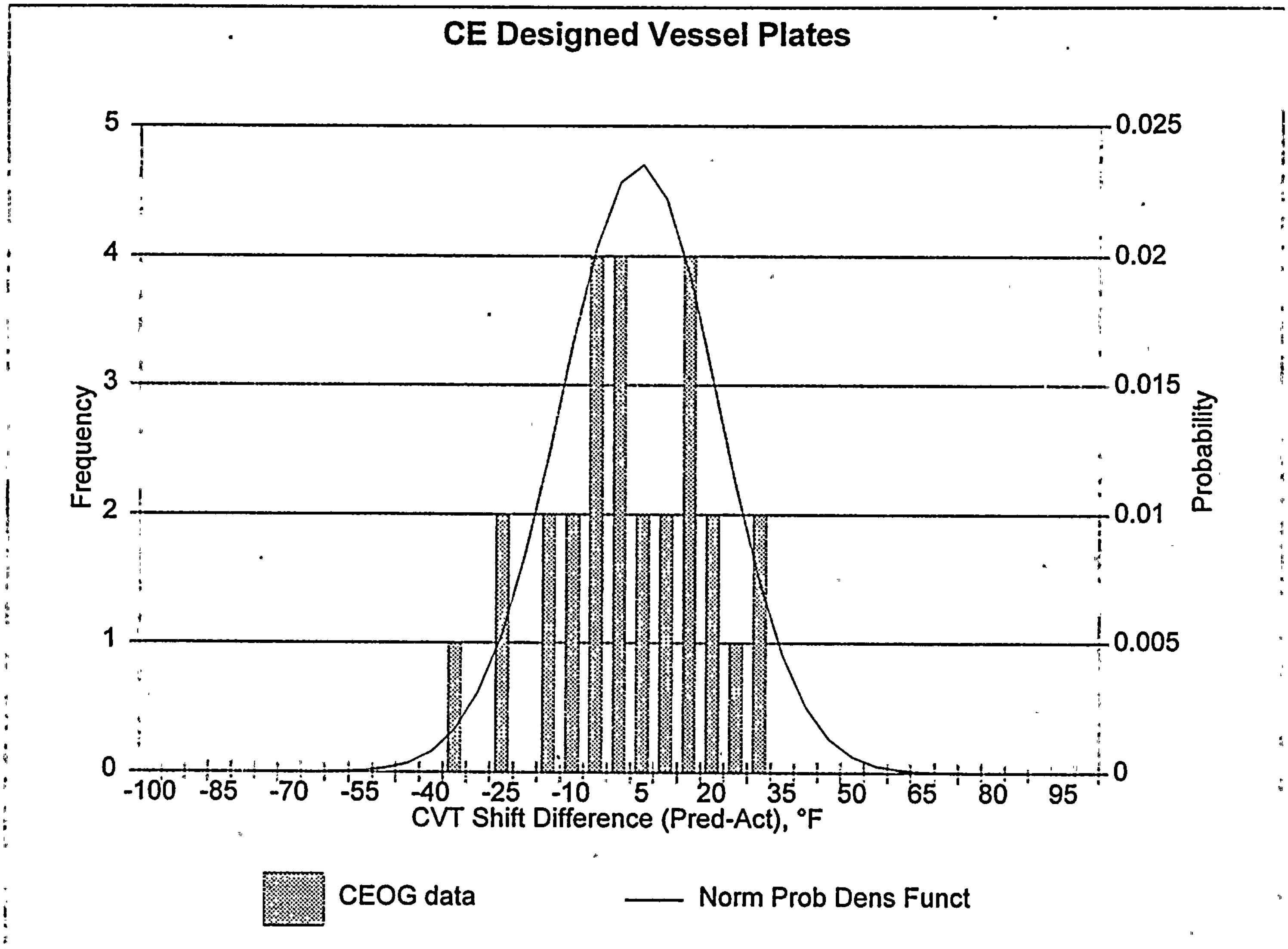

FIGURE 2 - HISTOGRAM OF COMBUSTION ENGINEERING DESIGNED PLATE DATA

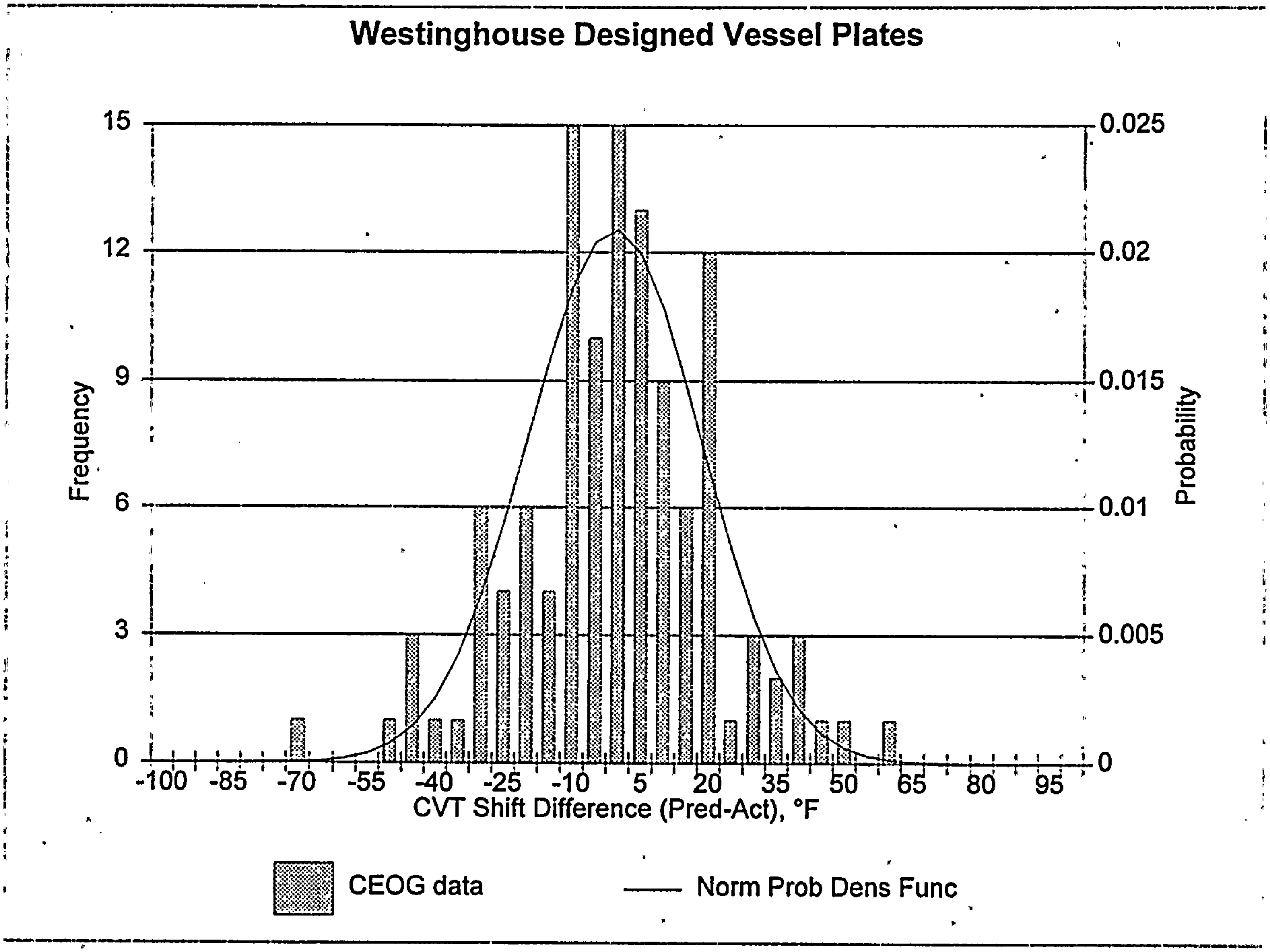

FIGURE 3 - HISTOGRAM OF WESTINGHOUSE DESIGNED PLATE DATA

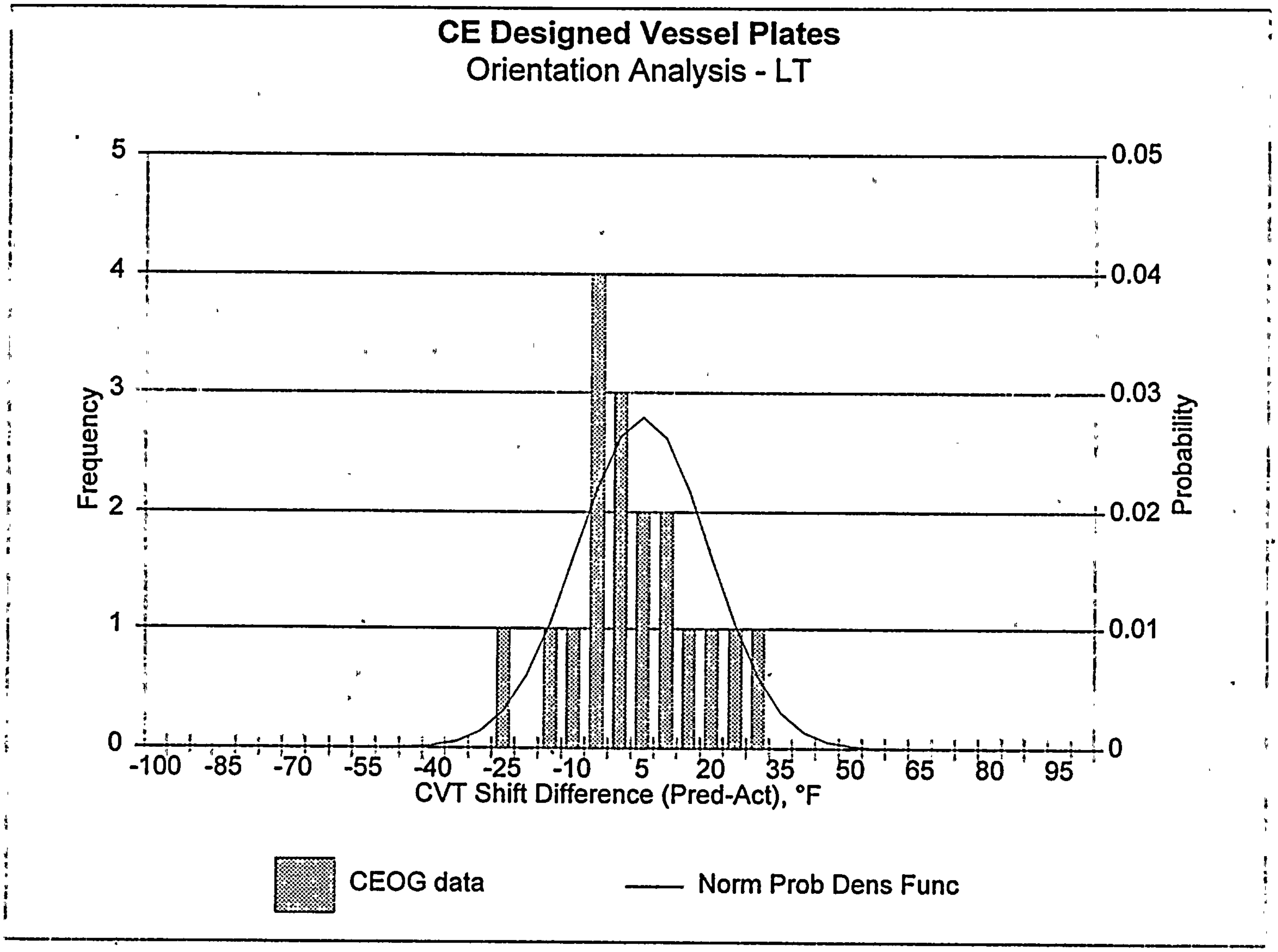

FIGURE 4 - HISTOGRAM OF CE DESIGNED PLATE DATA (LT ORIENTATION)

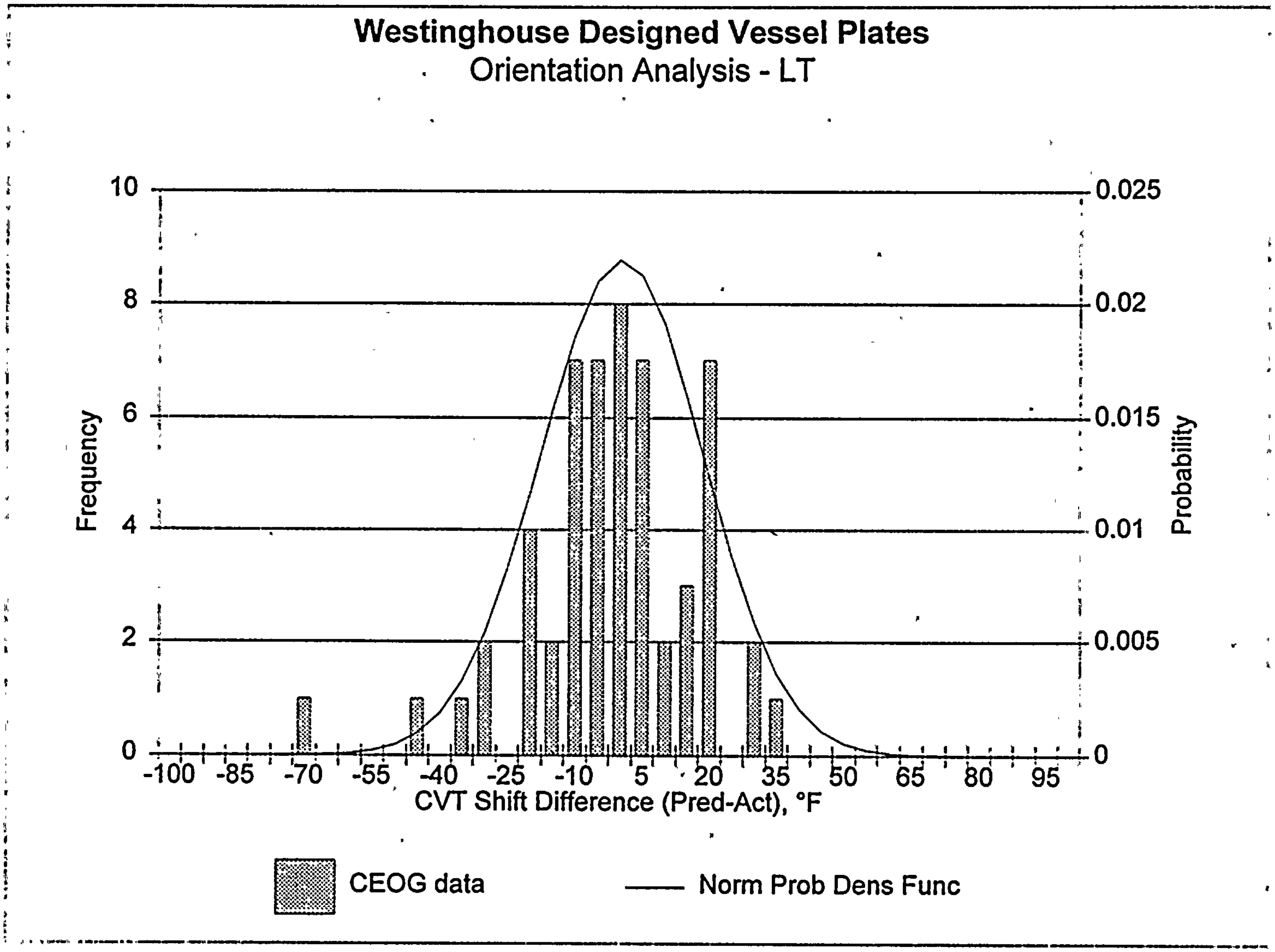

FIGURE 5 - HISTOGRAM OF WESTINGHOUSE DESIGNED PLATE DATA (LT ORIEN.)

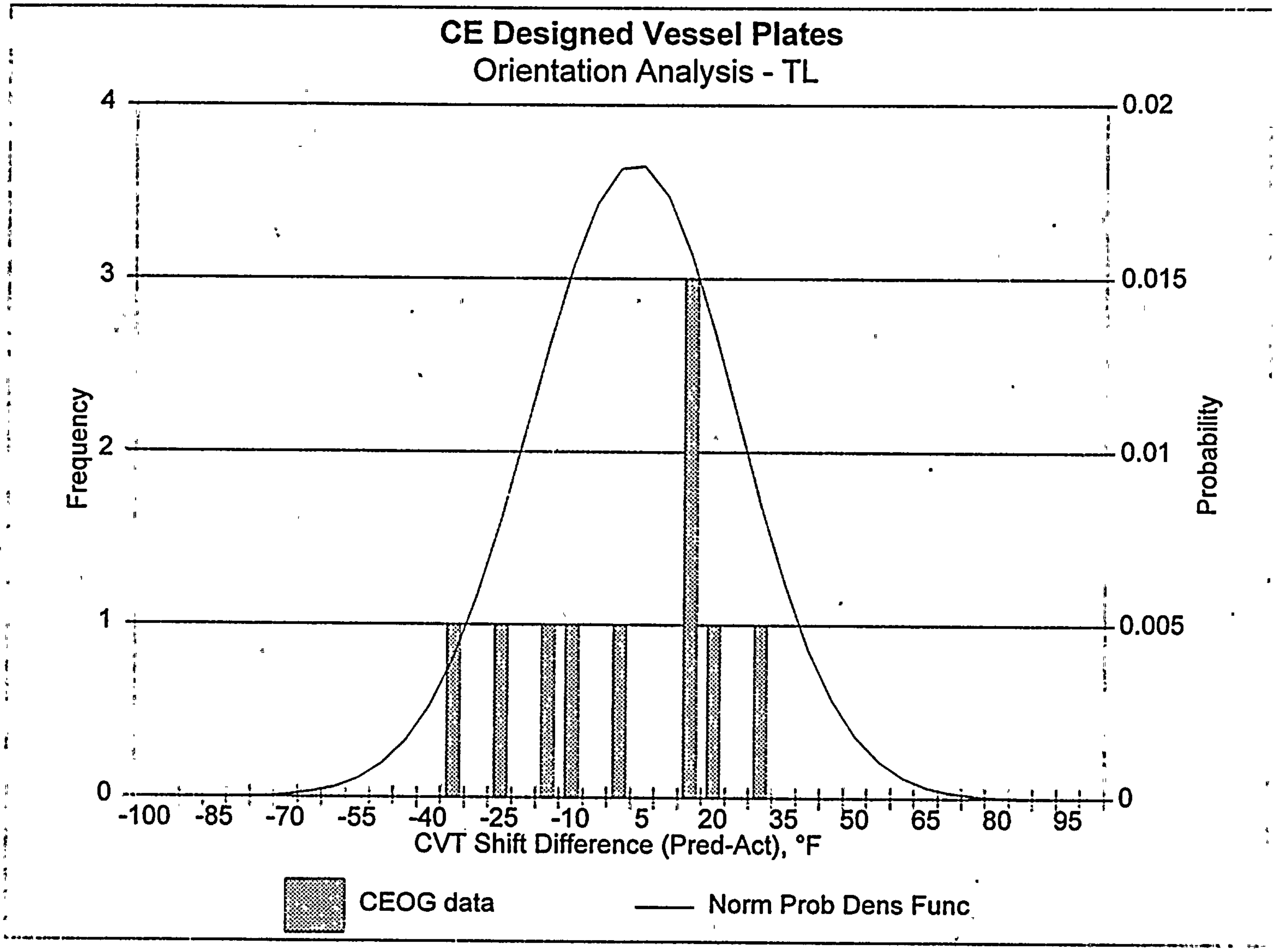

FIGURE 6 - HISTOGRAM OF CE DESIGNED PLATE DATA (TL ORIENTATION)

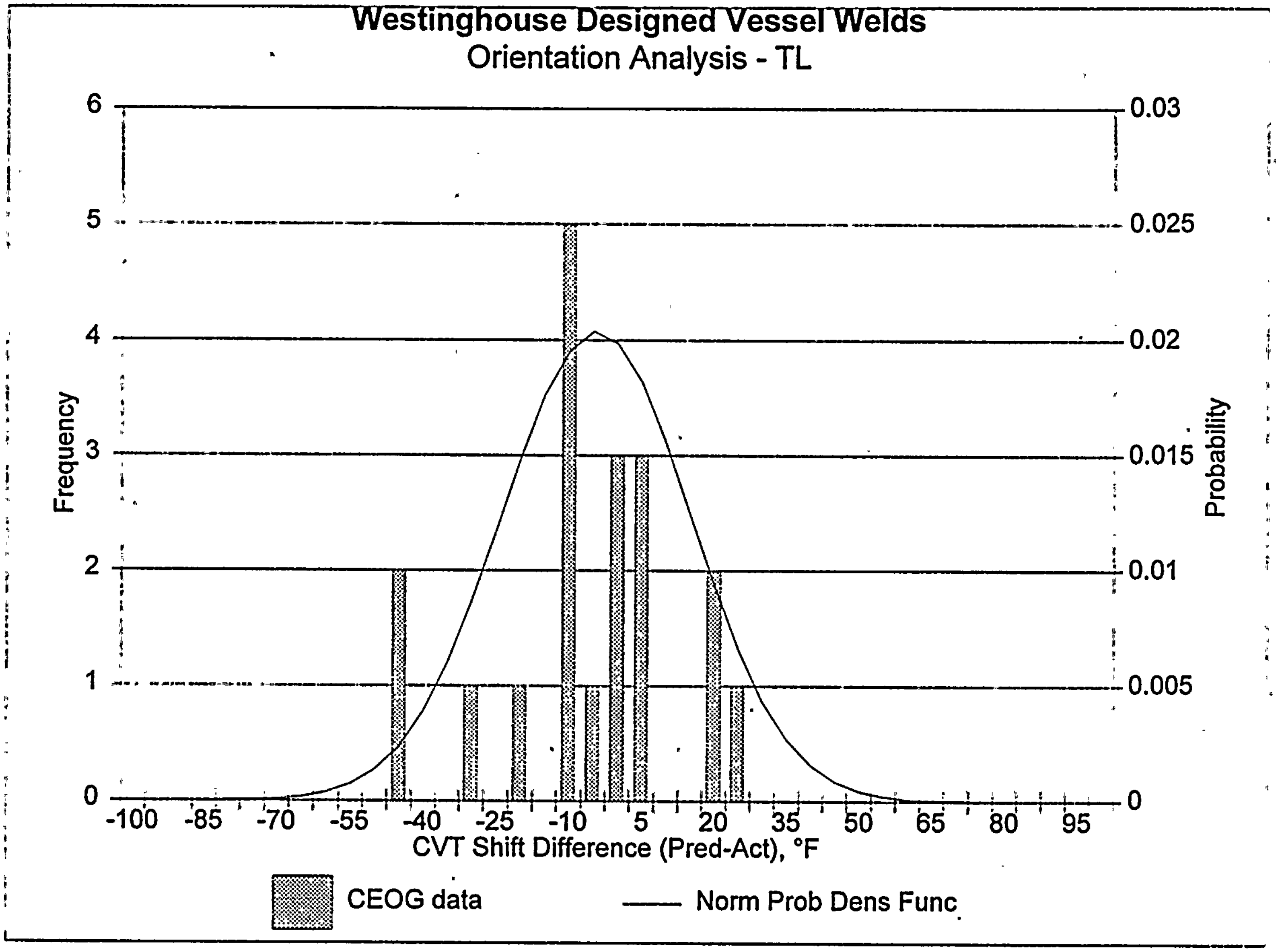

FIGURE 7 - HISTOGRAM OF WESTINGHOUSE DESIGNED PLATE DATA (TL ORIEN.)

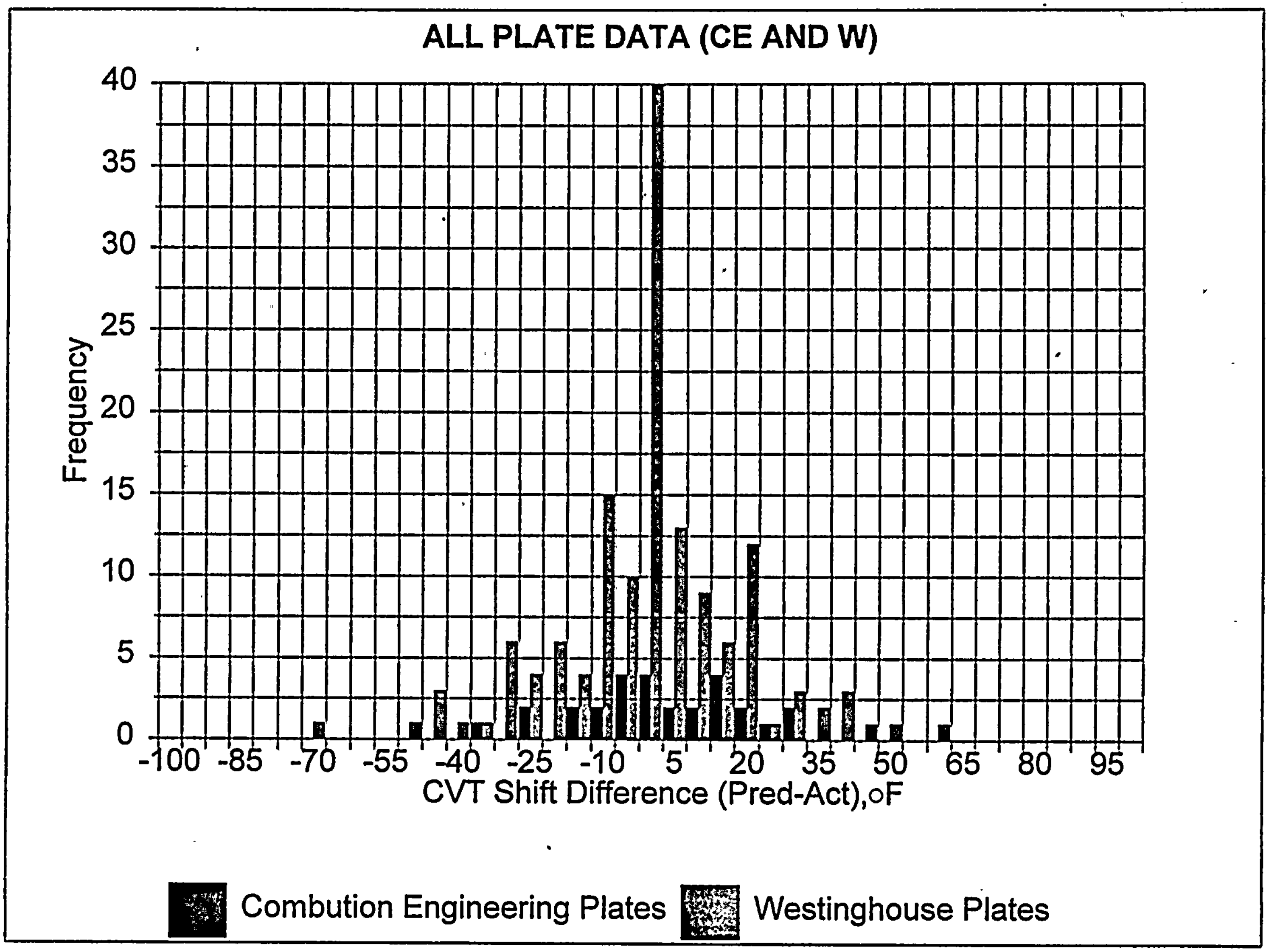

FIGURE 8 - HISTOGRAM OF ALL PLATE DATA (CE AND W DESIGNED)

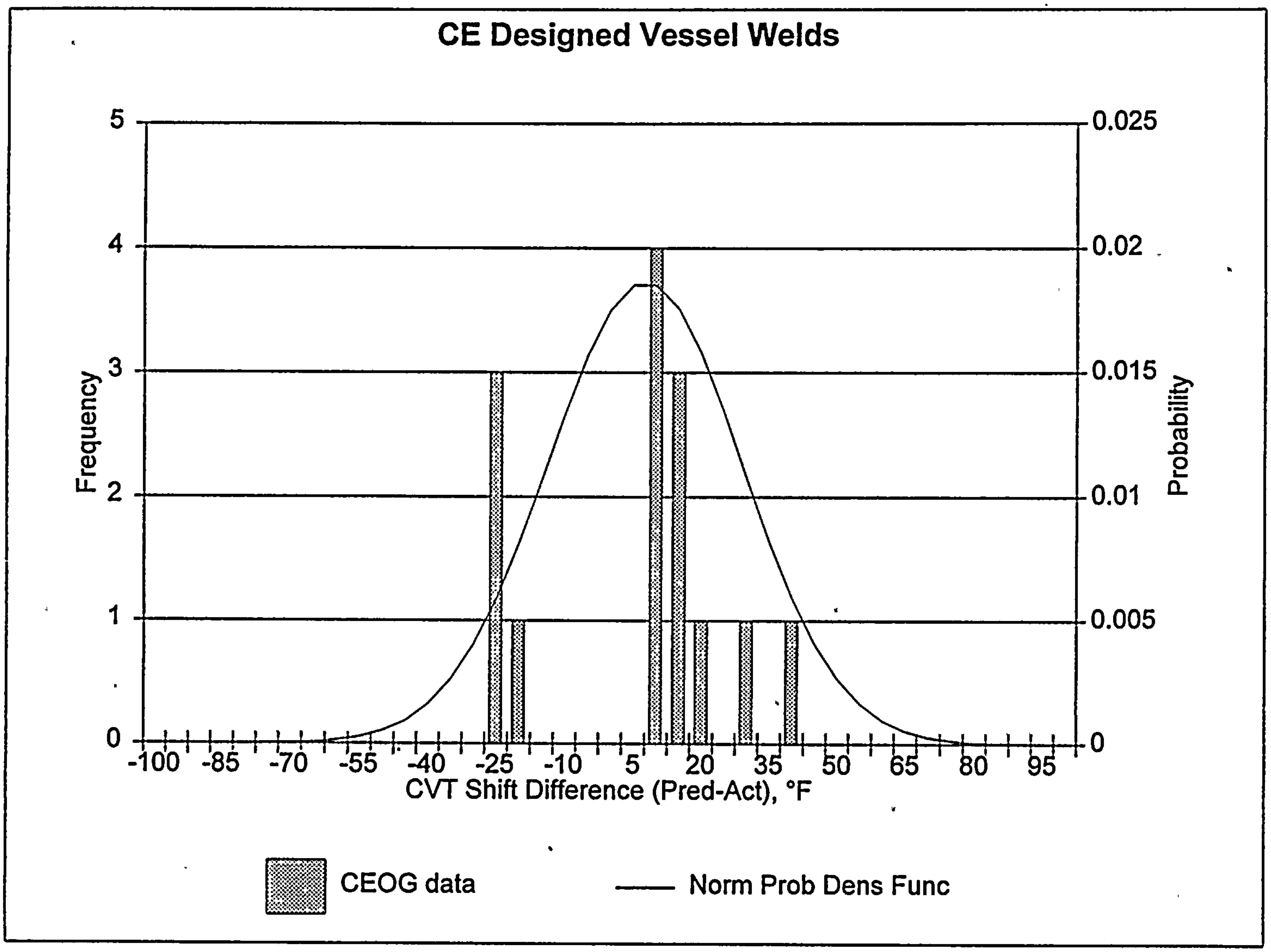

FIGURE 9 - HISTOGRAM OF COMBUSTION ENGINEERING DESIGNED WELD DATA

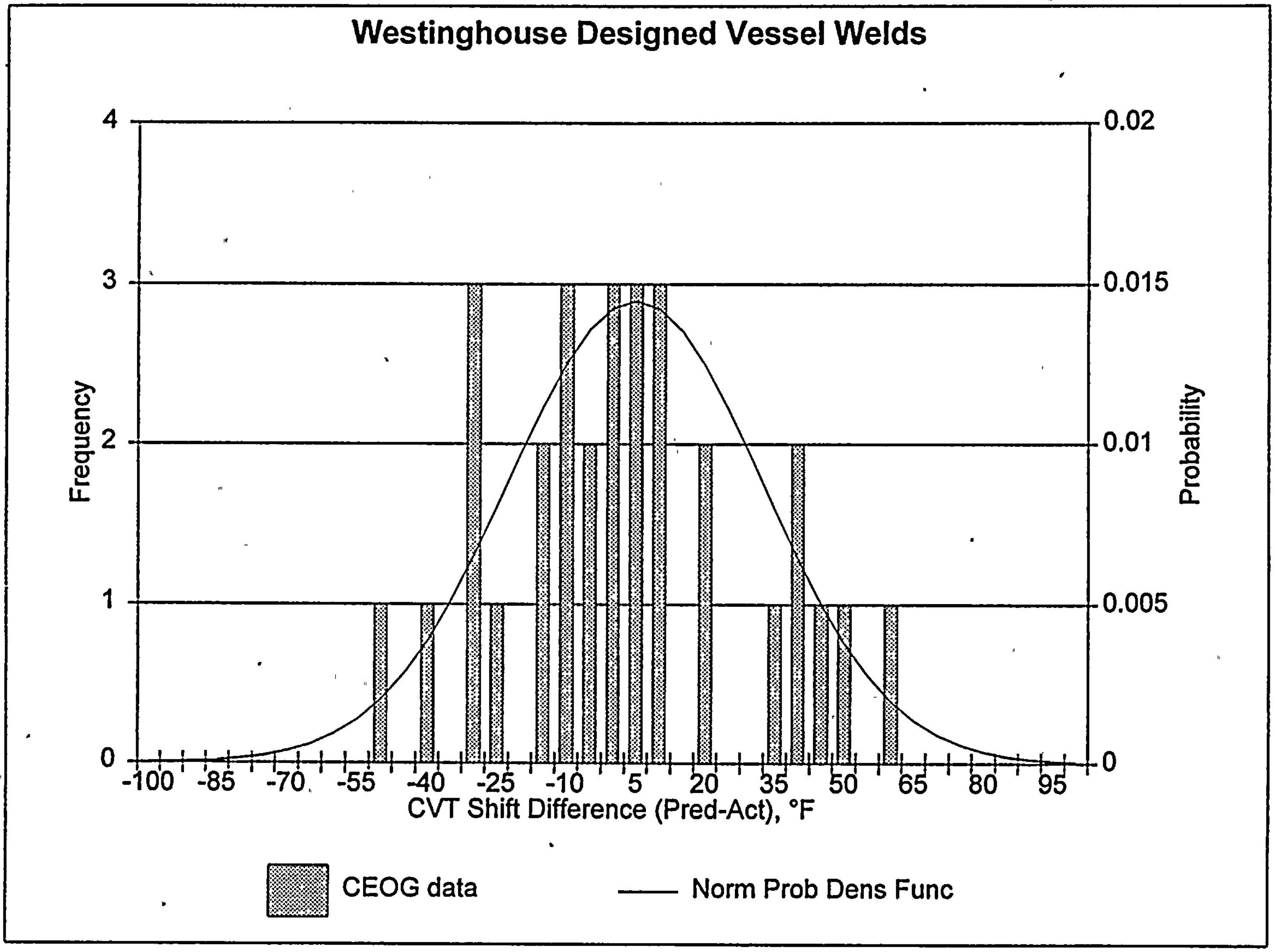

FIGURE 10 - HISTOGRAM OF WESTINGHOUSE DESIGNED WELD DATA

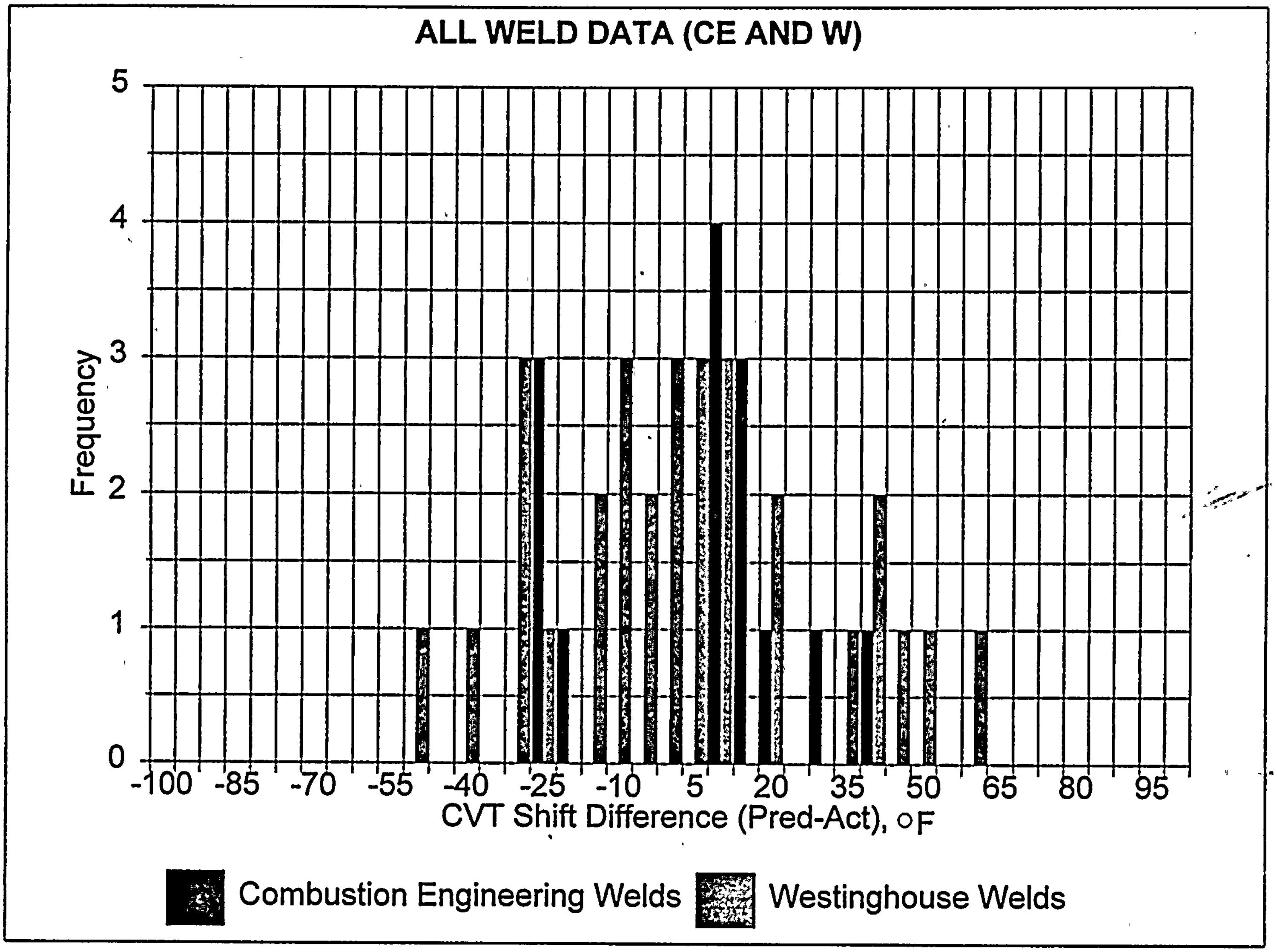

FIGURE 11 - HISTOGRAM OF ALL WELD DATA (CE AND W DESIGNED)