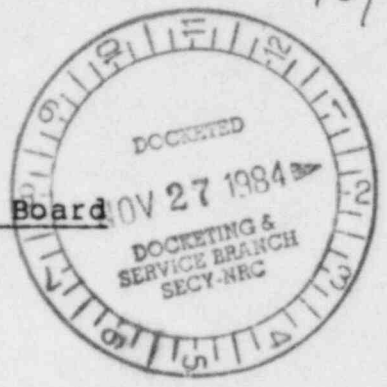
50-322 OL

I-SC-40 through I-SC-50

SUFFOLK COUNTY, 7/31/84

10/1/84



UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of LONG ISLAND LIGHTING COMPANY (Shoreham Nuclear Power Plant, Unit 1).	Docket No. 50-322-OL

SUFFOLK COUNTY'S EXHIBITS TO JOINT DIRECT TESTIMONY

~~CURRICULA VITAE~~

CRANKSHAFT EXHIBITS
40-50
VOLUME 2

NUCLEAR REGULATORY COMMISSION

Docket No. 50-322 Official Exh. No. 40-50

In the matter of LILCO

Staff	IDENTIFIED ✓
Applicant /	RECEIVED ✓
Intervenor	REJECTED
Cont'g Off'r	
Contractor	DATE 10-1-84
Other COUNTY'S	Witness
Reporter LPB	

UNITED STATES OF AMERICA
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Before the Atomic Safety and Licensing Board

In the Matter of	)	
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INDEX TO THE ATTACHMENTS AND EXHIBITS TO THE JOINT DIRECT TESTIMONY OF DR. ROBERT N. ANDERSON, PROFESSOR STANLEY G. CHRISTENSEN, G. DENNIS ELEY, DALE G. BRIDENBAUGH AND RICHARD B. HUBBARD REGARDING SUFFOLK COUNTY'S EMERGENCY DIESEL GENERATOR CONTENTIONS

VOLUME 2
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40. Christensen's Preliminary Crankshaft Calculations on ABS Rules

41. Deposition of Franz F. Pischinger, pgs. 1, 94, 97-98, 100-101, 108, 110, 185-187

43. Deposition of Woytowich, Blanding, and Giuffra (ABS) pgs. 1, 80-81, 93, 98-99, 112, 163-165, 167-168, and Exhibit 3 to the Deposition

44. Letter to TDI from ABS Concerning Stresses on the Crankshaft at Shoreham and their Approval of those Crankshafts

45. Yang's Report on Crankshaft Torsional Stresses Submitted to ABS for Approval

46. Letter from Alan Dynner to Blanding (ABS) Concerning Measurements at Shoreham which Dynner Believes to be inaccurate

47. ABS Calculations - Exhibit 3, 7/18/84 Deposition

48. Letter from Kobe Steel, Inc. to Greg Beshouri Concerning Crankshafts with Fillet Cold Rolling

49. Field Test of Emergency Diesel Generator 103 with 13 x 12 Crankshaft for SNPS, April 1984

50. Field Test of Emergency Diesel Generator 101 for SNPS, October 1984

THE ABS RULES FOR CRANKSHAFTS WITH SOLID WEBS STATES :

"THE PROPORTIONS OF CRANK WEBS ARE TO BE SUCH THAT THE EFFECTIVE RESISTING MOMENT OF THE WEB IN BENDING IS NOT TO BE LESS THAN 60% OF THE RESISTING MOMENT OF THE PINS AND JOURNALS IN BENDING."

THE RE-ENTRANT FILLET ACTS AS A SERIOUS STRESS RAISER WHEN CONSIDERING THE OBLIQUE SECTION OF THE WEB UNDER THE ACTION OF BENDING. THIS HAS BEEN SHOWN TO BE TRUE IN THE SECTION OF THE WEB OF THE FRACTURED CRANKSHAFT. THE NUCLEATION SITE OCCURRED AT THE BOTTOM OF THE RE-ENTRANT FILLET.

THE USE OF :

$$W t^2 \geq 0.35 d^3$$

IS PRECLUDED AS THE EFFECTIVE RESISTING MOMENT CANNOT BE OBTAINED FROM THE RECTANGLE CREATED BY W AND t

CALCULATIONS USING THE EFFECTIVE RESISTING MOMENT MUST THEREFORE BE USED. THESE ARE SHOWN AS FOLLOW.

THE USE OF THE 60% FACTOR OR 0·35 FACTOR MAY BE ARGUED. THE FACTORS GIVEN ARE RELATED TO CRANKWEBS FORMERLY HAVING W VALUES LESS AND C VALUES MORE THAN THOSE USED IN PRACTICE TODAY. *

ACCEPTING THE 60% FACTOR THE FOLLOWING HOLDS:

THE MOMENT OF RESISTANCE TO BENDING FOR ANY BEAM SECTION IS

$$\text{MOMENT OF RESISTANCE} = \sigma \cdot \int_{-y}^{+y} x y^2 dx \Big/ y$$

WHERE σ = STRESS

AND y = DISTANCE OF x FROM SOME NEUTRAL AXIS

THE VALUE OF I_{NA} (ROUND SECTION) $= \frac{\pi D^4}{64}$

$y = \frac{D}{2}$

$\therefore$ MOMENT OF RESISTANCE $= \sigma \left(\frac{\pi D^4}{64}\right) \Big/ \frac{D}{2}$

$$= \frac{\sigma \pi D^3}{32}$$

WHERE D = DIAMETER OF PIN OR JOURNAL WHICHEVER IS LEAST

$\therefore$ $D = d$ = 12 IN DIAMETER CRANK PIN.

AND

$$\frac{\text{EFFECTIVE } I_{NA} \text{ FOR WEB}}{y} \times \sigma \geqslant \frac{\sigma \pi d^3}{32} \times 0{\cdot}60$$

* REFER TO REMARKS IN DR. PISCHINGER DEPOSITION

THE EFFECTIVE MOMENT OF INERTIA OF THE SECTION ON THE OBLIQUE PLANE CAN ONLY BE OBTAINED BY SUMMATION METHOD.

THE OBLIQUE PLANE REQUIRES GEOMETRICAL DEVELOPMENT TO OBTAIN THE BOUNDARY OF THE RE-ENTRANT FILLET AND THAT PART OF THE JOURNAL FILLET CUT BY THE OBLIQUE PLANE. THE OIL PASSAGE WILL ALSO HAVE AN EFFECT WHICH MUST BE CONSIDERED AS IT WILL BE NEGATIVE IN VALUE. THE TRUE NEGATIVE VALUE WILL BE DEPENDENT ON THE DISTANCE OF ITS CENTER FROM THE NEUTRAL AXIS.

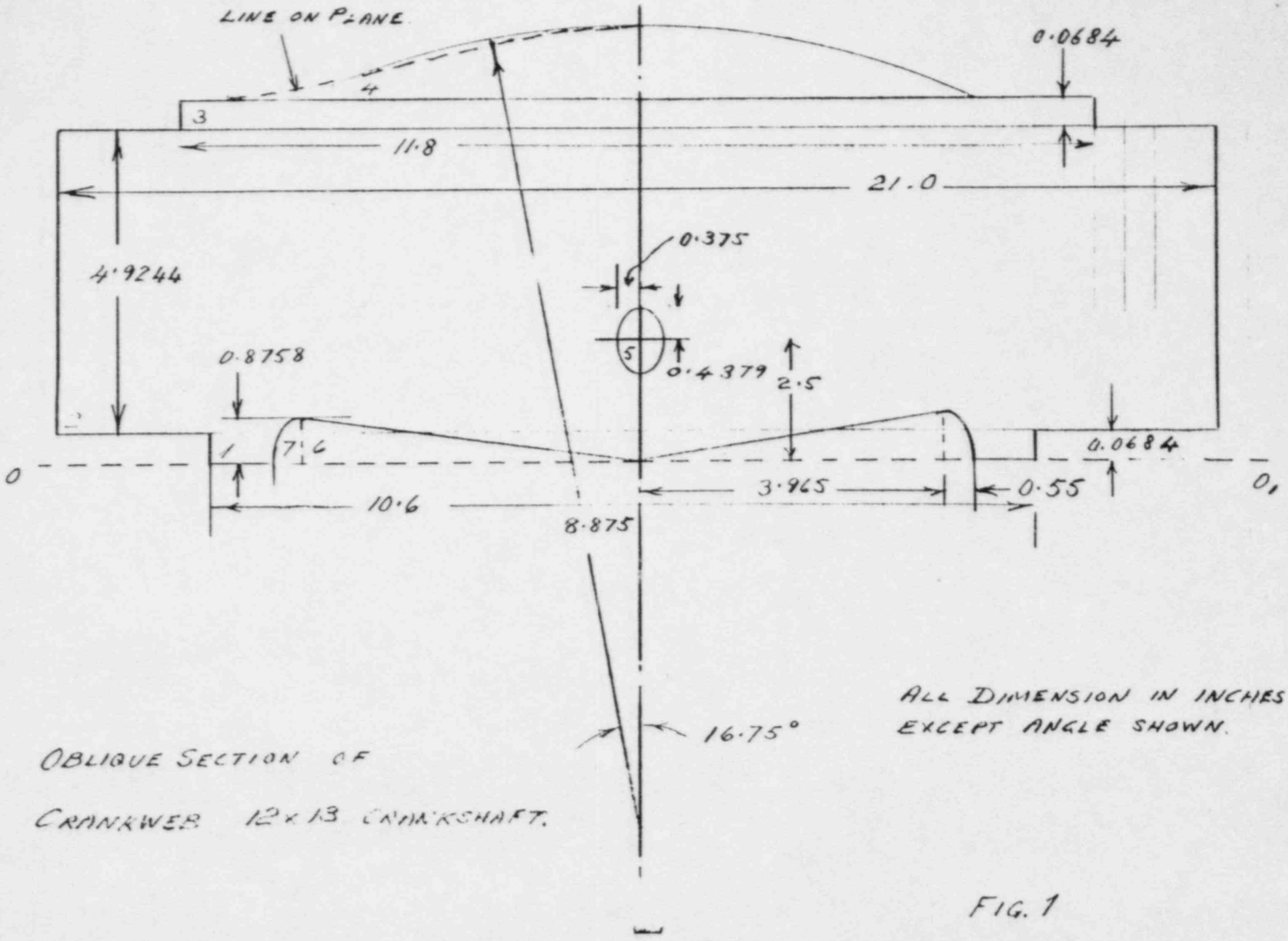
THE OBLIQUE PLAN SECTION IS AT SOME ANGLE θ TO THE AXIS OF THE CRANK PIN

$$\text{TAN } \theta = \frac{2}{4.5} = 0.4444 \qquad \text{TAN}^{-1} = 23.9625^\circ$$

SEE FIG. 1 FOR SKETCH OF SECTION THROUGH WEB ON OBLIQUE PLANE AT 23.9625 SAY 24° TO PIN AXIS.

CRANKSHAFT CALCULATIONS. ABS RULES

FIG 1 OVER



OBLIQUE SECTION OF

CRANKWEB 12 × 13 CRANKSHAFT.

FIG. 1

SUMMATION OF AREAS, 1ST AND 2ND MOMENTS.

No	SHAPE	AREA.	DIST.	1ST MOM.	2ND MON.I	$\bar{x}$	Ax^2
1	RECT. +	0.7250	0.0342	0.0248	0.0003	2.6253	4.9300
2	RECT. +	103.4124	2.5306	261.6954	208.9768	0.1289	1.7192
3	RECT. +	0.8071	5.0270	4.0573	0.0003	2.3675	4.5237
4	SEG. +	1.2895	5.2121	6.7210	0.0125	2.5526	8.4018
5	ELL. −	-0.5159	2.5000	-1.2897	-0.0247	0.1595	-0.0131
6	ELL. −	-0.7566	0.3717	-0.2812	-0.0406	2.2878	-3.9602
7	TRI. −	-3.4725	0.2919	-1.0138	-0.1480	2.3676	-19.4658
SUM.		101.4890		269.9138	208.7766		-3.8644

$$NA = \frac{269.9138}{101.4890} = 2.6595 \text{ ABOVE } 0\text{-}0,$$

$$\text{EFFECTIVE } I_{NA} = \Sigma I + \Sigma Ax^2$$
$$= 208.7766 - 3.8644$$
$$= 204.9122.$$

$$\sigma \frac{204.9122}{2.6595} = 77.0491 \times \sigma$$

THEN

$$77.0491\,\sigma = \frac{\sigma\,\pi d^3}{32} \times 0.6 \qquad \sigma \text{ CANCELS.}$$

$$d^3 = \frac{77.0491 \times 32}{\pi \times 0.6}$$

$$d = \sqrt[3]{1308.0261} = 10.9337$$

FROM THIS IT CAN BE SEEN THAT THE WEB STRENGTH IN BENDING IS EQUIVALENT TO A

PIN OR JOURNAL DIAMETER OF 10.9337 INCHES.

FROM THIS IT IS SEEN THAT THE MOMENT OF RESISTANCE ON THE OBLIQUE SECTION IS A VERY CRITICAL FIGURE IN THE STRENGTH OF THE CRANKSHAFT.

TAKE BHP AS 4890.
AND 1.1 x 4890 = 5379.
THEN:

FROM ABS CRANKSHAFT RULES THE MAXIMUM ALLOWABLE CYLINDER PRESSURE AT 4890 HP IS 1746 psi.

SIMILARLY AT START UP WHEN HP IS 5379 THE MAXIMUM ALLOWABLE CYLINDER PRESSURE IS 1651 psi.

THE STRENGTH OF THE WEB IS VERY CRITICAL WHEN RELATED TO MAXIMUM CYLINDER PRESSURE

THE CRANKSHAFTS DO NOT MEET ABS RULES FOR 4890 HP.