BROOKHAVEN NATIONAL LABORATORY
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Department of Nuclear Energy

Building 130

November 2, 1987

Mr. Edward Baker
U.S. Nuclear Regulatory Commission
I&E Vendor Programs Branch
Mail Stop EW/W-359
Washington, DC 20555

Ref: Bolt Testing

Dear Mr. Baker:

Enclosed are two copies of the test report on bolt characteristics performed by BNL. If there are any questions please contact Carl Czajkowski at 516-282-4420 or myself at the above listed phone number. The bolts passed all tests except chromium levels. This is not necessarily deleterious to performance, and should be discussed with Mr. Czajkowski.

As previously agreed upon, only the test results are presented, and no interpretation has been made.

Now that all test equipment is available, bolt testing can be conducted, and reports provided in less than six weeks time.

We are looking forward to doing additional work for the Vendor Branch.

Very truly yours,

John H. Taylor, Group Leader
Plant Systems and Equipment Analysis

JHT:af
Encl.

cc: R. Bari
C. Czajkowski
R. Hall
W. Kato
H. Kouts
W. Shier
File

A15

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

DATE: October 30, 1987

TO: John Taylor

FROM: Carl Czajkowski (FTS 666-4420) C Czajkowski

SUBJECT: USNRC Request for Testing of Bolting Materials

Attached please find the test reports for bolts identified as SO-18 through SO-28 (Figure 1). These bolts were subjected to hardness testing and wedge tensile testing in accordance with the following:

SO-18 through SO-25 - ASTM A 193-81a
ASTM A 370-77

SO-26 through SO-28 - ASTM A 325-81
ASTM F 606-79a

Additionally, a chemical analysis of alloying elements was performed on each of the bolts.

The results of the testing program were:

SO-18 - Meets mechanical requirements, exceeds chromium limits
SO-19 - Meets mechanical requirements, exceeds chromium limits
SO-20 - Meets mechanical requirements, exceeds chromium limits
SO-21 - Meets mechanical requirements, exceeds chromium limits
SO-22 - Meets mechanical and chemical specifications
SO-23 - Meets chemical requirements, exceeds maximum hardness
SO-24 - Meets mechanical and chemical specifications
SO-25 - Meets mechanical and chemical specifications
SO-26 - Meets mechanical and chemical specifications
SO-27 - Meets mechanical and chemical specifications
SO-28 - Meets mechanical and chemical specifications

This completes the task assigned to our group from your division. At this stage of the investigation, I am unsure of the route that our sponsors (USNRC) wish to take regarding additional testing of bolts which did not meet specification requirements (SO-18 through 21 and SO-23). I suggest that no additional testing take place until the NRC has reviewed the data and contacted BNL on which testing options they wish to pursue. If there are any questions, please contact me at the above number.

CC/ts
Attachments
cc: P. Soo (w/attachments)
M. Schuster " "
J. Svandrlik " "

TESTING OF 11 BOLTS

C. Czajkowski

October 30, 1987

Brookhaven National Laboratory
Department of Nuclear Energy
Nuclear Waste & Technology Division

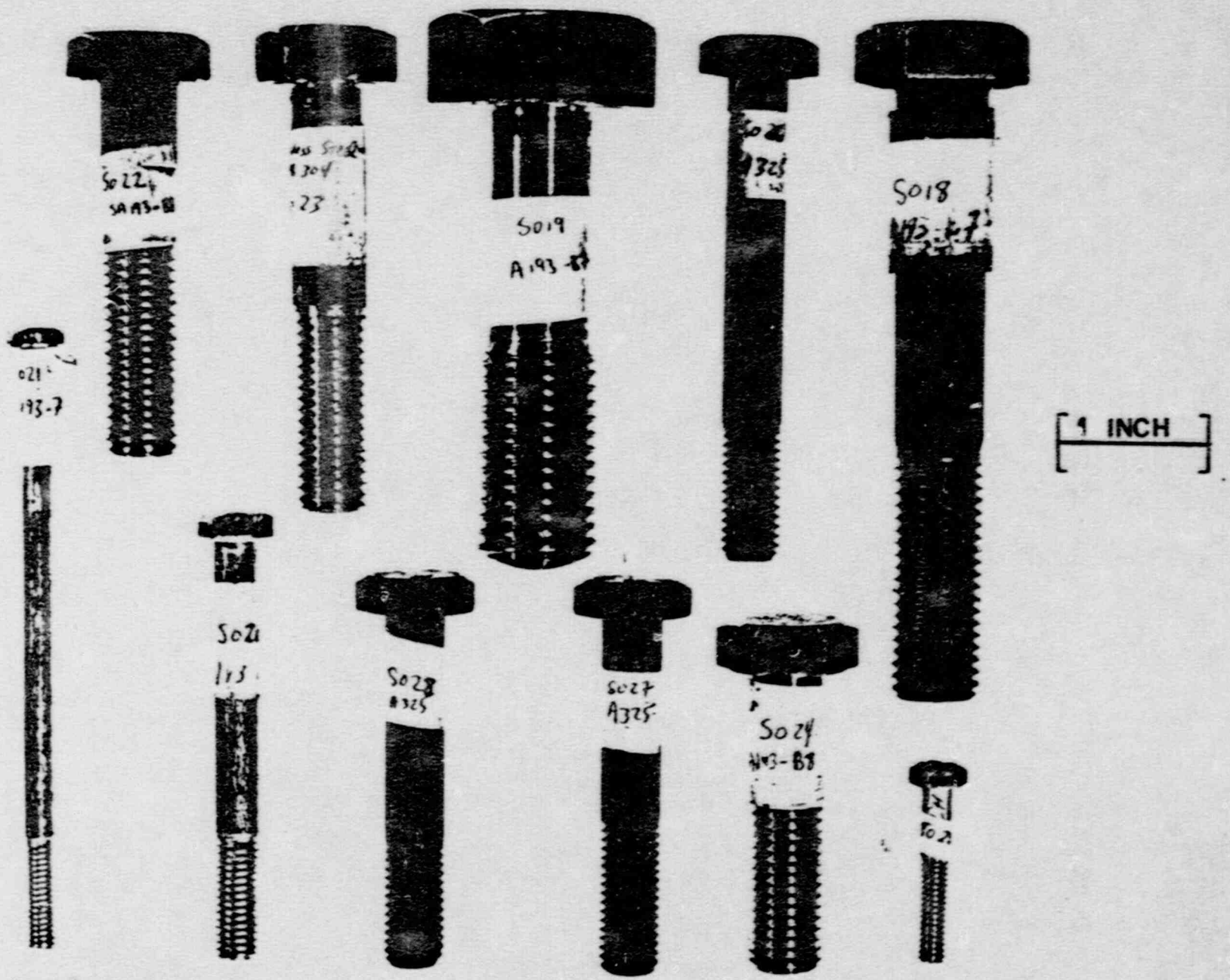

FIGURE 1 . PHOTOGRAPH OF

" AS RECEIVED " BOLTS.

BOLT IDENTIFICATION: SO-18 **BOLT SPECIFICATION:** A 193-B7

BOLT SIZE: 3/4 - 10 UNC

TENSILE STRENGTH:

Actual	Required by Specification
142.22 ksi	125 ksi (min.)

Failure Location - Threads

HARDNESS:

Actual	Required by Specification
59.16 R_A	Not Required

CHEMICAL ANALYSIS:

	Actual w/o	Required by Specification w/o
Carbon	0.34	0.37 - 0.49
Manganese	0.96	0.65 - 1.10
Phosphorus	0.12	0.035 max
Sulfur	0.006	0.040 max
Silicon	0.28	0.15 - 0.35
Chromium	1.55 (Note 1)	0.75 - 1.20
Nickel	0.06	-
Molybdenum	0.19	0.15 - 0.25
Vanadium	<0.05	-
Columbium + Tantalum	<0.05	-

< = Less than

COMMENTS: 1) Chromium value exceeds specification requirements even factoring in permissible variations (0.05% over)

BOLT IDENTIFICATION: SO-19 **BOLT SPECIFICATION:** A 193-B7

BOLT SIZE: 1" - 8 UNC

TENSILE STRENGTH:

Actual	Required by Specification
143.03 ksi	125 ksi (min.)

Failure Location - Shoulder

HARDNESS:

Actual	Required by Specification
27.6 R_c	Not Required

CHEMICAL ANALYSIS:

	Actual w/o	Required by Specification w/o
Carbon	0.40	0.37 - 0.49
Manganese	0.98	0.65 - 1.10
Phosphorus	0.005	0.035 max
Sulfur	0.016	0.040 max
Silicon	0.21	0.15 - 0.35
Chromium	1.80 (Note 1)	0.75 - 1.20
Nickel	0.34	-
Molybdenum	0.19	0.15 - 0.25
Vanadium	<0.05	-
Columbium + Tantalum	<0.05	-

< = Less than

COMMENTS: 1) Chromium value exceeds specification requirements even factoring in permissible variations (0.05% over)

BOLT IDENTIFICATION: SO-20 **BOLT SPECIFICATION:** A 193-B7

BOLT SIZE: 3/8" - 16 UNC

TENSILE STRENGTH:

Actual	Required by Specification
151.74 ksi	125 ksi (min.)

Failure Location - Threads

HARDNESS:

Actual	Required by Specification
23.83 R_C	Not Required

CHEMICAL ANALYSIS:

	Actual w/o	Required by Specification w/o
Carbon	0.41	0.37 - 0.49
Manganese	0.97	0.65 - 1.10
Phosphorus	<0.005	0.035 max
Sulfur	0.008	0.040 max
Silicon	0.27	0.15 - 0.35
Chromium	1.51 (Note 1)	0.75 - 1.20
Nickel	0.05	-
Molybdenum	0.22	0.15 - 0.25
Vanadium	<0.05	-
Columbium + Tantalum	<0.05	-

< = Less than

COMMENTS: 1) Chromium value exceeds specification requirements even factoring in permissible variations (0.05% over)

BOLT IDENTIFICATION: SO-21 **BOLT SPECIFICATION:** A 193-B7

BOLT SIZE: 1/4" - 20 UNC

TENSILE STRENGTH:

Actual	Required by Specification
158.80 ksi	125 ksi (min.)

Failure Location - Threads

HARDNESS:

Actual	Required by Specification
62.6 R_A	Not Required

CHEMICAL ANALYSIS:

	Actual w/o	Required by Specification w/o
Carbon	0.41	0.37 - 0.49
Manganese	0.94	0.65 - 1.10
Phosphorus	0.020	0.035 max
Sulfur	0.024	0.040 max
Silicon	0.27	0.15 - 0.35
Chromium	1.46 (Note 1)	0.75 - 1.20
Nickel	0.47	-
Molybdenum	0.23	0.15 - 0.25
Vanadium	<0.05	-
Columbium + Tantalum	<0.05	-

< = Less than

COMMENTS: 1) Chromium value exceeds specification requirements even factoring in permissible variations (0.05% over)

BOLT IDENTIFICATION: SO-22 **BOLT SPECIFICATION:** A 193-B8

BOLT SIZE: 5/8" - 11 UNC

TENSILE STRENGTH:

Actual	Required by Specification
98.14 ksi	75 ksi (min.)

Failure Location - Threads

HARDNESS:

Actual	Required by Specification
47 R_A	223 HB (max.)

(equates to 138 HB)

CHEMICAL ANALYSIS:

	Actual w/o	Required by Specification w/o
Carbon	0.06	0.08 max
Manganese	1.24	2.00 max
Phosphorus	0.030	0.045 max
Sulfur	0.033 (Note 1)	0.030 max
Silicon	0.40	1.00 max
Chromium	19.1	18.00 - 20.00
Nickel	8.8	8.00 - 10.50
Molybdenum	0.36	-
Vanadium	<0.05	-
Columbium + Tantalum	<0.05	-

< = Less than

COMMENTS: 1) Permissible variation for sulfur (0.005% over) by specification allows acceptance of this value.

BOLT IDENTIFICATION: SO-23 **BOLT SPECIFICATION:** A 193-B8

BOLT SIZE: 5/8" - 11 UNC

TENSILE STRENGTH:

Actual	Required by Specification
89.65 ksi	75 ksi (min.)

Failure Location - Threads

HARDNESS:

Actual	Required by Specification
63.6 R_A (Note 1)	223 HB (max.)
(equates to 262 HB)	

CHEMICAL ANALYSIS:

	Actual w/o	Required by Specification w/o
Carbon	0.06	0.08 max
Manganese	1.75	2.00 max
Phosphorus	0.050 (Note 1)	0.045 max
Sulfur	0.021	0.030 max
Silicon	0.72	1.00 max
Chromium	19.0	18.00 - 20.00
Nickel	9.0	8.00 - 10.50
Molybdenum	0.40	-
Vanadium	<0.05	-
Columbium + Tantalum	<0.05	-

< = Less than

COMMENTS: 1) Although specification allows a maximum hardness of 241 HB (A193), this bolt exceeds hardness maximum. 2) Permissible variation for phosphorus (0.010% over) by specification allows acceptance of this value.

BOLT IDENTIFICATION: SG-24 **BOLT SPECIFICATION:** A 193-B8

BOLT SIZE: 5/8" - 11 UNC

TENSILE STRENGTH:

Actual	Required by Specification
89.91 ksi	75 ksi (min.)

Failure Location - Threads

HARDNESS:

Actual	Required by Specification
61.3 R_A (Note 1)	223 HB (max.)
(equates to 234 HB)	

CHEMICAL ANALYSIS:

	Actual w/o	Required by Specification w/o
Carbon	0.05	0.08 max
Manganese	1.70	2.00 max
Phosphorus	0.020	0.045 max
Sulfur	0.025	0.030 max
Silicon	0.70	1.00 max
Chromium	19.3	18.00 - 20.00
Nickel	9.0	8.00 - 10.50
Molybdenum	0.42	-
Vanadium	<0.05	-
Columbium + Tantalum	<0.05	-

< = Less than

COMMENTS: 1) For bolt sizes 3/4 in. diameter and under, a maximum hardness of 241 HB is permitted (A193).

BOLT IDENTIFICATION: SO-25 **BOLT SPECIFICATION:** A 193-B8

BOLT SIZE: 1/4" - 20 UNC

TENSILE STRENGTH:

Actual	Required by Specification
114.46 ksi	75 ksi (min.)

Failure Location - Threads

HARDNESS:

Actual	Required by Specification
57.7 R_A	223 HB (max.)
(equates to 167 HB)	

CHEMICAL ANALYSIS:

	Actual w/o	Required by Specification w/o
Carbon	0.09 (Note 1)	0.08 max
Manganese	0.57	
Phosphorus	0.050 (Note 1)	0.045 max
Sulfur	0.021	0.030 max
Silicon	0.43	1.00 max
Chromium	19.3	18.00 - 20.00
Nickel	9.5	8.00 - 10.50
Molybdenum	0.36	-
Vanadium	<0.05	-
Columbium + Tantalum	<0.05	-

< = Less than

COMMENTS: 1) Permissible variations for both carbon (0.01% over) and phosphorus (0.010% over) by specification allows acceptance of these values.

BOLT IDENTIFICATION: SO-26 **BOLT SPECIFICATION:** A 325

BOLT SIZE: 1/2" - 13 UNC

TENSILE STRENGTH:

Actual	Required by Specification
144.3 ksi	120 ksi (min.)

Failure Location - Threads

HARDNESS:

Actual	Required by Specification
24.75 R_c	24 R_c min - 35 R_c max

(equates to 167 HB)

CHEMICAL ANALYSIS:

	Actual w/o	Required by Specification w/o
Carbon	0.33	0.27 min (Product)
Manganese	0.86	0.47 min (Product)
Phosphorus	0.008	0.048 max (Product)
Sulfur	0.013	0.058 max (Product)
Silicon	0.29	-
Chromium	0.08	-
Nickel	0.06	-
Molybdenum	<0.01	-
Vanadium	<0.05	-
Columbium + Tantalum	<0.05	-

< = Less than

COMMENTS: 1) Meets chemical requirements for Type 1 bolts.

BOLT IDENTIFICATION: SO-27 **BOLT SPECIFICATION:** A 325

BOLT SIZE: 1/2" - 13 UNC

TENSILE STRENGTH:

Actual	Required by Specification
133.17 ksi	120 ksi (min.)

Failure Location - Threads

HARDNESS:

Actual	Required by Specification
21.25 R_c (Note 1)	24 R_c min - 35 R_c max

CHEMICAL ANALYSIS:

	Actual w/o	Required by Specification w/o
Carbon	0.42 (Note 2)	0.27 min (Product)
Manganese	0.88	0.47 min (Product)
Phosphorus	0.005	0.048 max (Product)
Sulfur	0.025	0.058 max (Product)
Silicon	0.17	-
Chromium	<0.01	-
Nickel	0.08	-
Molybdenum	<0.01	-
Vanadium	<0.05	-
Columbium + Tantalum	<0.05	-

< = Less than

COMMENTS: 1) For bolts where both tensile and hardness tests are performed, acceptance shall be based on tensile results (in event of low hardness readings) - A 325. 2) Meets chemical requirements for Type 1 bolts.

BOLT IDENTIFICATION: SO-28 **BOLT SPECIFICATION:** A 325

BOLT SIZE: 1/2" - 13 UNC

TENSILE STRENGTH:

Actual	Required by Specification
141.48 ksi	120 ksi (min.)

Failure Location - Threads

HARDNESS:

Actual	Required by Specification
22 R_c (Note 1)	24 R_c min - 35 R_c max

CHEMICAL ANALYSIS:

	Actual w/o	Required by Specification w/o
Carbon	0.40 (Note 2)	0.27 min (Product)
Manganese	0.85	0.47 min (Product)
Phosphorus	<0.005	0.048 max (Product)
Sulfur	0.020	0.058 max (Product)
Silicon	0.21	-
Chromium	<0.01	-
Nickel	0.10	-
Molybdenum	<0.01	-
Vanadium	<0.05	-
Columbium + Tantalum	<0.05	-

< = Less than

COMMENTS: 1) For bolts where both tensile and hardness tests are performed, acceptance shall be based on tensile results (in event of low hardness readings) - A 325. 2) Meets chemical requirements for Type 1 bolts.