Southern California Edison Company

23 PARKER STREET

IRVINE, CALIFORNIA 92718

July 12, 1994

WALTER C. MARSH
MANAGER OF NUCLEAR REGULATORY AFFAIRS

TELEPHONE
(714) 454-4403

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Gentlemen:

Subject: **Docket Nos. 50-361 and 50-362**
Fastener Information
San Onofre Nuclear Generating Station
Units 2 and 3

Enclosed at the request of Mr. Mel Fields, NRC Project Manager for San Onofre Units 2 and 3, are the following SCE documents.

1. Memorandum from Mostafa S. Mostafa and W. W. Strom to M. B. Ramsey, Subject: Failure Analysis Report 94-005, Independent Lab Analysis of Fasteners from SONGS Warehouse, June 24, 1994.

2. Procedure SO123-XXXII-2.5, Rev. 1, PCN 1-2, Sampling Program for Assessing, Estimating, and Reporting Commercial Grade Item Quality, March 21, 1994.

If you have any questions on these documents, please let us know.

Sincerely,

Walter C. Marsh

cc: L. J. Callan, Regional Administrator, NRC Region IV
K. E. Perkins, Jr., Director, Walnut Creek Field Office, NRC Region IV
J. A. Sloan, NRC Senior Resident Inspector, San Onofre Units 2 & 3
M. B. Fields, NRC Project Manager, San Onofre Units 2 and 3

A001
1/1

June 24, 1994

M.B. Ramsey

SUBJECT: Failure Analysis Report 94-005
Independent Lab Analysis of Fasteners from SONGS Warehouse

BACKGROUND

Independent dimensional analysis of allthread stud material was requested by Mr. Mike Ramsey of ISEG/Root Cause. The results were to be compared to dimensional inspections which had been performed by SONGS QC staff on the same components using Johnson Gages.

Also, mechanical testing of a selected sample was requested to verify the mechanical properties including thread shear strength.

PROCEDURE

Five allthread studs 5/8" in diameter, 11 threads per inch, 36 inches in length, SA 193-B7 material, with class 2A thread fit were identified as samples #5, 11, 16, 23, and 31 from TLIS Test Package No 32KRT.PRN MTF-0166-94. The dimensional analysis was performed by B&B Metrology Company of Lake Elsinore, California. The three wire method and super micrometer were used to measure the pitch diameter, the major diameter and the minor diameter. The measurements were made in an environmentally controlled chamber at 68° F and 45% humidity.

The mechanical testing was performed on cut coupons from stud #16. The testing consisted of tension testing and proof load testing. Three tensile coupons were machined and tested at room temperature. The yield strength, ultimate tensile strength, elongation percent, and reduction of area were recorded. An additional pull test was performed on a full size threaded section and the tensile strength was measured.

The proof load test was performed per ASTM A-370 and F-606 Method 1, "Length Measurement" on three samples. Two samples were conventionally proof loaded to 87% of the minimum 2% off-set yield (105 ksi) as specified by ASTM A 193 for GR.B7 bolts. The other sample was proof loaded to a much higher valve (140 ksi) equivalent to the actual measured yield strength. This last test is not commonly performed for proof load testing, however it was carried out to determine the permanent plastic deformation (stretching) under these conditions.

The thread shear strength was verified on cut segments of stud #5, where the number of engaged threads on each side was varied. The number of engaged threads used was 9, 7, 6, 5, 4, and 3.

All the mechanical testing was performed at Atlas Testing Laboratories of Commerce, California.

RESULTS

Dimensional Analysis

The pitch diameters of the 5 allthread studs as measured by QC staff using Johnson Gages are listed in Table 1. The dimensions were tested by the three wire method in which three areas of the stud (ends and mid section) were measured, and the results are listed in Tables 2, 3, 4, 5 and 6 representing studs #5, 11, 16, 23, and 31, respectively. The QC Inspector who performed the Johnson Gage measurements had been contacted and it was determined the allthread ends and midsection were the tested areas. The "limits of size for standard series threads" per ASME B1.1 are listed in Table 7.

The three wires method is considered, if used properly, the most accurate and the most generally satisfactory method according to precision measuring tools hand book, Van Keuren*. Comparing the measured pitch diameter using the three wires method and the Johnson Gages as illustrated in Table 8 one finds the following:

1. Both methods appear to provide readings in the 0.0001" range, and provide a high degree of accuracy.

2. The maximum deviation from B1.1 standard limits is more consistent in the case of the three wires method than in the Johnson Gage method with the exception of stud #16.

3. Both methods identified the same studs as dimensionally out-of-tolerance

4. The identified out of tolerance range by both techniques was 1.1 to 2.0 mils (0.0011" - 0.002"). This out-of-tolerance condition, as demonstrated by the mechanical testing included in this report, is considered to have a negligible effect on the performance of the fastener.

5. No correlation could be made between out-of-tolerance pitch diameter readings and thread minor diameter readings.

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* Precision Measuring Tools Handbook No. 37, The Van Keuren Co.

Tension Testing

The results of the tension tests performed on sample #16 are listed in Table 9. The mechanical properties met the specified minimum values per ASTM A 193 Grade B7 fasteners. The pull test performed on the actual stud section also met the ASTM A193 minimum requirement; that is to say, despite the out-of-tolerance pitch diameter dimensions detected on these the studs, the minimum mechanical requirements were met.

Proof Load Testing

The results of the proof load test, where the threaded section of stud #13 was exposed to 87% of 105 ksi (The specified minimum yield strength by ASTM A193 - GR.B7) are listed in Tables 2 and 3. Both samples passed the proof load testing with stretching within the maximum allowed values. This test demonstrates, that even the stud was dimensionally out of tolerance, it still passed the proof load test. In other words, it met its mechanical requirements when torqued up to 87% of the specified minimum yield strength.

An unconventional proof load test, where the sample was exposed to 87% of the actual measured yield (140 ksi) was performed. The measured elongation indicated a permanent stretch of 0.00053", the maximum allowable stretch is 0.0005". That is to say, it was marginally out of range by only 0.00003" over 2" long gage length. See Table 12.

Minimum Number of thread Engagement

In order to demonstrate the thread shear strength of the known undersized thread profile, a series of pull tests were performed with a varying number of engaged threads. The results of the pull test on 9, 7, 6, and 5 threads did not exhibit any thread stripping and the fracture was a ductile fracture across the minor diameter cross section, occurring in the mid section of the sample. See Figures 1, 2, 3, and 4 representing the 9, 7, 6, and 5 thread engaged tests, respectively.

The four threads engaged case resulted in thread stripping as shown in Figures 5 and 6. The three threads engaged test resulted in stripping as shown in Figures 7 and 8.

In summary, the minimum number of engaged threads required to provide a good clamping joint without thread failure is five (5) threads. The actual number of engaged threads used on this type of studs is seven (6.9). This is provided by a nut of a length equal to one diameter (5/8"). This nut, as proven in this test, will provide an adequate thread engagement.

Summary and Conclusions

The results of the independent dimensional analysis performed on the studs was in agreement with the results previously detected by Johnson Gages.

The submitted worst case out of tolerance stud (out of tolerance by 0.002" on the pitch diameter) was mechanically proof load tested. The tested samples passed the proof load tests and met the minimum mechanical requirements specified by ASTM A-370 and F-606, Method 1.

The minimum number of engaged threads required to avoid stud thread stripping under ultimate load was determined to be 5 threads. The number of threads in a standard heavy hex nut is seven (6.9). This will provide adequate thread engagement and will prevent thread stripping under proper torquing application.

Mostafa S. Mostafa

Mostafa S. Mostafa
Sr. Root Cause Engineer

W. W. Strom
Supervisor Independent Safety
Engineering / Root Cause Group

MSMostafa:elg

cc: C. Chiu
K. Slagle
W. Frick
T. Herring III
D. Opitz
S. Brown
J. Rainsberry

FIGURES

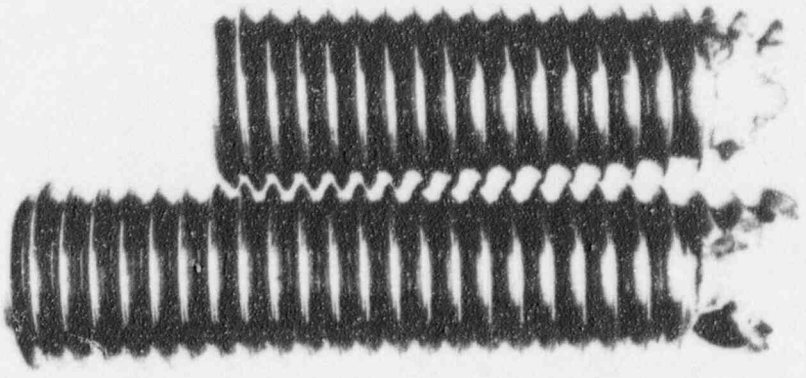

Figure 1. 9 Threads engaged

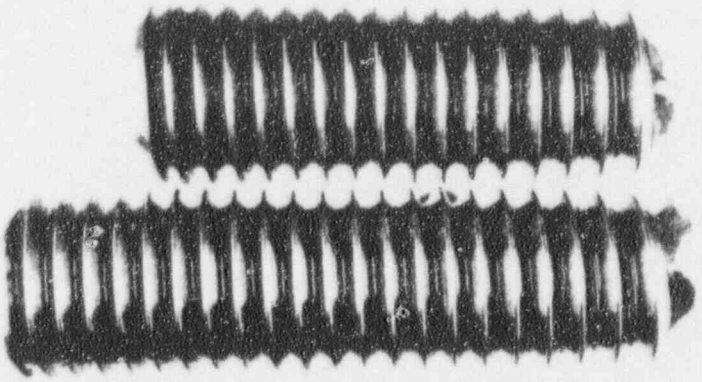

Figure 2. 7 Threads engaged

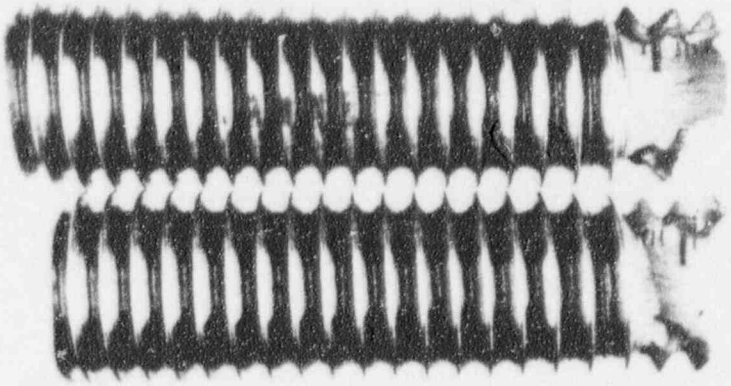

Figure 3. 6 Threads engaged

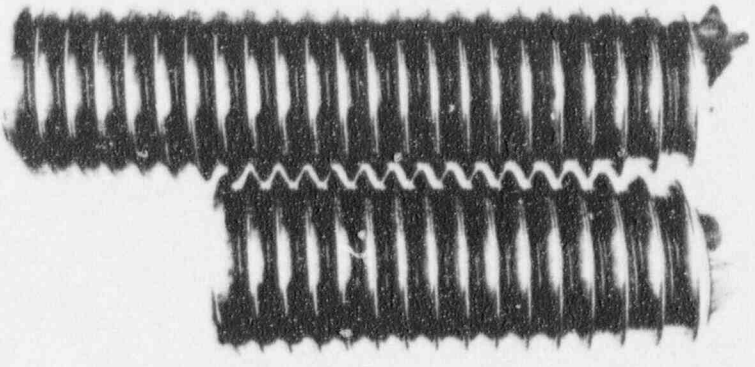

Figure 4. 5 Threads engaged

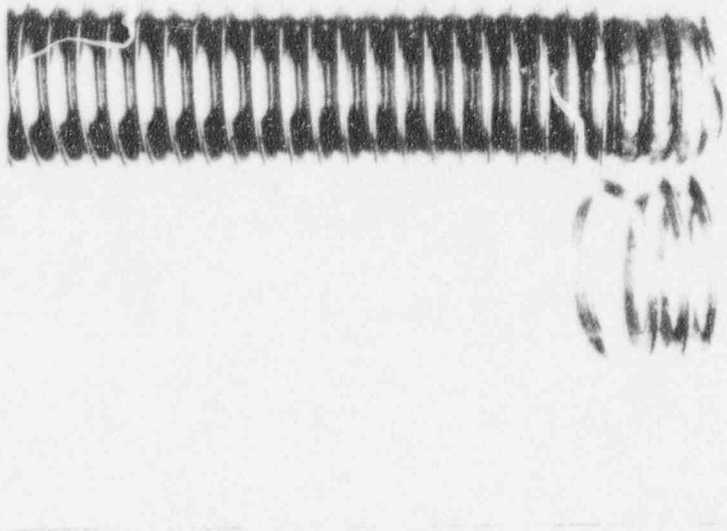

Figure 5. 4 Threads engaged

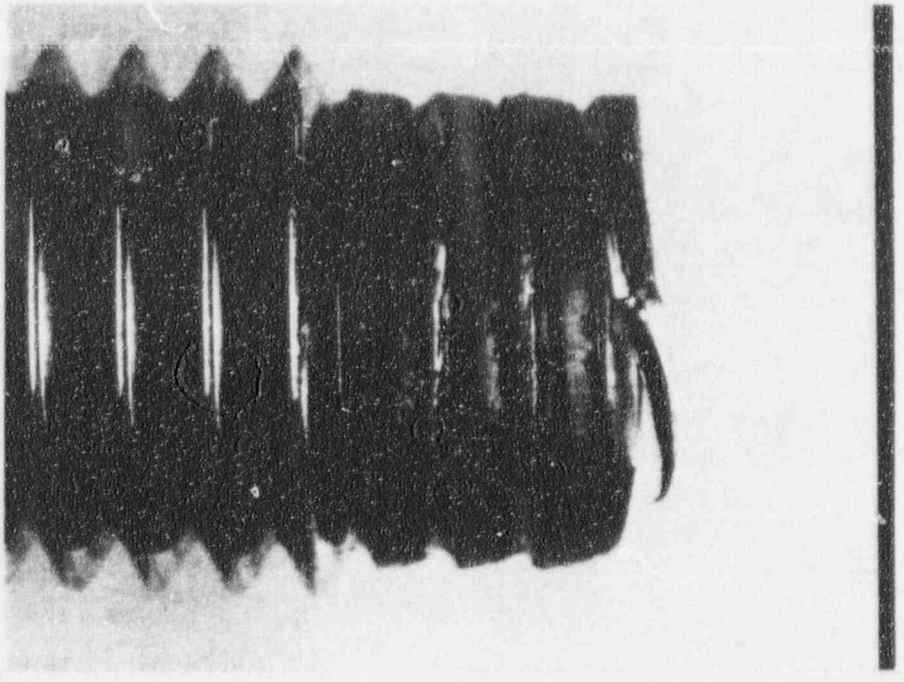

Figure 6. Close ups view of stripped Threads
4 Threads engaged

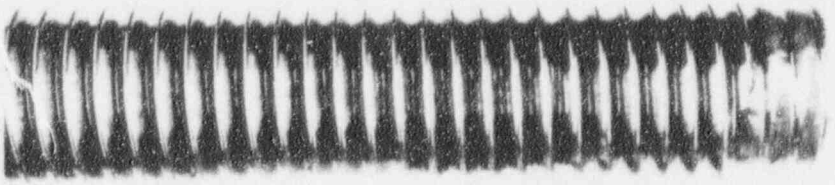

Figure 7. 3 Threads engaged

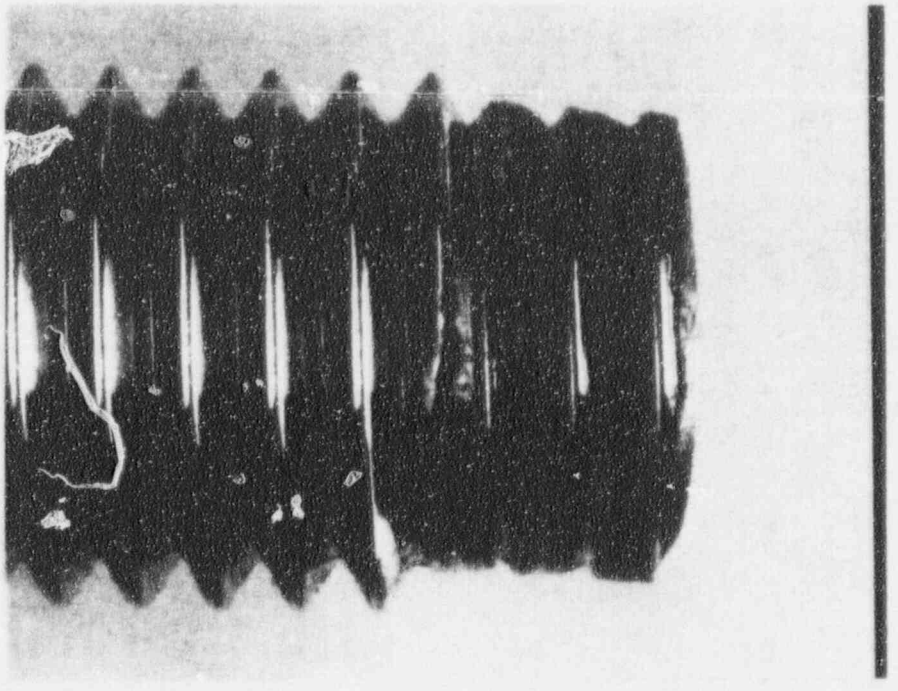

Figure 8. close up view of stripped Threads
(3 Threads engaged).

TABLES

TABLE. 1

W-0040-94 R-Ø MTF-0166-94
32KRT. PRN

W-IR-002-94 R1

2/09/94 09:59 PRINT-OUT OF KURT CHECK SPC DATA Page 1 of 1

Part Code: Q1011363 Chart No.: 2

Partname:	Rod,All Thread	Part No.:	Q1011363
Machine No.:	t 2	Seq. No.:	1
Customer:		Description:	5/8 - 11 x 36 UNC 2A
Chart Type:	Xbar & R	Subgroup Size:	18
Parameter:	(P D Size)		
Spec. Tol.:	0.5644-0.5589	Data Code:	1 = 1", 0 = 0"

Printout Between Dates ... START: 02/09/94 09:38
END: 02/09/94 09:56

SG#	IDENTIFIERS		MEAN	RANGE	SAMPLES...			
					(samples)			
1	Date:	02/09/94	0.5586	0.0048	#5 (0.5580)	(0.5587)	# (0.5588)	N
	Time:	09:38			#7 0.5595	0.5595	0.5599	N
	Oper:	FRL			#11 (0.5577)	(0.5574)	(0.5578)	N
	ECode:	0		W-0040-94	#12 0.5592	0.5602	0.5599	N
	Status:	OUT OF CONTROL			#13 0.5593	0.5595	0.5592	N
	M&TE#:	PE-0164 ✓			#16 (0.5554)	(0.5576)	(0.5576)	N
	M&TE#:	PE-0256			*			
	M&TE#:	PE-0245 ✓						
	Note:	P.D. SUBGROUP# 1: (UNSAT.) 3 EA. READINGS OBTAINED FOR EACH STUD. REF. MTF-0166-94, TLIS T/P# 32KRT.PRN, M/C# 305-05606. FRED R. LONG #16 2/9/94.						
2	Date:	02/09/94	0.5607	0.0043	#23 (0.5582)	(0.5584)	# (0.5588)	N
	Time:	09:50			#28 0.5619	0.5622	0.5625	C
	Oper:	FRL			#31 0.5616	0.5613	0.5615	C
	ECode:	0		W-0040-94	#35 0.5612	0.5616	0.5614	C
	Status:	IN CONTROL			#51 0.5609	0.5606	0.5604	N
	M&TE#:	PE-0164			#57 0.5598	0.5601	0.5597	N
	M&TE#:	PE-0256						
	M&TE#:	PE-0245						
	Note:	(Unsat.) P.D. SUBGROUP# 2. 3 EA. READINGS OBTAINED FROM EACH STUD. REF.MTF-0166-94, TLIS T/P# 32KRT.PRN, M/C# 305-05606. FRED R. LONG #16 2/9/94.						
3	Date:	02/09/94	0.0933	0.5600	#58 0.5600	0.5599	0.5599	N
	Time:	09:56			0.0000	0.0000	0.0000	
	Oper:	FRL			0.0000	0.0000	0.0000	
	ECode:	0			0.0000	0.0000	0.0000	
	Status:	OUT OF CONTROL			0.0000	0.0000	0.0000	
	M&TE#:	PE-0164			0.0000	0.0000	0.0000	
	M&TE#:	PE-0256						
	M&TE#:	PE-0245						
	Note:	P.D. SUBGROUP# 3: (SAT.) 1 STUD ONLY COVERED UNDER THIS SUBGROUP. 3 READINGS OBTAINED FOR STUD. REF. MTF-0166-94, TLIS T/P# 32KRT.PRN, M/C# 305-05606. FRED R. LONG #16 2/9/94.						

Unsat. items inspected w/ go - no/go ring gages. [signature] 2-9-94
Results: Sat.

N = none C = Cardinal

TABLE 1

Table 2

CERTIFICATE OF CALIBRATION

by

B & B METROLOGY
17504 Grand Avenue, Lake Elsinore, Ca. 92530
(909) 678-5546 (800) 523-2835

Traceable to NIST and CONFORMS to MIL-STD-45662A

Customer: SO. CALIF. EDISON	Test Number: 0425-7
5000 PACIFIC COAST HWY.	Test Date: APRIL 25, 1994
SAN CLEMENTE, CA. 92674	Next Cal: N/A
Model No.: 5/8-11	NIST NUMBER: N/A
Serial No.: NONE	Condition Received:
Asset No.: 5	Within Tolerance
Manufacturer: NONE	Inoperative
Description: ALL THREAD TYPE STUD	Out of Tolerance
Metrologist: BB4	Temp.: 68 ,F Humidity: 45%

Calibration Standards Used

mfg.	model	asset no.	cal'd	due
MTI	162-102	BB075	OCT. 19, 1993	OCT. 19, 1994
VKC	34HS	BB079	FEB. 4, 1993	FEB. 4, 1995
MTI	519-302	BB116	OCT. 19, 1993	OCT. 19, 1994
MRV	S14B	BB200	OCT. 25, 1993	OCT. 25, 1994

Procedure Used: CP-29 Uncertainty of Measurement: 20 PPM

Condition Returned:	Within Tolerance	Out of Tolerance	Other See Remarks

Accuracy : N/A

Remarks:

	MAJOR DIA.	PITCH DIA.	MINOR DIA.
1.	.6200	.5578	.5027
2.	.6204	.5582	.5015
3.	.6206	.5583	.5026

POSITION #1 IS THE END THAT IS NUMBERED, #2 IS THE CENTER, AND #3 THE OTHER END.

LABORATORY SUPERVISOR : Mike Brown

B9-14/232

TABLE 2

Table 3

CERTIFICATE OF CALIBRATION

by

B & B METROLOGY
17504 Grand Avenue, Lake Elsinore, Ca. 92530
(909) 678-5546 (800) 523-2835

Traceable to NIST and CONFORMS to MIL-STD-45662A

Customer: SO. CALIF. EDISON	Test Number: 0425-4
5000 PACIFIC COAST HWY.	Test Date: APRIL 25, 1994
SAN CLEMENTE, CA. 92674	Next Cal: N/A
Model No.: 5/8-11	NIST NUMBER: N/A
Serial No.: NONE	Condition Received:
Asset No.: 11	Within Tolerance
Manufacturer: NONE	Inoperative
Description: ALL THREAD TYPE STUD	Out of Tolerance
Metrologist: BB4	Temp.: 68 °F Humidity: 45%

Calibration Standards Used

mfg.	model	asset no.	cal'd	due
MTI	162-102	BB075	OCT. 19, 1993	OCT. 19, 1994
VKC	34HS	BB079	FEB. 4, 1993	FEB. 4, 1995
MTI	519-302	BB116	OCT. 19, 1993	OCT. 19, 1994
MRV	S14B	BB200	OCT. 25, 1993	OCT. 25, 1994

Procedure Used: CP-29 Uncertainty of Measurement: 20 PPM

Condition Returned:	Within Tolerance	Out of Tolerance	Other See Remarks

Accuracy : N/A

Remarks:

	MAJOR DIA.	PITCH DIA.	MINOR DIA.
1.	.6200	.5579	.5031
2.	.6200	.5580	.5025
3.	.6200	.5578	.5023

POSITION #1 IS THE END THAT IS NUMBERED, #2 IS THE CENTER, AND #3 THE OTHER END.

LABORATORY SUPERVISOR : Mike Burns

BB-14/232

TABLE 3

Table 4

CERTIFICATE OF CALIBRATION

by

B & B METROLOGY
17504 Grand Avenue, Lake Elsinore, Ca. 92530
(909) 678-5546 (800) 523-2835

Traceable to NIST and CONFORMS to MIL-STD-45662A

Customer: SO. CALIF. EDISON	Test Number: 0425-6
5000 PACIFIC COAST HWY.	Test Date: APRIL 25, 1994
SAN CLEMENTE, CA. 92674	Next Cal: N/A
Model No.: 5/8-11	NIST NUMBER: N/A
Serial No.: NONE	Condition Received:
Asset No.: 16	Within Tolerance
Manufacturer: NONE	Inoperative
Description: ALL READ TYPE STUD	Out of Tolerance
Metrologist: BB4	Temp.: 68 ,F Humidity: 45%

Calibration Standards Used

mfg.	model	asset no.	cal'd	due
MTI	162-102	BB075	OCT. 19, 1993	OCT. 19, 1994
VKC	34HS	BB079	FEB. 4, 1993	FEB. 4, 1995
MTI	519-302	BB116	OCT. 19, 1993	OCT. 19, 1994
MRV	S14B	BB200	OCT. 25, 1993	OCT. 25, 1994

Procedure Used: CP-29 Uncertainty of Measurement: 20 PPM

Condition Returned:	Within Tolerance	Out of Tolerance	Other See Remarks

Accuracy : N/A

Remarks:

	MAJOR DIA.	PITCH DIA.	MINOR DIA.
1.	.6203	.5582	.5045
2.	.6200	.5580	.5032
3.	.6190	.5569	.5033

POSITION #1 IS THE END THAT IS NUMBERED, #2 IS THE CENTER, AND #3 THE OTHER END.

LABORATORY SUPERVISOR : Michael Burns

BB-14/232

TABLE 4

Table 5

CERTIFICATE OF CALIBRATION

by

B & B METROLOGY
17504 Grand Avenue, Lake Elsinore, Ca. 92530
(909) 678-5546 (800) 523-2835

Traceable to NIST and CONFORMS to MIL-STD-45662A

Customer: SO. CALIF. EDISON	Test Number: 0425-5
5000 PACIFIC COAST HWY.	Test Date: APRIL 25, 1994
SAN CLEMENTE, CA. 92674	Next Cal: N/A
Model No.: 5/8-11	NIST NUMBER: N/A
Serial No.: NONE	Condition Received:
Asset No.: 23	Within Tolerance
Manufacturer: NONE	Inoperative
Description: ALL THREAD TYPE STUD	Out of Tolerance
Metrologist: BB4	Temp.: 68 ,F Humidity: 45%

Calibration Standards Used

mfg.	model	asset no.	cal'd	due
MTI	162-102	BB075	OCT. 19, 1993	OCT. 19, 1994
VKC	34HS	BB079	FEB. 4, 1993	FEB. 4, 1995
MTI	519-302	BB116	OCT. 19, 1993	OCT. 19, 1994
MRV	S14B	BB200	OCT. 25, 1993	OCT. 25, 1994

Procedure Used: CP-29 Uncertainty of Measurement: 20 PPM

Condition Returned: Within Tolerance Out of Tolerance Other See Remarks

Accuracy : N/A

Remarks:

	MAJOR DIA.	PITCH DIA.	MINOR DIA.
1.	.6200	.5578	.5030
2.	.6200	.5579	.5030
3.	.6201	.5578	.5023

POSITION #1 IS THE END THAT IS NUMBERED, #2 IS THE CENTER, AND #3 THE OTHER END.

LABORATORY SUPERVISOR : Mike Burns

BB-14/232

TABLE 5

Table 6

CERTIFICATE OF CALIBRATION

by

B & B METROLOGY
17504 Grand Avenue, Lake Elsinore, Ca. 92530
(909) 678-5546 (800) 523-2835

Traceable to NIST and CONFORMS to MIL-STD-45662A

Customer: SO. CALIF. EDISON	Test Number: 0425-1
5000 PACIFIC COAST HWY.	Test Date: APRIL 25, 1994
SAN CLEMENTE, CA. 92674	Next Cal: N/A
Model No.: 5/8-11	NIST NUMBER: N/A
Serial No.: NONE	Condition Received:
Asset No.: 31	Within Tolerance
Manufacturer: NONE	Inoperative
Description: ALL THREAD TYPE STUD	Out of Tolerance
Metrologist: BB4	Temp.: 68 F Humidity: 45%

Calibration Standards Used

mfg.	model	asset no.	cal'd	due
MTI	162-102	BB075	OCT. 19, 1993	OCT. 19, 1994
VKC	34HS	BB079	FEB. 4, 1993	FEB. 4, 1995
MTI	519-302	BB116	OCT. 19, 1993	OCT. 19, 1994
MRV	S14B	BB200	OCT. 25, 1993	OCT. 25, 1994

Procedure Used: CP-29 Uncertainty of Measurement: 20 PPM

Condition Returned: Within Tolerance | Out of Tolerance | Other See Remarks

Accuracy : N/A

Remarks:

	MAJOR DIA.	PITCH DIA.	MINOR DIA.
1.	.6194	.5609	.5040
2.	.6197	.5614	.5056
3.	.6195	.5612	.5056

POSITION #1 IS THE END THAT IS NUMBERED, #2 IS THE CENTER, AND #3 THE OTHER END.

LABORATORY SUPERVISOR : Mike Burns

BB-14/232

TABLE 6

TABLE 3A LIMITS OF SIZE FOR STANDARD SERIES THREADS (UN/UNR) (CONT'D)

Nominal Size and Threads/in.	Series Designation	External (1) Class	Allowance	Major Diameter Max. (2)	Major Diameter Min.	Major Diameter Min. (3)	Pitch Diameter Max. (2)	Pitch Diameter Min.	Pitch Diameter Tolerance	UNR Minor Diam. Max. (4) (Ref.)	Internal (1) Class	Minor Diameter Min.	Minor Diameter Max.	Pitch Diameter Min.	Pitch Diameter Max.	Pitch Diameter Tolerance	Major Diameter Min.
7/16-28 or 0.500-28	UNEF	2A	0.0011	0.4989	0.4924	...	0.4757	0.4720	0.0037	0.4583	2B	0.461	0.470	0.4768	0.4816	0.0048	0.5000
		3A	0.0000	0.5000	0.4935	...	0.4788	0.4740	0.0028	0.4574	3B	0.4610	0.4676	0.4768	0.4804	0.0036	0.5000
7/16-32 or 0.500-32	UN	2A	0.0010	0.4990	0.4930	...	0.4787	0.4762	0.0035	0.4618	2B	0.468	0.474	0.4797	0.4842	0.0045	0.5000
		3A	0.0000	0.5000	0.4940	...	0.4797	0.4771	0.0026	0.4628	3B	0.4660	0.4719	0.4797	0.4831	0.0034	0.5000
1/2-12 or 0.5625-12	UNC	1A	0.0018	0.5609	0.5437	...	0.5068	0.4990	0.0078	0.4617	1B	0.472	0.490	0.5084	0.5186	0.0102	0.5625
		2A	0.0018	0.5609	0.5495	0.5437	0.5068	0.5016	0.0052	0.4617	2B	0.472	0.490	0.5084	0.5152	0.0068	0.5625
		3A	0.0000	0.5625	0.5511	...	0.5084	0.5045	0.0039	0.4633	3B	0.4720	0.4843	0.5084	0.5135	0.0051	0.5625
1/2-16 or 0.5625-16	UN	2A	0.0014	0.5611	0.5517	...	0.5205	0.5158	0.0047	0.4868	2B	0.495	0.509	0.5219	0.5280	0.0061	0.5625
		3A	0.0000	0.5625	0.5531	...	0.5219	0.5184	0.0035	0.4880	3B	0.4950	0.5040	0.5219	0.5265	0.0046	0.5625
1/2-18 or 0.5625-18	UNF	1A	0.0014	0.5611	0.5480	...	0.5250	0.5182	0.0068	0.4950	1B	0.502	0.515	0.5264	0.5353	0.0089	0.5625
		2A	0.0014	0.5611	0.5524	...	0.5250	0.5205	0.0045	0.4950	2B	0.502	0.515	0.5264	0.5323	0.0059	0.5625
		3A	0.0000	0.5625	0.5538	...	0.5264	0.5230	0.0034	0.4964	3B	0.5020	0.5106	0.5264	0.5308	0.0044	0.5625
1/2-20 or 0.5625-20	UN	2A	0.0013	0.5612	0.5531	...	0.5287	0.5245	0.0042	0.5017	2B	0.508	0.520	0.5300	0.5355	0.0055	0.5625
		3A	0.0000	0.5625	0.5544	...	0.5300	0.5268	0.0032	0.5030	3B	0.5080	0.5162	0.5300	0.5341	0.0041	0.5625
1/2-24 or 0.5625-24	UNEF	2A	0.0012	0.5613	0.5541	...	0.5342	0.5303	0.0039	0.5117	2B	0.517	0.527	0.5354	0.5405	0.0051	0.5625
		3A	0.0000	0.5625	0.5553	...	0.5354	0.5325	0.0029	0.5129	3B	0.5170	0.5244	0.5354	0.5392	0.0038	0.5625
1/2-28 or 0.5625-28	UN	2A	0.0011	0.5614	0.5549	...	0.5382	0.5345	0.0037	0.5188	2B	0.524	0.532	0.5393	0.5441	0.0048	0.5625
		3A	0.0000	0.5625	0.5560	...	0.5393	0.5365	0.0028	0.5199	3B	0.5240	0.5301	0.5393	0.5429	0.0036	0.5625
1/2-32 or 0.5625-32	UN	2A	0.0010	0.5615	0.5555	...	0.5412	0.5377	0.0035	0.5243	2B	0.529	0.536	0.5422	0.5467	0.0045	0.5625
		3A	0.0000	0.5625	0.5566	...	0.5422	0.5396	0.0026	0.5253	3B	0.5290	0.5344	0.5422	0.5456	0.0034	0.5625
5/8-11 or 0.625-11	UNC	1A	0.0016	0.6234	0.6052	...	0.5644	0.5561	0.0083	0.5152	1B	0.527	0.548	0.5660	0.5787	0.0107	0.6250
		2A	0.0016	0.6234	0.6113	0.6052	0.5644	0.5589	0.0055	0.5152	2B	0.527	0.548	0.5660	0.5732	0.0072	0.6250
		3A	0.0000	0.6250	0.6129	...	0.5660	0.5619	0.0041	0.5168	3B	0.5270	0.5391	0.5660	0.5714	0.0054	0.6250
5/8-12 or 0.625-12	UN	2A	0.0015	0.6234	0.6120	...	0.5693	0.5639	0.0054	0.5242	2B	0.535	0.553	0.5709	0.5780	0.0071	0.6250
		3A	0.0000	0.6250	0.6136	...	0.5709	0.5668	0.0041	0.5258	3B	0.5350	0.5483	0.5709	0.5762	0.0053	0.6250
5/8-16 or 0.625-16	UN	2A	0.0014	0.6236	0.6142	...	0.5830	0.5782	0.0048	0.5491	2B	0.557	0.571	0.5844	0.5906	0.0062	0.6250
		3A	0.0000	0.6250	0.6156	...	0.5844	0.5808	0.0036	0.5505	3B	0.5570	0.5652	0.5844	0.5890	0.0046	0.6250
5/8-18 or 0.625-18	UNF	1A	0.0014	0.6236	0.6105	...	0.5875	0.5805	0.0070	0.5575	1B	0.565	0.578	0.5889	0.5980	0.0091	0.6250
		2A	0.0014	0.6236	0.6149	...	0.5875	0.5828	0.0047	0.5575	2B	0.565	0.578	0.5889	0.5949	0.0060	0.6250
		3A	0.0000	0.6250	0.6163	...	0.5889	0.5854	0.0035	0.5589	3B	0.5650	0.5730	0.5889	0.5934	0.0045	0.6250

TABLE 7

TABLE 8 PITCH DIAMETER DIMENSIONS

I. D. #	Pitch Diameter Johnson Gage			Pitch Diameter Three Wires Method			Max. Deviation from B1.1	
	Reading 1	Reading 2	Reading 3	Reading 1	Reading 2	Reading 3	Johnson Gages	Three Wires Method
5	0.5580*	0.5587	0.5588	0.5578*	0.5582	0.5583	-0.0009"	-0.0011"
11	0.5577	0.5574*	0.5578	0.5579	0.5580	0.5578*	-0.0015"	-0.0011"
16	0.5554*	0.5576	0.5576	0.5582	0.5580	0.5569*	-0.0035"	-0.0020"
23	0.5582*	0.5584	0.5588	0.5578*	0.5579	0.5578	-0.0007"	-0.0011"
31	0.5616	0.5613	0.5615	0.5609	0.5614	0.5614	-----	-----

* Identifies the maximum out of tolerance measured.
B1.1 Pitch diameter limits: 0.5589 (Min), 0.5644 (MAX)

TABLE 8

ATLAS TESTING LABORATORIES, INC.

A SUBSIDIARY OF ANALYSTS, INC.

6929 E SLAUSON AVE • COMMERCE, CA 90040 • (213) 722-8810

CHEMISTS — METALLURGISTS — ENGINEERS

Table 9.

AT

IN ACCOUNT WITH

SOUTHERN CALIFORNIA EDISON
5000 PACIFIC COAST HWY.
SAN CLEMENTE, CA 92672

DATE 5/4/94

CUSTOMER ORDER NO.

CUSTOMER SHIPPER NO.

LABORATORY NO. 405813

IDENTIFIED Stud-5/8"-11 UNC-2A

PART NO.

Submitted As:

MATERIAL AISI 4140 Steel

SPECIFICATION ASME SA193
ASTM A193

HEAT TREATING CO.

WITNESSED BY Gr. B7

MECHANICAL TEST REPORT

	ACTUAL SIZE	ACTUAL AREA	YIELD STRENGTH: ACTUAL LOAD IN LBS.	YIELD STRENGTH: POUNDS PER SQ. INCH	TENSILE STRENGTH: ACTUAL LOAD IN LBS.	TENSILE STRENGTH: POUNDS PER SQ. INCH	ELONGATION IN 1"	ELONGATION PERCENT	REDUCED DIMENSION	REDUCTION OF AREA PERCENT	HARDNESS
	TENSILE TEST (Machined Cpns.)										
1	.250	.0491	6,900	140,500	7,500	152,700	.21	21.0	.158	60.0	
2	.255	.0510	7,200	141,200	7,800	152,900	.19	19.0	.160	60.0	
3	.254	.0506	7,050	139,500	7,680	151,800	.22	22.0	.160	60.0	
	AXIAL TENSILE (Full Size)										
#1		.226	*31,000	137,200	34,100[a]	150,900		Location of Fracture Middle of Exposed Section			
MAXIMUM REQUIREMENTS											
MINIMUM REQUIREMENTS				105,000		125,000		16.0%		50.0%	

Test Method: ASTM-F606 & ASTM-E8

(a)Maximum load to fracture
* Approximate yielding load

YIELD STRENGTH AT .2% Offset

REMARKS: Conforms to requirements.

Code:
- ☐ (F) Indicates flaw
- ☐ (G) " broke outside gauge mark
- ☐ (@) " broke at gauge mark

SUBSCRIBED AND SWORN TO BEFORE ME THIS

_____ DAY OF _____ 19____

_____ NOTARY PUBLIC

IN AND FOR THE COUNTY OF LOS ANGELES, STATE OF CALIFORNIA

ATLAS TESTING LABORATORIES, INC. JULY 7, 1955 CALIFORNIA

RESPECTFULLY SUBMITTED

ATLAS TESTING LABORATORIES, INC.

TABLE 9

ATLAS TESTING LABORATORIES, INC.
A SUBSIDIARY OF ANALYSTS, INC.
6929 E SLAUSON AVE. • COMMERCE, CA 90040 • (213) 722-8810
CHEMISTS — METALLURGISTS — ENGINEERS

ar
IN ACCOUNT WITH

Table 10

SOUTHERN CALIFORNIA EDISON
5000 PACIFIC COAST HWY.
SAN CLEMENTE, CA 92672

DATE	5/4/94	CUSTOMER ORDER NO.	CUSTOMER SHIPPER NO.
LABORATORY NO.	405813	IDENTIFIED Stud-5/8"-11 UNC-2A	PART NO.
MATERIAL	AISI 4140 Steel		SPECIFICATION

SAMPLE #2:

Proof loaded to 20,650 pounds (based on 87% of the minimum 2% offset yield of the material which is 105 ksi)

Result: Permanent deformation is 0.0004-inch; maximum allowable 0.0005-inch (pass)

Test Method: ASTM-F606 para. 3.2.3 Method 1, length measurement.

REMARKS: For information only.

SUBSCRIBED AND SWORN TO BEFORE ME THIS
_____ DAY OF _____ 19____

_____ NOTARY PUBLIC
IN AND FOR THE COUNTY OF LOS ANGELES, STATE OF CALIFORNIA

ATLAS TESTING LABORATORIES, INC. — JULY 7, 1995 — CALIFORNIA

RESPECTFULLY SUBMITTED
ATLAS TESTING LABORATORIES, INC.

TABLE 10

ATLAS TESTING LABORATORIES, INC.
A SUBSIDIARY OF ANALYSTS, INC.
6929 E SLAUSON AVE • COMMERCE, CA 90040 • (213) 722-8810
CHEMISTS — METALLURGISTS — ENGINEERS

IN ACCOUNT WITH

SOUTHERN CALIFORNIA EDISON
5000 PACIFIC COAST HWY.
SAN CLEMENTE, CA 92672

Table 11

DATE	5/4/94	CUSTOMER ORDER NO.	CUSTOMER SHIPPER NO.
LABORATORY NO.	405813	IDENTIFIED Stud-5/8"-11 UNC-2A	PART NO.
MATERIAL	Submitted As: AISI 4140 Steel		SPECIFICATION

SAMPLE #3:

Proof loaded to 20,650 pounds (based on 87% of the minimum 2% offset yield of the material which is 105 ksi)

Result: Permanent deformation is 0.00045-inch; maximum allowable 0.0005-inch ; (pass)

Test Method: ASTM-F606 para. 3.2.3 Method 1, length measurement.

REMARKS: For information only.

SUBSCRIBED AND SWORN TO BEFORE ME THIS
_____ DAY OF _____, 19____

_____ NOTARY PUBLIC
IN AND FOR THE COUNTY OF LOS ANGELES, STATE OF CALIFORNIA

ATLAS TESTING LABORATORIES, INC. JULY 7, 1995 CALIFORNIA

RESPECTFULLY SUBMITTED
ATLAS TESTING LABORATORIES, INC.

TABLE 11

ATLAS TESTING LABORATORIES, INC.
A SUBSIDIARY OF ANALYSTS INC
6929 E. SLAUSON AVE. • COMMERCE, CA 90040 • (213) 722-8810
CHEMISTS — METALLURGISTS — ENGINEERS

ar
IN ACCOUNT WITH

SOUTHERN CALIFORNIA EDISON
5000 PACIFIC COAST HWY.
SAN CLEMENTE, CA 92672

Table 12.

DATE 5/4/94 CUSTOMER ORDER NO. CUSTOMER SHIPPER NO.

LABORATORY NO. 405813 IDENTIFIED Stud-5/8"-11 UNC-2A PART NO.

MATERIAL Submitted As: AISI 4140 STEEL SPECIFICATION ASTM-A 193 ASME-A193 Gr. B7

SAMPLE #1:

Proof loaded to 27,530 pounds (based on 87% of the actual 2% offset yield of the material which is 140 ksi) with 10-seconds hold-at-load.

Result: Permanent deformation is
0.0053-inch/ maximum allowable
0.0005 inch/(fail)

Proof loaded @ 20,650 pounds (based on 87% of the minimum 2% offset yield of the material which is 105 ksi)

Result: Permanent deformation is
0.0009-inch/ maximum allowable
0.0005-inch/ (fail)

Test Method: ASTM-F606 Pars.3.2.3 Method 1, length measurement

REMARKS: For information only.

UNCONVENTIONAL TEST
FOR INFORMATION ONLY

SUBSCRIBED AND SWORN TO BEFORE ME THIS
_____ DAY OF _____ 19____

_____ NOTARY PUBLIC
IN AND FOR THE COUNTY OF LOS ANGELES, STATE OF CALIFORNIA

ATLAS TESTING LABORATORIES, INC. CITY OF VERNON JULY 7, 1955 CALIFORNIA

RESPECTFULLY SUBMITTED

ATLAS TESTING LABORATORIES, INC.

TABLE 12