

FEB 17 1981

Ref # 1

L

Docket No. 50-410

MEMORANDUM FOR: Robert L. Tedesco, Assistant Director
for Licensing
Division of Licensing

FROM: James P. Knight, Assistant Director
for Components and Structures Engineering
Division of Engineering

SUBJECT: DYMIDAG THREADBAR SYSTEM FOR SPLICING OF REINFORCING
STEEL BARS - NINE MILE POINT 2

Plant Name: Nine Mile Point 2
 Docket No.: 50-410
 Licensing Stage: Post CP
 Responsible Branch and
 Project Manager: Licensing Branch 1, Kenneth L. Kiper
 Description of task: Review of DYMIDAG Threadbar System for Splicing
of Reinforcing Steel Bars
 Review Status: Completed

- References:
1. Letter from Gerald K. Rhode of Niagara Mohawk Power Corporation (NMPC) to L. S. Rubenstein of NRC, dated October 28, 1980.
 2. Letter from Gerald K. Rhode of NMPC to Robert L. Tedesco of NRC, dated October 28, 1980.

We have reviewed the additional information provided by the applicant in the second reference. Based on this review, our earlier review of the first reference, and the meeting with applicant and its representative on August 14, 1980, we recommend that the applicant be permitted to use the DYMIDAG Thread Bar System for splicing of reinforcing steel bars, provided following conditions are met:

1. Commitment to comply with the applicable provisions of Section III, Division 2 of ASME Boiler and Pressure Vessel Code, 1980 Edition, including summer addenda.

8102270927 KA
CF 289

L/1a.

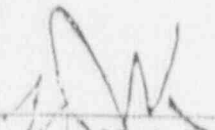
2. Compliance with the applicable provisions of Sections 7.5 and 7.6 of ACI Code 349-76, "Code Requirements for Nuclear Safety Related Concrete Structures". Prior to the use of unstaggered splices, provide following information to substantiate and justify their use.
 - a. Statistical summary of test data which substantiates that the strain measured over the full length of connector (at 0.9 yield) does not exceed that of an unspliced bar by more than 50 percent;
 - b. Sample calculations indicating that the stress levels in reinforcing bars are below 0.5 times specified yield strength under all applicable load combinations for some of the locations where the use of unstaggered splices is intended. These locations should include at least a typical joint situation, such as, wall floor junctions. These calculations should include complete analysis procedures and assumptions used in arriving at the stress levels in reinforcing bars, and sketches showing the details of reinforcing;
 - c. Tensile test data on spliced (unstaggered) specimens consisting of group of bars to determine their efficiency. Preferably, the number of bars in a group should be at least five. These data should be provided for bar sizes 11, 14, and 18. Compare the these results with similar unspliced specimens. The test shall be performed and reported in accordance with Section CC-4333.2 of the above mentioned ASME code.
 - d. The criterion for minimum spacing between the sleeves of adjacent bars and discuss its adequacy in terms of concrete placement, compaction and avoidance of void formation.

James P. Knight, Assistant Director
for Components and Structures Engineering
Division of Engineering

cc: R. Vollmer
F. Schauer
B. Youngblood
D. Jeng
K. Kiper
H. Chokshi

DISTRIBUTION
J. Knight
F. Schauer
D. Jeng
→ N. Chokshi
Central File
SEB Reading File

CONTACT: H. C. Chokshi x26075



OFFICE	DE:SEB NChokshi;ash	DE:SEB DJeng	DE:SEB FSchauer	DE:A/DC&SE JKnight	
SURNAME					
DATE	2/17/81	2/17/81	2/17/81	2/17/81	

Let - 3

6

Niagara Mohawk Power Corporation
Nine Mile Point Unit 2
Docket No. 50-410

- Presentation

DYWIDAG Threadbar

- Introduction
- Code Requirements
- Unstaggered Splices
 - Statistical Summary
 - Calculations
 - Spacing Criteria

MARCH 6, 1981

U/1c

- Use of DWIDAG splices will comply with the requirements of ASME III Code, Division II and ACI 349.
- Test results have shown that the DWIDAG splice meets the requirements for unstaggered splices:
 1. Strain over length of the full connector at 90% yield is less than 50% of an unspliced bar.
 2. Maximum computed design load stress in bar is less than .5 fy.
 3. Splices develop at least 125% of the specified yield strength of bar in tension.

DYWIDAG Threadbar, grade 60 ksi, Splice System

Statistical Summary of Elongation in a Spliced Bar Specimen versus Elongation of an Unspliced Bar Specimen at 90% of minimum required yield (54 ksi)

total elongation over 10 inches

$$\bar{\epsilon} = \frac{\sum \epsilon_i}{n} = \frac{0.0245}{8} = 0.0030625$$

Specimen #	Elongation in 10 inch							Average
#6: Spliced Specimen	0.0245	0.0270	0.0230	0.0265	0.0250	0.0210	0.0245	
Unspliced Specimen	0.0195							0.0245
E in %	26	38	18	36	28	8	26	
#7: Spliced Specimen	0.028	0.025	0.0285	0.028	0.027	0.022	0.0264	
Unspliced Specimen	0.026							0.0264
E in %	8	-4	10	8	4	-15	2	
#8: Spliced Specimen	0.037	0.0335	0.0365	0.033	0.032	0.031	0.0338	
Unspliced Specimen	0.028							0.0338
E in %	32	20	30	18	14	11	21	
#9: Spliced Specimen	0.038	0.0355	0.037	0.035	0.0365	0.039	0.0368	
Unspliced Specimen	0.030							0.0368
E in %	27	18	23	17	22	30	23	
#10: Spliced Specimen	0.0485	0.047	0.0465	0.0495	0.0465	0.045	0.0471	
Unspliced Specimen	0.035							0.0471
E in %	39	34	33	41	33	29	35	
#11: Spliced Specimen	0.0455	0.0475	0.039	0.0415	0.046	0.0395	0.0431	
Unspliced Specimen	0.034							0.0431
E in %	34	40	15	22	35	16	27	
#14: Spliced Specimen	0.045	0.050	0.051	0.0505	0.0495	0.050	0.0493	
Unspliced Specimen	0.042							0.0493
E in %	7	19	21	20	18	19	17	
#18: Spliced Specimen	0.0845	0.079	0.081	0.076	0.0845	0.082	0.0812	
Unspliced Specimen	0.056							0.0812
E in %	51	41	45	36	51	46	45	

* Cause of high strain level due to Bar end of spec -

DESIGNER/DATE E. L. CHAO 3-1-81	REVIEWER/CHECKER/DATE Sam Chen 3/1/81	INDEPENDENT REVIEWER/DATE Sam Chen 3/1/81	1 OF 2
PROJECT/TITLE REVIEW REACTOR BUILDING FLOOR SLAB DESIGN 44129-0		QA CATEGORY / CODE CLASS 1	

REFERENCE EXISTING DESIGN, CALCULATION SHEET P. C33.5' ITEM 21
 FOR FIXED END SPAN. $L = 6'-0$ $d = 8''$ $b = 12''$
 $f'_c = 3,000$ psi (28 DAYS).

(1) TOP REINFORCEMENT: $\phi = 0.9$ $\rho = 12'' \times 1/2$, T. & B.
 $M_{max} = 5.0 \text{ K-FT}$ A_s (REQ'D) = 0.67 in^2
 USG $A_s = 0.79 \text{ in}^2$ $\rho = 0.79 / (6 \times 12) = 0.00883$ $\omega = 0.11$
 $A_s = M_{max} / (a_n \times d) = 5.0 / (a_n \times 8) = 0.79$
 $a_n = 5.0 / (0.79 \times 8) = 0.7912$
 $a_n = \phi f_y (1 - 0.59 \omega) / 12000 = 0.7912$
 $0.9 f_y (1 - 0.59 \times 0.11) / 12000 = 0.7912$
 $\therefore f_y = 11,282 \text{ psi}$ $\leftarrow (< 0.5 f_y)$
 (3900 = psi)

(2) BOTTOM REINFORCEMENT:
 $M_{max} = 167 (6)^2 / 8 = 7.515 \text{ K-FT}$ A_s (REQ'D) = 0.5 in^2
 USG $A_s = 0.79 \text{ in}^2$ $\rho = 0.00883$ $\omega = 0.11$
 $A_s = M_{max} / (a_n \times d) = 7.515 / (a_n \times 8) = 0.79$
 $a_n = 7.515 / (0.79 \times 8) = 1.189$
 $a_n = \phi f_y (1 - 0.59 \omega) / 12000 = 1.189$
 $0.9 f_y (1 - 0.59 \times 0.11) / 12000 = 1.189$
 $\therefore f_y = 16,954 \text{ psi}$

NO. 12177	2 OF 2	
PREPARED BY/DATE E.L. CHAO 3-1-81	REVIEWER/CHECKER/DATE Sam Chao 3/1/81	INDEPENDENT REVIEWER/DATE Sam Chao 3/1/81
SUBJECT/TITLE REACTOR BUILDING, FLOOR SLAB DESIGN (@ EL. 30A:6)		QA CATEGORY/CODE CLASS 1

REFERENCE EXISTING DESIGN, CALCULATION SHEET PC33-4, ITEM 23.

FOR FIXED END SPAN. $L = 6'0"$ $d = 8"$, $b = 12"$

$f'_c = 3,100$ psi (28 DAYS).

(1) TOP REINFORCEMENT:

5 @ 12" o/c, T. & B.

$$M_{max} = 7.344 \text{ K-FT} \quad \text{REQ'D } A_s = 0.32 \text{ in}^2$$

$$\text{USE } A_s = 0.79 \text{ in}^2 \quad \rho = \frac{0.79}{12 \times 8} = 0.00823 \quad \text{USE } \omega = 0.11$$

$$A_s = \frac{M_n}{Q_n d} = \frac{7.344}{Q_n \times 8} = 0.79$$

$$Q_n = \frac{7.344}{0.79 \times 8} = 1.162$$

$$Q_n = \phi f_y (1 - 0.59 \omega) / 12,000 = 1.162$$

$$0.9 f_y (1 - 0.59 \times 0.11) / 12,000 = 1.162$$

$$\therefore f_y = 16,532 \text{ psi}$$

(2) BOTTOM REINFORCEMENT:

$$M_{max} = 6.76 \text{ K-FT} \quad \text{REQUIRED } A_s = 0.504 \text{ in}^2$$

$$\text{USE } A_s = 0.79 \text{ in}^2 \quad \rho = 0.00823 \quad \text{USE } \omega = 0.11$$

$$A_s = \frac{M_n}{Q_n d} = \frac{6.76}{Q_n \times 8}$$

$$Q_n = \frac{6.76}{0.79 \times 8} = 1.07$$

$$Q_n = \phi f_y (1 - 0.59 \omega) / 12,000 = 1.07$$

$$0.9 f_y (1 - 0.59 \times 0.11) / 12,000 = 1.07$$

$$\therefore f_y = 15,257 \text{ psi}$$

MINIMUM SPACING CRITERIA FOR SPLICES TO AVOID FORMATION OF VOIDS
DURING CONCRETE PLACEMENT:

1. THE CLEAR DISTANCE BETWEEN PARALLEL SPLICES IN A LAYER SHALL BE NOT LESS THAN THE NOMINAL DIAMETER OF THE BARS, NOR 1 IN.
2. IN CASE OF COMPRESSION MEMBERS, THE CLEAR DISTANCE BETWEEN LONGITUDINAL BARS SHALL NOT BE LESS THAN ONE AND ONE HALF TIMES THE NOMINAL BAR DIAMETER, NOR 1½ IN.

THE ABOVE CRITERIA IS IN COMPLIANCE WITH ACI-349-76.

IN CASE OF NINE MILE UNIT-2 PROJECT, THE MINIMUM CLEAR DISTANCE BETWEEN PARALLEL SPLICE WILL NOT BE LESS THAN SIX TIMES THE NOMINAL DIAMETER OF THE BAR NOR 6 IN.

DWIDAG Threshor Splice System (grade 60 ksi)
 Combination of 6 - #11 Splices

Columbia University Test No. 82636, May 7, 1980

18.4 kips
18.5 kips

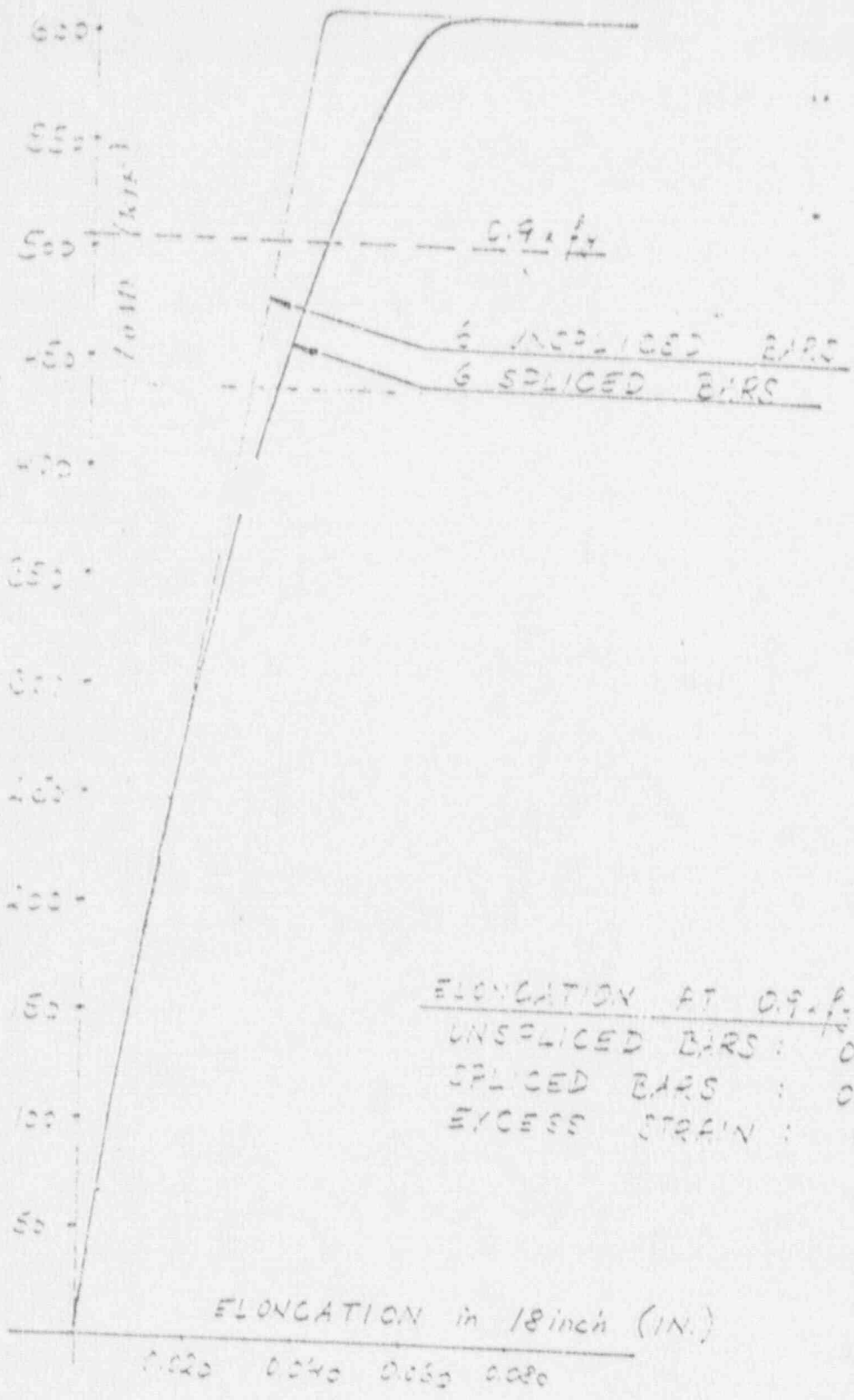
Elongation (in.) E in 18 in.	Load (KIP)						Total Load (K)	Unspliced Bar	
	#18	#19	#20	#21	#22	#23		#24	6X
0.	0	0	0	0	0	0	0	0	0
0.004	10	10	10	11	12	13	66	10	60
0.008	20	20	21	23	23	25	131	20	120
0.012	30	29	32	33	32	35	191	30	180
0.016	40	36	43	43	40	45	247	40	240
0.020	49	43	52	51	47	53	295	50	300
0.024	55	50	60	59	54	60	338	60	360
0.028	61	57	70	65	60	68	381	69	414
0.032	67	63	76	71	66	74	417	79	474
0.036	73	68	82	76	71	79	449	88	528
0.040	78	74	86	81	76	85	480	98	588
0.044	82	80	91	86	81	89	509	102	612
0.048	86	85	95	91	86	94	537	102	612
0.052	91	90	98	96	91	98	564	102	612
0.056	95	95	99	100	95	102	586	102	612
0.060	98	100	100	102	99	103	602	102	612
0.064	102	102	101	102	101	102	610		
0.068	102	102	101	102	102	102	611		
0.072	102	102	101	102	102	102	612		
0.076	102	102	102	102	102	102	612		
0.080	102	102	102	102	102	102	612		

Dyckerhoff & Widmann, Inc.



DATE	SCALE	DWG
APPROVED		NRC-1

DYWIDAG THREADBAR SPLICE SYSTEM (GRADE 60 KSI)



#11 BARS

COLUMBIA UNIVERSITY TEST NR 2536

Dyckerhoff & Widmann, Inc.



COMBINATION OF
6 #11 SPICED THREADBARS

DATE 3-5-41	SCALE	DWG
APPROVED	1/17/41	NRC-2

DYWIDAG Threadbar Splice System (grade 60 ksi)

Combination of 6 - #14 Splices

Columbia University Test No. S2637, March 14, 1980

Elongation (in.) E in 22 in.	Load (KIP)						Total	Unspliced Bar	
	#2	#3	#4	#5	#6	#7		#1	6X
0.	0	0	0	0	0	0	0	0	0
0.004	15	14	14	14	14	13	84	11	66
0.008	30	28	28	28	28	26	168	22	132
0.012	44	40	42	40	42	39	247	34	204
0.016	55	52	53	51	53	51	315	46	276
0.020	67	64	64	61	64	63	383	57	342
0.024	79	75	74	70	75	74	447	69	414
0.028	89	84	85	80	85	83	506	81	486
0.032	99	93	93	89	93	92	559	93	558
0.036	107	101	101	97	101	101	608	104	624
0.040	114	108	108	105	109	108	652	114	684
0.044	121	114	113	112	115	114	689	125	750
0.048	126	119	118	118	120	119	720	134	804
0.052	130	124	122	123	125	123	747	140	840
0.056	124	128	126	128	128	127	771	140	840
0.060	136	131	129	132	131	131	790		
0.064	137	134	131	135	133	134	804		
0.068	138	136	133	138	136	137	818		
0.072	138	137	134	138	138	138	823		
0.076	138	138	135	138	138	139	826		
0.080	138	138	136	138	138	138	827		

Dyckerhoff & Widmann, Inc.



DATE 3-17-80

SCALE

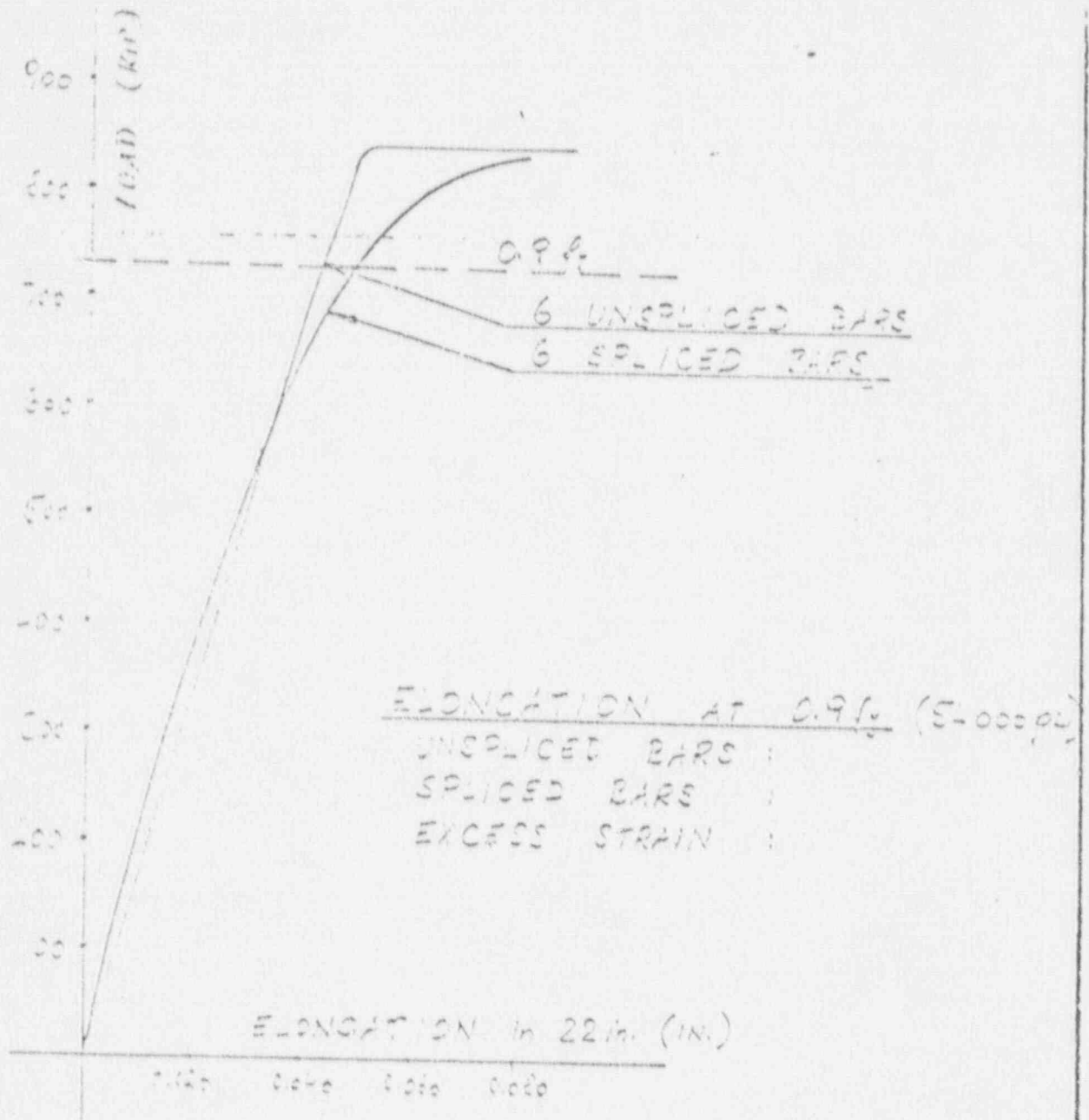
DWG

APPROVED

11/11/80

N/C-3

DWYDAG THREADBAR SPLICE SYSTEM (GRADE 60KSI)



COLUMBIA UNIVERSITY TEST NR2687

Dyckerhoff & Widmann, Inc.



COMBINATION OF
6 #14 SPLICED THREADBARS

DATE 3-5-81 SCALE 1

DWG
NRC-4

APPROVED [Signature]

DYWIDAG Threadbar Splice System (grade 60 ksi)

Combination of 6 - #18 Splices

Columbia University Test No. 82638, May 7, 1980

Elevation (in.) E in 18 in.	#17	#18	#29	#20	#21	#22	Total*	Unspliced Bar #23	6X
0.	0	0	0	0	0	0	0	0	0
0.010	40	44	46	42	42	40	234	39	234
0.020	80	84	86	84	80	80	494	78	468
0.030	110	116	118	122	116	114	696	116	698
0.040	134	144	143	150	136	144	854	155	930
0.050	156	168	164	174	158	168	988	194	1164
0.060	174	189	181	192	175	184	1095	230	1380
0.070	192	205	198	208	192	200	1195	250	1500
0.080	210	217	214	220	211	213	1285	250	1500
0.090	232	226	230	238	222	223	1351		
0.100	232	233	240	233	232	232	1402		
0.110	238	238	249	236	237	236	1434		
0.120	240	241	250	238	240	239	1448		
0.130	242	244	250	239	242	240	1457		
0.140	244	246	250	240	244	241	1465		
0.150	245	247	250	240	245	242	1469		

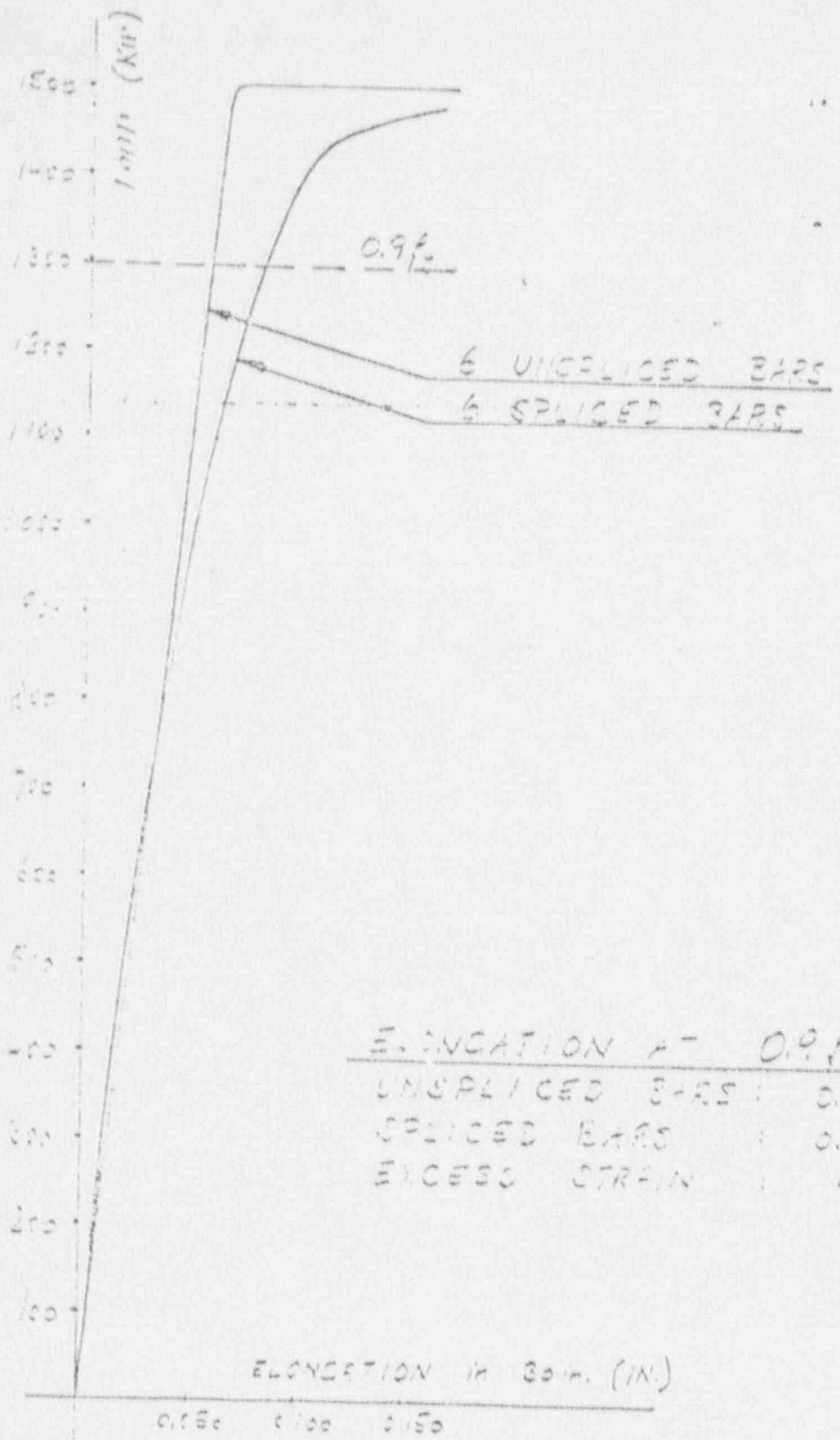
Dyckerhoff & Widmann, Inc.



DATE 3-5-81 SCALE
APPROVED


DWG
VRC-5

COMBINATION OF 6 #12 SPICED THREADBARS (GRADE 60KSI)



ELONGATION AT 0.9 f_u (54000 psi)
 UNSPLICED BARS : 0.056
 SPICED BARS : 0.022
 EXCESS STRAIN : 46%

COLUMBIA UNIVERSITY TEST NR 22632

Dyckerhoff & Widmann, Inc.			
	COMBINATION OF 6 #12 SPICED THREADBARS		
	DATE 1-11-44	SCALE	DWG
APPROVED	1/11/44	NRC-6	