



February 24, 1988

Ms. C. M. Abbate  
Vendor Inspection Branch  
Office of Nuclear Reactor Regulation  
U.S. Nuclear Regulatory Commission  
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Rockville, MD 20852

TRANSMITTAL OF FINAL REPORT ON TEST OF SAFETY/RELATED THREADED FASTENERS -  
TASK ORDER 88-1 (FIN A6181) - BLB-23-88

- Ref: (a) R. D. Folker ltr to S. B. Milan, RFD-224-87, Transmittal of  
Revision 2 of the NRC Form 189 for Technical Assistance for  
Vendor Program Inspections (FIN A6181), October 1987  
(b) Task Order 88-1 Project 1, "Test of Safety Related Threaded  
Fasteners", October 20, 1987

Dear Ms. Abbate:

In accordance with FIN A6181, Reference (a), EG&G Idaho, Inc. is providing technical assistance to the Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation. This assistance involves the evaluation of vendor-related problems with hardware supplied to the nuclear industry. Task Order 88-1, Reference (b), required technical assistance on testing 18 threaded fasteners from the Rancho Seco Nuclear power plant.

The enclosed report satisfies the work scope requirements of Task Order 88-1 and EG&G Milestone Chart Node 144-46.

During the course of performing the fastener tests on samples RS-12, RS-13, RS-14, RS-15, RS-16, and RS-10 in accordance with ASTM specification A-193, M-86, Grade 8B, several problems were experienced relating to measurement of the Rockwell hardness of fasteners.

- ASTM A-193 does not define where on the fastener hardness measurements are to be taken. It should specify where these measurements are to be taken and list any options on location.
- ASTM A-193 implies that nowhere on the fastener should the Rockwell hardness exceed Rb 96. The wrenching flats on the heads of cold-headed Type B8 fasteners are not, and probably should be, excluded from the defined maximum hardness requirements since hardness values exceeding Rb 96 in the vicinity of the wrenching flats are probably desirable.



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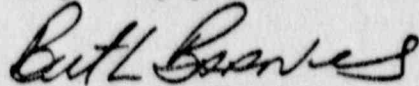
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While the problems described above were resolved by subjective judgements, the dilemma regarding accepting or rejecting fasteners could certainly yield widely varying results depending on who and how the test results are interpreted. It is also probable that the corresponding ASME material specifications are also deficient, since the ASME usually adopts ASTM specifications with few if any changes except to assign a new number.

Very truly yours,



B. L. Barnes, Manager  
Reactor Inspections & Safeguards

jm

cc: H. E. Polk, NRC/NRR  
J. O. Zane, EG&G Idaho (w/o Encl.)

TESTS OF SAFETY-RELATED THREADED FASTENERS  
FROM RANCHO SECO NUCLEAR POWER PLANT

1. INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Regulation, Vendor Inspection Branch submitted 13 cap screws, 4 studs, and 1 nut to EG&G Idaho, Inc., for testing. This assignment was authorized and funded by Task Order 88-1, FIN A6181, Project 1. Previously submitted individual test reports for threaded fasteners are included as an attachment.

2. TESTING AND ANALYSIS

In order to determine the acceptance standards for each threaded fastener, the identification grade marks on each fastener (Figures 1 through 20) were correlated with the grade marks and related specifications identified in the Industrial Fastener Institute's Fastener Standards. When the grade marks were not in accordance with the ASTM identification procedures, or the fastener was not identified with a grade mark, the ASTM specification that was identified in the NRC shipping document (Table 1), was used to evaluate the fastener. The results of this correlation are presented in Table 2. Not all of the requirements defined in the ASTM Standards were evaluated. For example, process requirements for the fasteners and the dimensional requirements for the threads were defined but not evaluated. The tests defined in the NRC Task Order were the tests that were accomplished.

2.1 Mechanical Tests

Tensile and hardness tests were conducted in accordance with ASTM A-370, Mechanical Testing of Steel Products, or ASTM F606, Method for Conducting Tests to Determine the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers and Rivets, which are the standards for mechanical testing of steel fasteners. The specific tests required and

the accept-reject criteria for each fastener were determined by reviewing the standard applicable to each grade of fastener.

### 2.1.1 Hardness Tests

Hardness tests were performed using a standard Rockwell hardness tester. Acceptable hardness machine performance was verified by performing hardness tests on certified test blocks prior to testing each fastener. A total of four hardness tests were performed on each fastener and an average hardness value was then calculated based on the four measurements. The results are reported in either Rockwell C or Rockwell B scale units.

### 2.1.2 Tensile Tests

Tensile tests were accomplished at Detroit Testing Laboratories, Inc., in accordance with ASTM A-370 using a 125,000 pound load capacity, Tinius-Olsen tensile test machine. Extensometer load versus deflection values were automatically recorded and retained for each tensile test. Full-size specimens were tested in accordance with ASTM F-606 and ultimate loads were determined. Standard one-half-inch round reduced length tensile specimens were machined and tested for fasteners RS-1, RS-2, RS-3, and RS-4 and elongations were determined in a 2.00-inch gauge length. Decreased length specimens were prepared for those fasteners that were too short for standard tensile specimens. Decreased length one-half-inch round reduced section tensile specimens were prepared for fasteners RS-11, RS-12, RS-16, RS-19 and RS-20. Decreased length three-eighths-inch round reduced section tensile specimens were prepared for fasteners RS-13, RS-14 and RS-15. Percent elongations in one inch were determined for decreased length specimens RS-11 and RS-16. Percent elongations in one-half inch were determined for specimens RS-12, RS-13, RS-14, RS-15, and RS-19.

### 2.2 Chemical Analysis

Samples for chemical analysis were machined from each threaded fastener and the analysis was accomplished at National Spectrographics Laboratories. The specific elements required for product analysis are

defined in the ASTM standard that is specified for each fastener, and only the results obtained for the required elements are reported in the individual fastener reports. The reproducibility of the chemical analyses results reported by National Spectrographic Laboratories were within  $\pm 5\%$ .

### 3. DISCUSSION OF RESULTS

A review of the test results revealed the following significant findings:

- Fasteners RS-1 and RS-4 met the chemical and mechanical requirements of ASTM Standard A-193, Grade B-7.
- Fastener RS-2 had a reported elongation value of 15%; whereas, ASTM Standard A-193, Grade B-7 requires a minimum elongation value of 16%.
- Fastener RS-3 had a reported ultimate tensile strength of 123.3 Ksi; whereas, ASTM Standard A-193, Grade B-7 required a minimum ultimate tensile strength value of 125 Ksi.
- Fasteners RS-5 and RS-6 met the chemical and mechanical requirements of ASTM Standard A-449 type 1.
- Fastener RS-7 met the chemical requirements of SAE Standard J-429, Grade 8.
- Fasteners RS-8, RS-9, and RS-10 met the chemical and mechanical requirements of ASTM Standard A-354, Grade BD. The initial carbon analysis of 0.27% for fastener RS-9 was within the analysis tolerance of  $\pm 5\%$  of the Standard's requirement of 0.28%. The carbon content was reanalyzed and reported as 0.30% which confirms the compliance with the minimum required carbon content of 0.28% for fastener RS-9.

- Fasteners RS-12 and RS-19 met the chemical and mechanical requirements of ASTM Standard A-193, Grade B8.
- Fasteners RS-12, RS-13, RS-14, RS-15, and RS-19 were after deliberation judged to meet the minimum evaluated requirements defined in ASTM A-193 M-86, Grade B8. However, fasteners RS-12, RS-13, RS-14, RS-15, RS-16 and RS-20 did not meet the maximum Rockwell hardness of Rb 96 that is specified in ASTM Standard A-193 M-86, Grade B8. The nonconforming hardness measurements were obtained on the wrenching flats of the heads. ASTM A-193 M-86, Grade B8 does not specify where hardness measurements are to be taken. As a second check on hardness of the nonconforming fasteners, the core hardness at the mid radius of a transverse section through the threaded area was determined after the tensile tests were completed. These core hardness test results were in conformance with the maximum specified Rockwell hardness of Rb 96. The dilemma presented by those fasteners having nonconforming wrenching flat head hardness and conforming thread area core hardness was resolved in favor of acceptable hardness by engineering judgement.
- Fastener RS-11 did not meet the maximum carbon content of 0.08% as defined in ASTM A-193 M86, Grade B8. The initial carbon analysis was 0.092% and the verification analysis was 0.082%.
- Fastener RS-16 did not meet the maximum carbon content of 0.08% and did not meet the minimum chromium content of 18.00% as defined in ASTM A-193 M86, Grade B8. The initial carbon analysis was 0.091% and the verification analysis was 0.093%. The initial chromium analysis was 17.7% and the verification analysis was 17.3%.
- Fastener RS-20 did not meet the maximum carbon content of 0.08% as defined in ASTM A-193 M86, Grade B8. The ~~initial carbon~~ analysis was 0.10% and the verification analysis was 0.099%.

#### 4. SUMMARY OF RESULTS

- Fasteners RS-2, RS-3, RS-11, RS-16, and RS-20 did not meet the minimum defined requirements.
- Fasteners RS-1, RS-4, RS-5, RS-6, RS-7, RS-8, RS-9, RS-10, RS-12, RS-13, RS-14, RS-15, and RS-19 met the minimum defined requirements evaluated.

TABLE 1. INFORMATION ON RANCHO SECO BOLT-STUD TEST SAMPLES SUBMITTED BY NRC (Shipping Document)

<u>ID</u>	<u>Material Stock Code</u>	<u>Bin Location</u>	<u>Grade Mark</u>	<u>Class</u>	<u>Description</u>
RS1	042223	A39L09	✓ SA 193 B7	II	Stud
RS2	042223	A39L09	✓ SA 193 B7	II	Stud
RS3	042222	A39L09	✓ SA 193 B7	II	Stud
RS4	042222	A39L09	✓ SA 193 B7	II	Stud
RS5	026736	A41F21	✓ A449 ✓	II	Cap Screw
RS6	026736	A41F21	✓ A449 ✓	II	Cap Screw
RS7	110340	G02B06	SAE Gr 8	I/2	Nut
RS8	009025	A39J05	SAE Gr 8 <sup>c</sup>	II	Cap Screw
RS9	009025	A39J05	SAE Gr 8 <sup>c</sup>	II	Cap Screw
RS10	009025	A39J05	SAE Gr 8 <sup>c</sup>	II	Cap Screw
RS11	008932	A39G09	304 SS	II	Cap Screw
RS12	103118	A39F08	304 SS	I/2	Cap Screw
RS13	103103	A39C07	304 SS	I/2	Cap Screw
RS14	103103	A39C07	304 SS	I/2	Cap Screw
RS15	103103	A39C07	304 SS	I/2	Cap Screw
RS16	008932	A39G09	304 SS	II	Cap Screw
RS17 <sup>a</sup>	Warehouse	-- <sup>b</sup>	SA 193 B7	II	Cap Screw
RS18 <sup>a</sup>	Warehouse	-- <sup>b</sup>	SA 193 B7	II	Cap Screw
RS19	008928	--	304	II	Cap Screw
RS20	103118	--	304	I	Cap Screw

a. RS17 and RS18 held until further notice.

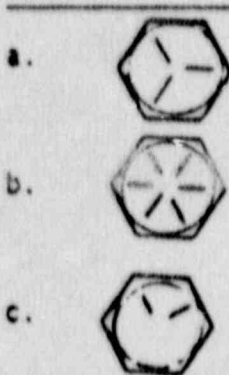
b. GRS Quarantined.

c. See note d on Table 2.



TABLE 2. HEAD MARKINGS AND REQUIRED ASTM STANDARDS FOR FASTENERS SUBMITTED FOR EVALUATION

Sample Identification	Head Marking	ASTM Standard <sup>d</sup>
RS-1	B-7C, H1	/A-193 Grade B-7
RS-2	B-7C, H1	/A-193 Grade B-7
RS-3	B-7C, Y5	/A-193 Grade B-7
RS-4	B-7C, Y5	/A-193 Grade B-7
RS-5	-- <sup>a</sup> , B $\bar{I}$ S	/A-449
RS-6	-- <sup>a</sup> , B $\bar{I}$ S	/A-449
RS-7	Blue plastic thread locking insert	/SAE J-429, Grade 8 <sup>d</sup>
RS-8	-- <sup>b</sup> , CSS	/A-354 Grade BD
RS-9	-- <sup>b</sup> , CSS	/A-354 Grade BD
RS-10	-- <sup>b</sup> , CSS	/A-354 Grade BD
RS-11	-- <sup>c</sup>	A-193 Grade B8
RS-12	-- <sup>c</sup>	A-193 Grade B8
RS-13	N	A-193 Grade B8
RS-14	N	A-193 Grade B8
RS-15	N	A-193 Grade B8
RS-16	-- <sup>c</sup>	A-193 Grade B9
RS-19	N 304	A-193 Grade B8
RS-20	-- <sup>c</sup>	A-193 Grade B8



d. Where possible, ASTM specifications were used to evaluate all fasteners herein even though in many cases SAE, ASME, and other specifications are equivalent. Based upon the head markings, RS-8, RS-9, and RS-10 could have been evaluated against either ASTM A-354, Grade BD or against SAE Grade 8. The former of these was arbitrarily selected. Sample RS-7 was the only exception; this fastener was evaluated against an SAE specification.

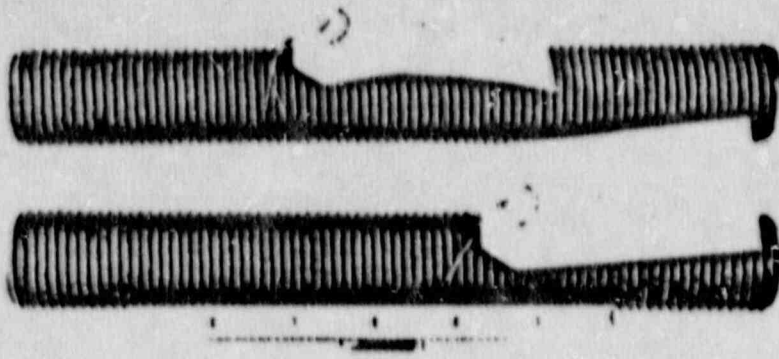


Figure 1. Photograph of studs RS-1 and RS-2.



Figure 2. Photomicrograph at 1.5 magnifications of the identification marks on studs RS-1 and RS-2.

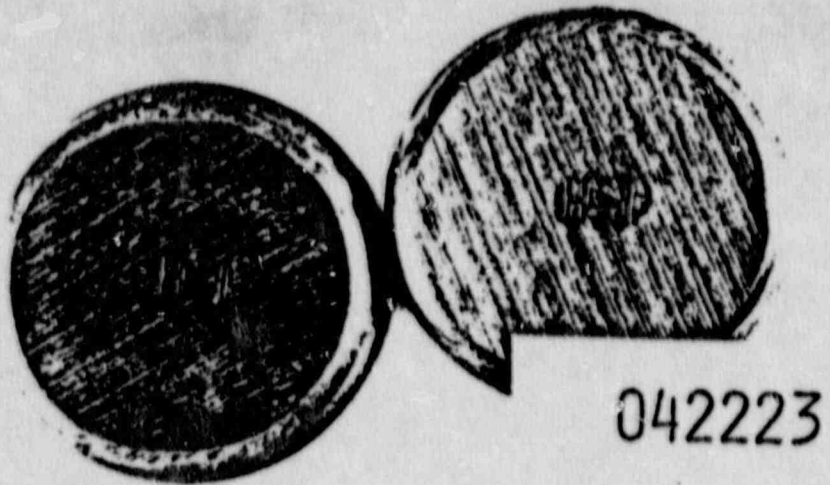


Figure 3. Photomicrograph at 1.5 magnifications of the identification marks on studs RS-1 and RS-2.

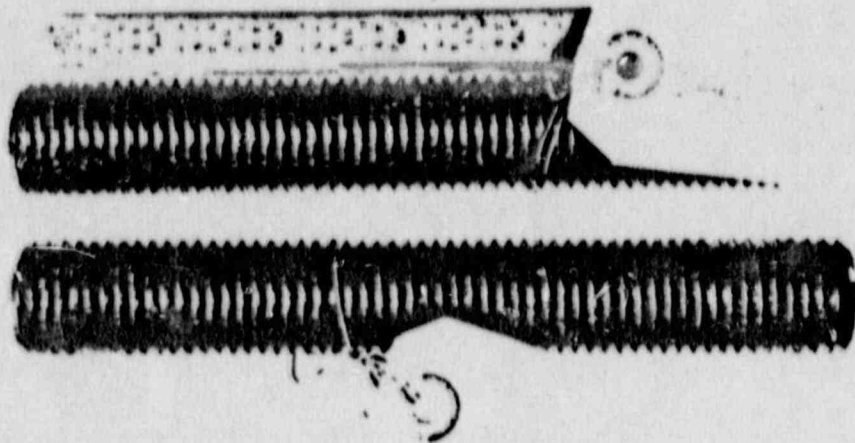


Figure 4. Photograph of studs RS-3 and RS-4.



Figure 5. Photomicrographs at 1.2 magnifications of the identification marks on studs RS-3 and RS-4.



Figure 6. Photomicrograph at 1.2 magnifications of the identification marks on studs RS-3 and RS-4.

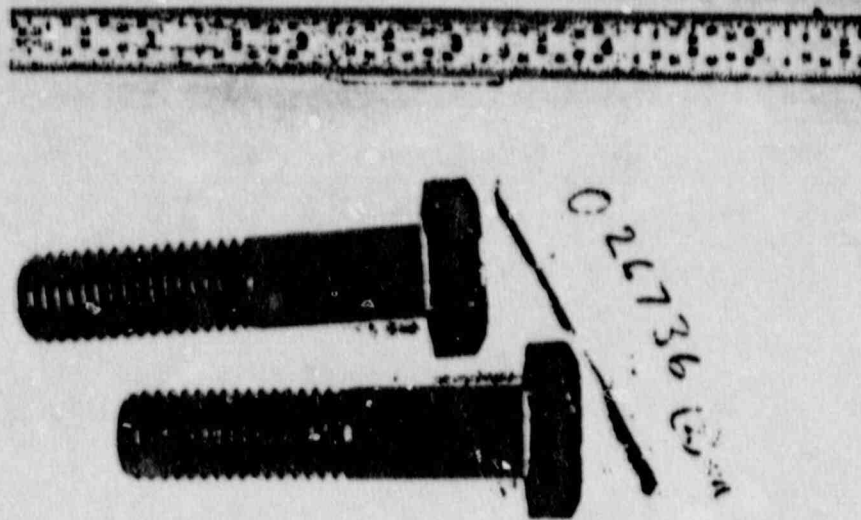
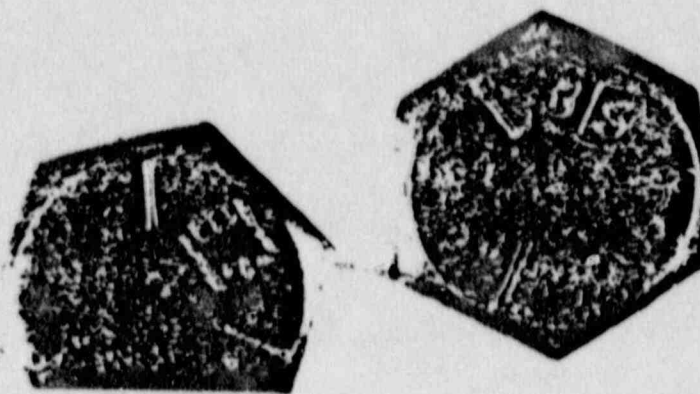


Figure 7. Photograph of cap screws RS-5 and RS-6.



026736

Figure 8. Photomicrograph at 1.5 magnifications of the identification marks on cap screws RS-5 and RS-6.



110340



Figure 9. Photograph of nut RS-7.

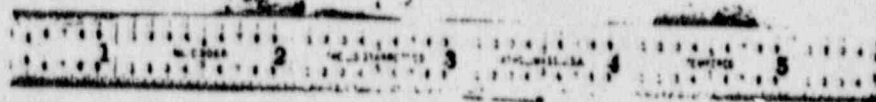


Figure 10. Photograph of nut RS-7.

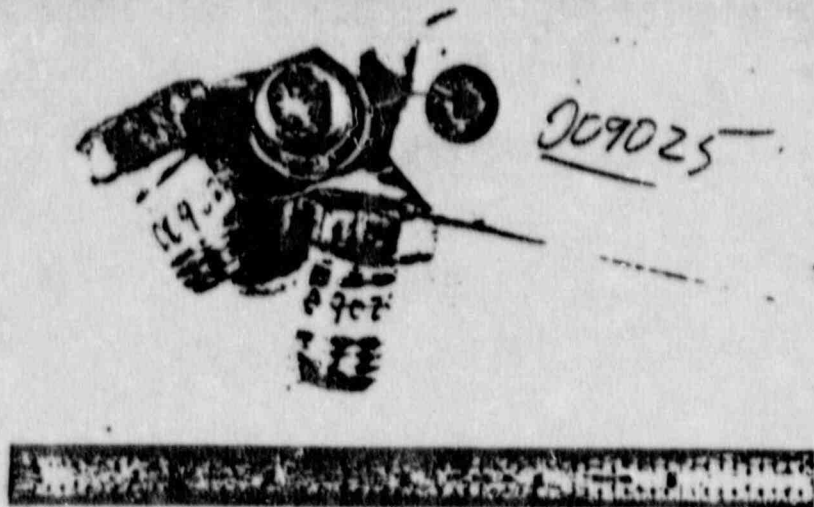


Figure 11. Photograph of cap screws RS-8, RS-9, and RS-10.



Figure 12. Photomicrographs at 1.6 magnifications of the identification marks on cap screws RS-8, RS-9, and RS-10.

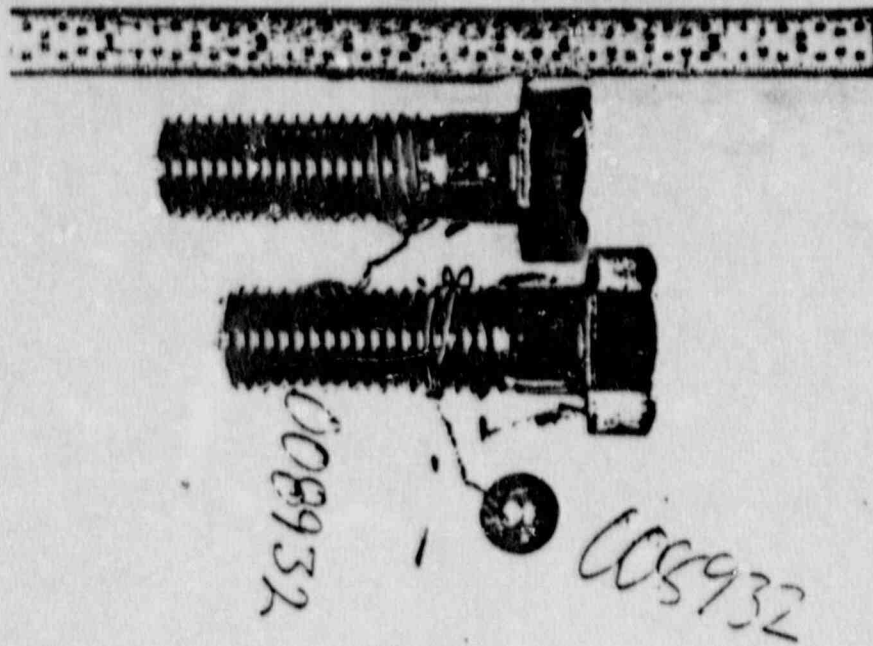


Figure 13. Photographs of cap screws RS-11 and RS-16.



Figure 14. Photomicrograph at 1.5 magnifications of cap screws RS-11 and RS-16.



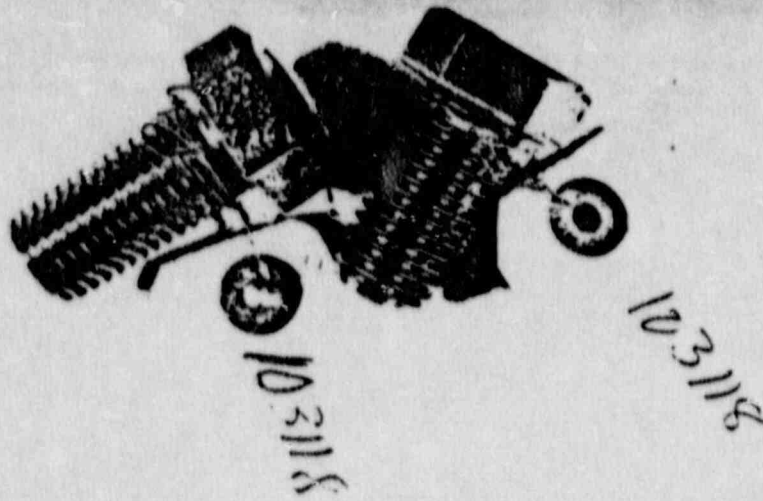


Figure 15. Photographs of cap screws RS-12 and RS-20.

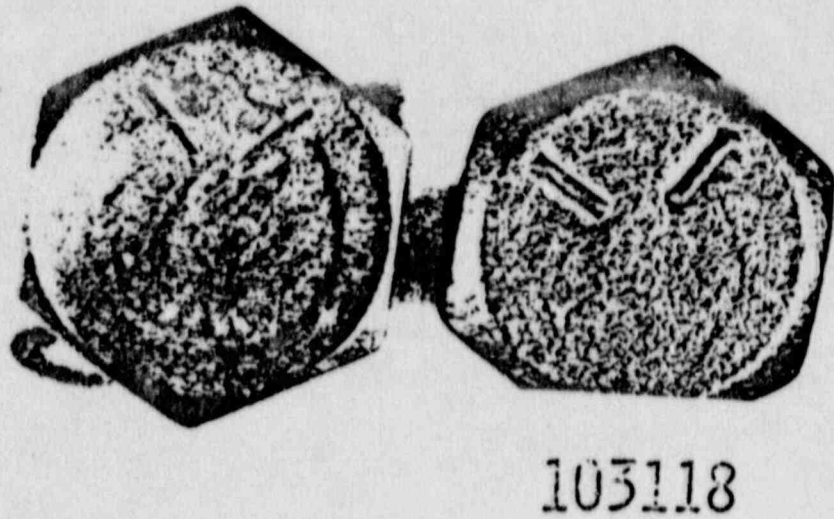


Figure 16. Photomicrograph at 1.5 magnifications of cap screws RS-12 and RS-20.

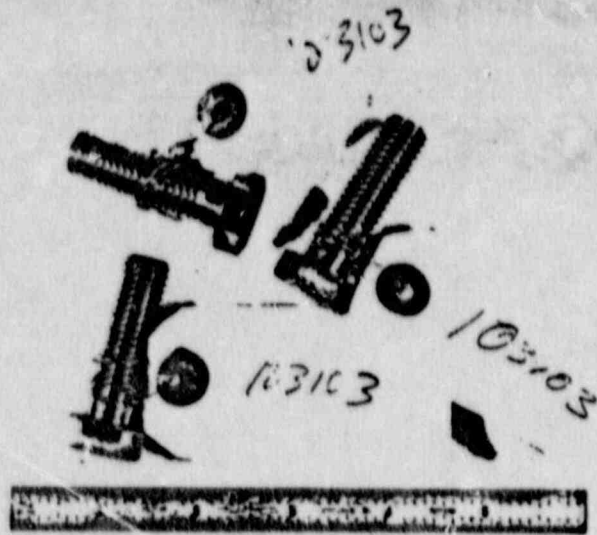


Figure 17. Photograph of cap screws RS-13, RS-14, and RS-15.

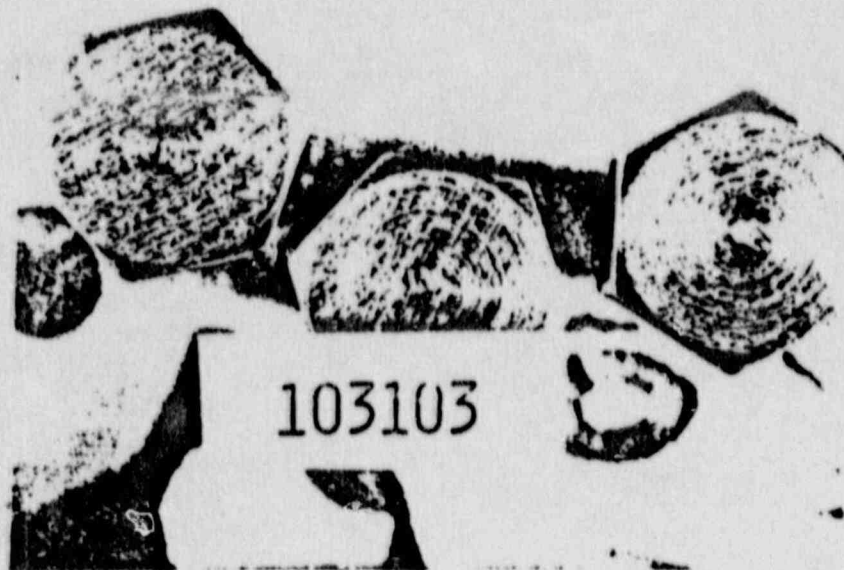
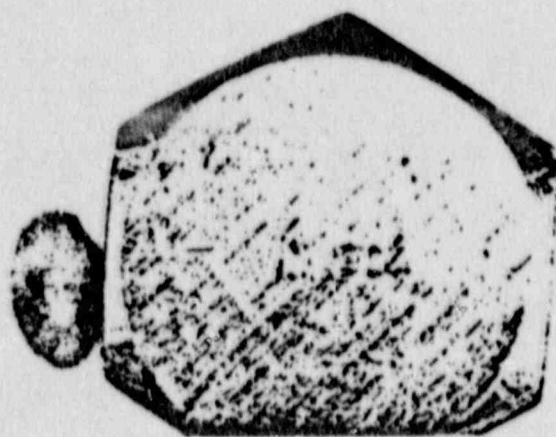


Figure 18. Photomicrograph at 1.5 magnifications of cap screws RS-13, RS-14, and RS-15.



Figure 19. Photograph of cap screw RS-19.



008928

Figure 20. Photograph at 1.6 magnifications of cap screw RS-19.

ATTACHMENT

(Individual Test Reports for Threaded Fasteners)

Sample Identification: RS-1  
Source: Rancho Seco  
Sample Type: Stud  
Size: 1-1/4 inch dia. x 8 threads/in. x 9-1/2 in. overall length  
Identification Grade Mark: B7C  
ASTM Standard: A-193 Grade B-7

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon - 0.37 - 0.49	0.40
Chromium - 0.75 - 1.20	1.00
Manganese - 0.65 - 1.10	0.79
Molybdenum - 0.15 - 0.25	0.15
Silicon - 0.15 - 0.35	0.26
Phosphorus - less than 0.035	0.018
Sulfur - less than 0.040	0.017

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Strength - 125 Ksi	152.6 Ksi
0.2% Offset Yield Strength - 105 Ksi	142.3 Ksi
Elongation - 16%	17%
Reduction in area - 50%	52%
Hardness - not specified	Rc 33-34

Remarks:

Fastener meets the minimum evaluated requirements defined in ASTM A-449-86  
Type 1

Sample Identification: RS-2  
Source: Rancho Seco  
Sample Type: Stud  
Size: 1-1/4 inch dia. x 8 threads/in. x 9-1/2 in. overall length  
Identification Grade Mark: B7C  
ASTM Standard: A-193 Grade B-7

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon - 0.37 - 0.49	0.40
Chromium - 0.75 - 1.20	1.00
Manganese - 0.65 - 1.10	0.77
Molybdenum - 0.15 - 0.25	0.15
Silicon - 0.15 - 0.35	0.24
Phosphorus - less than 0.035	0.018
Sulfur - less than 0.040	0.019

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Strength - 125 Ksi	125.3 Ksi
0.2% Offset Yield Strength - 105 Ksi	123.0 Ksi
+ Elongation - 16%	15%
Reduction in area - 50%	54%
Hardness - not specified	Rc 26-28

Remarks:

Fastener does not meet the minimum elongation requirements defined in ASTM A-193 M-86 Grade B-7.

+Indicates that results are not within specification limits.

Sample Identification: RS-3  
Source: Rancho Seco  
Sample Type: Stud  
Size: 1 inch dia. x 8 threads/in. x 7 in. overall length  
Identification Grade Mark: B7C  
ASTM Standard: A-193 Grade B-7

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon - 0.37 - 0.49	0.40
Chromium - 0.75 - 1.20	0.86
Manganese - 0.65 - 1.10	0.90
Molybdenum - 0.15 - 0.25	0.20
Silicon - 0.15 - 0.35	0.22
Phosphorus - less than 0.035	0.011
Sulfur - less than 0.040	0.024

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

+ Ultimate Tensile Strength - 125 Ksi	123.3 Ksi
0.2% offset Yield Strength - 105 Ksi	110.4 Ksi
Elongation - 16%	21%
Reduction in area - 50%	61%
Hardness - not specified	Rc 26-28

Remarks:

Fastener does not meet the minimum ultimate tensile strength requirements defined in ASTM A-193 M-86 Grade B-7.

+Indicates test results not within specification limits.

Sample Identification: RS-4  
Source: Rancho Seco  
Sample Type: Stud  
Size: 1 inch dia. x 8 threads/in. x 7 in. overall length  
Identification Grade Mark: B7C  
ASTM Standard: A-193 Grade B-7

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon - 0.37 - 0.49	0.40
Chromium - 0.75 - 1.20	0.84
Manganese - 0.65 - 1.10	0.93
Molybdenum - 0.15 - 0.25	0.20
Silicon - 0.15 - 0.35	0.22
Phosphorus - less than 0.35	0.011
Sulfur - less than 0.040	0.023

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Strength - 125 Ksi	126.8 Ksi
0.2% Offset Yield Strength - 105 Ksi	114.2 Ksi
Elongation - 16%	22%
Reduction in area - 50%	61%
Hardness - not specified	Rc 27-28

Remarks:

Fastener meets the minimum evaluated requirements defined in ASTM A-193 M06 Grade B7.



Sample Identification: RS-5  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 5/8 inch dia. x 11 threads/in. x 2-11/16 in. shank length  
Identification Grade Mark:  
ASTM Standard: A-449 Type 1

CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon 0.25 - 0.58	0.38
Manganese - not less than 0.57	0.76
Phosphorus - not more than 0.048	0.010
Sulfur - not more than 0.058	0.012
Boron - not controlled	less than 0.0005

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Load - 27,100 lbs	32,300 lbs
Proof Load - 19,200 lbs	Acceptable
Maximum Rockwell Hardness - Rc 34	Rc 23-26

Remarks:

Fastener meets the minimum evaluated requirements defined in ASTM A-449-86 Type 1.

Sample Identification: RS-6  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 5/8 inch dia. x 11 threads/in. x 2-11/16 in. shank length  
Identification Grade Mark:  
ASTM Standard: A-449 Type 1

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon - 0.25 - 0.58	0.38
Manganese - not less than 0.57	0.75
Phosphorus - not more than 0.048	0.008
Sulfur - not more than 0.058	0.012
Boron - not controlled	less than 0.0005

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Load - 27,100 lbs	31,600 lbs
Proof Load - 19,200 lbs	Acceptable
Maximum Rockwell Hardness - Rc 34	Rc 23-27

Remarks:

Fastener meets the minimum evaluated requirements defined in ASTM A-449-86 Type 1.

Sample Identification: RS-7  
Source: Rancho Seco  
Sample Type: Nut, self locking  
Size: 1-1/2 inch dia. x 12 threads/in.  
Identification Grade Mark: Blue nylon insert (See Table 2)  
SAE Standard: SAE J-429 Grade 8

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon 0.28 - 0.55	0.44
Phosphorus less than 0.070	0.025
Sulfur less than 0.045	0.020
Boron not controlled	less than 0.0005

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Hardness not specified

Rb 97-100

Remarks:

Fastener meets the minimum evaluated requirements defined in SAE J-429 Aug. 83 Grade 8.

Sample Identification: RS-8  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 5/8 inch dia. x 11 threads/in. x 1 in. shank length  
Identification Grade Mark:  
ASTM Standard: A-354 Grade BD

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon 0.28 - 0.55	0.28
Phosphorus less than 0.040	0.010
Sulfur less than 0.045	0.005

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Load - 33,900 lbs	36,100 lbs
Proof Load - 27,100 lbs	Acceptable
Hardness Rockwell - Rc 26-36	Rc 34-35

Remarks:

Fastener meets the minimum evaluated requirements defined in ASTM A-354 Grade BD.

Sample Identification: RS-9  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 5/8 inch dia. x 11 threads/in. x 1 in. shank length  
Identification Grade Mark:  
ASTM Standard: A-354 Grade BD

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon 0.28 - 0.55  
Phosphorus less than 0.040  
Sulfur less than 0.045

0.27 and 0.30\*  
0.010  
0.024

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Load - 33,900 lbs  
Proof Load - 27,100 lbs  
Hardness - Rockwell C 26-36

36,100 lbs  
Acceptable  
Rc 33-36

Remarks:

Fastener meets the minimum evaluated requirements defined in ASTM A-354 Grade BD.

\*Carbon verification analysis was 0.30%.

Sample Identification: RS-10  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 5/8 inch dia. x 11 threads/in. x 1 in. shank length  
Identification Grade Mark:  
ASTM Standard: A-354 Grade BD

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon - 0.28 - 0.55	0.28
Phosphorus less than 0.040	0.012
Sulfur less than 0.045	0.024

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Load - 33,900 lbs	37,400 lbs
Proof Load - 27,100 lbs	Acceptable
Hardness - Rockwell C 26-36	Rc 33-35

Remarks:

Fastener meets the minimum evaluated requirements defined in ASTM A-354 Grade BD.

Sample Identification: RS-11  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 3/4 inch dia. x 10 threads/in. x 2-1/2 in. shank length  
Identification Grade Mark: B8  
ASTM Standard: A-193 Grade B-8

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

<del>Carbon - less than 0.08</del>	<del>0.092 and 0.082 **</del>
Chromium - 18.00 - 20.00	18.3
Nickel - 8.00 - 10.50	8.42
Manganese - less than 2.00	1.15
Phosphorus - less than 0.045	0.027
Silicon - less than 1.00	0.61
Sulfur - less than 0.030	0.009

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Strength - 75 Ksi	103.5 Ksi
0.2% Offset Yield Strength - 30 Ksi	76.1 Ksi
Elongation - 30%	51% *
Reduction in area - 50%	70%
Maximum Rockwell Hardness - Rb 96	Rc 38-39 and Rb 93-95 **

Remarks:

Fastener does not meet the chemical requirements defined in ASTM A-193 M-86 Grade B8.

+Indicates test results not within specification limits.

\*Elongation in 1.0 inch.

\*\*Internal hardness at the mid radius of a transverse section through the threaded section was determined to be Rb 93-95.

\*\*\*Carbon verification analysis was 0.082.

Sample Identification: RS-12  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 3/4 inch dia. x 10 threads/in. x 1-3/4 in. shank length  
Identification Grade Mark: (See Table 2):  
ASTM Standard: A-193 Grade B-8

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon - less than 0.08	0.063
Chromium - 18.00 - 20.00	18.47
Nickel - 8.00 10.50	8.86
Manganese - less than 2.00	1.56
Phosphorus - less than 0.045	0.030
Silicon - less than 1.00	0.68
Sulfur - less than 0.030	0.012

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Strength - 75 Ksi	95.8 Ksi
0.2% Offset Yield Strength - 30 Ksi	63.7 Ksi
Elongation - 30%	92% *
Reduction in area - 50%	75%
Maximum Rockwell Hardness - Rb 96	Rb 87-91

Remarks:

Fastener meets the minimum evaluated requirements defined in ASTM A-193 M-86 Grade B-8.

\*Elongation in 0.5 inch.



Sample Identification: RS-13  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 1/2 inch dia. x 13 threads/in. x 1-3/4 in. shank length  
Identification Grade Mark: N (See Table 2)  
ASTM Standard: A-193 Grade B-8

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon - less than 0.08	0.060
Chromium - 18.00 - 20.00	18.67
Nickel - 8.00 - 10.50	8.01
Manganese - less than 2.00	0.98
Phosphorus - less than 0.045	0.028
Silicon - less than 1.00	0.90
Sulfur - less than 0.030	0.026

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Strength - 75 Ksi	110.4 Ksi
0.2% Offset Yield Strength - 30 Ksi	69.6 Ksi
Elongation - 30%	84% *
Reduction in area - 50%	76%
Maximum Rockwell Hardness - Rb 96	Rc 27-28 and Rb 93-94 **

Remarks:

Fastener meets the minimum evaluated requirements defined in ASTM A-193 M80 Grade B8.

\*Elongation in 0.5 inch.

\*\*Internal hardness at the mid radius of a transverse section through the threaded area was determined to be Rb 93-94.

Sample Identification: RS-14  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 1/2 inch dia. x 13 threads/in. x 1-3/4 in. shank length  
Identification Grade Mark: N (See Table 2)  
ASTM Standard: A-193 Grade B-8

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon - less than 0.08	0.064
Chromium - 18.00 - 20.00	18.76
Nickel - 8.00 - 10.50	8.10
Manganese - less than 2.00	0.96
Phosphorus - less than 0.045	0.029
Silicon - less than 1.00	0.84
Sulfur - less than 0.030	0.026

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Strength - 75 Ksi	119.6 Ksi
0.2% Offset Yield Strength - 30 Ksi	80.4 Ksi
Elongation - 30%	68% *
Reduction in area - 50%	70%
Maximum Rockwell Hardness - Rb 96	Rc 26-27 and Rb 92-95**

Remarks:

Fastener meets the minimum evaluated requirement defined in ASTM B-193 M-85 Grade B8.

\*Elongation in 1/2 inch.

\*\*Internal hardness at the mid radius of a transverse section through the threaded area was determined to be Rb 92-95.

Sample Identification: RS-15  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 1/2 inch dia. x 13 threads/in. x 1-3/4 in. shank length  
Identification Grade Mark: N (See Table 2)  
ASTM Standard: A-193 Grade B-8

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon - less than 0.08	0.061
Chromium - 18.00 - 20.00	18.71
Nickel - 8.00 - 10.50	8.02
Manganese - less than 2.00	0.97
Phosphorus - less than 0.045	0.025
Silicon - less than 1.00	0.75
Sulfur - less than 0.030	0.025

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Strength - 75 Ksi	117.5 Ksi
0.2% Offset Yield Strength - 30 Ksi	80.4 Ksi
Elongation - 30%	72% *
Reduction in Area - 50%	70%
Maximum Rockwell Hardness - Rb 96	Rc 29-30 and Rb 90-94**

Remarks:

Fastener meets the minimum evaluated requirement defined in ASTM A-193 M86 Grade BB

\*Elongation in 0.5 inch.

\*\*Internal hardness at the mid radius of a transverse section through the threaded area was RB 90-94.

Sample Identification: RS-16  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 3/4 inch dia. x 10 threads/in. x 2-1/2 in. shank length  
Identification Grade Mark: (See Table 2)  
ASTM Standard: A193 Grade B-8

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

* Carbon - less than 0.08	0.091 and 0.093 **
* Chromium - 18.00 - 20.00	17.7 and 17.3 ***
Nickel - 8.00 - 10.50	9.35
Manganese - less than 2.00	1.23
Phosphorus - less than 0.045	0.026
Silicon - less than 1.00	0.44
Sulfur - less than 0.030	
Molybdenum	0.41

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Strength - 75 Ksi	93.9 Ksi
0.2% Offset Yield Strength - 30 Ksi	74.4 Ksi
Elongation - 30%	51% *
Reduction in area - 50%	71%
+ Maximum Rockwell Hardness - Rb 96	Rc 35-36 Rb 90-91 ****

Remarks:

Fastener does not meet the chemical requirements as defined in ASTM A-193 M-86 Grade B8.

+Indicates the test results not within specification limits.

\*Elongation in 1.0 inch.

\*\* Carbon verification analysis was 0.093%.

\*\*\* Chromium verification analysis was 17.32%.

\*\*\*\* Internal hardness at the mid radius of a transverse section through the threaded area was Rb 90-91.

Sample Identification: RS-19  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 3/4 inch dia. x 10 threads/in. x 1-3/4 in. shank length  
Identification Grade Mark: N 304 (See Table 2)  
ASTM Standard: A-193 Grade B-8

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CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

Carbon - less than 0.08	0.062
Chromium - 18.00 - 20.00	18.55
Nickel - 8.00 - 10.50	8.27
Manganese - less than 2.00	1.27
Phosphorus - less than 0.045	0.015
Silicon - less than 1.00	0.55
Sulfur - less than 0.030	0.020

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Strength - 75 Ksi	97.5 Ksi
0.2% Offset Yield Strength - 30 Ksi	48.1 Ksi
Elongation - 30%	98% *
Reduction in area - 50%	74%
Maximum Rockwell Hardness - Rb 96	Rb 91-92

Remarks:

Fastener meets the minimum evaluated requirements defined in ASTM A-193  
M-86 Grade B8.

\*Elongation in 1.0 inch.

Sample Identification: RS-20  
Source: Rancho Seco  
Sample Type: Cap Screw  
Size: 3/4 inch dia. x 10 threads/in. x 1-7/16 in. shank length  
Identification Grade Mark: (See Table 2)  
ASTM Standard: A-193 Grade B-8

CHEMICAL COMPOSITION (wt%)

ASTM Chemical Specifications

Actual Chemical Analysis Results

*Carbon <del>less than 0.08</del>	<del>0.10 and 0.099</del>
Chromium - 18.00 - 20.00	18.15
Nickel - 8.00 - 10.50	8.65
Manganese - less than 2.00	1.22
Phosphorus - less than 0.045	0.023
Silicon - less than 1.00	0.57
Sulfur - less than 0.030	0.012

MECHANICAL PROPERTIES

Minimum ASTM Mechanical Specifications

Actual Mechanical Measurements

Ultimate Tensile Strength - 75 Ksi	99.4 Ksi *
0.2% Offset Yield Strength - 30 Ksi	83.9 Ksi
Elongation - 30%	**
Reduction in area - 50%	**
Maximum Rockwell Hardness - Rb 96	Rc 39 and Rb 90-97 ***

Remarks:

Fastener does not meet the minimum carbon requirements defined in ASTM A-193 M-86 Grade B8.

+Indicates the test results were not within specification limits.

\*Indicates maximum load, test was terminated before fracture.

\*\*Not determined, test was terminated before fracture.

\*\*\*Internal hardness at the mid radius of a transverse section through the threaded section was Rb 90-97.

\*\*\*\*Carbon content was initially reported by National Spectrographic Laboratories as 0.18% which was a typographical error. The carbon content should have been reported as 0.10%. The carbon verification analysis was 0.099%.