



# **11** TOWER OUTRIGGER BOOM ANCHOR RODS

(2011) – 4 Rods

Fabrication Process

# TABLE OF CONTENTSTower Outrigger Boom

#### 2011 TIMELINE

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#### ADDITIONAL DOCUMENTS

ASTM A123 ASTM A143 ASTM A153 ASTM A354 ASTM A490

Loca and	ition Item	Component Description	Rod (no head) or Bolt (with head)	Threads Cut or Rolled	Supplier	Diameter (in)	Overall Length (ft)	Overall Length (mm)	Quant Installed includi spare	ity I (not ing s)	De- Iumidified Zone?	Tighten Method	Final Tension (fraction of Fu or UTS)	Date Tension or Loading Complete	Date Re- Inspected (by 4/8/13)	Date Re- Inspected (by 4/23/13)	Date Re- Inspected (by 5/5/13)	Notes		
	1	E2 Shear Key - Connect to Concrete - Above Column, Under OBG [S1, S2]	rod	Cut	Dyson	3	17.2 10.0	5235 3035	60 36	- 96	No	Tension	0.7	3/5/2013	daily check	daily check	daily check	Tensioned to 0.75 Fy, with lockoff at ~ 0.7 Fu 32 of 96 rods broke after tensioning, then tension level lowered		
	2	E2 Shear Key - Connect to Concrete - Above Bent Cap, Under Crossbeam [S3, S4]	rod	Cut	Dyson	3	21.9	6676	96	- 192	No	Tension	0.7	4/1/2013	daily check	daily check	daily check	Tensioned to 0.75 Fy, with lockoff at ~ 0.7 Fu		
	L	E2 Bearing - Connect to Concrete - Under OBG [B1, B2, B3, B4]	rod	Cut	Dyson	3	22.6 22.2	6902 6777	64 32	102		Tension	0.7	4/9/2013	daily check	daily check	daily check	Tensioned to 0.75 Fy, with lockoff at ~ 0.7 Fu		
Keys		E2 Shear Key - Connect to OBG [S1, S2]	rod	Cut	Dyson	3	4.4	1337 537	96 64			<b>_</b> .			4/6/2013	4/17/13 to	- 10 10 0 1 0			
l Shear	3	E2 Shear Key - Connect to Crossbeam [S3, S4]	rod	Cut	Dyson	3	4.3 1.7	1312 512	96 64	96 64		Iension	0.7	9/12/2012	4/8/2013	4/23/13	5/3/2013	Tensioned to 0.75 Fy, with lockoff at ~ 0.7 Fu		
igs and	4	E2 Bearing - Connect to OBG [B1, B2, B3, B4]	rod	Cut	Dyson	2	3.6	1105	224		No	Tension	0.7	9/12/2012	4/6/2013	4/17/13 to 4/23/13	5/3/2013	Tensioned to 0.75 Fy, with lockoff at ~ 0.7 Fu		
E2 Bearin	5	E2 Bearing Assembly Bolts (Spherical Bushing Halves)	rod	Cut	Dyson for Lubrite for Hochang	1	2.4	733	96		96		No	Tension	0.61	July 2009	not accessible	not accessible	not accessible	Connect 2 halves of the spherical bushing assembly housing together at Lubrite; rods are internal to bearings and <b>all rods are not</b> <b>accessible</b> after bearing assembly at Hochang (December 2009 & January 2010); rods tensioned to 0.7 Fy.
e	6	E2 Bearing Assembly Bolts (Retaining Rings)	Socket Head Cap Screw	Cut	Dyson for Hochang	1	0.2	55	336	;	No	snug + 1/4 turn	~0.4	January 2010	4/6/2013 (for 32 accessible bolts)	4/23/2013 (for 32 accessible bolts)	5/3/2013 (for 32 accessible bolts)	Bolts thread into drill and tap holes to attach retaining rings that secure the Lubrite spherical bushing assembly in the bottom housing; bolts are mechanically galvanized, not hot dip galvanized; bolts are internal to bearings and not accessible after bearing assembly at Hochang, except for a small number of bolts in limited areas -> 32 of 336 bolts are accessible.		
ge				55 Cut									0.26	9/26/2012	4/6/2013	4/20&22/2013	5/4/2013	With DL after load transfer (current condition)		
able	7	PWS Anchor Rods - PWS Socket to	rod	(20%)	Dyson	3-1/2	27.9 to 31.8	8500 to	274		Yes	Load	0.29	N/A	N/A	N/A	N/A	With DL + Added DL		
nch Ci		Anchorage		219 Rolled		•		9700				Transfer	0.32	N/A	N/A	N/A	N/A	Service Load (Group 1)		
٩				(0078)									0.35	N/A	N/A	N/A	N/A	SEE (Seismic)		
	8	Tower Saddle Tie Rods	rod	Rolled	Dyson	4	6.0 to 17.5	1840 to	25		Yes	Tension	0.41	7/14/2012	N/A	N/A	N/A	Load During Construction - Tensioned to 0.5 Fy		
						2 @ Throadc		5525					0.08	N/A	4/6/2013	4/19/2013	5/3/2013	Additional tension in the rods from cable with service load		
ver	9	Turned Rods at Tower Saddle Segment Splices	rod	Cut	Dyson	[~3-1/16 @ Shank]	1.5 1.4	463 415	100 8	00         108         Yes         108           8         108         Yes         108           90         Head Yes, Nut No         108		108 Yes		Tension snug	0.45 ~0.1	4/6/2011 7/14/2012	4/6/2013	4/19/2013	5/3/2013	segments; 100 rods tensioned prior to saddle erection; 8 rods only snug tight after tie rod tensioning due to conflict with tie rods.
o of Tov	10	Tower Saddle to Grillage Anchor Bolts	Hex Bolt	Cut	Dyson	3	1.2	360	90			snug	~0.1	3/25/2013	4/6/2013	4/19/2013	5/3/2013	Snug tightened before and after load transfer: Initial Tensic complete on 5/20/2011; final tension complete on 3/25/201		
	<mark>11</mark>	Tower Outrigger Boom (for Maintenance) at Top of Tower	(Hex Bolt	Cut	Dyson	3	<mark>2.1</mark>	<mark>630</mark>	4		No	(snug)	<mark>~0.1</mark> )	July 2012	<mark>4/6/2013</mark>	<mark>4/19/2013</mark>	<mark>5/4/2013</mark>	Act as pins for swinging out and then securing the maintenance outrigger boom at the top of 2 of 4 tower head chimneys. At each boom, one bolt is loaded and other bolt is unloaded in the current boom position. The currently unloaded bolt will be installed snug tight when the boom is swung out for use (future position).		
om of wer	12	Tower Anchor Rods - Tower at Footing (3" Dia)	rod	Cut	Vulcan Threaded Products	3	25.6	7789	388		Yes	Tension	0.48	4/17/2013	N/A	4/20/2013 4/22/2013	5/5/2013	Tensioned to 1800 kN = 404.7 kips; Tension before and after load transfer: Initial Tension Late 2010 through Early 2011; Final Tension 2013		
Botto To	13	Tower Anchor Rods - Tower at Footing (4" Dia)	rod	Cut	for KOS for KFM (04-0120E4)	4	25.7	7839	36		Yes	Tension	0.37	4/17/2013	N/A	4/20/2013 4/22/2013	5/5/2013	Tensioned to 2530 kN = 568.8 kips; Tension before and after load transfer: Initial Tension Late 2010 through Early 2011; Final Tension 2013		
ast dles	14	East Saddle Anchor Rods	rod	Cut	Dyson for JSW	2	2.6	800	32		Yes	snug	~0.1	May 2010	4/7/2013	4/21/2013	5/3/2013	specified gap under nut/washer at one end of rod and 2 nuts snug against each other at other end of rod -> snug tight for portion of rod		
Sad	15	Fast Saddle Tie Rods	Hex Bolt	Cut	Dyson	3	47	1420	18		Yes	snua	~0.1	4/13/2012	N/A	N/A	N/A	Snug tightened before load transfer		
	10		TICK DOIL	Out	Byson	Ŭ		1420	10		100	ondg	0.2	N/A	4/7/2013	4/21/2013	5/3/2013	Additional tension in tie rods from cable with service load		
East Cable	16	B14 Cable Bands - Cable Brackets - at East End of Bridge - Strongback Anchor Rods	rod	Rolled	Dyson	3	10.3 to 11.1	3129 to 3372	24		No	Tension	0.16	2/8/2013	4/7/2013	4/21/2013	5/4/2013	pre-compress neoprene between strongback and cable band		
W2 Bent Cap	17	W2 Bikepath Anchor Rods	rod	Cut	Dyson	~1-3/16 [Metric M30]	1.5	460	43		No	Not Dete	rmined Yet	N/A	N/A	N/A	N/A	Details for bikepath connections are being redesigned and are not final. The 18 anchor rods at the bottom connections will be abandoned. The 25 anchor rods at the top connections will be used and supplemented with additional anchor rods. These rods will be tensioned on the separate YBITS-2 Contract.		
	Total = 2306 New information after 5/6/2013 Update is highlighted Red												ation after 5/6/	2013 Update	is highlighted	Red				





STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION

# NOTICE TO CONTRACTORS AND

# **SPECIAL PROVISIONS**

### FOR CONSTRUCTION ON STATE HIGHWAY IN

SAN FRANCISCO COUNTY IN SAN FRANCISCO

FROM 0.6 KM TO 1.3 KM EAST OF THE YERBA BUENA TUNNEL EAST PORTAL

**DISTRICT 04, ROUTE 80** 

For Use in Connection with Standard Specifications Dated JULY 1999, Standard Plans Dated JULY 1999, and Labor Surcharge and Equipment Rental Rates.

> CONTRACT NO. 04-0120F4 04-SF-80-13.2/13.9

Bids Open: February 1, 2006 Dated: August 1, 2005

OSD

persons or entities hired by subcontractors who will provide other services or materials for the project, and shall have the following:

- A. A tensile testing machine capable of breaking the largest size of reinforcing bar to be tested.
- B. Operators who have received formal training for performing the testing requirements of ASTM Designation: A 970/A 970M.
- C. A record of annual calibration of testing equipment performed by an independent third party that has 1) standards that are traceable to the National Institute of Standards and Technology, and 2) a formal reporting procedure, including published test forms.

The Engineer shall be notified in writing when any lots of headed bar reinforcement are ready for testing. The notification shall include the number of lots to be tested and the location where the tests are to be conducted. After notification has been received, test samples will be randomly selected by the Engineer from each production lot of headed bar reinforcement which is ready for shipment to the jobsite. If epoxy coating is required, test samples will be taken after the headed bar reinforcement has been prepared for epoxy coating. The Engineer will be at the testing site within a maximum of one week after receiving written notification that the samples are at the testing site and ready for testing. In the event the Engineer fails to be present at the testing site within the time allowed, and if, in the opinion of the Engineer, completion of the work is delayed or interfered with by failure of the Engineer to be present at the testing site, the Contractor will be compensated for any resulting loss in the same manner as provided for in Section 8-1.09, "Right of Way Delays," of the Standard Specifications.

A minimum of 3 samples from each production lot shall be tested. One tensile test shall be conducted on each sample.

Tensile tests shall conform to the requirements specified in ASTM Designation: A 970/A 970M, Section 7, except that at rupture, there shall be visible signs of necking in the reinforcing bar 1) at a minimum distance of one bar diameter away from the head to bar connection for friction welded headed bar reinforcement, or 2) outside the affected zone for integrally forged headed bar reinforcement.

The affected zone for integrally forged headed bar reinforcement is the portion of the reinforcing bar where any properties of the bar, including the physical, metallurgical, or material characteristics, have been altered during the manufacturing process.

If one of the test specimens fails to meet the specified requirements, one retest shall be performed on one additional sample, selected by the Engineer, from the same production lot. If the additional test specimen, or if more than one of the original test specimens fail to meet these requirements, all headed bar reinforcement in the lot represented by the tests will be rejected in conformance with the provisions in Section 6-1.04, "Defective Materials," of the Standard Specifications.

A Production Test Report for all testing performed on each lot shall be prepared by the independent testing laboratory and submitted to the Engineer as specified herein. The report shall be signed by an engineer who represents the laboratory and is registered as a Civil Engineer in the State of California. The report shall include the following information for each set: contract number, bridge number, lot number, bar size, type of headed bar reinforcement, physical conditions of test sample, any notable defects, limits of affected zone, location of visible necking area, and the ultimate strength of each headed bar.

Each unit of headed bar reinforcement in a production lot to be shipped to the site shall be tagged in a manner such that production lots can be accurately identified at the jobsite. All unidentified headed bar reinforcement received at the jobsite will be rejected.

#### MEASUREMENT AND PAYMENT

Full compensation for headed bar reinforcement shall be considered as included in the contract price paid per kilogram for bar reinforcing steel (bridge) and no separate payment will be made therefor.

Full compensation for epoxy-coated headed bar reinforcement shall be considered as included in the contract price paid per kilogram for bar reinforcing steel (epoxy-coated) (bridge) and no separate payment will be made therefor.

#### **10-1.59 STEEL STRUCTURES**

Construction of steel structures shall conform to the provisions in Section 55, "Steel Structures," of the Standard Specifications and these special provisions.

Fabricators and suppliers shall be certified under the AISC Quality Certification Program, Category Cbr, Major Steel Bridges, with endorsement F, Fracture Critical members, except that certification will not be required for fabrication of the tower strut façade and tower skirt. Alternatively, ISO 9001:2000 certification standard may be substituted for the AISC Quality Certification Program.

Details of box girder and crossbeam connections shall conform to the AASHTO Standard Specifications for Highway Bridges, unless otherwise shown on the plans.

Attention is directed to "Accelerated Working Drawings Submittal," of these special provisions.

Contract No. 04-0120F4 297 A. Minimum tension shall be verified using the "Pre-Installation Verification Turn-of-the-Nut Method," of the "Structural Bolting Handbook," published by the Steel Structures Technology Center, Incorporated, except that the required rotation shall be as given in Table 8.2. of this section and the required tension shall be as shown in the following table:

	Required Tension, I	*
Bolt Size, mm	A325M Bolts	A490M Bolts
M16	96 000	120 000
M20	149 000	188 000
M22	185 000	232 000
M24	215 000	270 000
M27	280 000	351 000
M30	342 000	428 000
M36	499 000	625 000
*The above values for design, actual installa	are 5% higher than the req tion and inspection, rounder	uired pretension values used d to the nearest kN.

#### Pre-Installation Verification Required Tension N\*

B. Rotational-capacity tests in accordance with the requirements in Section 11.5.6.4.2 "Rotational-Capacity Tests," of the AASHTO LRFD Bridge Construction Specifications, except that Table 11.5.6.4.1-2 "Nut Rotation from the Snug Condition," is replaced by Table 8.2. of this section.

Test results shall confirm both the minimum bolt tension and the rotational capacity of the bolts. If either test fails, the Contractor shall modify the nut rotation in Table 8.2. of this section until the requirements of both tests are satisfied. No adjustment in compensation will be allowed for modifications to the nut rotations as necessary to satisfy test requirements. Revisions to Table 8.2. shall be approved by the Engineer prior to bolting operations.

The Engineer will randomly sample and perform quality assurance testing of high strength fasteners. Samples will be obtained at locations chosen by the Engineer. The Contractor shall provide the number of bolts specified below to the Engineer for quality assurance testing:

Bolt Sampling	Size
Lot Size	Sample Size
(No. of Bolts)	(No. of Bolts)
2 to 15	3
16 to 25	4
26 to 50	5
51 to 90	7
91 to 150	8
151 to 280	9
281 to 10,000	12
10,001 to 500,000	16
500,001 and over	20

Steel fasteners, designated on the plans as A 354, Grade BC, and A 354, Grade BD, shall conform to the requirements of ASTM Designation: A 354. Steel fastener components for steel fasteners designated as A 354 shall include a bolt, nut and hardened washer. Nuts for steel fasteners designated as A 354 shall conform to Section 55-2.01, "Description," of the Standard Specifications.

Steel fasteners designated on the plans as A 354, Grade BD shall be dry blast cleaned in accordance with the provisions of Surface Preparation Specification No. 10, "Near White Blast Cleaning," of the "SSPC: The Society for Protective Coatings.

Steel fasteners designated on the plans as A 354, Grade BC, and A 354, Grade BD, shall be galvanized in accordance with the requirements in Section 75-1.05, "Galvanizing," of the Standard Specifications and shall conform to the requirements in ASTM Designation: A123 for bolts and ASTM Designation: A153 for nuts and hardware. Steel fastener assemblies designated as A354, Grade BD, shall be galvanized within 4 hours of being dry blast cleaned.

## The Contractor shall submit certified test reports showing that the A 354, Grade BD fasteners conform to the provisions in ASTM Designation: A 143.

Steel fasteners, designated on the plans as A 354, Grade BC, and A 354, Grade BD, shall conform to the requirements of ASTM Designation: A 354. Steel fastener components for steel fasteners designated as A 354 shall include a bolt, nut and hardened washer. Nuts for steel fasteners designated as A 354 shall conform to Section 55-2.01, "Description," of the Standard Specifications. Nuts shall be zinc coated and be furnished with a dry lubricant conforming to Supplementary Requirement S1 and S2 in ASTM Designation: A 563.

Steel fasteners designated on the plans as A 354, Grade BD shall be tensioned not less than the value shown on the plans. Prior to installation, the Contractor shall submit to the Engineer for approval the methods and equipment to be used to tension steel fasteners designated as A354, Grade BD in accordance with Section 55-1.02, "Drawings," of the Standard Specifications. Working drawings shall include methods and equipment to be used to evaluate: 1) the presence of a lubricant, 2) the efficiency of the lubricant, and 3) the compatibility of the high strength steel bolt, nut and hardened washer.

Except where sub-punching is permitted, bolt holes shall be drilled or reamed, unless otherwise shown on the plans.

#### Punching

The first paragraph of Section 55-3.14A(1) "Punching," of the Standard Specifications shall not apply.

Punching or sub-punching of Grade 250 structural steel where the material is thicker than 16 mm will not be permitted. Punching or sub-punching of high-strength structural steel where the material is thicker than 12 mm will not be permitted.

#### **Prestressing High-Strength Bolts**

High-strength A354 bolts shall be tensioned by means of hydraulic jacks so that the force in the bolts shall not be less than the value shown on the plans.

The maximum temporary tensile stress (jacking stress) in high-strength bolts shall not exceed 75 percent of the specified minimum ultimate tensile strength of the material. Prestressing forces in high-strength bolts shall consider all losses, including creep of steel, losses due to sequence of stressing, and other losses specific to the method or system of prestressing used by the Contractor.

Hydraulic jacks used for prestressing high-strength bolts shall be calibrated in accordance with the requirements in Section 50-1.08, "Prestressing," of the Standard Specifications.

Final prestressing high strength A354 bolts at the tower anchorage shall be performed after the full dead load is transferred to the cable system.

#### ASSEMBLY

The method of erection of the suspended structure and tower shall be determined by the Contractor to meet the seismic design load criteria and ensure control of box girder and tower deflections due to wind induced oscillations.

The Contractor shall carry out the necessary structural analyses for the erection procedure to demonstrate the adequacy of the procedure. Details of these analyses and of any supplementary damping or other measures shall be submitted to the Engineer for review and approval.

Wind pressure effects during erection shall be calculated using a gust wind appropriate to a return period of not less than 25 years and shall allow for variation of speed with height per ANSI ASCE 7-95. The 25-year wind corresponds to a 77 mph one-hour average wind speed (and a corresponding 3-second gust wind speed of 100 mph) at deck elevation of 50 meters, as well as a critical flutter wind speed threshold of 112 mph based on a 1000-year return period. The Contractor shall provide temporary connections between adjacent lift sections in order to ensure sufficient torsional stiffness of the suspended structure. The Contractor shall also provide the proper support of the suspended structure during all stages of erection. The Contractor shall similarly ensure control of tower deflections due to wind-induced oscillations at all stages of erection and shall provide holdback stays or other damping devices as necessary. All such temporary measures shall be approved by the Engineer.

Wind design loads may be reduced during lifting operations.

Seismic loading during erection shall conform to the seismic loading requirements specified in "TEMPORARY TOWERS," subsection "TEMPORARY TOWER DESIGN," subsection "Seismic Design Loads," of these special provisions.

The erection procedure shall be such that the maximum stresses in any part of the permanent structure do not cause any permanent deformation or damage. Appropriate values of loads and safety factors for erection loading conditions shall be submitted by the Contractor to the Engineer for review and approval.

The details of any fastenings which the Contractor may require in any part of the permanent works for erection, and the procedure for their removal, shall be submitted to the Engineer for approval.

#### Tower

Tower lifts shall be in lengths as indicated on the plans. Exterior plates of the tower shafts shall be fabricated with direction of rolling aligned along the vertical direction of the tower. Within each lift, the number of transverse splices of the Contract No. 04-0120F4





DEPARTMENT OF TRANSPORTATION - District 4 Toll Bridge Program 333 Burma Rd. Oakland, CA 94607 (510) 622-5660, (510) 286-0550 fax



August 24, 2007

Contract No. 04-0120F4 04-SF-80-13.2 / 13.9 Self-Anchored Suspension Bridge Letter No. 05.03.01-000487

Michael Flowers Project Executive American Bridge/Fluor Enterprises, a JV 375 Burma Road Oakland, CA 94607

Dear Michael Flowers,

#### **Department Audit of Dyson Corporation**

The Department has reviewed ABF letter 257, dated August 14, 2007, and the "Corrective Action Request" from the Dyson Corporation, dated August 09, 2007. Based upon the information provided and in accordance with Special Provisions section 8-4, "Audits," the Dyson Corporation receives a "Pass" for the Department audit. This "Pass" applies only to the Dyson Corporation. Suppliers and subcontractors to the Dyson Corporation are subject to separate MFSQA reviews and audits. The following table summarizes the current status of associated audits:

Company	Letter No.	Date of Notice	MFSQA	AUDIT
AAA Galvanizing	321	06-18-2007	Approved	
	336	06-22-2007	Approved	
Art Galvanizing	403	07-25-2007		Contingent Pass
	320	06-18-2007	Approved	
Central Testing Lab	413	07-26-2007		Fail
Custom Industrial Processing	325	06-18-2007	Not Approved	
Industrial Coatings Inc	444	08-06-2007	Approved	
	361	07-05-2007	Approved	
Mechanical Galv-Plating Corp	432	08-02-2007		Pass
	337	06-22-2007	Approved	
North American Galvanizing	421	07-31-2007		Fail
	297	06-06-2007	Approved	
Stork Herron Testing Lab	417	07-30-2007		Contingent Pass
TC Industries	367	07-09-2007	Approved	
	296	06-06-2007	Approved	
Tensile Testing Metallurgical Lab	409	07-26-2007		Pass
Universal Galvanizing	338	06-25-2007	Approved	

American Bridge/Fluor Enterprises, a JV August 24, 2007 Page 2 of 2

The Contractor is reminded that work may not proceed at the facilities receiving a "Contingent Pass," until the outstanding issues detailed in the Department's letters have been addressed.

If you have any further questions, please contact Gary Lai at the Working Drawing Campus.

Sincerely,

Dusell

GARY PURSELL Resident Engineer

cc: Rick Morrow Mazen Wahbeh

file: 05.03.01, 55.0097

DEPARTMENT OF TRANSPORTATION - District 4 Toll Bridge Program 333 Burma Rd. Oakland, CA 94607 (510) 622-5660, (510) 286-0550 fax



February 13, 2009

Contract No. 04-0120F4 04-SF-80-13.2 / 13.9 Self-Anchored Suspension Bridge Letter No. 05.03.01-003482

Michael Flowers Project Executive American Bridge/Fluor, A JV 375 Burma Road Oakland, CA 94607

Dear Michael Flowers,

#### Submittal 135, Rev. 4 - MFSQA for Stork Herron Testing Laboratory (STHL)

The Department has completed review of Submittal ABF-SUB-000135R04, "Manufacturing and Fabrication Self Qualification Audit (MFSQA) – Stork Herron Testing Laboratory," dated February 13, 2009. The submittal is "Approved," and accordingly, Mr. Shane Levermann may perform NDT (MT) on the Project for the Dyson Corporation.

If you have any questions, please contact Mohammad Fatemi (916) 813-3677.

Sincerely,

<<< ORIGINAL SIGNED >>>

GARY PURSELL Resident Engineer

cc: Rick Morrow Brian Boal Gary Lai Mohammad Fatemi file: 05.03.01, 55.0135 DEPARTMENT OF TRANSPORTATION - District 4 Toll Bridge Program 333 Burma Rd. Oakland, CA 94607 (510) 622-5660, (510) 286-0550 fax



Flex your power Be energy efficient!

October 18, 2007

Contract No. 04-0120F4 04-SF-80-13.2 / 13.9 Self-Anchored Suspension Bridge Letter No. 05.03.01-000706

Michael Flowers Project Executive American Bridge/Fluor Enterprises, a JV 375 Burma Road Oakland, CA 94607

Dear Michael Flowers,

#### **Department Audit - Art Galvanizing Works**

The Department is in receipt of ABF-CAL-LTR-000271, dated August 29, 2007, responding to the Department's review of Submittal ABF-SUB-000160R00, MFSQA for Art Galvanizing Works. Based upon the information provided, Art Galvanizing Works is receiving a Pass. The following issues must be satisfactorily addressed in writing prior to the start of fabrication:

- 1. The previous response to MFSQA response R6 indicated positively that there is a separation between Quality Control and Production. Currently, the same individual is managing both Production and Quality Control. Please confirm whether or not a third party will be used for Quality Control.
- 2. Regarding the Observations:
  - a. **Observation 1:** This matter is closed as it does not relate directly to production.
  - b. **Observation 2:** This matter is closed. The Department notes and accepts the Contractor's explanation.
  - c. **Observation 3:** This item was meant to convey that Art Galvanizing Works did not have facilities to handle blasting independently. Maximum capacity is 3 feet in length, while rods for this Contract are up to 15 feet long. The Department notes and accepts the Contractor's explanation. This matter will be closed pending submission of procedures detailing the blasting and inspection of the material.
  - d. **Observation 4-8:** These issues can be resolved by addressing the previous comment regarding the separation between Quality Control and Production.

American Bridge/Fluor Enterprises, a JV October 18, 2007 Page 2 of 2

The Department requests that notification be provided prior to the start of any work at this facility for this Contract.

If you have further questions, please contact Dr. Venkatesh Iyer at 858.967.6363.

Sincerely,

Pussell

GARY PURSELL Resident Engineer

cc: Rick Morrow, Brian Boal, Mazen Wahbeh, Vankatesh Iyer file: 05.03.01, 55.0160

## **REQUEST FOR INFORMATION (RFI)**

RFI No.:	ABF-RFI-001631	R00 Submitted By:	Hester, Daniel	Pages:	8
				Pages Attached:	7
RFI Date:	05-February-200	9 Contact Name:	Sheffield, Pat	Phone No.	
Subject:	Heat Treatment	of A354 Grade BD Mater	ial		
Referenc	es:				1
Sub/Sup:	DYS	Sub RFI #:			
Response	e Required by: 1	2-February-2009	Response affects	s critical path activity?	

#### **Description:**

ABFJV's supplier (The Dyson Corporation) is in the process of procuring ASTM A354 Grade BD material for use on the project. The mill that Dyson is proposing to use for the material (Gerdau-Ameristeel) is also capable of performing the requisite heat treatment and their own facility (Gerdau-Macsteel). The proposed heat treating facility operates a continuous quench & temper line using induction heating technology. Dyson proposes to procure "fully upgraded" materials from Gerdau-Ameristeel in the quenched & tempered condition in accordance with the contract requirements (ASTM A354 Gr. BD). Consequently, Dyson has the following questions:

1. It is understood that an audit would not be required of the mill/heat treatment facility. Please verify Dyson's understanding.

2. Unlike other facilities, Gerdau-Macsteel heat treating operation is "truly continuous". What would be considered as the heat treat "lot size" for mechanical testing purposes?

Please see the attached for information on the heat treatment facility.

#### **Contractor Disposition:**

This RFI is being submitted for:

The Cost and Time Impact from this RFI is: Not selected

Response:	Agreed Ext. Due Date:					
	Pages:	1				
	Pages Attach	ied: 0				
1. Correct, an audit is not required for this mill/heat treatmen	it facility.					
<ul> <li>2. With the information provided by Gerdau-Macsteel, the here unless the following occurred during heat treatment:</li> <li>A. An interruption in heat treatment operations,</li> <li>B. The end of a shift or a personnel change,</li> <li>C. A change in the material mill heat.</li> </ul>	at treatment run would be considered	one lot,				
Administrative Action:						

This response resolves the RFI.

Date:	12-February-2009	Respondent:	Brignano, Bob	Phone No.:	510-286-0503
-------	------------------	-------------	---------------	------------	--------------



### **QUENCH AND TEMPER AT IT'S FINEST**

The Heat Treating Division of MACSTEEL had its beginnings nearly twenty-five years ago as a "greenfield" operation in Huntington, Indiana. The location was selected for its proximity to major customer bases and it allowed ample room for future expansion. MACSTEEL engineering carefully analyzed available manufacturing processes then "re-engineered" additional capabilities. The resulting unique quench and temper line was able to achieve the following results:

- **1** Straightness deviations of less than 0.030 inch per 3 ft. of tubing material and 0.125" per 5 ft. of bar material.
- **2** Rockwell C hardness uniformity of less than 4 points.
- **3** One-half commercial heat treat tolerances as cited by the (ASTM) American Society Testing and Materials in its A519 specification.

Today, MACSTEEL's Heat Treating Division has three full quench and temper lines coupled with a host of value-added services. Operators are highly skilled and undergo continual technical training that exceeds typical industry practice. With nearly a quarter century of experience MACSTEEL has taken heat treating from an art to a science.



### WHY MACSTEEL HEAT TREATING?

The Heat Treating Division of MACSTEEL is a complete stateof-the-art facility specializing in technically advanced induction heating for long length bars and tubes.

Value-added support equipment for customized cutting, straightening, tensile testing and metallographic analysis are part of what this unique facility has to offer. Another distinctive attribute of this facility is that it can accommodate long bar from 12 to 35 ft. and tube product from 12 to 60 ft. in length. Customers receive the added benefit of single-source responsibility with an array of technical expertise and support that goes through the complete ranks of MACSTEEL in all their world class production facilities. MACSTEEL is recognized for its state-of-the-art metallurgical services and highly experienced product development support.



The heart of the MACSTEEL Quench and Temper opera heating stages prior to entering MACSTEEL's custom d

## THE REAL ADVANTAGE OF FROM

#### ONE PIECE AT A TIME

Each bar or tube is individually heat treated, ONE BAR AT A TIME. This is better than "batch" heat treating.

#### UNIFORM HEATING

Each rotating bar or tube is uniformly heated to a precise temperature through computer controlled induction coils.

#### INDIVIDUAL BAR & TUBE QUENCHING

Every bar or tube is individually quenched through a proprietary quench process that achieves optimum transformation kinetics.

#### SUPERIOR STRAIGHTNESS

Rotation of individual bars or tubes through the spray quench leads to superior straightness.

## THE STEEL HEAT TREATING PROCESS

Individually, every bar or tube is processed through precision controlled induction heating coils to the optimum hardening temperature. The next step is a proprietary quench that achieves the highest quench factor for the most complete transformation. Induction tempering then provides a uniform structure to meet your strength and hardness requirements.

Full length heat treating of bar and tubing enables MACSTEEL customers to machine distortion-free parts, eliminate production processes and save money.

This is really the essence of what makes MACSTEEL's Heat Treating Division unique and special in today's market place.



Bar or tube passes through a series of induction ned quench chamber.

## UENCH AND TEMPER (Q&T) ACSTEEL

#### STRENGTH AND TOUGHNESS

Each bar and tube transforms to a martensitic structure that is tempered in line to the desired strength and toughness.

#### UNIFORM HARDNESS

Every bar and tube has uniform hardness end-to-end, pieceto-piece and order-to-order.

#### STRESS FREE & DECARB FREE

Each bar and tube is STRESS FREE, decarb free and ready for your critical part applications.

#### VALUE-ADDED SERVICES

Orders can be CUSTOM CUT (saw or plasma) for specific product applications along with a host of other available services.







Rockwell Hardness Testing.

## QUALITY, CONSISTENCY, DEPENDABILITY

MACSTEEL takes great pride in the quality of its products and in the consistency in which they are delivered. Quality control measures are routine throughout our entire quench and temper process assuring you a reliable product with no need for additionally stress relieving. Also, when MACSTEEL is specified for the raw material as well, you can count on a **stress free and decarb free** product. In any production process a "consistent" quality material is what puts dollars on the bottom line. And that's exactly what you get from the MACSTEEL Heat Treating Division.

## ASK FOR THE MACSTEEL EXPERTS

Let us help you discover new ways to save on your application with a heat treated product. Our people are ready and eager to help you right from the initial design all the way through the production process. Heat treating before machining is a perfect way for you to machine distortion-free parts and eliminate several production steps, thereby saving bottom-line dollars. Test our capabilities. We're ready to work with you from concept to reality. From long-run OEM contract orders to Steel Service Center conversion work, MACSTEEL Heat Treating Division is ready, willing and more than able.









CUSTOM CUTTING

#### **GRADES TREATED**

All heat treatable grades of carbon, alloy, and stainless steels.

#### HEAT TREATMENTS

- Quench & Temper
- Thru-hardening
- Surface hardening
- Normalizing
- Stress Relief Annealing

#### **BAR PRODUCTS**

- Hot Finished or Cold Finished
- Size range—0.875" to 4.125"
- Hex Shape (Inquire)

#### **TUBULAR PRODUCTS**

- Welded or DOM
- Hot Finished Seamless
- Cold Drawn Seamless
- Size range—0.75" to 6.25" O.D.

#### LENGTH CAPACITY

- BAR—12 ft. to 35 ft.
- TUBE—12 ft. to 60 ft.
- Max. weight per piece—2000 lb.

#### **STRAIGHTNESS TOLERANCES**

- BAR—0.125" per 5 ft.
- IUBE-0.030" per 3 ft.

#### CUTTING

- Close tolerance custom cutting...saw and plasma
- Cut to length for product applications

#### OTHER VALUE-ADDED SERVICES

- Demagnetization
- Chamfering
- Metallurgical support
- Complete traceability
- Complete test reports
- Small quantities available
- Hex bundling

- Stenciling/color coding
- Experimental or trial orders encouraged
- Short lead times
- On-time, all-the-time delivery
- Overseas packaging

**ON-TIME ALL-THE-TIME DELIVERY** 

**CONSISTENT QUALITY** 

#### **PRECISION QUENCH & TEMPER LINE #3**

DEMAG

PLASMA CUT-TO-LENGTH

## **TYPICAL APPLICATIONS**



- Automotive drivetrains & suspensions
- Automotive safety appliances
- Axle tubing
- Bolting stock

- Motor shafting
- Off-road equipment
- OCTG high pressure casing & tubing
- Oil country accessories





- Crane booms
- Farm equipment machinery
- Gun barrels
- King pins
- Machinery

- Perforator guns
- Screw machine parts
- Stabilizer bars
- Torsion bars
- Truck & Trailers







25 Commercial Road • Huntington, IN 46750 • 260-356-9520 • Fax 260-356-9522 www.gerdaumacsteel.com

ered trademark of MACSTEEL. NSI 0903-5M Printed in U.S.A.



25 Commercial Road Huntington, IN 46750 (219) 356-9520 Direct (219) 355-2202 Fax (219) 355-9522 Dmelchi@Gerdaumacsteel.com

February 5, 2009

Dyson Corp. Attn: Mr. Pat Sheffield 53 Freedom Road Painesville, OH 44077

Subject: Single bar processing vs. batch processing

Dear Mr. Sheffield:

Thank you for allowing me to give a brief overview of our Induction quench and temper heat treating lines. We will receive your material/order for processing at our facility in Huntington Indiana. Your material will be assigned a unique mill order number for our internal tracking. The material will then be run when it is received "complete".

Material is placed on the inlet table and the line is adjusted appropriately for the material size. A three piece sample run will be made and the material qualified for hardness and mechanical properties. After qualifications process is completed we will run the order in its entirety. The material will be run in a bale for bale fashion to maintain traceability. The bars will be processed one-after-another for the entire order. No separate batches will be made or will be distinguishable. In-process checks will be made at the front, middle and back of the material run to validate material specifications. A material sample will be procured for submission to an outside laboratory for any Charpy Impact testing requirements. Material will exit the line and drop into an exit bunk. The material bales will be taken to the finishing operation for further work.

The induction heat treat line consists of 9-18 induction coils for austenitizing. The induction equipment is a minimum of a 1 MWatt unit operating at a nominal 3 KHz. The material is conveyed individually through the coils on skewed rolls for uniform heating and adequate support. The material is butted together on the roll conveyor to provide for uninterrupted heating. The temperature of the material is measured using an infrared pyrometer and recorded for traceability to the order.

The material moves into a robust water quench for superior transformation into martensite. The high pressure spray system is applied to each individual bar in a uniform matter. Each bar sees the same quenching as the material is conveyed through the quench. The uniform quenching is what produces outstanding straightness control.

The Tempering of the bar is then carried out on the bar with the use of induction coils. The individual bars are conveyed through 7-14 induction coils from an 850kWatt inverter operating at a nominal 1 KHz. The material continues to be conveyed on skewed rolls with precision speed control. The tempering temperature is monitored with pyrometers.

Quench and tempered material is rolled off the line onto a cooling table where the material can cool in air. A chain drive will index material across the table. The material will finally exit into a bunk.

The finishing operation will trim two inches of material from each end of the bar. The direct bar ends are harder due to some heat loss during tempering. The cut bars will be chamfered and placed on an inspection table. Each individual bar will be checked for straightness, size. Steel stamping identification of the heat number and any color coding necessary will be applied. Material is tallied and packed for shipment.

#### Page 2

If you have any questions or comments, please feel free to contact me on this matter.

Sincerely,

Doug Melchi Metallurgist DEPARTMENT OF TRANSPORTATION - District 4 Toll Bridge Program 333 Burma Rd. Oakland, CA 94607 (510) 622-5660, (510) 286-0550 fax



May 20, 2009

Contract No. 04-0120F4 04-SF-80-13.2 / 13.9 Self-Anchored Suspension Bridge Letter No. 05.03.01-004164

Michael Flowers Project Executive American Bridge/Fluor, A JV 375 Burma Road Oakland, CA 94607

Dear Michael Flowers,

#### Submittal 1084 - Tower Boom - Lift 5

The Department has completed review of Submittal ABF-SUB-001084R00, "Tower Boom - Lift 5," dated March 27, 2009. The submittal has been "Reviewed" as outlined by the following comment:

#### **CATEGORY A:**

1. The Mast and Boom System called for on top of the tower legs shall be deleted and addressed in CCO 93.

If you have further questions regarding this matter, please contact Gary Lai at (510) 808-4542.

Sincerely,

#### <<< ORIGINAL SIGNED >>>

GARY PURSELL Resident Engineer

cc: Rick Morrow, Scott Kennedy, Mark Woods file: 05.03.01, 55.1084



A JOINT VENTURE

375 Burma Road Oakland CA 94607 Phone 510-808-4600 / Fax 510-808-4601 LETTER OF SUBMITTAL SAS Superstructure Project

 Run Date
 27-Mar-09

 Time
 11:46 AM

Dated	· 27-Mar	-2009			SUBMITTAI	∟ No:	ABF-SUB-001084	Rev:	0	
To:	Gary Pr Californ 333 Bur Oakland Phone:	ursell nia Depart rma Road d (510) 6	ment of Transportation I CA 94607 22-5100 Fax: (510) 622	-5165	Co/. Contr Sub/Sup Sub/Supplie	Job # ract # plier: r No:	660110 04-0120F4 ZPM ZPM-TF-0140R00		•	
Subje Schee	ect: Towe	er Boom ·	LIFT 5		RESUBMITT	Spec Stand AL/SU	ial Provis. (SP) RE lard Spec. (SS) RE IPPLEMENTAL RE	:F: :F: :F:		
We ar	re sending	the follo	owing attached items:	<ul> <li>Attached</li> </ul>	🗌 Via Fax					
✓ PI Co SI So	lans/Dwgs ertificates o pecs chedule	of Compli	ance Design Calculat	Report tions Letter	Samples Payroll Change ( Other	Order				
Item	Date	Copies	Description		Drawing No	Rev	Subcon Dwg No	Rev	Status	Pages
01	27-Mar-0	96	BOOM ASSEMBLY		ZPM-04-01-003970	0	Z929-0 A/B	0	Pending	
02	27-Mar-0	96	BOOM ASSEMBLY		ZPM-04-01-003971	0	Z929-0 B/B	0	Pending	
03	27-Mar-0	96	SUPPORTING SEAT 1		ZPM-04-01-003972	0	Z929-SA1	0	Pending	
04	27-Mar-0	96	SUPPORTING SEAT 2		ZPM-04-01-003973	0	Z929-SA2	0	Pending	
05	27-Mar-0	96	MAST SUB-ASSEMBLY		ZPM-04-01-003974	0	Z929-SA3	0	Pending	
06	27-Mar-0	96	STRUT SUB-ASSEMBLY	/	ZPM-04-01-003975	0	Z929-SA4	0	Pending	
07	27-Mar-0	96	BOOM SUB-ASSEMBLY		ZPM-04-01-003976	0	Z929-SA5	0	Pending	
08	27-Mar-0	96	BRACING SUB-ASSEME	BLY	ZPM-04-01-003977	0	Z929-SA6	0	Pending	
09	27-Mar-0	96	SHEAVE		ZPM-04-01-003978	0	Z929-SA7	0	Pending	
10	27-Mar-0	96	PIPE		ZPM-04-01-003979	0	Z929-A1	0	Pending	
These	e are trans	mitted a	s checked below:							
✔ Fo	or Approva or Your Use	l e	☐ For Rev ☐ For Information	iew/comment rmation	Return Fo     Other	or Corr	ection			
Rema	ırks:									
CC:										
Pleas	e review /	approve	by: 18-May-2009		Submitte	d By:	Sc Pro	ott Ye	nager	
					Checked & Ser	nt By:	<<< Orig	inal	Signed >>>	•

Document Control



SAM FRANCISCO ROUTE 80 E BRIDGE NOS.: STATE OF CALL ENGINEER: CA CONTRACTOR: CONTRACTOR:	NO. DATE	A4 Z929-SA5 2225 2225 2225 201 P NOTE: L WELDS SHALL L WELDS SHALL J SHALL SHALL S SHALL SHALL S SHALL SHALL SHALL SHALL SHALL S SHALL S
INVESTIGATION CONTRACT NO. 10. SHAREN DAT MICHINER CO. LTD. SHAREN ZHENAN PORT MICHINER CO. LTD. SHAREN AND BAY BRIDGE, EAST SPAN SELF-ANCHORED SUSPENSION SPAN EAST OF YERBA BUENA ISLAND, DISTRICT 04, SF COUNTY, CA. 34-0006L PM 8.2, KP 13.2 & 34-0006R PM 8.7, KP 13.9 FORNIA DEPT. OF TRANSPORTATION CONTRACT NO. 04-0120F4 LITRANS T.Y.LIN / MOFFATT & NICHOL, .V. AMERICAN BRIDGE / FLUOR ENTERPRISES, JV. BOOM ASSEMBLY BOOM ASSEMBLY 08/30/07 2929-0A/B 00	198	Z923-A3





March 3, 2011

Contract No. 04-0120F4 04-SF-80-13.2 / 13.9 Self-Anchored Suspension Bridge Letter No. 05.03.01-009173

Brian A Petersen Project Executive American Bridge/Fluor, A JV 375 Burma Road Oakland, CA 94607

Dear Brian Petersen,

#### Submittal 2021, Rev. 1 - Tower Boom Details (CA, ESD, PL, TB)

The Department has completed the review of Submittal ABF-SUB-002021R01, "Tower Boom Details (CA, ESD, PL, TB)," dated February 22, 2011. The submittal is "Approved as Noted" as outlined by the following comment:

#### **CATEGORY A:**

1. Revise PL 10 x 100 x 80 as noted to add a 13mm diameter hole for a lock in accordance with Contract Plan Sheet 932S2/1204, Sections G-G and H-H.

If you have any questions, please contact Gary Lai at the Working Drawing Campus.

Sincerely,

#### <<< ORIGINAL SIGNED >>>

RICK MOROW Construction Manager (Tower)

For: PETER SIEGENTHALER Resident Engineer

Attachment

file: 05.03.01, 55.2021, 56.2374



A JOINT VENTURE

375 Burma Road Oakland CA 94607 Phone 510-808-4600 / Fax 510-808-4601 LETTER OF SUBMITTAL SAS Superstructure Project

 Run Date
 01-Mar-11

 Time
 10:53 AM

Dated:	22-Feb-2	011		SUBMITTAL								
To:	Peter Sie	egentha	ler	Co/.	Job #	660110						
	California	California Department of Transportation Contract # 04-0120F4										
	333 Burn	na Road	I	Sub/Sup	plier:	ZPM						
	Oakland		CA 94607	Sub/Supplie	r No:	ZPM-TF-0174R01						
	Phone:	(510) 6	22-5100 Fax: (510) 622-5165									
Subje	ct: TOWE	ER - Boo	om Details (CA, ESD, PL, TB)		Spec Stanc	ial Provis. (SP) RE lard Spec. (SS) RE	:F: 1 :F:	0-1.59				
Scheo	lule ID:			RESUBMITT	AL/SU	IPPLEMENTAL RE	F:					
We ar	e sending t	he follo	wing attached items:  Attached	🗌 Via Fax								
V PI	ans/Dwgs		Design Report	Samples								
	ertificates of	Compli	ance Calculations	Pavroll								
	becs		Copy of Letter	Change C	Order							
So	chedule			Other								
Item	Date	Copies	Description	Drawing No	Rev	Subcon Dwg No	Rev	Status	Pages			
01	17-Feb-11	6	TOWER BOOM CHANNEL	ZPM-04-01-005300	1	CA7-2	1	Pending				
02	17-Feb-11	6	TOWER BOOM SUPPORT	ZPM-04-01-005301	1	ESD1-TBSA7-1	1	Pending				
03	17-Feb-11	6	TOWER BOOM SUPPORT	ZPM-04-01-005302	1	ESD1-TBSA7-2	1	Pending				
04	17-Feb-11	6	TOWER BOOM SUPPORT	ZPM-04-01-005303	1	ESD1-TBSA7-3	1	Pending				
05	17-Feb-11	6	TOWER BOOM SUPPORT	ZPM-04-01-005304	1	ESD1-TBSA7-4 A/B	1	Pending				
06	17-Feb-11	6	TOWER BOOM SUPPORT	ZPM-04-01-005305	1	ESD1-TBSA7-4 B/B	1	Pending				
07	17-Feb-11	6	TOWER BOOM SUPPORT	ZPM-04-01-005306	1	ESD1-TBSA7-5	1	Pending				
08	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005308	1	PL7-13	1	Pending				
09	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005309	1	PL7-14	1	Pending				
10	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005311	1	PL7-17	1	Pending				
11	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005312	1	PL7-18	1	Pending				
12	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005313	1	PL7-19	1	Pending				
13	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005314	1	PL7-2	1	Pending				
14	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005316	1	PL7-21	1	Pending				
15	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005318	1	PL7-23	1	Pending				
16	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005319	1	PL7-24	1	Pending				
17	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005320	1	PL7-26	1	Pending				
18	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005321	1	PL7-27	1	Pending				
19	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005322	1	PL7-28	1	Pending				
20	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005323	1	PL7-29	1	Pending				
21	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005324	1	PL7-3	1	Pending				
22	17-Feb-11	6	BOOM PLATE	ZPM-04-01-005325	1	PL7-4	1	Pending				
23	18-Feb-11	6	TOWER BOOM LAYOUT	ZPM-04-01-005326	1	TB7-1	1	Pending				
24	17-Feb-11	6	TOWER BOOM LAYOUT	ZPM-04-01-005327	1	TB7-2	1	Pending				
25	17-Feb-11	6	TOWER BOOM LAYOUT	ZPM-04-01-005328	1	TB7-3	1	Pending				



LETTER OF SUBMITTAL SAS Superstructure Project

Dated:	22-Feb-2011			SUBMITTAL	No:	ABF-SUB-002021	Rev: 1	
То:	Peter Siegenthal California Departr 333 Burma Road	l <b>er</b> ment of Trans	sportation	Co/Jo Contra	ob # act #	660110 04-0120F4 ZDM		
	Oakland Phone: (510) 62	CA 22-5100 Fa	94607 x: (510) 622-5165	Sub/Supplier	No:	ZPM ZPM-TF-0174R01		
26 1	17-Feb-11 6	BOOM PLA	ΓE	ZPM-04-01-005558	0	PL7-24a	0	Pending
27 1	17-Feb-11 6	BOOM PLAT	ΓE	ZPM-04-01-005559	0	PL7-32	0	Pending
These are transmitted as checked below:								
02/25/20 03/01/20	011: Submit udpat 011: Submit updat	ed TB7-1, TE ed drawings	87-2. TB8-3 to Caltrans. CA7-2, PL7-27, ESD1-TBSA7-	3, ESD1-TBSA7-4 A/B, E	SD1	TBSA7-5 to Caltra	ns	
CC:								
Please	review / approve l	<b>by :</b> 08-M	ar-2011	Submitted	l By:	Sab	rina Levi	ne
						Pro	ject Manage	r
				Checked & Sent	t By:	<<< Orig	inal Sig	ned >>>

Document Control



•	Length(mm)	Quantity	Remarks	
BD	635	4	Boom Hinge	
BC	838	8	Boom End Tie Down Rod	
20	336	2	Sheave Shaft	
	70	16	Fixed Beam To Hinge Base	
	110	4	Stopper Base To Tower Head	
	130	10	Hinge Base To Tower Head	



5591 MORRILL ROAD JACKSON, MICHIGAN 49201

## CODE OQN3

#### CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER	CUSTOMER PART NUMBER	HEAT NUMBER	WORK ORDER NUMBER	DATE	
2000211-5		M39159	245969 101	2/01/10	
REPORT TO		SHIP TO	)		
CHICAGO STEEL & 700 CENTRAL AVEN	IRON LLC NUE	CHICAGO STEEL & IRON, LLC 300 EAST JOE ORR RD			
UNIVERSITY PARK	, IL 60466	CHICAGO HEIGH	TS , IL 60411		
GRADE	SIZE	)	L FAIGHT.		
4140	<u>3"</u>	2ND 2	0'	8	
ASTM A29/A29M-05;	CUSTOMER SPECIFIC, A322-07; A304-05; E381-0	л понs 1	i,		
		5			
4	CHEMICAL ANAL	YSIS			
C Mn	P S Si Ni	Cr Mo	Cu Sn	Al	
0.43 0.87 0.	009 0.032 0.26 0.18	0.88 0.18	0.22 0.008	0.025	
V Nb					
0.007 0.002					
GRAIN SIZE	SPECIFICATION ASTM E112	FINE GRAIN	5 - 8		
HARDENABILITY	SPECIFICATION ASTM A255/	A3 0 4			
THEORETICAL J1 2 3 4 5 6 58 58 58 58 58 58	5 7 8 9 10 11 12 13 14 8 57 56 55 53 51 49	1 15 16 18 20 22 9 47 46 45	24 26 28 30 43 41	32 34 38	
MACROCLEANLINESS	PECIFICATION ASTM E381				
PLATE I	PI	ATE II			
S R AVERAGE 1 1	C 1 NONE		Q.A REVIEWED	The summer of the	
		546 B	DI 2014		
PAGE 1					
We certify If Gerdau MacSteel Monroe	al these data are correct and in comp	bliance with specified rec	quirements.		
3000 East Front Street		Wendy	( Adams Wendy	I. Craig	
Monroe, MI 48161			(7) Iy Assurance Representative		



5591 MORRILL ROAD JACKSON, MICHIGAN 49201

## CODE OQN3

#### CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER	CUSTOMER PART NUMBER	HEAT NUMBER	WORK ORDER NUMBER	DATE
2008244-3		M39159	245969 107	12/01/10
		11227222	101 606CPN	12/01/10

REPORT TO

SHIP TO

CHICAGO STEEL & IRON LLC 700 CENTRAL AVENUE CHICAGO STEEL & IRON, LLC 300 EAST JOE ORR RD

UNIVERSITY PARK , IL 60466

CHICAGO HEIGHTS , IL 60411

ORDERED							
GRADE	з" з"	RND	LENGTH				
¥		CUSTOMER SPECIFICATIONS	la				
ASTM A29/A29M-05; A	322-07; A304-	05; E381-01	8 - S				
PEDUCTION DATIO							
REDUCTION RATIO							
RATIO# 5.1 TO 1.	0						
** MATERIAL 100% ARC FURNACE A BEEN REPAIREL TO MERCURY OR TEMPERATURES E GERDAU MACSTEE TO ENSURE THAT	MELTED AND MA ND CONTINUOUS BY WELDING TO ANY OTHE DURING PROCESS L MONITORS AL PRODUCTS SHI	ANUFACTURED IN S CASTING METHO AND THIS MATE CR METAL ALLOY SING OR WHILE I L INCOMING SCR PPED ARE FREE	THE U.S.A. BY THE ELECTRIC D. THE PRODUCT HAS NOT RIAL HAS NOT BEEN EXPOSED THAT IS LIQUID AT AMBIENT N OUR POSSESSION. AP AND ALL HEATS OF STEEL OF RADIOACTIVE MATERIAL.				
			ж				
	52						
		÷e	Q.A. ASWEWED				
			DYSON				
		N					
PAGE 2 OF 2							
We certify that	these data are corre	ect and in compliance	with specified requirements				
Serdau MacSteel Monroe 3000 East Front Street Aonroe, MI 48161			Wandy C. C. Roig, Wendy J. Craig				
			Cuality Assurance Representative				

#### CONTRACT CHANGE ORDER MEMORANDUM

DATE: 6/14/2011	Page 1 of 1
-----------------	-------------

TO: Pete Siegenthaler, Prin TE /					FILE:	E.A.	04 - 0120F4			
FROM: Kannu Balan Senior TE						CO-RTE-PM SF-80-13.2/13.9				
					FE	FED. NO.				
CCO#: <b>128</b>	SUPPL	LEMENT#: 0 Category Code: CXPA			CONTIN	CONTINGENCY BALANCE (incl. this change) \$168.545.011.11			45,011.11	
COST: <b>\$94,</b> :	COST: \$94,317.00 INCREASE ☑ DECREASE □					HEADQUARTERS APPROVAL REQUIRED?			✓ NO	
SUPPLEMENTAL	. FUNDS	PROVIDED:		\$0.00	IS THIS ENVIRO	IS THIS REQUEST IN ACCORDANCE WITH				
CCO DESCRIPTI	ON:				PROJEC	PROJECT DESCRIPTION:				
Tower Maintenance Enhancements					CONSTR	CONSTRUCT SELF-ANCHORED SUSPENSION BRIDGE				
Original Contract Tir	me:	Time Adj. This Cha	ange: Previously Approved C Time Adjustments:		1 CCO	Percent (includir	age Time Adjusted: ng this change)	Total a CCO(s	# of Unrecor s): (including	nciled Deferred Time () this change)
2490	Day(s)	0	Day(s)	501	Day(s)		<b>20</b> %		1	

#### THIS CHANGE ORDER PROVIDES FOR:

Providing Tower Outrigger Booms in lieu of the Tower Booms required in the original Contract plan sheets.

Use of the Tower Booms originally called for in the Contract Plans required installation of winches and utilities for those winches at the top of the Tower. The winches would be used infrequently and make maintenance difficult. Further, the booms called for in the Contract Plans did not have the capacity or reach to lift items as large as struts. The new outrigger booms have been designed to address these deficiencies. The updated design has a sliding boom that is not visible when not in use. Michael Gulli (Rigging Engineer) from Maintenance requested on May 19, 2009, outrigger booms at the top of the SAS Towers instead of the booms shown on the plan sheets.

The total cost of this change order is \$94,317.00, which can be financed from the contingency fund. A detailed cost analysis is on file.

There will be no time adjustment for this change, as it does not affect the controlling operation.

This change order has concurrence from Peter Siegenthaler (Principal Engineer), Rick Morrow (Sup. BE), Michael Gulli (Maintenance), and Jing Chen (District Design).

CONCURRED BY:					ESTIMATE OF COST	
Construction Engineer:	PCE, Pete Siegenthaler, Prin TE	Date	9/27/10		THIS REQUEST	TOTAL TO DATE
Bridge Engineer:	Rick Morrow, Sup BE	Date	9/20/10	ITEMS	\$0.00	\$0.00
Project Engineer:		Data	3/20/10	FORCE ACCOUNT	\$0.00	\$0.00
Project Manager:		Date		AGREED PRICE	\$0.00	\$0.00
Floject Manager.		Date		ADJUSTMENT	\$94,317.00	\$94,317.00
FHWA Rep.:		Date		TOTAL	\$94,317.00	\$94,317.00
Environmental:		Date			FEDERAL PARTICIPATION	
Other (specify):	Struct Maint, Michael Gulli, Bill Bon	Date	5/19/09		PARTICIPATING IN F	PART VONE
Other (specify):	District Design, Jing Chen	Date	3/10/11		G (MAINTENANCE)	NON-PARTICIPATING
District Prior Approval By		Date			N (if more than one Fundin	ng Source or P.I.P. type)
HQ (Issue Approve) By:		Date				O FUNDED AS FOLLOWS
Resident Engineer's Signature:		Date		FEDERAL FUNDING S	OURCE	PERCENT
Name	Bala	6-1	4-11			

ADA Notice: For individuals with sensory disabilities, this document is available in alternate formats. For information call: (916) 654-6410 or TDD (916) 654-3880 or write Records and Forms Management, 1120 N Street, MS-89, Sacramento, CA 95814.

DEPARTMENT OF TRANSPORTATION -Toll Bridge Program 333 Burma Rd. Oakland, CA 94607 (510) 622-5660, (510) 286-0550 fax



Flex your power Be energy efficient!

June 16, 2011

Contract No. 04-0120F4 04-SF-80-13.2 / 13.9 Self-Anchored Suspension Bridge Letter No. 05.03.01-009642

Brian A Petersen Project Executive American Bridge/Fluor, A JV 375 Burma Road Oakland, CA 94607

Dear Brian Petersen,

#### Authority to Proceed - CCO 128S1 - Tower Boom Bearings

In accordance with the provisions of Section 4-1.03, "Changes," of the Standard Specifications you are hereby authorized to proceed with the changes presented in the attached draft change order and Plan Sheets 932S2R1 and 932S4R1 for Contract Change Order (CCO) No. 128S1, "Tower Boom Bearings."

The general scope of CCO 128S1 includes replacing the PTFE film on the bearing surfaces at the hinge on the Tower outrigger boom with self-lubricating bearing plates.

An electronic (PDF) copy of the plan sheets will be transmitted via the PMIV Plan Sheet Library. Please provide a summary of cost impacts due to the changes presented in this change order. Upon review, substantiation and agreement on scope and cost, the final CCO will be issued.

If you have any questions contact Kannu Balan at 510-286-0511.

Sincerely,

RICK MORROW Construction Manager (Tower)

For: PETER SIEGENTHALER Resident Engineer

Attachment

cc: Mark Woods, Kannu Balan file: 05.03.01, 49.128S1

#### DEPARTMENT OF TRANSPORTATION

DIVISION OF ENGINEERING SERVICES Office of Structural Materials Quality Assurance and Source Inspection

Bay Area Branch 690 Walnut Ave.St. 150 Vallejo, CA 94592-1133 (707) 649-5453 (707) 649-5493

**Project Name:** 

**Contractor:** 

Contract #: <u>04-0120F4</u> Cty: <u>SF/ALA</u> Rte: <u>80</u> PM: <u>13.2/13.9</u> File #: <u>76.15</u>

**Report No:** 

#### SOURCE INSPECTION REPORT

Resident Engineer:Siegenthaler, Peter Address: 333 Burma Road City: Oakland, CA 94607

SAS Superstructure

Prime Contractor: American Bridge/Fluor Enterprises, a JV

Dyson Corp. & Subs

Date Inspected:	01-Aug-2011

OSM Arrival Time: 800 OSM Departure Time: 1630 Location: Painesville and Cleveland

SIR-003499

<b>Quality Control</b>	Contact:	Russ Wels	sh		Quality Contro	ol Present:	Yes	No	
Material transfe	er:	Yes	No	N/A	Sampled Items	5:	Yes	No	N/A
Stock Transfer:		Yes	No	N/A	OK to Cut: Yes No		No	N/A	
<b>Rebar Test Witness:</b>		Yes	No	N/A	Delayed/Cancelled: Yes No		No	N/A	
Other:									
Bridge No:	34-0006				<b>Component:</b>	Main Cable	Anchor Ro	ods	
Bid Item:	66				Lot No:	B337-016-11	and B33	87-017-1	11

#### **Summary of Items Observed:**

On this date, Quality Assurance Inspector (QAI) Dustyn Broening was present at Dyson Corporation in Painesville, OH, as requested, to monitor the fabrication main cable PWS anchor rods for the San Francisco Oakland Bay Bridge (SFOBB) project.

This QAI met with Dyson QC Manager (QCM) Russell Welsh who accompanied this QAI to the location where main cable anchor rod activities were in-process.

Dyson has prepared (42ea) Main Cable Anchor Rods to be shipped to Monnig Ind. galvanizing facility. Dyson is selecting rods from heat #3M75738-2, lot #OPY a quantity of (40ea) and heat #3M75738-1, lot OQW a quantity of (2ea) that have been deemed acceptable and per specification. These rods are to be shipped at Dysons' own risk per Sales Manager Pat Shefield due to no results from the Caltrans Translab for lot #OPY and OQW. The main cable anchor rods that are to be shipped at Dysons' own risk are as follows:

- First bundle consists of OPY4-1, OPY4-12, OPY4-15, OPY4-16, OPY4-17 and OPY4-18.
- Second bundle consists of OPY4-2, OQW-3, OPY4-4, OQW-5, OPY4-13 and OPY4-14.
- Third bundle consists of OPY4-6, OPY4-7, OPY4-8, OPY4-9, OPY4-10 and OPY4-11.
- Fourth bundle consists of OPY3-16, OPY3-20, OPY3-22, OPY3-23, OPY3-24 and OPY3-26.
- Fifth bundle consists of OPY3-18, OPY3-19, OPY3-21, OPY3-25, OPY3-27.
- Sixth bundle consists of OPY2-27, OPY2-28, OPY2-29, OPY2-30, OPY2-31, and OPY2-32.
- Seventh Bundle consists of OPY2-33, OPY2-34, OPY2-35, OPY2-36, OPY2-37, OPY2-38 and OPY2-39.

This QAI accompanied this QCM to The Art Galvanizing Works Inc. galvanizing shop in Cleveland, OH to Green

### SOURCE INSPECTION REPORT

( Continued Page 2 of 2 )

Tag a quantity of (175ea) 7" diameter 4UNC 2A X 3.50"-4UNC 2B hex coupling nuts, ASTM A194 grade 7 (2nd heat treat lot) to be sent back to Dyson in Painesville, OH.

This QAI received and reviewed The Art Galvanizing Works Certificate of Conformance and galvanizing certifications for 7" diameter 4UNC 2A X 3.50"-4UNC 2B hex coupling nuts, ASTM A194 grade 7 which are to be sent back to Dyson in Painesville, OH to machine internal threads. The coupling nuts heat number is K5109 and Dyson heat treat lot number OKS was assigned per Heat Treatment Lot per contract document requirements. These Coupling nuts (175ea) were green tagged and lot number B337-016-11 was assigned.

This QAI attached a Green Tag with Lot No. B337-016-11 to the material to be shipped.

This QAI observed QCM perform random mill thickness readings per ASTM A153/ F2329 and were found to be satisfactory.

This QAI received and reviewed MTR's for a quantity of (14ea) 1" diameter ASTM A354-07 Grade BC Bolts, heat #M658800, Dyson Lot #OHD and a quantity of (8ea) 3" diameter ASTM A354 Grade BD, Bolts heat #M39159, Dyson lot #OQN which are to be sent to The Art Galvanizing Works Inc. at 3935 Valley Rd, Cleveland OH for galvanizing process.

This QAI attached a Green Tag with Lot No. B337-017-11 and MTR to the material to be shipped.

#### **Summary of Conversations:**

As noted in the body of the report above. Other basic communication was performed between this QAI and the QCM during this visit.

#### Comments

This report is for the purpose of determining conformance with the contract documents and is not for the purpose of making repair or fit for purpose recommendations. Should you require recommendations concerning repairs or remedial efforts please contact Nina Choy 510-385-5910, who represents the Office of Structural Materials for your project.

Inspected By:	Broening, Dustyn	Quality Assurance Inspector
<b>Reviewed By:</b>	Edmondson,Fred	QA Reviewer

#### DEPARTMENT OF TRANSPORTATION

DIVISION OF ENGINEERING SERVICES Office of Structural Materials Quality Assurance and Source Inspection

Bay Area Branch 690 Walnut Ave.St. 150 Vallejo, CA 94592-1133 (707) 649-5453 (707) 649-5493 Contract #: <u>04-0120F4</u> Cty: <u>SF/ALA</u> Rte: <u>80</u> PM: <u>13.2/13.9</u> File #: <u>76.8</u>

#### **COMPONENT MATERIAL INSPECTION REPORT**

Resident Engineer:Siegenthaler, Peter Address: 333 Burma Road City: Oakland, CA 94607

Contractor: Dyson Corp. & Subs

**Location:** Dyson Painesville OH

Bridge No.: 34-0006

Report No: CMI-000368 Date Inspected: 01-Aug-2011

OSM Arrival Time: 800 OSM Departure Time: 1630 Component:# Bolts

The following material has been inspected in accordance with Section 6 of the Standard Specifications at the above location. At this point in the fabrication process it appears to comply with contract plans and specifications.

To be shipped to the following vendor or locations: The Art Galvanizing Works Inc. at 3935 Valley Rd, Cleveland OH

Lot # B337-017-11	<b>Bid Item #</b> 66	<b>Quantity</b> 14	ea	Material Description 1" diameter ASTM A354-07 Grade BC Bolts, heat #M658800,
				Dyson Lot #OHD
B337-017-11	66	8	ea	3" diameter ASTM A354 Grade BD, Bolts heat #M39159,
				Dyson lot #OQN

Identification: 3" diameter ASTM A354 Grade BD, Bolts heat #M39159, Dyson lot #OQN and 1" diameter ASTM A354-07 Grad

#### Summary of Items Observed:

On this date, Quality Assurance Inspector (QAI) Dustyn Broening was present at Dyson Corporation in Painesville, OH, as requested, to monitor the fabrication main cable PWS anchor rods for the San Francisco Oakland Bay Bridge (SFOBB) project.

This QAI received and reviewed MTR's for a quantity of (14ea) 1" diameter ASTM A354-07 Grade BC Bolts, heat #M658800, Dyson Lot #OHD and a quantity of (8ea) 3" diameter ASTM A354 Grade BD, Bolts heat #M39159, Dyson lot #OQN which are to be sent to The Art Galvanizing Works Inc. at 3935 Valley Rd, Cleveland OH for galvanizing process.

This QAI attached a Green Tag with Lot No. B337-017-11 and MTR to the material to be shipped.

#### **Summary of Conversations:**

As noted in the body of the report above. Other basic communication was performed between this QAI and the QCM during this visit.

#### Comments

This report is for the purpose of determining conformance with the contract documents and is not for the purpose of making repair or fit for purpose recommendations. Should you require recommendations concerning repairs or remedial efforts please contact Nina Choy 510-385-5910, who represents the Office of Structural Materials for
### COMPONENT MATERIAL INSPECTION REPORT

( Continued Page 2 of 2 )

your project.

Inspected By:	Broening, Dustyn	Quality Assurance Inspector

Reviewed By: Edmondson, Fred

QA Reviewer

### DEPARTMENT OF TRANSPORTATION

DIVISION OF ENGINEERING SERVICES Office of Structural Materials Quality Assurance and Source Inspection

Bay Area Branch 690 Walnut Ave.St. 150 Vallejo, CA 94592-1133 (707) 649-5453 (707) 649-5493 Contract #: <u>04-0120F4</u> Cty: <u>SF/ALA</u> Rte: <u>80</u> PM: <u>13.2/13.9</u> File #: <u>76.15</u>

### SOURCE INSPECTION REPORT

Resident Engineer:Siegenthaler, Peter Address: 333 Burma Road City: Oakland, CA 94607

<b>Report No:</b>	SIR-003520	
Date Inspected	<b>d:</b> 09-Aug-201	1

Project Name: Prime Contractor: Contractor:	SAS Super American Dyson Cor	rstructure Bridge/Fluc p. & Subs	or Enterp	rises, a JV	O	OSM Arrival SM Departure 7 Loca	Time: 3 Fime: tion: Pa	800 1630 inesville	e, OH
Quality Control Co Material transfer: Stock Transfer: Rebar Test Witness Other:	ontact: s:	Russ Wels Yes Yes Yes	h No No No	N/A N/A N/A	Quality Contro Sampled Items: OK to Cut: Delayed/Cancel	l Present:	Yes Yes Yes Yes	No No No	N/A N/A N/A
Bridge No: Bid Item:	34-0006 53, 66, 68				Component: Lot No:	Main Cable Ai B337-019-11,	nchor Ro B337-02	ods, Tov 20-11, B	ver Access and 337-021-11, B3

### Summary of Items Observed:

On this date, Quality Assurance Inspector (QAI) Dustyn Broening was present at Dyson Corporation in Painesville, OH, as requested, to monitor the fabrication main cable PWS anchor rods for the San Francisco Oakland Bay Bridge (SFOBB) project.

This QAI received and reviewed MTR's for a quantity of (8ea) 3.50"-4UNC 2B x 11" long Coupler Nuts ASTM A194 Grade 7, heat #T1313, Dyson Lot #LNA which are to be sent to The Art Galvanizing Works Inc. at 3935 Valley Rd, Cleveland OH for galvanizing process.

This QAI attached a Green Tag with Lot No. B337-019-11 and MTR to the material to be shipped.

This QAI received and reviewed MTR's for a quantity of (67ea) 8" outside diameter with 4" internal diameter, 3. 5" spherical round plate washer, ASTM A514, heat #813P72220, Dyson lot #ONQ2 which are to be sent to American Bridge Manufacturing at 2000 American Bridge Way, Coraopolis, PA 15108 for painting process.

This QAI attached Green Tag with Lot No. B337-020-11 and supporting MTR's to the material to be shipped.

This QAI selected a quantity (7ea) 8" outside diameter with 4" internal diameter, 3.5" spherical round plate washer, ASTM A514, heat #813P72220, Dyson lot #ONQ2 to be sent to the Trans Lab for sampling. The frequency of sampling was in conformance with contract documents. This QAI reviewed the supporting documentation and verified that the hex nut material conformed to ASTM A514.

### SOURCE INSPECTION REPORT

( Continued Page 2 of 3 )

The samples were placed in a cardboard box. The box was closed-up for shipment to the Caltrans Trans Lab.

A TL 101 with supporting documentation was placed into a pouch and attached to the box. This QA inspector assigned Lot No. B337-021-11 to this sample shipment. (See attached photos).

This QAI selected a quantity (3ea) 1" diameter ASTM A354-07 Grade BC Bolts, heat #M658800, Dyson Lot #OHD to be sent to the Trans Lab for sampling. The frequency of sampling was in conformance with contract documents. This QAI reviewed the supporting documentation and verified that the material conformed to ASTM A354-07 Grade BC.

The samples were placed in a cardboard box. The box was closed-up for shipment to the Caltrans Trans Lab.

A TL 101 with supporting documentation was placed into a pouch and attached to the box. This QA inspector assigned Lot No. B337-022-11 to this sample shipment. (See attached photos).

This QAI selected a quantity (3ea) 3" diameter fastener assemblies including ASTM A354 Grade BD, Bolts heat #M39159, Dyson lot #OQN, ASTM A563 grade DH heavy hex nuts 3" diameter 4 UNC 2B heat #M653662, Dyson lot #NGB and 3" diameter ASTM F436 Type 1, Hardened Flat Washers heat #A065729, Dyson lot #MGA, to be sent to the Trans Lab for sampling. The frequency of sampling was in conformance with contract documents.

The samples were placed in same cardboard box as the 1" diameter bolts. The box was closed-up for shipment to the Caltrans Trans Lab.

A TL 101 with supporting documentation was placed into a pouch and attached to the box. This QA inspector assigned Lot No. B337-023-11 to this sample shipment. (See attached photos).





### SOURCE INSPECTION REPORT

(Continued Page 3 of 3)



### **Summary of Conversations:**

As noted in the body of the report above. Other basic communication was performed between this QAI and the QCM during this visit.

### Comments

This report is for the purpose of determining conformance with the contract documents and is not for the purpose of making repair or fit for purpose recommendations. Should you require recommendations concerning repairs or remedial efforts please contact Nina Choy 510-385-5910, who represents the Office of Structural Materials for your project.

Inspected By:	Broening, Dustyn	Quality Assurance Inspector
<b>Reviewed By:</b>	Edmondson,Fred	QA Reviewer



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Page 1 of 1

Wednesday, August 24, 2011

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### STRUCTURAL MATERIALS TESTING LABORATORY FORM TM-3 (REV. 07/11)

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### FASTENER ASSEMBLY WORKSHEET

SM Number	11-0807	Lot Number	13337023 11	Date Received	8/18
Contract Number	04-0120F4	TL-0101 Number	C539346	Date Tested	8/24
Lab Technician	FRED	Test Temperature	.700	Page_	of

BOLTS: A354	Grande	BD (	HDG		general second second second	
Sample No.	14	1B	16			
Heat / Mfg. Lot No.	DQN	Atte. Heat	# M3915	ç		
Product Markings						
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Pitch Diameter	2.842	2.837	2.840			
Bolt Length	25" .		$\geq$			
Ring Gage Go/No-Go				/		
Zinc Coating Thick.	6.48	3.50	4.31	V		
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NUTS: A563	ÐH	HI	DG-			
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Mfg. Lot No.	NGB 5		>			
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WASHER: F434	10	HDG	-	2	-		
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Product Markings							11
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.00" 4UNC 2A x 25.00" Lg. Heavy Hex Bolt (Assembly to consist of 1 Nut & 1 Washer) w/ 6.50" of useable thread er Tower Access Detail No.16B, Sheet 515S2 and Dyson Fabrication Sketch. Material per ASTM-A354, Gr BD, Hot Dipped Galvanized per Caltrans Standard Specification 75-1.05 and ASTM-A123 w/near white metal blast prior to alvanize.

瓶行LGQL き砂砂切ね. Rd. in Stock Code OQN Use only 1 Heat! Qty Breakdown: 5 pcs on order (3 pc. QA Samples .113896) + 2 extra = 10 pcs. total;

C: Caltrans Special Provisions Apply. AFG: See Routing HIP:

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ALTRANS SAMPLE MATERIAL (3 Pieces may be required) .00" 4UNC 2A x 25.00" Lg. Heavy Hex Bolt (Assembly to consist of 1 Nut & 1 Washer) w/ 6.50" of useable thread er Tower Access Detail No.16B, Sheet 515S2 and Dyson Fabrication Sketch. Material per ASTM-A354, Gr BD, Hot Dipped Galvanized per Caltrans Standard Specification 75-1.05 and ASTM-A123 w/near white metal blast prior to AVADIZPURETAROOURSWerkom S.O. L113895

C: Caltrans Special Provisions Apply. AFG: Caltrop to select samples from finished lot of materials HIP: HLL:

Tatl shor Um

5/13/11

### OQN

STORK Materials Technology Stork Herron Testing Laboratories

6/21/2011

Steve Marsh Dyson Corp. 53 Freedom Road PAINESVILLE, OH 44077-1232

Date Received: 6/17/2011

Test Report No.: DYS006-11-06-27890-1

Material Testing and Non-Destructive Testing

5405 E. Schaaf Road Cleveland, OH 44131 USA

Telephone : (216) 524-1450 Fax : (216) 524-1459 Website : www.storkherron.com

P.O. No.: 78606

TEST REPORT ITAR-CONTROLLED DATA

Sample Description:

One (1) 3" Dia. Bar, Material: AISI 4140, per ASTM A354 Grade BD, Job# L113895 L113896 L113895 L113896, Cust PO # 660110-SA-017 C/O 024, Heat#/Heat Code: M39159/OQN3

#### **TENSILE TEST PER ASTM E 8, ASTM A 370**

	Dia. (in.)	Yield Strength .2% Offset (ksi)	Ultimate Strength (ksi)	%Elongation in 4D	%Reduction of Area
Results:	.4980	132	156	16	48
Required:	-	115 Min.	140 Min.	14 Min.	40 Min.

#### CONFORMANCE

The sample meets the tensile requirements of ASTM A354, Grade BD.

The reported results represent the actual attributes of the material tested and indicate full compliance with all applicable specification and contract requirements.

#### Export Controlled (ITAR)

This document contains technical data whose export and re-export/re-transfer is subject to control by the U.S. Department of State under the Arms Export Control Act and the International Traffic in Arms Regulations. The Department of State's prior written approval is required for the export or re-export/re-transfer of such technical data to any foreign person, foreign entity or foreign organization whether in the United States or abroad.

The above testing was performed in accordance with the latest revision of the applicable commercial, military and/or International test method unless otherwise noted. The above services were performed in accordance with Herron Testing Laboratories' Quality Assurance Program Edition 1, Revision 3 dated 6/30/09, Information and statements in this report are derived from material, information and/or specifications furnished by the client and exclude any tins report are derived from material, information and/or specifications furnished by the client and exclude any expressed or implied warranties as to the filness of the material tested or analyzed for any particular purpose or use. This report is the confidential property of our client and may not be used for advertising purposes. This report shall not be reproduced except in full, without written approval of this laboratory. The recording of false, fictilious or fraudulent statements or entries on this document may be punished as a felony under Federal Statutes. Sample remnants are held for a minimum of 6 months following issuance of test results, at which point they will be discarded unless estimation by the oligient. This metrical uses real contemponent by macroin or characted. discarded unless notified in writing by the client. This material was not contaminated by mercury or chlorinated solvents during the handling and processing at Stork-Herron Testing Laboratories facilities

Kasera Ramu

Karen Baumiller Customer Services Manager



#### 5591 MORRILL ROAD JACKSON, MICHIGAN 49201

CODEOQN

e. *	CERTIFIED MATERIAL TEST REPORT							
customer order number 2008244 - 3	CUSTOMER PART NUMBER	неат NUI M3915	MBER WORK ORDER NUMBER 9 245969 101	DATE 12/01/10				
REPORT TO			SHIP TO					
CHICAGO STEEL & 700 CENTRAL AVEN	IRON LLC UE	CHICAGO 300 EAST	STEEL & IRON, LLC JOE ORR RD					
UNIVERSITY PARK	, IL 60466	CHICAGO	HEIGHTS , IL 6041	1				
	OF	DERED						
GRADE	SIZE ·	מואמ	LENGTH					
4140		RIND CATIONS	20					
ASTM A29/A29M-05;	A322-07; A304-05; E	381-01						
	CHEMICAL	ANALYSTS						
	Chilling Chill	MANDIO10						
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8	s			а				
GRAIN SIZE S	PECIFICATION ASTM	E112 FINE (	GRAIN 5-8	÷				
HARDENABILITY S	PECIFICATION ASTM 2	A255/A304						
THEORETICAL J1 2 3 4 5 6	7 8 9 10 11 12	13 14 15 16 18	20 22 24 26 28 30	32 34				
58 58 58 58 58 58	57 56 55 53 51	49 47 46	45 43 41	38				
MACROCLEANLINESS S	PECIFICATION ASTM E	381						
PLATE I		PLATE II						
S R AVERAGE 1 1	C 1 N	ONE	Q.A PEVIEWE	D				
			DÝSON'					
PAGE 1		3*						
We certify the	at these data are correct and	in compliance with spec	cified requirements.					
Gerdau MacSteel Monroe		Wenn	157. Crain Wand					
Monroe MI 48161								

-----



#### 5591 MORRILL ROAD JACKSON, MICHIGAN 49201

### CODEOQN

CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER	CUSTOMER PART NUMBER	HEAT NUMBER M39159	WORK ORDER NUMBER	DATE 12/01/10
2008244.5				

REPORT TO

CHICAGO STEEL & IRON LLC 700 CENTRAL AVENUE CHICAGO STEEL & IRON, LLC 300 EAST JOE ORR RD

SHIP TO

UNIVERSITY PARK , IL 60466

CHICAGO HEIGHTS , IL 60411

X.1. F.	0	RDERED	
GRADE	SIZE		LENGTH
4140:	3 "	RND	20
1	CUSTOM	ER SPECIFICATIONS	
ASTM A29/A29M-05; A:	322-07; A304-05;	E381-01	
· · ·			
REDUCTION RATIO			·
RATIO# 5.1 TO 1	. 0		
14			
** MATERIAL 100% ARC FURNACE A BEEN REPAIREI TO MERCURY OF TEMPERATURES I GERDAU MACSTEE TO ENSURE THAT	MELTED AND MANUF. AND CONTINUOUS CA. ) BY WELDING AND ( TO ANY OTHER MI )URING PROCESSING 3L MONITORS ALL II PRODUCTS SHIPPE	ACTURED IN STING METHO THIS MATE ETAL ALLOY OR WHILE I NCOMING SCR D ARE FREE	THE U.S.A. BY THE ELECTRIC D. THE PRODUCT HAS NOT RIAL HAS NOT BEEN EXPOSED THAT IS LIQUID AT AMBIENT N OUR POSSESSION. AP AND ALL HEATS OF STEEL OF RADIOACTIVE MATERIAL.
· .			
			Q.A. AEWEWED
			DYSON

We certify that these data are correct and in compliance with specified requirements.

Gerdau MacSteel Monroe 3000 East Front Street Monroe, MI 48161

PAGE 2 OF

Wendy J. Craig

Quality Assurance Representative

### Dyson Corporation Hot Dip Galv. Worksheet

The Art Galvanizing Works, Inc.

Date: 8/5/11

Per ASTM A153 / F2329

Customer
American Bridge
Order # Dyson / Art
L 11 3895
Description
e.

Inchector	
mapector,	

### Art Galvanizing Gage \_ 1\_

Galv. Thickness / Mils.

	1	2	3	4	5
а	8-1	8.9	10.1	9.4	10.2
b	8.6	8.1	8-4	. 8.2	8.8
с	9.2	8-4	8.9	100	9.4

Custome	er
Order # Dyso	n / Art
Descriptio	on

	1	2	3	4	5
а					
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-	
_	Customer
	Order # Dyson / Art
	Description
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	1	2	3	4	5	
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CERTS

DATE	8/5/2011							
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ТО	DYSON CO	RP -		PO#	79350			
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Patricia M.

STRUCTURAL MATERIALS TESTING LABORAT	TEST SPEC	MEN PREPADAT	
FORM TL-652 (REV. 3/05)	AN	DRECORD	APPROVED FOR USE BY SMTL QUALITY MANAGER: STRENGL
SM No.	04) 0000018 Contract No. D4-0130F4	equesting Lab Techniciar ビル&い	Date Needed
TL-0101 No. C5393446	E.A./Spec. Desg./Object D	ate Received 8//8 / //	Date Tested/Provided
∭tMachine Shop Work Requested	Instructions	5.00	] Chemistry Lab
M standard round tension test specimen, circle one: 0.500" 0.350" 0.250"	3"Bolt Heat #M3	9159 AFB	ype of material: Work Requested
<ul> <li>I standard rectangular tension test specimen, circle one: 18" long, 8" gage length 8" long 2" gage length</li> </ul>	alasta astala	wite d	<ul> <li>I neoprene verification</li> <li>oil swell</li> </ul>
[] Charpy, circle one: 10mm x 10mm	Washires For He	ardness Test	<ul> <li>Zinc coating weight</li> <li>steel chemistry analysis</li> </ul>
[))thardness measurement sample (fasteners) [ ] weld nugget			[] other:
[ ] chemistry slug			] Other (explain)
[ ] other:		50 50	
[] see instructions →	16 17 17		
Comments or further instructions	Ther	eceived service is accent	alte
		a a	
		Receiving Lab Technicia	Data

STRUCTURAL MATERIALS TESTING LABORATORY FORM TL-652a (REV. 10/10)

# Specimen Preparation Information



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2

3

## Charpy Impact Specimens





SPC	А	В	С	D
#	Note #2	0.394	0.079	2.165
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2				
3				

/ НОТСН ШІТН	
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V	٦
l	_ <u>_</u>
D	

NOTE:

I. ALL MEASUREMENTS IN INCHES

SPEC #

HEAT # XXX

2. MEASUREMENT "A" 0.394, 0.295, 0.197, 0.098 TOLERANCE + .001

MATERIAL

SURFACE

X

NOTCH

ORIENTATION

3. SPECIMENS ARE TO BE SURFACE GROUND

## **Reduced Tensile Round Specimens**

MAMAAAA		- manananan
	DIA	



NOTE: SPECIMEN DIA 1. 0.500 +.010 2. 0.350 +.007

# **Reduced Tensile Flat Specimens**



SPC WIDTH # Α В

NOTE: SPECIMEN WIDTH 1. 0.500 - 80

APPROVED FOR USE BY SMTL QUALITY MANAGER le AMan

### DEPARTMENT OF TRANSPORTATION

DIVISION OF ENGINEERING SERVICES Office of Structural Materials Quality Assurance and Source Inspection

Bay Area Branch 690 Walnut Ave.St. 150 Vallejo, CA 94592-1133 (707) 649-5453 (707) 649-5493

Contract #: 04-0120F4 Cty: SF/ALA Rte: 80 PM: 13.2/13.9 File #: 76.9

### **REPORT OF INSPECTION OF MATERIAL**

Resident Engineer: Casey, William				<b>Report No:</b> RIM-000106	
	Address: 33	33 Burma Road		Date Inspected: 12-Oct-2011	
	City: O	akland, CA 9460	07		
Projec	t Name: SAS S	uperstructure		OSM Arrival Time: 800	
Prime	Contractor: A	merican Bridge/I	Fluor Enterprises,	, a JV OSM Departure Time: 1630	
Contractor: Dyson Corp. & SubsLocation: Painesville, OH					
The following material has been inspected in accordance with Section 6 of the Standard Specifications and found to substantially comply* with contract plans and specifications.					
<b>Item</b> 1	Lot # B305-026-11	<b>Bid Item#</b> 53	<b>Quantity</b> 5	Material Description 3.00" 4UNC 2B Heavy Hex Nut, A563 Gr. DH, HDG	
2	B305-026-11	53	5	3.00" 4UNC 2A X 25" Heavy Hex Bolt, A354 Gr. BD,	
				HDG,	
3	B305-026-11	53	5	3.00" dia. Hardened Flat Washer, F436 Type 1, HDG,	
4	B305-026-11	53	9	1.00" dia. 8UNC 2A X 33" Double End Stud, A354 Gr. BC,	
				HDG,	
5	B305-026-11	53	18	1.00" 8UNC 2B Dyson D-Loc Nut w/ Poly insert, A563 Gr.	
				DH, HDG.	
6	B305-027-11	66	6	3.50"- 4UNC 2B X 51" Extension Rods, A354 Gr. BD,	
				HDG	

Identification: 1.00", 3.00", 3.5" Bolts, Nuts and Washers

### **Summary of Items Observed:**

On this date, Quality Assurance Inspector (QAI) Fred Edmondson was present at the Dyson Corporation in Painesville, OH as requested to monitor the fabrication of various high strength rods, bolts and washers for the San Francisco Oakland Bay Bridge (SFOBB) project.

This QAI met with Dyson Corporation Quality Control Supervisor (QCS) Mr. Russell Welsh and Mr. Mark Roach, KTA inspector.

This QAI reviewed supporting documentation and conducted a random visual inspection of the following items to be shipped to the job-site. The items appeared to in general compliance with the contract documents and this QAI assigned Lot Numbers as follows: Lot No. B305-027-11 - 6 ea 3.50"- 4UNC 2B X 51" Extension Rods, A354 Gr. BD, HDG, and Lot No. B305-026-11 for the following: 5 ea - 3.00" 4UNC 2A X 25" Heavy Hex Bolt, A354 Gr. BD, HDG, 5 ea - 4UNC 2B Heavy Hex Nut, A563 Gr. DH, HDG, 5 ea - 3.00" dia. Hardened Flat Washer, F436 Type 1, HDG, 9 ea - 1.00" dia. 8UNC 2A X 33" Double End Stud, A354 Gr. BC, HDG, 18 ea - 1.00" 8UNC 2B Dyson D-Loc Nut w/ Poly insert, A563 Gr. DH, HDG.



Shipped to: Oakland,

CA

### **REPORT OF INSPECTION OF MATERIAL**

( Continued Page 2 of 2 )





### **Summary of Conversations:**

Fundamental conversation, necessary to complete the tasks at hand, occurred between this QAI and Dyson personnel.

### Comments

This report is for the purpose of determining conformance with the contract documents and is not for the purpose of making repair or fit for purpose recommendations. Should you require recommendations concerning repairs or remedial efforts please contact Nina Choy 510-385-5910, who represents the Office of Structural Materials for your project.

Inspected By:	Edmondson, Fred	Quality Assurance Inspector
<b>Reviewed By:</b>	Levell, Bill	QA Reviewer

### CERTIFICATE OF COMPLIANCE

225 DYSON C	CORP.				
DN DOMEST	53 Free IC NUT Painesvill	53 Freedom Road Painesville, OH 44077		440-946-3500 440-352-2700 fax	
DYSON ORDER#	CUSTOMER ORDER#	ITEM NUMBER	QUANTITY SHIPPED	DATE SHIPPED	
L 113895	660110-SA-017 C/O 024	1 of 10	5 pcs	10/12/11	
CUSTOMER American Bridge / 375 Burma Road Oakland, CA 9460 USA	Fluor JV )7	PRODUCT DESC 3.00 <sup></sup> 4UNC-2A x 25.00 <sup>+</sup> lg. hr thread per Tower Access Detail Standard Specification 75-1 05 SPECIFICATIONS ASTM-A354 Gra 10-1.59, 10-1.60,	RIPTION cavy hex bolt tassembly to consist of 1 Nut & 1No. 16B, Sheet 51552 and Dyson Fabricatic & ASTM-A123 w/mear white metal blass or S ade BD with special pro 10-1.61 std specification	e 1 Washer) w/6.50° of useable on Sketch, HDG per Caltrans inr In ealwanize REF: CCO 128 V ISIONS ns 75-1.05	

#### DRAWING

**Tower Access Detail No.16B** 

> The product listed above was manufactured, tested, sampled, and inspected in accordance with the specification, purchase order, and any supplementary requirements and was found to meet those requirements unless otherwise noted.

Hardness Results: 363 HBW

and the second s	STATE OF CALIFORNIA · DEPARTMENT OF TRANSPORTATION INSPECTION RELEASE TAG
	STATE LOT NO. B305-A26-11
	CONTRACT NO. 04-0120 F4
	FM 92 1554 FOR 1000 1000 TO DATE 10-12-11
	Based upon selective sampling

Altachments: Mill Test Report Mechanical Test Report Galvanizing Certification

Deborah

-

Q.A. Admin. Assistant 10/11/11

LARGE DIAMETER FASTENERS & FORGINGS / STANDARDS & SPECIALS / COMMERCIAL, MILITARY & NUCLEAR SPECIFICATIONS



5591 MORRILL ROAD JACKSON, MICHIGAN 49201

### CODE OQN3

### CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER	CUSTOMER PART NUMBER	HEAT NUMBER	WORK ORDER NUMBER	DATE
2000211-5		M39159	245969 101	2/01/10
REPORT TO		SHIP TO	1	
CHICAGO STEEL & 700 CENTRAL AVEN	IRON LLC NUE	CHICAGO STEEL 300 EAST JOE	, & IRON, LLC ORR RD	
UNIVERSITY PARK	, IL 60466	CHICAGO HEIGH	TS , IL 60411	
GRADE	SIZE ORDEREL	)	L FNGT	
4140	<u>3"</u> R	ND 2	0'	×
ASTM A29/A29M-05;	CUSTOMER SPECIFICA A322-07; A304-05; E381-0	אסחי 1	,	
		5		
4	CHEMICAL ANAL	YSIS		
C Mn	P S Si Ni	Cr Mo	Cu Sn	Al
0.43 0.87 0.	009 0.032 0.26 0.18	0.88 0.18	0.22 0.008	0.025
л мр				
0.007 0.002				
GRAIN SIZE	SPECIFICATION ASTM E112	FINE GRAIN	5 - 8	
HARDENABILITY	SPECIFICATION ASTM A255/A	4304		
THEORETICAL J1 2 3 4 5 6 58 58 58 58 58 58	5 7 8 9 10 11 12 13 14 3 57 56 55 53 51 49	1 15 16 18 20 22 9 47 46 45	24 26 28 30 43 41	32 34 38
MACROCLEANLINESS	SPECIFICATION ASTM E381			
PLATE I	PL	ATE II		
S R AVERAGE 1 1	C 1 NONE		Q.A. SEVIEWED	Constraint of the second se
		3 <b>-</b> 5 8	1.2 + - 33 39	E.
PAGE 1				
We certify th	hat these data are correct and in comp	liance with specified rec	quirements.	
Gerdau MacSteel Monroe 3000 East Front Street	ei ei	Wendy ??	Chang Wendy 1	. Craio
Monroe, MI 48161			YASSURANCE Representative	



5591 MORRILL ROAD JACKSON, MICHIGAN 49201

## CODE OQN3

### CERTIFIED MATERIAL TEST REPORT

CUSTOMER ORDER NUMBER	CUSTOMER PART NUMBER	HEAT NUMBER	WORK ORDER NUMBER	DATE
2008244-3		M39159	245969 107	12/01/10
		11227222	101 606CPN	12/01/10

REPORT TO

SHIP TO

CHICAGO STEEL & IRON LLC 700 CENTRAL AVENUE CHICAGO STEEL & IRON, LLC 300 EAST JOE ORR RD

UNIVERSITY PARK , IL 60466

CHICAGO HEIGHTS , IL 60411

		ORDERED	
GRADE	3"	RND	LENGTH 20'
¥		CUSTOMER SPECIFICATIONS	la
ASTM A29/A29M-05; A	322-07; A304-	05; E381-01	8 - S
REDUCTION PATTO			
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RATIO# 5.1 TO 1.	0		
** MATERIAL 100% ARC FURNACE A BEEN REPAIREL TO MERCURY OR TEMPERATURES E GERDAU MACSTEE TO ENSURE THAT	MELTED AND MA ND CONTINUOUS BY WELDING TO ANY OTHE DURING PROCESS L MONITORS AL PRODUCTS SHI	ANUFACTURED IN S CASTING METHO AND THIS MATE ER METAL ALLOY SING OR WHILE I L INCOMING SCR PPED ARE FREE	THE U.S.A. BY THE ELECTRIC D. THE PRODUCT HAS NOT RIAL HAS NOT BEEN EXPOSED THAT IS LIQUID AT AMBIENT N OUR POSSESSION. AP AND ALL HEATS OF STEEL OF RADIOACTIVE MATERIAL.
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	52		
		÷	Q.A. ASWEWED
			DYSON
		N	
PAGE 2 OF 2			
We certify that	these data are corre	ect and in compliance	with specified requirements
Serdau MacSteel Monroe 3000 East Front Street Aonroe, MI 48161			Wandy C. C. Roig, Wendy J. Craig
			Cuality Assurance Representative

CERTS

DATE	8/5/2011	1	.]		1	<u> </u>	T		
	THE	ART	GAIV	ANIZ	NGM	ike	INIC		
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### CERTIFICATE OF COMPLIANCE

DYSON CORP. 53 Freedom Road 440-946-3500 DIN DOMESTIC NUT Painesville, OH 44077 440-352-2700 fax DYSON CUSTOMER ITEM QUANTITY DATE ORDER# ORDER# NUMBER SHIPPED SHIPPED S 113921 660110-SA-017 C/O 024 3 of 10 5 pcs 10/11/11 CUSTOMER PRODUCT DESCRIPTION American Bridge / Fluor JV 3.00" 4UNC 2B (+0.050" O/S) Heavy Hex Nut, HDG per 375 Burma Road Caltrans Standard Specification 75-1.05 and ASTM A153. Oakland, CA 94607 Waxed & Dyed, ANSI B18.2.2 REF: CCO 128 Work USA SPECIFICATIONS ASTM-A563 Grade DH with special provisions 10-1.59, 10-1.60, 10-1.61 std specifications 75-1.05 DRAWING

ANSI B18.2.2

The product listed above was manufactured, tested, sampled, and inspected in accordance with the specification, purchase order, and any supplementary requirements and was found to meet those requirements unless otherwise noted.

Hardness Results: 285/302 HBW

<u>Attachments:</u> Mill Test Report Galvanizing Certification

Deborah A. Smith Q.A. Admin. Assistant 10/11/11

LARGE DIAMETER FASTENERS & FORGINGS / STANDARDS & SPECIALS / COMMERCIAL, MILITARY & NUCLEAR SPECIFICATIONS

ET GERDAU AMERISTEEL

ST PAUL MN 55119 USA ST PAUL STEEL MILL 1678 RED ROCK ROAD (651) 731-5600

Chemical and Physical Test Report ¢ MADE IN UNITED STATES

M-075095

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Customer Requirements SOURCE: GA-STP CASTING: STRAND CAST



This material, including the bittels, was produced and manufactured in the United States of America

Bhaskar Yalamanchili

**Quality Director** としの人気

Gerdau Ameristeel

THE ABOVE FIGURES ARE CERTIFIED EXTRACTS FROM THE ORIGINAL CHEMICAL AND PHYSICAL TEST RECORDS AS CONTAINED IN THE PERMANENT RECORDS OF COMPANY. Metallurgical Services Manager

ST PAUL STEEL MILL

Seller warrants that all material furnished shalf compty with specifications subject to standard published manufacturing variations. NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, ARE MADE BY THE SELLER, AND SPECIFICALLY EXCLUDED ARE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR a PARTICULAR PURPOSE. In no event shall seller be liable for indirect, consequential or punitive darnages arising out of or related to the materials furnished by seller. And the seller that do not conform to specifications must be made from buyer to seller timmediately turnished by seller.

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Sheet1

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DATE: 8/22/2011			
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CERTIFICA	TION AND MUST REMAIL	NATTACHED.	
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·-	CERTIFICATE	OF COMPLIANCE		
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DYSON ORDER#	CUSTOMER ORDER#	ITEM NUMBER	QUANTITY SHIPPED	DATE SHIPPED
S 113943	660110-SA-017 C/O 024	5 of 10	5 pcs	10/11/11
CUSTOMER American Bridge / Flu 375 Burma Road Oakland , CA 94607	or JV	PRODUCT DESC 3.00" Dia. Harder Standard Specific CCO 128 Work	RIPTION ned Flat Washer, HDG pe cation 75-1.05 and ASTM	er Caltrans A153 REF:
USA DRAWING		SPECIFICATION ASTM F436-07a with special pro- specifications 75	S a Type 1 (modified for a visions 10-1.59, 10-1.60, -1.05	loy steel) 10-1.61 std

The product listed above was manufactured, tested, sampled, and inspected in accordance with the specification, purchase order, and any supplementary requirements and was found to meet those requirements unless otherwise noted.

Hardness result: 38 HRC

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Reference: RFI # ABF-RFI-002560R00 approving the use of alloy steel for the production of these components.

<u>Allachments:</u> Material Test Report Galvanizing Certification

Deborah A. Smith Q.A. Admin. Assistant 10/11/11

PORM: NSB39036 DATE: 03/04/11

ARCELORMITTAL STEELTON LLC PRODUCT TESTING LABORATORY PHONE: (717) 986-2552 ELLT1 STBELTON, PA

CERTIFIED TEST REPORT

PURCHASE ORDER: 76733

CODE ONX "

PAINESVILLE, ON 44077 THE DYSON CORPORATION

53 FREEDOM ROAD

SOLD TO:

ROB RUPLE

ATTN:

WILL ORDER: SB015-7528

AISI,4140; FINE GRAIN PER AN STL SPEC RFOOI REV #2 09/24/08, FORGING QUALITY ELECTRIC FCE VACUUN DEGASSED ROLLED ELOON 2 T/R & FAX ATTN: ROB RUPLE #440-352-2700 -INTO & OUT OF STORAGE HEAT NUMBER: 217N637 TEST & INSPECTION: SPECIFICATION:

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BLOOM/BILLET CROSS SECTION: 10" X 10" BLOOM

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GRAIN SIZE: FINE GR. PER ASTN A-29

NO WELDING WAS PERFORMED ON THIS MATERIAL. THIS MATERIAL HAS NOT BEEN CONTANIMATED OR COME IN CONTACT WITH MERCURY OR RADIOACTIVE ELEMENTS OR THEIR COMPOUNDS. 3.45 TO I REDUCTION RATIO:

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QUALITY STEEL HANUFACTURED IN THE U.S.A. MELTED AND

ISO 9001:2000 CERTIPIED QMS

I CERTIFY THAT THE ABOVE RESULTS ARE A TRUE AND CORRECT COPY OF ACTUAL TEST RECORDS MAINTAINED BY ARCHLOR-MITTAL STEELTON LLC AND ARE IN FULL COMPLIANCE WITH THE REQUIREMENTS OF THE SPECIFICATION/FURCHASE ORDER CITED ABOVE. THIS REPORT SHALL NOT BE ALIERED AND MUST BE TRANSMITTED IN FULL.

NGR. OP Q.A. & METALLURGIAN SVCS./C.I. NYERS who 0

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## **REQUEST FOR INFORMATION (RFI)**

RFI No.: ABF-RFI-002912R00 Submitt	ed By: <u>McNichol, Dan</u>	Pages: 10					
RFI Date: 05-July-2012 Contact	t Name: McNichol, Dan	Phone No. <u>510-808-4585</u>					
Subject: Tower Boom Rod Tension							
References:							
Sub/Sup: ABF Sub RFI #:							
Response Required by: 11-July-2012	Response affect	cts critical path activity?					
Description:							
Each tower boom has four (4) dia. 1" A35 932S2R2/1204. This requires nearly 20to tension is not required to counteract rod e be lowered to between .25Fu and .35Fu. <b>Contractor Disposition:</b>	Each tower boom has four (4) dia. 1" A354 BC galvanized rods that require tensioning to 0.50Fu per sheet 932S2R2/1204. This requires nearly 20tons per rod. Per discussions with CT and T.Y. Lin this amount of tension is not required to counteract rod elongation when the boom is in service. The tension in each rod may be lowered to between .25Fu and .35Fu. Please confirm.						
This RFI is being submitted for:							
The Cost and Time Impact from this RFI is: Not selected							
Response: Agreed Ext. Due Date:							
		Pages: 1					
		Pages Attached: 0					
Stressing of the tower boom 1"-dia A354 BC anchor rods may be reduced from 0.50 Fu to between 0.25Fu and 0.30Fu.							
Administrative Action:							

This response resolves the RFI. No further action required.

Date:17-July-2012Respondent:Awal, MohammadPhone No.:510-385-8257	
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### Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products<sup>1</sup>

This standard is issued under the fixed designation A123/A123M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\varepsilon$ ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

#### 1. Scope\*

1.1 This specification covers the requirements for zinc coating (galvanizing) by the hot-dip process on iron and steel products made from rolled pressed and forged shapes, castings, plates, bars, and strips.

1.2 This specification covers both unfabricated products and fabricated products, for example, assembled steel products, structural steel fabrications, large tubes already bent or welded before galvanizing, and wire work fabricated from uncoated steel wire. This specification also covers steel forgings and iron castings incorporated into pieces fabricated before galvanizing or which are too large to be centrifuged (or otherwise handled to remove excess galvanizing bath metal).

NOTE 1—This specification covers those products previously addressed in Specifications A123-78 and A386-78.

1.3 This specification does not apply to wire, pipe, tube, or steel sheet which is galvanized on specialized or continuous lines, or to steel less than 22 gage (0.0299 in.) [0.76 mm] thick.

1.4 The galvanizing of hardware items that are to be centrifuged or otherwise handled to remove excess zinc (such as bolts and similar threaded fasteners, castings and rolled, pressed and forged items) shall be in accordance with Specification A153/A153M.

1.5 Fabricated reinforcing steel bar assemblies are covered by the present specification. The galvanizing of separate reinforcing steel bars shall be in accordance with Specification A767/A767M.

1.6 This specification is applicable to orders in either inch-pound units (as A123) or SI units (as A123M). Inchpound units and SI units are not necessarily exact equivalents. Within the text of this specification and where appropriate, SI units are shown in parentheses. Each system shall be used independently of the other without combining values in any way. In the case of orders in SI units, all testing and inspection shall be done using the metric equivalent of the test or inspection method as appropriate. In the case of orders in SI units, such shall be stated to the galvanizer when the order is placed.

#### 2. Referenced Documents

- 2.1 ASTM Standards:<sup>2</sup>
- A47/A47M Specification for Ferritic Malleable Iron Castings
- A90/A90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
- A143/A143M Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
- A153/A153M Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
- A384/A384M Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
- A385 Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
- A767/A767M Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
- A780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
- A902 Terminology Relating to Metallic Coated Steel Products
- **B6** Specification for Zinc
- B487 Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section
- **B602** Test Method for Attribute Sampling of Metallic and Inorganic Coatings
- B960 Specification for Prime Western Grade-Recycled (PWG-R) Zinc
- E376 Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Testing Methods

#### \*A Summary of Changes section appears at the end of this standard.

<sup>&</sup>lt;sup>1</sup>This specification is under the jurisdiction of ASTM Committee A05 on Metallic-Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.13 on Structural Shapes and Hardware Specifications.

Current edition approved May 1, 2012. Published July 2012. Originally approved in 1928. Last previous edition approved in 2009 as A123/A123M - 09. DOI: 10.1520/A0123\_A0123M-12.

<sup>&</sup>lt;sup>2</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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### 3. Terminology (See Fig. 1)

3.1 Definitions:

3.1.1 The following terms and definitions are specific to this specification. Terminology A902 contains other terms and definitions relating to metallic-coated steel products.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 average coating thickness, n—the average of three specimen coating thicknesses.

3.2.2 *black*, *adj*—denotes the condition of not galvanized or otherwise coated. For purposes of this specification the word

"black" does not refer to the color or condition of surface, or to a surface deposit or contamination.

3.2.3 *coating thickness grade*, n—the numerical value from Table 1 at the intersection of a material category and a thickness range.

3.2.4 gross dross inclusions, n—the iron/zinc intermetallics present in a galvanized coating in a form other than finely dispersed pimples.

3.2.4.1 *Discussion*—These inclusions would create an exposed steel spot if they were removed from the coating. These



Single-specimen Articles

Articles whose Surface Area is equal to or less than 160 sq.in. (100,000 sq. mm)



Each Specimen (5 or more measurements widely dispersed) must have Minimum Average Coating Thickness of (Table 1) -1 grade

All Test Articles (Specimens) Together must have Minumum Average Coating Thickness of (Table 1) FIG. 1 Single- and Multi-Specimen Articles

### 🖽 A123/A123M – 12

TABLE 1 Minimum Average Coating Thickness Grade by Material Category

Material Category	All Specimens Tested Steel Thickness Range (Measured), in. (mm)						
29 61	<½16 <b>(&lt;1.6)</b>	1/16 to <1/8 (1.6 to <3.2)	1/8 to 3/16 (3.2 to 4.8)	>¾16 to <¼ (>4.8 to <6.4)	≥1⁄4 (≥6.4)		
Structural Shapes and Plate	45	65	75	75	100		
Strip and Bar	45	65	75	75	100		
Pipe and Tubing	45	45	75	75	75		
Wire	35	50	60	65	80		
Reinforcing Bar	22	1000	1992	1222	100		

inclusions are raised surfaces and are easily knocked off through contact with lifting straps or chains, tools, fixtures, or other galvanized parts.

3.2.5 *material category*, *n*—the general class or type of material or process of manufacture, or both, that nominally describes a unit of product, or from which a unit of product is made. For example, bar grating belongs to the category "strip," handrail belongs to the category "pipe," etc.

3.2.6 multi-specimen article, n—a unit of product whose surface area is greater than 160 in.<sup>2</sup>[100 000 mm<sup>2</sup>]. For thickness testing purposes, articles whose surface area is greater than 160 in.<sup>2</sup> are subdivided into three continuous local sections, nominally equal in surface area, each of which constitutes a specimen. In the case of any such local section containing more than one material category or steel thickness range as delineated in Table 1, that section will contain more than one specimen (see Fig. 1).

3.2.7 sample, n—a collection of individual units of product from a single lot selected in accordance with Section 7, and intended to represent that lot for acceptance. If a sample is taken as representing the lot for acceptance, the sample shall be taken at random from the lot without regard to the perceived quality or appearance of any individual unit in the lot being sampled. The sample consists of one or more test articles.

3.2.8 single-specimen article, n—a unit of product whose surface area is equal to or less than 160 in.<sup>2</sup> [100 000 mm<sup>2</sup>] or that is centrifuged or otherwise similarly handled in the galvanizing process to remove excess galvanizing bath metal (free zinc). For thickness testing purposes, the entire surface area of each unit of product constitutes a specimen. In the case of any such article containing more than one material category or steel thickness range as delineated in Table 1, that article will contain more than one specimen (see Fig. 1).

3.2.9 specimen, n—the surface of an individual test article or a portion of a test article, upon which thickness measurements are to be performed, which is a member of a lot, or a member of a sample representing that lot. For magnetic thickness measurements, specimen excludes any area of the surface which is subject to processes (such as flame cutting, machining, threading, etc.) that can be expected to result in surface conditions not representative of the general surface condition of the test article, or is disqualified by the measurement method. The minimum average coating thickness grade for any specimen shall be one coating grade below that required for the appropriate material category and thickness in Table 1. For a unit of product whose surface area is equal to or less than 160 in.<sup>2</sup> [100 000 mm<sup>2</sup>], the entire surface area of each test article constitutes a specimen. In the case of an article containing more than one material category or steel thickness range as delineated in Table 1, that article will contain more than one specimen, as appropriate (see Fig. 1).

3.2.10 specimen coating thickness, n—the average thickness from no less than five test measurements on a specimen, when each measurement location is selected to provide the widest dispersion (in all applicable directions) of locations for the steel category of the test article within the confines of the specimen volume.

3.2.11 *test article*, *n*—an individual unit of product that is a member of the sample and that is examined for conformance to a part of this specification.

#### 4. Ordering Information

4.1 Orders for coatings provided under this specification shall include the following:

4.1.1 Quantity (number of pieces to be galvanized) and total weight.

4.1.2 Description (type and size of products) and weight.

4.1.3 ASTM specification designation and year of issue.

4.1.4 Material identification (see 5.1) and surface condition or contamination.

4.1.5 Sampling plan, if different from 7.3.

4.1.6 Special test requirements (see 8.1).

4.1.7 Special requirements (special stacking, heavier coating weight, etc.).

4.1.8 Tagging or piece identification method.

#### 5. Materials and Manufacture

5.1 *Steel or Iron*—The specification, grade, or designation and type and degree of surface contamination of the iron or steel in articles to be galvanized shall be supplied by the purchaser to the hot-dip galvanizer prior to galvanizing.

NOTE 2—The presence in steels and weld metal, in certain percentages, of some elements such as silicon, carbon, and phosphorus tends to accelerate the growth of the zinc-iron alloy layer so that the coating may have a matte finish with little or no outer zinc layer. The galvanizer has only limited control over this condition. The mass, shape, and amount of cold working of the product being galvanized may also affect this condition. Practice A385 provides guidance on steel selection and discusses the effects of various elements in steel compositions (for example, silicon), that influence coating weight and appearance.

5.2 *Fabrication*—The design and fabrication of the product to be galvanized are the responsibilities of the designer and the fabricator. Practices A143/A143M, A384/A384M, and A385 provide guidance for steel fabrication for optimum hot dip galvanizing and shall be complied with in both design and fabrication. Consultation between the designer, fabricator, and

Licensee=Dept of Transportation/5950087001 Not for Resale, 05/16/2013 14:43:25 MDT galvanizer at appropriate stages in the design and fabrication process will reduce future problems.

#### 5.3 *Castings*—The composition and heat treatment of iron and steel castings shall conform to specifications designated by the purchaser. Some types of castings have been known to show potential problems with predisposition to being embrittled during the normal thermal cycle of hot-dip galvanizing. It is the responsibility of the purchaser to heat treat or otherwise allow for the possibility of such embrittling phenomena. The requirements for malleable iron castings to be galvanized shall be as stated in Specification A47/A47M.

5.4 Zinc—The zinc used in the galvanizing bath shall conform to Specification B6, or Specification B960, or both. If a zinc alloy is used as the primary feed to the galvanizing bath, then the base material used to make that alloy shall conform to Specification B6, or Specification B960, or both.

5.5 *Bath Composition*—The molten metal in the working volume of the galvanizing bath shall contain not less than an average value of 98.0 % zinc by weight.

NOTE 3—The galvanizer may choose to add trace amounts of certain elements (for example, aluminum, nickel, and tin) to the zinc bath to help in the processing of certain reactive steels or to enhance the cosmetic appearance of the finished product. The use of these trace elements is permitted provided that the bulk chemistry of the galvanizing bath is at least 98.0 % zinc by weight. The elements can be added to the galvanizing bath as part of a pre-alloyed zinc feed, or they can be added to the bath by the galvanizer using a master feed alloy.

#### 6. Coating Properties

6.1 Coating Thickness—The average thickness of coating for all specimens tested shall conform to the requirements of Table 1 for the categories and thicknesses of the material being galvanized. Minimum average thickness of coating for any individual specimen is one coating grade less than that required in Table 1. Where products consisting of various material thicknesses or categories are galvanized, the coating thickness grades for each thickness range and material category of material shall be as shown in Table 1. In the case of orders in SI units, the values in Table 1, shall be applicable as metric units in micrometres. In the case of orders in inch-pound units, the measured value shall be converted to coating grade units by the use of Table 2. The specification of coating thicknesses heavier than those required by Table 1 shall be subject to mutual agreement between the galvanizer and the purchaser. (Fig. 2 is a graphic representation of the sampling and



NOTE 1—Each specimen comprises nominally one third of the total surface area of the article. A minimum of five measurements should be made within the volume of each specimen, as widely dispersed within that volume as is practical, so as to represent as much as possible, the general coating thickness within that specimen volume.

#### FIG. 2 Articles Made of Many Components

specimen delineation steps, and Fig. 3 is a graphic representation of the coating thickness inspection steps.)

6.1.1 For articles whose surface area is greater than 160 in.<sup>2</sup> [100 000 mm<sup>2</sup>] (multi-specimen articles), each test article in the sample must meet the appropriate minimum average coating thickness grade requirements of Table 1, and each specimen coating thickness grade comprising that overall average for each test article shall average not less than one coating grade below that required in Table 1.

6.1.2 For articles whose surface area is equal to or less than 160 in.<sup>2</sup> [100 000 mm<sup>2</sup>] (single-specimen articles), the average of all test articles in the sample must meet the appropriate minimum average coating thickness grade requirements of Table 1, and for each test article, its specimen coating thickness shall be not less than one coating grade below that required in Table 1.

6.1.3 No individual measurement, or cluster of measurements at the same general location, on a test specimen shall be cause for rejection under the coating thickness requirements of this specification provided that when those measurements are averaged with the other dispersed measurements to determine the specimen coating thickness grade for that specimen, the requirements of 6.1.1 or 6.1.2, as appropriate are met.

NOTE 4—The coating thickness grades in Table 1 represent the minimum value obtainable with a high level of confidence for the ranges typically found in each material category. While most coating thicknesses

TABLE 2	Coating	Thickness	Grade <sup>A</sup>
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Coating Grade	mils	oz/ft <sup>2</sup>	μm	g/m <sup>2</sup>
35	1.4	0.8	35	245
45	1.8	1.0	45	320
50	2.0	1.2	50	355
55	2.2	1.3	55	390
60	2.4	1.4	60	425
65	2.6	1.5	65	460
75	3.0	1.7	75	530
80	3.1	1.9	80	565
85	3.3	2.0	85	600
100	3.9	2.3	100	705

<sup>A</sup> The values in micrometres (µm) are based on the Coating Grade. The other values are based on conversions using the following formulas: mils =  $\mu$ m × 0.03937; oz/ff<sup>2</sup> =  $\mu$ m × 0.02316; g/m<sup>2</sup> =  $\mu$ m × 7.067.



FIG. 3 Coating Thickness Inspection Steps

will be in excess of those values, some materials in each category may be less reactive (for example, because of chemistry or surface condition) than other materials of the steel category spectrum. Therefore, some articles may have a coating grade at or close to the minimum requirement shown in **Table 1**. In such cases, the precision and accuracy of the coating thickness measuring technique should be taken into consideration when rejecting such articles for coating thickness below that required by this specification. Purchasers desiring a guarantee of heavier coatings than the minimum thicknesses shown herein should use the special requirements (see 4.1.6) to specify coating thickness grades higher than those shown in **Table 1**. In addition, the purchaser should anticipate the need for test batches or extra preparation steps, or both, such as blasting before galvanizing or other methods, to attempt to reach the higher requirements with consistency. Some higher-than-standard thicknesses may be impractical or unattainable.

6.2 *Finish*—The coating shall be continuous (except as provided below), and as reasonably smooth and uniform in thickness as the weight, size, shape of the item, and necessary handling of the item during the dipping and draining operations

at the galvanizing kettle will permit. Except for local excess coating thickness which would interfere with the use of the product, or make it dangerous to handle (edge tears or spikes), rejection for nonuniform coating shall be made only for plainly visible excess coating not related to design factors such as holes, joints, or special drainage problems (see Note 6). Since surface smoothness is a relative term, minor roughness that does not interfere with the intended use of the product, or roughness that is related to the as-received (un-galvanized) surface condition, steel chemistry, or steel reactivity to zinc shall not be grounds for rejection (see Note 7). Surface conditions related to deficiencies related to design, detailing, or fabrication as addressed by Practice A385 shall not be grounds for rejection. The zinc coating on threaded components of articles galvanized under this specification shall conform to that required in Specification A153/A153M. Surfaces that remain uncoated after galvanizing shall be renovated in accordance with the methods in Practice A780 unless directed by the purchaser to leave the uncoated areas untreated for subsequent renovation by the purchaser.

6.2.1 Each area subject to renovation shall be 1 in. [25 mm] or less in its narrowest dimension.

6.2.2 The total area subject to renovation on each article shall be no more than  $\frac{1}{2}$  of 1 % of the accessible surface area to be coated on that article, or 36 in.<sup>2</sup> per short ton [256 cm<sup>2</sup> per metric ton] of piece weight, whichever is less.

Note 5—Inaccessible surface areas are those which cannot be reached for appropriate surface preparation and application of repair materials as described in Practice A780. Such inaccessible areas, for example, would be the internal surfaces of certain tanks, poles, pipes, tubes, and so forth.

6.2.3 The thickness of renovation shall be that required by the thickness grade for the appropriate material category and thickness range in Table 1 in accordance with the requirements of 6.1, except that for renovation using zinc paints, the thickness of renovation shall be 50 % higher than that required by Table 1, but not greater than 4.0 mils.

6.2.4 When areas requiring renovation exceed the criteria previously provided, or are inaccessible for repair, the coating shall be rejected.

NOTE 6—The requirements for the finish of a galvanized product address themselves to a visual type of inspection. They do not address the matter of measured coating thickness variations that can be encountered because of different steels or different thicknesses of a given steel being used in an assembly.

NOTE 7—Items which are prepared for galvanizing by abrasive cleaning will generally develop a thicker coating with a moderately rougher surface.

6.3 *Threaded Components in Assemblies*— The zinc coating on external threads shall not be subjected to a cutting, rolling, or finishing tool operation, unless specifically authorized by the purchaser. Internal threads are not prohibited from being tapped or retapped after galvanizing. Coatings shall conform to the requirements of Specification A153/A153M.

6.4 *Appearance*—Upon shipment from the galvanizing facility, galvanized articles shall be free from uncoated areas, blisters, flux deposits, and gross dross inclusions. Lumps, projections, globules, or heavy deposits of zinc which will interfere with the intended use of the material will not be

Licensee=Dept of Transportation/5950087001 Not for Resale, 05/16/2013 14:43:25 MDT permitted. Plain holes of  $\frac{1}{2}$ -in. [12.5-mm] diameter or more shall be clean and reasonably free from excess zinc. Marks in the zinc coating caused by tongs or other items used in handling the article during the galvanizing operation shall not be cause for rejection unless such marks have exposed the base metal and the bare metal areas exceed allowable maximums from 6.2.1 and 6.2.2. The pieces shall be handled so that after galvanizing they will not freeze together on cooling.

NOTE 8—Depending upon product design or material thickness, or both, filming or excess zinc buildup in plain holes of less than  $\frac{1}{2}$ -in. [12.5-mm] diameter may occur that requires additional work to make the holes usable as intended.

6.5 Adherence—The zinc coating shall withstand handling consistent with the nature and thickness of the coating and the normal use of the article, without peeling or flaking.

NOTE 9—Although some material may be formed after galvanizing, in general the zinc coating on the articles covered by this specification is too heavy to permit severe bending without damaging the coating.

### 7. Sampling

7.1 Sampling of each lot shall be performed for conformance with the requirements of this specification.

7.2 A lot is a unit of production or shipment from which a sample is taken for testing. Unless otherwise agreed upon between the galvanizer and the purchaser, or established within this specification, the lot shall be as follows: For testing at a galvanizer's facility, a lot is one or more articles of the same type and size comprising a single order or a single delivery load, whichever is the smaller, or any number of articles identified as a lot by the galvanizer, when these have been galvanized within a single production shift and in the same bath. For test by the purchaser after delivery, the lot consists of the single order or the single delivery load, whichever is the smaller, unless the lot identity, established in accordance with the above, is maintained and clearly indicated in the shipment by the galvanizer.

7.3 The method of selection and number of test specimens shall be agreed upon between the galvanizer and the purchaser. Otherwise, the test specimens shall be selected at random from each lot. In this case, the minimum number of specimens from each lot shall be as follows:

Number of Pieces in Lot	Number of Specimens		
3 or less	all		
4 to 500	3		
501 to 1 200	5		
1 201 to 3 200	8		
3 201 to 10 000	13		
10 001 and over	20		

NOTE 10—Where a number of identical items are to be galvanized, a statistical sampling plan may be desired. Such a plan is contained in Test Method B602 which addresses sampling procedures for the inspection of electrodeposited metallic coatings and related finishes. If Test Method B602 is used, the level of sampling shall be agreed upon between the galvanizer and the purchaser at the time the coating order is placed.

7.4 A test specimen which fails to conform to a requirement of this specification shall not be used to determine the conformance to other requirements.

#### 8. Test Methods

8.1 *Test Requirements*—The following tests shall be conducted to ensure that the zinc coating is being furnished in accordance with this specification. The specifying of tests for adhesion and embrittlement shall be subject to mutual agreement between the galvanizer and purchaser. Visual inspection of the coating shall be made for compliance with the requirements.

8.2 *Thickness of Coating Test*—The thickness of coating is determined by one or more of the three methods described as follows.

8.2.1 *Magnetic Thickness Measurements*— The thickness of the coating shall be determined by magnetic thickness gage measurements in accordance with Practice E376 unless the methods described in 8.2.2, 8.2.3, or 8.2.4 are used. For each specimen (as described in 3.2.9) five or more measurements shall be made at points widely dispersed throughout the volume occupied by the specimen so as to represent as much as practical, the entire surface area of the test specimen. The average of the five or more measurements thus made for each specimen is the specimen coating thickness.

8.2.1.1 For articles whose surface area is greater than 160 in.<sup>2</sup> [100 000 mm<sup>2</sup>] (multi-specimen articles as described in 3.2.6), the average of the three specimen coating thickness grades comprising each test article is the average coating thickness for that test article. A specimen must be evaluated for each steel category and material thickness within the requirements for each specimen of the test article.

8.2.1.2 For articles whose surface area is equal to or less than 160 in.<sup>2</sup> [100 000 mm<sup>2</sup>] (single-specimen articles as described in 3.2.8), the average of all specimen coating thickness grades is the average coating thickness for the sample.

8.2.1.3 In the case of threaded components, the thickness of coating shall be made on a portion of the article that does not include any threads.

8.2.1.4 The use of magnetic measurement methods is appropriate for larger articles, and is appropriate for smaller articles when there is sufficient flat surface area for the probe tip to sit flat on the surface using Practice E376.

8.2.2 Stripping Method—The average weight of coating shall be determined by stripping a test article, a specimen removed from a test article, or group of test articles in the case of very small items such as nails, etc., in accordance with Test Method A90/A90M unless the methods described in 8.2.1, 8.2.3, or 8.2.4 are used. The weight of coating per unit area thus determined is converted to equivalent coating thickness values in accordance with Table 2 (rounding up or down as appropriate). The thickness of coating thus obtained is the test article coating thickness, or in the case of a specimen removed from a test article, is the specimen average coating thickness.

8.2.2.1 The stripping method is a destructive test and is appropriate for single specimen articles, but is not practical for multi-specimen articles.

8.2.3 Weighing Before and After Galvanizing—The average weight of coating shall be determined by weighing articles before and after galvanizing, subtracting the first weight from the second and dividing the result by the surface area unless the

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methods described in 8.2.1, 8.2.2, or 8.2.4 are used. The first weight shall be determined after pickling and drying and the second after cooling to ambient temperature. The weight of coating per unit area thus determined is converted to equivalent coating thickness values according to Table 2 (rounding up or down as appropriate). The thickness of coating thus obtained is the test article coating thickness.

8.2.3.1 The weighing before and after method is appropriate for single-specimen articles, but is not practical for multi-specimen articles.

NOTE 11—Both the stripping method and the weighing before and after method do not take into account the weight of iron reacted from the article that is incorporated into the coating. Thus, the methods may underestimate coating weight (and therefore the calculated thickness) by up to 10 %. The accuracy of both methods will be influenced by the accuracy to which the surface area of the articles tested can be determined.

8.2.4 *Microscopy*—The thickness of coating shall be determined by cross-sectional and optical measurement in accordance with Test Method B487 unless the methods described in 8.2.1, 8.2.2, or 8.2.3 are used. The thickness thus determined is a point value. No less than five such measurements shall be made at locations on the test article which are as widely dispersed as practical, so as to be representative of the whole surface of the test article. The average of no less than five such measurements is the specimen coating thickness.

8.2.4.1 The microscopy method is a destructive test and is appropriate for single-specimen articles, but is not practical for multi-specimen articles.

8.2.5 *Referee Method*—In the event of a dispute over thickness of coating measurements, the dispute shall be resolved as follows:

8.2.5.1 For multi-specimen articles, a new sample shall be taken randomly from the lot of material, which has twice the number of test articles as the sample which failed to conform to this specification. If the lot size is such that the sample size cannot be doubled, then the sample size shall be as previous, but the number of widely dispersed sites at which measurements were made shall be doubled, and these sites will constitute the new sample. This new sample shall be measured using magnetic thickness gages which have been calibrated for accuracy against reference material thickness standards. If the lot is found to be nonconforming by the new sample, the galvanizer has the right to sort the lot for conforming articles by individual test, to re-galvanize non-conforming articles, or to renovate the nonconforming articles in accordance with 6.2.

8.2.5.2 For single-specimen articles, a new sample shall be taken randomly from the lot of material, which has twice the number of test articles as the sample which failed to conform to this specification. The test method for the new sample shall be selected by mutual agreement between the purchaser and galvanizer. If the lot is found to be nonconforming by the new sample, the galvanizer has the right to sort the lot for conforming articles by individual test, to re-galvanize non-conforming articles, or to renovate the nonconforming articles in accordance with 6.2.

8.3 *Adhesion*—Determine adhesion of the zinc coating to the surface of the base metal by cutting or prying with the point of a stout knife, applied with considerable pressure in a manner

tending to remove a portion of the coating. The adhesion shall be considered inadequate if the coating flakes off in the form of a layer of the coating so as to expose the base metal in advance of the knife point. Do not use testing carried out at edges or corners (points of lowest coating adhesion) to determine adhesion of the coating. Likewise, do not use removal of small particles of the coating by paring or whittling to determine failure.

8.4 *Embrittlement*—Test for embrittlement shall be made in accordance with Practice A143/A143M. These tests shall not be required unless strong evidence of embrittlement is present.

#### 9. Inspection, Rejection, and Retest

9.1 *Inspection by the Galvanizer*—It is the responsibility of the galvanizer to ensure compliance with this specification. This shall be achieved by an in-plant inspection program designed to maintain the coating thickness, finish, and appearance within the requirements of this specification unless the inspection is performed in accordance with 9.2.

9.2 Inspection By the Purchaser—The purchaser shall accept or reject material by inspection either through the galvanizer's inspector, the purchaser's inspector, or an independent inspector. The inspector representing the purchaser shall have access at all times to those areas of the galvanizer's facility which concern the application of the zinc coating to the material ordered while work on the contract of the purchaser is being performed. The galvanizer shall afford the inspector all reasonable facilities to satisfy him that the zinc coating is being furnished in accordance with this specification.

9.3 *Location*—The material shall be inspected at the galvanizer's plant prior to shipment. However, by agreement the purchaser is not prohibited from making tests which govern the acceptance or rejection of the materials in his own laboratory or elsewhere.

9.4 *Reinspection*—When inspection of materials to determine conformity with the visual requirements of 6.2 warrants rejection of a lot, the galvanizer is not prohibited from sorting the lot and submit it once again for acceptance after he has removed any nonconforming articles and replaced them with conforming articles.

9.5 The sampling plan that was used when the lot was first inspected shall be used for resampling of a sorted lot. By mutual agreement, the galvanizer is not prohibited from submitting the lot remaining after sorting and removing non-conforming articles without replacement of the nonconforming articles. In such case, the now-smaller lot shall be treated as a new lot for purposes of inspection and acceptance.

9.6 Materials that have been rejected for reasons other than embrittlement are not prohibited from being stripped and regalvanized and again submitted for inspection and test at which time they shall conform to the requirements of this specification.

#### 10. Certification

10.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed by this specification and the requirements have been met.

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When specified in the purchase order or contract, a report of the test results shall be furnished.

#### 11. Keywords

11.1 coatings—zinc; galvanized coatings; steel products—metallic coated; zinc coatings—steel products

#### SUMMARY OF CHANGES

Committee A05 has identified the location of selected changes to this standard since the last issue (A123/A123M - 09) that may impact the use of this standard. (May 15, 2012)

#### (1) Revised Table 1.

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### Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement<sup>1</sup>

This standard is issued under the fixed designation A 143/A 143M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

#### 1. Scope

1.1 This practice covers procedures that can be followed to safeguard against the possible embrittlement of steel hot-dip galvanized after fabrication, and outlines test procedures for detecting embrittlement. Conditions of fabrication may induce a susceptibility to embrittlement in certain steels that can be accelerated by galvanizing. Embrittlement is not a common occurrence, however, and this discussion does not imply that galvanizing increases embrittlement where good fabricating and galvanizing procedures are employed. Where history has shown that for specific steels, processes and galvanizing procedures have been satisfactory, this history will serve as an indication that no embrittlement problem is to be expected for those steels, processes, and galvanizing procedures.

1.2 This practice is applicable in either inch-pounds or SI units. Inch-pounds and SI units are not necessarily exact equivalents. Within the text of this practice and where appropriate, SI units are shown in brackets.

1.3 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

#### 2. Referenced Documents

2.1 ASTM Standards: <sup>2</sup>

F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets

#### 3. Terminology

#### 3.1 Definition:

3.1.1 *embrittlement*, *n*—the loss or partial loss of ductility in a steel where an embrittled product characteristically fails by fracture without appreciable deformation; types of embrittlement usually encountered in galvanized steel are related to aging phenomena, cold working, and absorption of hydrogen.

#### 4. Factors in Embrittlement

4.1 Embrittlement or loss of ductility in steel is often associated with strain-aging. Strain-aging refers to the delayed increase in hardness and strength, and loss of ductility and impact resistance which occur in susceptible steels as a result of the strains induced by cold working. The aging changes proceed slowly at room temperature, but proceed at an accelerated rate as the aging temperature is raised and may occur rapidly at the galvanizing temperature of approximately 850°F [455°C].

4.2 Hydrogen embrittlement may also occur due to the possibility of atomic hydrogen being absorbed by the steel. The susceptibility to hydrogen embrittlement is influenced by the type of steel, its previous heat treatment, and degree of previous cold work. In the case of galvanized steel, the acid pickling reaction prior to galvanizing presents a potential source of hydrogen. However, the heat of the galvanizing bath partially expels hydrogen that may have been absorbed. In practice hydrogen embrittlement of galvanized steel is usually of concern only if the steel exceeds approximately 150 ksi [1100 MPa] in ultimate tensile strength, or if it has been severely cold worked prior to pickling.

4.3 Loss of ductility of cold-worked steels is dependent on many factors including the type of steel (strength level, aging characteristics), thickness of steel, and degree of cold work, and is accentuated by areas of stress concentration such as caused by notches, holes, fillets of small radii, sharp bends, etc.

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<sup>&</sup>lt;sup>1</sup> This practice is under the jurisdiction of ASTM Committee A05 on Metallic-Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.13 on Structural Shapes and Hardware Specifications.

Originally Prepared by Subcommittee A05.10 on Embrittlement Investigation of Committee A05 on Corrosion of Iron and Steel and based on an investigation made by Battelle Memorial Institute under American Society for Testing and Materials' sponsorship. See *Proceedings*, Am. Soc. Testing Mats., Vol 31, Part I, 1931, p. 211; also paper by Samuel Epstein, "Embrittlement of Hot-Dip Galvanized Structural Steel," see *Proceedings*, Am. Soc. Testing Mats., Vol 32, Part II, 1932, p. 293.

Current edition approved May 1, 2007. Published June 2007. Originally approved in 1932. Last previous edition approved in 2003 as A 143/A 143M - 03.

<sup>&</sup>lt;sup>2</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

4.4 Low temperatures increase the risk of brittle failure of all plain carbon steels including steel that has been galvanized. The rate at which this temperature loss of ductility occurs varies for different steels. The expected service temperature should thus be taken into account when selecting the steel.

#### 5. Steels

5.1 Open-hearth, basic-oxygen, and electric-furnace steels shall be used for galvanizing. Other materials that can be galvanized include continuous cast slabs, steel or iron castings, and wrought iron.

#### 6. Cold Working and Thermal Treatment

6.1 For intermediate and heavy shapes, plates, and hardware, cold bend radii should not be less than that which is proven satisfactory by practice or by the recommendations of the steel manufacturer. These criteria generally depend on the direction of grain, strength, and type of steel. A cold bending radius of three times  $(3\times)$  the section thickness, or as recommended in AISC Manual of Steel Construction,<sup>3</sup> will ordinarily ensure satisfactory properties in the final product. Although sharper bending on thin sections can usually be tolerated, embrittlement may occur if cold bending is especially severe. If the design requires sharper bending than discussed herein, the bending should be done hot, or if done cold the material should be subsequently annealed or stress relieved as noted in 6.3.

6.2 Smaller shapes, including thickness up to 1/4 in. [6.4 mm] may be cold worked by punching without subsequent annealing or stress-relieving. Shapes 5/16 to 11/16 in. [8 to 18 mm] in thickness are not seriously affected as to serviceability by cold punching or if the punching is done under good shop practice. The heavier shapes, <sup>3</sup>/<sub>4</sub> in. [19 mm] and over, shall be reamed with at least <sup>1</sup>/<sub>16</sub> in. [1.6 mm] of metal removed from the periphery of the hole after punching, or shall be drilled, or thermally treated prior to galvanizing as noted in 6.3.

6.3 Fabrication in accordance with the principles outlined in 6.1 and 6.2 will normally obviate the need for thermal treatment. However, if required, proper thermal treatment shall precede galvanizing of the steel. For heavy cold deformation exemplified by cold rolling, sheared edges, punched holes, or cold-formed rods and bolts, subcritical annealing at temperatures from 1200 to 1300°F [650 to 705°C] should be employed. For less severe cold deformation typified by cold bending, roll forming, etc., it is advisable to limit the thermal treatment to stress relieving at a maximum of 1100°F [595°C] to avoid excessive grain growth or alternatively to fully normalize the steel at temperatures from 1600 to 1700°F [870 to 925°C]. The time at temperature should be approximately 1 h/in. [24 min/cm] of section thickness.

6.4 Flame cut copes on structural beams shall have a minimum radius of 1 in. [2.5 cm]. After cutting, the cut surface shall be ground to remove notches, grooves, and irregular surface features to leave the surface smooth.

#### 7. Preparation for Galvanizing

7.1 Hydrogen can be absorbed during pickling and in some instances, as noted in 4.2, may contribute to embrittlement of the galvanized product. The likelihood of this, or of surface cracking occurring, is increased by excessive pickling temperature, prolonged pickling time, and poor inhibition of the pickling acid. Heating to 300°F [150°C] after pickling and before galvanizing in most cases results in expulsion of hydrogen absorbed during pickling.

7.2 Abrasive blast cleaning followed by flash pickling may also be employed when over-pickling is of concern or when very high strength steel, ultimate tensile strength higher than 150 ksi [1100 MPa], must be galvanized. The abrasive blast cleaning does not generate hydrogen while it is cleaning the surface of the steel. The flash pickling after abrasive blast cleaning is used to remove any final traces of blast media before hot-dip galvanizing.

#### 8. Responsibility for Avoiding Embrittlement

8.1 Design of the product and selection of the proper steel to withstand normal galvanizing operations without embrittlement are the responsibility of the designer. The fabricator shall be responsible for employing suitable fabrication procedures. The galvanizer shall employ proper pickling and galvanizing procedures.

#### 9. Testing for Embrittlement of Steel Shapes, Steel **Castings, Threaded Articles, and Hardware Items**

9.1 Subject to base material and dimensional limitations, the tests given in 9.2, 9.3, 9.4, or 9.5, or a combination thereof, shall apply. If one test specimen should be found embrittled by these tests, two additional specimens should be tested. Failure of either the second or the third specimen shall be cause for rejection of the lot (see Note 1) that the samples represent.

NOTE 1-A lot is a unit of production from which a sample may be taken for testing. Unless otherwise agreed upon by the manufacturer and the purchaser, or established within this practice, the lot shall be as follows: For test at a manufacturer's facility, a lot is one or more articles of the same type and size comprising a single order or a single delivery load, whichever is the smaller, or a smaller number of articles identified as a lot by the manufacturer, when these have been galvanized within a single production shift. For test by purchaser after delivery, the lot consists of the single order or the single delivery load, whichever is the smaller, unless the lot identity, established in accordance with the above, is maintained and clearly indicated in the shipment by the manufacturer.

9.2 A bend test for embrittlement of galvanized steel hardware such as bolts, pole and tower steps, braces, rods, reinforcing bars, etc., consists of bending the article and comparing the degree of bending to that which is obtained on a similar ungalvanized article. The article, before and after galvanizing, may be clamped in a vise and using a lever if necessary, bent until cracking of the base steel occurs, or to 90° whichever is less. The galvanized article should withstand a degree of bending substantially the same as the ungalvanized article. Flaking or spalling of the galvanized coating is not to be construed as an embrittlement failure. For threaded articles, the test shall be made on the unthreaded portion.

9.3 Small steel castings and steel hardware of such shape or size that do not permit bending may be struck a sharp blow

<sup>&</sup>lt;sup>3</sup> Available from American Institute of Steel Construction (AISC), One East Wacker Drive, Suite 3100, Chicago, IL 60601-2001. 9th Edition.

with a 2-lb [1-kg] hammer and the results for both galvanized and ungalvanized samples compared. If the article withstands such a blow in the ungalvanized condition, but after galvanizing cracks under the blow, it shall be considered embrittled.

9.4 A test for embrittlement of galvanized steel angles is detailed as follows:

9.4.1 Test Specimen-A test specimen with a length determined by the table in 9.4.2.1 and by Fig. 1 shall be cut from the steel angle before galvanizing. A hole shall be made in the test specimen at its midlength, using the same procedure as will be employed in the fabricated material which the specimen represents, whether this be by punching, punching and reaming, or drilling. The dimensional values, diameter, and location of hole shall be not less than those employed in the structural details. Care should be taken not to place the hole near stamped or rolled-in identification marks. The specimen shall then be galvanized. For determining the elongation after fracture, a 2-in. [51-mm] gage length (Fig. 1) shall be prick-punched in the middle of the edge of the vertical leg of the galvanized angle along a line parallel to its length and centered directly under the hole. For specimens under 1/2 in. [13 mm] in thickness, or those in which the distance from the edge of the hole to the edge of the angle is less than 3/8 in. [10 mm], a 1-in. [25-mm] gage length shall be used.

9.4.2 Procedure:

9.4.2.1 The test shall be made in a universal testing machine, or by other means such as a press with the load applied slowly, until fracture of the galvanized test specimen occurs. The length of the test specimen and the distance between the supports are shown in the following table:

Bending Load

- Gage Marks

upports, <i>L</i> <sub>1</sub> , i in. [mm]	n. [mm]
14 [356]	18 [457]
20 [508] 2	24 [610]
30 [762]	36 [914]
	apports, L1,       i         in. [mm]       14 [356]         120 [508]       2         30 [762]       3

9.4.2.2 After the test, the distance along the gage length from each punch mark to the corresponding edge of the fracture shall be measured to 0.01 in. [0.25 mm] with a flexible scale and the percentage of elongation calculated from the sum of these distances.

9.4.2.3 For determining the percentage reduction of thickness after fracture, the reduction shall be measured with a ball-point micrometer at the three locations indicated in Fig. 2: namely a, outer side of hole; b, inner side of hole; and c, middle of leg. The percentage reduction of thickness shall be calculated on the basis of the original thickness of the angle and the average of the three values at a, b, and c.

9.4.2.4 The test shall be made upon galvanized specimens having a temperature not below  $60^{\circ}$ F [16°C] and not over 90°F [32°C] when tested.

9.4.3 *Requirements*—The elongation measured in accordance with 9.4.2.2 shall be not less than 5 % with the following exception: when the specimen does not show 5 % elongation, the reduction in thickness shall be measured in accordance with 9.4.2.3. The sum of the percentage of elongation plus the average percentage reduction of thickness shall not be less than 10.

9.5 For hot-dip galvanized externally threaded fasteners, an alternate test to Section 9.2 for embrittlement is detailed in Test Method F 606.

#### 10. Keywords

10.1 coatings-zinc; galvanized coatings; steel productsmetallic coated; zinc coatings-steel products



FIG. 2 Measurement of Reduction of Thickness after Fracture

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2



# Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware<sup>1</sup>

This standard is issued under the fixed designation A 153/A 153M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\varepsilon$ ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

#### 1. Scope\*

1.1 This specification covers zinc coatings applied by the hot-dip process on iron and steel hardware. The hot-dip galvanizing process consists of parts being immersed in molten zinc for a sufficient time to allow a metallurgical reaction between iron from the steel surface and the molten zinc, resulting in the formation of Zn/Fe alloy layers bonding the coating to the steel surface.

1.2 This specification is intended to be applicable to hardware items that are centrifuged or otherwise handled to remove excess galvanizing bath metal (free zinc). Coating thickness grade requirements reflect this.

1.3 This specification is applicable to orders in either inch-pound units (as A 153) or in SI units (as A 153M). Inch-pound units and SI units are not necessarily exact equivalents. Within the text of this specification and where appropriate, SI units are shown in brackets. Each system shall be used independently of the other without combining values in any way. In the case of orders in SI units, all testing and inspection shall be done using the metric equivalent of the test or inspection method as appropriate. In the case of orders in SI units, such shall be stated to the galvanizer when the order is placed.

1.4 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

#### <sup>1</sup>This specification is under the jurisdiction of ASTM Committee A05 on Metallic-Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.13 on Structural Shapes and Hardware Specifications.

Current edition approved May 1, 2009. Published May 2009. Originally approved in 1933. Last previous edition approved in 2005 as A 153/A 153M - 05.

#### 2. Referenced Documents

- 2.1 ASTM Standards:<sup>2</sup>
- A 90/A 90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
- A 143/A 143M Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
- A 780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
- A 902 Terminology Relating to Metallic Coated Steel Products
- **B** 6 Specification for Zinc
- B 487 Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section
- B 960 Specification for Prime Western Grade-Recycled (PWG-R) Zinc
- E 376 Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Examination Methods
- F 1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
- F 1789 Terminology for F16 Mechanical Fasteners

#### 3. Terminology

3.1 Definitions:

<sup>&</sup>lt;sup>2</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.1 The following terms and definitions are specific to this specification. Terminology A 902 contains other terms and definitions relating to metallic-coated steel products. Terminology F 1789 contains other terms and definitions relating to mechanical fasteners.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 average coating thickness, n—the average of the specimen coating thickness values for the samples in an inspection lot.

3.2.2 *bare spots*, n—uncoated areas on the surface of the steel part that contain no measurable zinc coating.

3.2.3 *dross inclusions*, n—the iron/zinc intermetallics present in a galvanized coating in a form other than the layer growth of the coating.

3.2.4 *individual measurement*, n—the reading from a magnetic thickness gauge of a single coating spot thickness, or the microscopic reading of a coating thickness as seen in an optical microscope at one spot.

3.2.5 *inspection lot*, n—the quantity of identical parts cleaned, fluxed and galvanized together at one time in an appropriate container that is being submitted for acceptance as a group.

3.2.6 malleable casting, n—a steel article that has been subjected to a prolonged anneal to decarburize or graphitize the part to remove as much of the carbon as possible or to convert the carbon to graphite, which permits plastic deformation in compression without rupture.

3.2.7 *sample*, n—a collection of individual units of product from a single inspection lot selected in accordance with Section 6 and intended to represent that inspection lot for acceptance.

3.2.8 specimen, *n*—an individual test article upon which thickness measurements or weight determinations are performed.

3.2.9 specimen coating thickness, n—the average thickness from no less than five test measurements on a specimen, when each measurement location is selected to provide the widest dispersion (in all applicable directions) of locations within the specimen volume.

3.2.10 *threaded areas*, *n*—the sections of a steel part that have threads formed before hot-dip galvanizing.

#### 4. Materials and Manufacture

4.1 *Steel or Iron*—Ferrous articles to be hot-dip zinc coated shall conform to specifications designated by the purchaser.

4.2 Zinc—The zinc used for the coating shall conform to Specification **B** 6, or Specification **B** 960, or both, and shall be at least equal to the grade designated as "Prime Western."

4.2.1 If a zinc alloy is used as the primary feed for the galvanizing bath, then the base material used to make that alloy shall conform to Specification B 6 or Specification B 960, or both.

4.2.2 The molten metal in the working volume of the galvanizing bath shall contain not less than an average value of 98.0 % zinc by weight [mass].

NOTE 1—The galvanizer may choose to add trace amounts of certain elements (for example, aluminum, nickel, bismuth, or tin) to the zinc bath to help in the processing of certain reactive steels or to enhance the cosmetic appearance of the finished product. The elements can be added to the galvanizing bath as a master feed alloy, or they can be added to the bath by the galvanizer as individual feeds.

4.3 Minimum Coating Weight [Mass] or Minimum Coating Thickness—The minimum coating weight [mass] or the minimum coating thickness shall conform to the requirements prescribed in Table 1 for the material category and thickness of material in which the article belongs.

4.4 *Threaded Articles*—The zinc coating on threads shall not be subjected to a cutting, rolling, or finishing-tool operation, unless specifically authorized by the purchaser. In order to meet overtapping allowances, tapping the threads of nuts or tapped holes after galvanizing is not prohibited.

4.5 *Touch-up and Repair*—Bare spots that are found on parts after galvanizing shall be renovated by use of the methods found in Practice A 780 if the following criteria are met. The bare spots shall have an area totalling not more than 1 % of the surface area to be coated excluding threaded areas of the piece and the bare spots shall not include any threaded areas of the

#### TABLE 1 Thickness or Weight [Mass] of Zinc Coating for Various Classes of Material

NOTE 1-- Length of the piece, stated in Classes B-1, B-2, and B-3, refers to the finished dimension of the piece after fabrication.

	Weight [Mass] of Zinc Coating, oz/ft²[g/m²] of Surface, Minimum		Coating Thickness, mils [microns], Minimum	
Class of Material	Average of Specimens Tested	Any Individual Specimen	Average of Specimens Tested	Any Individual Specimen
Class A—Castings—Malleable Iron, Steel Class B—Rolled, pressed, and forged articles (except those which would be included under Classes C and D):	2.00 [610]	1.80 [550]	3.4 [86]	3.1 [79]
B-1—%16 in. [4.76 mm] and over in thickness and over 15 in. [381 mm] in length	2.00 [610]	1.80 [550]	3.4 [86]	3.1 [79]
B-2—under %is in. [4.76 mm] in thickness and over 15 in. [381 mm] in length	1.50 [458]	1.25 [381]	2.6 [66]	2.1 [53]
B-3-any thickness and 15 in. [381 mm] and under in length	1.30 [397]	1.10 [336]	2.2 [56]	1.9 [48]
Class C—Fasteners over % in. [9.52 mm] in diameter and similar articles. Washers $\%_6$ in. and $\frac{1}{4}$ in. [4.76 and 6.35 mm] in thickness	1.25 [381]	1.00 [305]	2.1 [53]	1.7 [43]
Class D—Fasteners % in. [9.52 mm] and under in diameter, rivets, nails and similar articles. Washers under %16 in. [4.76 mm] in thickness	1.00 [305]	0.85 [259]	1.7 [43]	1.4 [36]

piece. The thickness of the repair shall be equal to the surrounding galvanized coating except for repairs made by paints containing zinc dust in which case the thickness of the repair shall be 50 % greater than the thickness of the galvanized coating required for the class of material, but shall not be greater than 4.0 mils [100  $\mu$ m]. Repair thickness measurements shall be made in accordance with Practice A 780. The galvanizer shall make repairs unless directed by the purchaser to deliver items unrepaired for subsequent renovation by the purchaser.

#### 5. Workmanship, Finish, and Appearance

5.1 The zinc-coated articles shall be free from uncoated areas, blisters, flux deposits, dross inclusions, and other types of projections that would interfere with the intended use of the articles, or other defects not consistent with good galvanizing practice.

5.2 The zinc coating shall be smooth and reasonably uniform in thickness.

NOTE 2—Smoothness of surface is a relative term. Minor roughness that does not interfere with the intended use of the part, or roughness that is related to the as-received (ungalvanized) surface condition of the part, shall not be grounds for rejection.

NOTE 3—Since this specification is applicable to items that are centrifuged or otherwise handled to remove excess bath metal (see 1.2), irregular coating distribution is not normally encountered. Drainage problems, which manifest themselves as local excess coating thickness that would interfere with function or as edge tears or spikes that present a safety hazard because of their sharpness, are grounds for rejection under the terms of 5.1.

5.3 Embrittlement is a potential condition of steel that is cold-worked, depending on such factors as the steel type (strength level, aging characteristics), thickness, degree of cold work, and galvanizing process. The galvanizer, the designer and the fabricator shall take precautions against embrittlement. The precautions to fabricate properly and prepare the material for galvanizing to prevent embrittlement are described in Practice A 143/A 143M.

NOTE 4—Low service temperatures increase the risk of brittle failure of all plain carbon steels including those which have been galvanized. This temperature embrittling effect varies with type of steel. The expected service temperature should thus be taken into account when selecting steels for galvanizing.

5.4 Malleable castings shall be of such composition as will preclude the possibility that they become embrittled by the galvanizing process, or they shall be either cooled from the anneal, or subsequently heat-treated so as to immunize them against embrittlement.

5.5 The zinc coating shall adhere tenaciously to the surface of the base metal.

5.6 If the galvanized material covered by this specification is bent or otherwise fabricated to the degree that causes the zinc coatings to stretch or compress beyond the limit of elasticity, any cracking or flaking of the coating resulting from the bending or fabricating shall not be cause for rejection.

#### 6. Sampling

6.1 Test specimens shall be selected at random from each inspection lot.

6.2 The method of selection and sample size shall be agreed upon between the galvanizer and the purchaser. Otherwise, the sample size selected from each lot shall be as follows:

Number of Pieces in Lot	Sample Size
3 or less	all
4 to 500	3
501 to 1200	5
1201 to 3200	8
3201 to 10 000	13
10 001 and over	20

6.3 A specimen that fails to conform to a requirement of this specification shall not be used to determine the conformance to other requirements.

6.4 The method of sampling for fasteners that are required to meet the standards of the Fastener Quality Act is described in Guide F 1470. Sample quantities and definitions of terminology are included in the referenced specification.

#### 7. Test Methods

7.1 Tests shall be made to ensure that the zinc coating is being furnished in accordance with this specification and as specified for the following:

7.1.1 Minimum coating weight [mass] or minimum coating thickness in 4.3.

7.1.2 Finish and appearance in 5.1 and 5.2.

7.1.3 Embrittlement in 5.3 and 5.4.

7.1.4 Adherence in 5.5.

7.2 Average Weight [Mass] of Coating:

7.2.1 The average weight [mass] of the zinc coating shall be determined by weighing specimens after pickling and drying and again after galvanizing unless the method described in 7.2.2 is used. The number of specimens that are used to determine the average of an inspection lot shall be derived from Section 6.

Note 5—This method does not take into account the weight [mass] of iron reacted from the article that is incorporated into the coating. It will thus underestimate coating weight [mass] by up to approximately 10%. Base metal reactivity will affect the extent of underestimation.

7.2.2 In the case of materials inspected after galvanizing, the average weight [mass] of coating shall be determined by stripping the number of specimens derived in Section 6 in accordance with Test Method A 90/A 90M, and averaging the results of the individual specimens, unless the method described in 7.2.1 is used.

7.3 Average Thickness of Coating:

7.3.1 In the case of fasteners such as bolts, nuts, and screws, the determination of the thickness of coating shall be made on a portion of the article that does not include any threads.

7.3.2 The average thickness of coating shall be determined by magnetic thickness gage in accordance with Practice E 376 unless the method described in 7.3.3 is used. The thickness shall be measured on at least five widely separated spots on a specimen. No individual spot measurement shall be cause for rejection. If an individual spot does not provide a coating thickness reading, this spot must be repaired in accordance with 4.5. The five or more individual coating thickness measurements on a specimen must be averaged to determine the specimen average coating thickness. The average coating thickness for the inspection lot is determined by averaging the

Licensee=Dept of Transportation/5950087001 Not for Resale, 10/05/2012 15:12:10 MDT specimen average coating thickness values for the number of specimens derived from Section 6.

The thickness thus determined is a point value. No less than

# 7.3.3 The thickness of coating shall be determined by cross section and optical measurement in accordance with Test Method B 487, unless the method described in 7.3.2 is used. 9. Rejection and Retest

9.1 For all galvanized articles except those fasteners that must meet the requirements of the Fastener Quality Act, the following sections are used to determine rejection and retesting.

prior to shipments, unless otherwise specified, and shall be so

conducted as not to interfere unnecessarily with the operation

9.2 When partial inspection of materials to determine conformity with visual requirements of Section 5 warrants rejection of a lot, the galvanizer is not prohibited from sorting the lot and submitting it once again for inspection.

9.3 The number of specimens in a sample of a lot permitted to fail to conformance tests shall be agreed upon between the galvanizer and the purchaser.

9.4 If a set of test specimens fails to conform to the requirements of this specification, two additional sets shall be tested, both of which shall conform to the requirements in every respect, or the lot of material represented by the specimens shall be rejected.

9.5 Materials that have been rejected for reasons other than embrittlement are not prohibited from being stripped, regalvanized, and resubmitted for test and inspection. They shall then conform to the requirements of this specification.

#### **10.** Packaging

10.1 The supplier shall employ such methods of packaging zinc-coated articles as shall be required to ensure their receipt by the purchaser in satisfactory condition, with the use to be made of the article being taken into consideration.

#### 11. Certification

11.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each inspection lot have been either tested or inspected as directed by this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

#### 12. Keywords

12.1 coatings, zinc; galvanized coatings; steel hardware, zinc coated; steel products, metallic coated; zinc coatings, steel products

five such measurements shall be made at locations on the specimen, which are as widely dispersed as practical, so as to be representative of the whole surface of the specimen. The average of no less than five such measurements is the specimen average coating thickness. The average coating thickness for the inspection lot is determined by averaging the specimen average coating thickness values for the number of specimens derived from Section 6. 7.4 *Finish and Appearance*—The test for finish and appear-

1.4 Finish and Appearance—The test for finish and appearance shall be conducted through visual inspection without additional magnification.

7.5 *Embrittlement*—Hardware that is susceptible to embrittlement shall be tested in accordance with Practice A 143/ A 143M. The tests shall be performed through agreement between the galvanizer and the purchaser.

7.6 Adherence—Determine adherence of the zinc coating to the surface of the base metal by cutting or prying with the point of a stout knife, applied with considerable pressure in a manner tending to remove a portion of the coating. The adherence shall be considered inadequate if the coating delaminates in the form of a layer of skin so as to expose the base metal in advance of the knife point. Do not use testing carried out at edges or corners (points of lowest coating adherence) to determine adherence of coating. Likewise, do not use removal of small particles of the coating by paring or whittling to determine failure.

#### 8. Inspection

8.1 The inspector representing the purchaser shall have access at all times while work on the contract of the purchaser is being performed, to those areas of the manufacturer's work which concern the application of the zinc coating to the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the zinc coating is being furnished in accordance with this specification. All inspection and tests shall be made at the place of manufacture

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## 🕼 A 153/A 153M – 09

#### SUMMARY OF CHANGES

Committee A05 has identified the location of selected changes to this standard since the last issue, A 153/A 153M - 05, that may impact the use of this standard. (May 1, 2009)

(1) Revised 4.2 and 4.2.1 to add new zinc standard B 960.

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### Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners<sup>1</sup>

This standard is issued under the fixed designation A354; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\varepsilon$ ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

#### 1. Scope\*

1.1 This specification<sup>2</sup> covers the chemical and mechanical requirements of quenched and tempered alloy steel bolts, studs, and other externally threaded fasteners 4 in. and under in diameter for application at normal atmospheric temperatures, where high strength is required and for limited application at elevated temperature (Note 1). Any alloy steel capable of meeting the minimum mechanical and chemical properties set forth in this specification may be used.

NOTE 1—For bolts, studs, or other externally threaded fasteners, to be used at elevated temperatures, refer to Specification A193/A193M.

1.2 Two levels of bolting strength are covered, designated Grades BC and BD. Selection will depend upon design and the stresses and service for which the product is to be used.

NOTE 2—Quenched and tempered alloy steel bolts for structural steel joints up through  $1\frac{1}{2}$  in. in diameter are covered in Specification A490. Alloy steel bolts, studs, and other externally threaded fasteners (that is, heavy hex-structural bolts over  $1\frac{1}{2}$  in., hex bolts, anchor bolts, and countersunk bolts) exhibiting similar mechanical properties to bolts conforming to Specification A490 shall be covered by Grade BD of this specification.

When bolts of Grade BD of this specification are considered for pretentioned applications in excess of 50 % of the bolt tensile strength, the additional requirements of head size, maximum tensile strength, nut size and strength, washer hardness, tests, and inspections contained in Specification A490 should be carefully considered.

1.3 Nuts are covered in Specification A563. Unless otherwise specified, the grade and style of nut for each grade of fastener shall be as follows:

Grade of Fastener and Surface Finish	Nut Grade and Style <sup>A</sup>
BC, plain (or with a coating of insufficient thick- ness to require over-tapped nuts)	C, heavy hex
BC, zinc-coated (or with a coating thickness re- guiring over-tapped nuts)	DH, heavy hex
BD, all finishes	DH, heavy hex

 $^{\rm A}$  Nuts of other grades and styles having specified proof load stresses (Specification A563, Table 3) greater than the specified grade and style of nut are suitable.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 Terms used in this specification are defined in Terminology F1789 unless otherwise defined herein.

#### 2. Referenced Documents

- 2.1 ASTM Standards:<sup>3</sup>
- A193/A193M Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
- A490 Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
- A563 Specification for Carbon and Alloy Steel Nuts
- A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
- **B695** Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
- D3951 Practice for Commercial Packaging
- F436 Specification for Hardened Steel Washers
- F606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets

\*A Summary of Changes section appears at the end of this standard.

<sup>&</sup>lt;sup>1</sup>This specification is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.02 on Steel Bolts, Nuts, Rivets and Washers.

Current edition approved Dec. 15, 2011. Published December 2011. Originally approved in 1952. Last previous edition approved in 2007 as A354-07a. DOI: 10.1520/A0354-11.

 $<sup>^2</sup>$  For ASME Boiler and Pressure Vessel Code applications see related Specification SA-354 in Section II of that Code.

<sup>&</sup>lt;sup>3</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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F788/F788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series

F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

F1789 Terminology for F16 Mechanical Fasteners

F2329 Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

2.2 ASME Standards:<sup>4</sup>

B1.1 Unified Screw Threads

B18.2.1 Square and Hex Bolts and Screws, Inch Series

B18.24 Part Identifying Number (PIN) Code System Standard for B18 Fastener Products

#### 3. Ordering Information

3.1 Orders for bolts and studs (including nuts and accessories) under this specification shall include the following:

3.1.1 ASTM designation and year of issue,

3.1.2 Name of product (that is, bolt or stud),

3.1.3 Grade (that is, BC or BD),

3.1.4 Quantities (number of pieces by size, including nuts), 3.1.5 Size and length,

3.1.6 Washers—Specify quantity and size (separate from bolts) (4.3),

3.1.7 *Zinc Coating*—When zinc-coated Grade BC fasteners are required, specify the zinc-coating process required, for example hot-dip, mechanically deposited, or no preference (see 4.4).

3.1.8 Other Finishes-Specify other protective finish, if required.

3.1.9 Specify if inspection at point of manufacture is required,

3.1.10 Specify if Certification (Section 14) is required, and 3.1.11 Specify additional testing (Section 9) or special requirements.

3.1.12 For establishment of a part identifying system, see ASME B18.24.

#### 4. Materials and Manufacture

4.1 The steel shall be made by the open-hearth, electric-furnace, or basic-oxygen process.

4.2 All fasteners shall be heat-treated. At the option of the manufacturer, heat treatment may be performed on the raw material, during the manufacturing operations, or after final machining. Heat treatment shall consist of quenching in a liquid medium (except Grade BD sizes  $1\frac{1}{2}$  in. and smaller shall be quenched in oil) from above the transformation temperature and then temperating by reheating to a temperature of not less than  $800^{\circ}$ F ( $427^{\circ}$ C) for Grade BC and for Grade BD.

4.3 When used, suitable hardened washers shall be quenched and tempered (non-carburized) in accordance with Specification F436.

4.4 Zinc Coatings, Hot-Dip and Mechanically Deposited:

4.4.2 When "hot-dip" is specified, the fasteners shall be zinc coated by the hot-dip process in accordance with the requirements of Specification F2329.

4.4.3 When mechanically deposited is specified, the fasteners shall be zinc-coated by the mechanical-deposition process in accordance with the requirements of Class 55 of Specification B695.

4.4.4 When no preference is specified, the supplier may furnish either a hot-dip zinc coating in accordance with Specification F2329, or a mechanically deposited zinc coating in accordance with Specification B695, Class 55. Threaded components (bolts and nuts) shall be coated by the same zinc-coating process and the supplier's option is limited to one process per item with no mixed processes in a lot.

Note 3—When the intended application requires that assembled tension exceeds 50% of minimum bolt proof load, an anti-galling lubricant may be needed. Application of such a lubricant to nuts and a test of the lubricant efficiency are provided in Supplementary Requirement S1 of Specification A563 and should be specified when required.

4.5 Zinc-coated bolts and nuts shall be shipped in the same container unless specifically requested otherwise by the purchaser.

NOTE 4—Research conducted on bolts of similar material and manufacture indicates that hydrogen-stress cracking or stress cracking corrosion may occur on hot-dip galvanized Grade BD bolts.

#### 5. Chemical Composition

5.1 All fasteners shall be made from alloy steel conforming to the chemical composition requirements in accordance with Table 1. The steel shall contain sufficient alloying elements to qualify it as an alloy steel.

NOTE 5—Steel is considered to be alloy, by the American Iron and Steel Institute, when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits: manganese, 1.65 %; silicon, 0.60 %; copper, 0.60 %; or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, chromium up to 3.99 %, cobalt, columbium, molybde-num, nickel, titanium, tungsten, vanadium, zirconium, or any other alloying elements added to obtain a desired alloying effect.

5.2 Product analysis may be made by the purchaser from finished material representing each lot of fasteners. The chemical composition thus determined shall conform to the requirements given in Table 1. Choice of alloy steel composition necessary to ensure meeting the specified mechanical requirements shall be made by the manufacturer and shall be reported to the purchaser for information purposes only.

5.3 Application of heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted.

5.4 Chemical analyses shall be performed in accordance with Test Methods, Practices, and Terminology A751.

#### 6. Mechanical Properties

6.1 Fasteners shall not exceed the maximum hardness specified in Table 2. Fasteners less than three diameters in length

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<sup>&</sup>lt;sup>4</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http:// www.asme.org.

**TABLE 1** Chemical Requirements

	Alloy Steel	
Element	Heat Analysis, %	Product Analysis, %
Carbon:		110
For sizes through 1½ in.	0.30 to 0.53	0.28 to 0.55
For sizes larger than 1½ in.	0.35 to 0.53	0.33 to 0.55
Manganese, min	0.60	0.57
Phosphorus, max	0.035	0.040
Sulfur, max	0.040	0.045
Alloying Elements	A	A
Alloy	Steel with Boron Addition	
Element	Heat Analysis, %	Product Analysis, %
Carbon		
For sizes through	0.30-0.48	0.28-0.50
1 ½ in.		
For sizes larger than	or sizes larger than 0.35-0.53	
1 ½ in.		
Manganese, min	langanese, min 0.60	
Phosphorus, max	0.040	0.045
Sulfur, max	0.040	0.045
Boron	0.0005-0.003	0.0005-0.003
Alloying Elements	A	Â

<sup>A</sup>Steel, as defined by the American Iron and Steel Institute, shall be considered to be alloy when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits: Manganese, 1.65 %; silicon, 0.60 %; copper, 0.60 % or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, chromium up to 3.99 %, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other alloying elements added to obtain a desired alloying effect.

TABLE 2 Hardness Requirements for Full-Size Fasteners

Size, in.			Hard	ness	
	Grade	in. Grade Brinell		Rockwell C	
		Minimum	Maximum	Minimum	Maximum
1/4 to 21/2	BC	255	331	26	36
Over 21/2	BC	235	311	22	33
1/4 to 21/2	BD	311	363	33	39
Over 21/2	BD	293	363	31	39

and studs less than four diameters in length shall have hardness values not less than the minimum nor more than the maximum hardness limits required in Table 2, as hardness is the only requirement.

6.2 Fasteners  $1\frac{3}{8}$  in. in diameter or less for Grade BC and  $1\frac{1}{4}$  in. in diameter or less for Grade BD, other than those excepted in 6.1, shall be tested full size and shall conform to the tensile strength and either the proof load or the yield strength requirements in accordance with Table 3.

6.3 Fasteners larger than 1<sup>3</sup>/<sub>8</sub> in. in diameter for Grade BC and fasteners larger than 1<sup>3</sup>/<sub>4</sub> in. in diameter for Grade BD, other than those excepted in 6.1, shall preferably be tested full size and when so tested, shall conform to the tensile strength and either the proof load or yield strength requirements in accordance with Table 3. When equipment of sufficient capacity for full-size testing is not available, or when the length of the fastener makes full-size testing impractical, machined specimens shall be tested and shall conform to the requirements in accordance with Table 4. In the event that fasteners

are tested by both full-size and by the machined test specimen methods, the full-size test shall govern if a controversy between the two methods exists.

6.4 For fasteners on which both hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence in the event that there is controversy over low readings of hardness tests.

#### 7. Dimensions

7.1 *Bolts*—Unless otherwise specified, the bolts shall be Hex Head with dimensions conforming to the latest issue of ASME B18.2.1.

7.2 *Studs*—Studs shall have dimensions conforming to those specified by the purchaser.

7.3 Threads:

7.3.1 Unless otherwise specified, threads shall be the Unified National Coarse Thread Series as specified in B1.1, and shall have Class 2 A tolerances.

7.3.2 When specified, threads shall be the Unified National Fine Thread Series, 8-Pitch Thread Series for sizes over 1 in. or 14-Pitch UNS on 1 in. size as specified in ANSI B1.1 and shall have Class 2A tolerances.

7.3.3 Unless otherwise specified, bolts and studs to be used with nuts or tapped holes that have been tapped oversize, in accordance with Specification A563, shall have Class 2A threads before hot dip or mechanically deposited zinc coating. After zinc coating, the maximum limit of pitch and major diameter may exceed the Class 2A limit by the following amount:

Diameter, in.	Oversize Limit, in. (mm) <sup>4</sup>
1/4	0.016
5/16 , 3/8	0.017
7/16 , 1/2	0.018
%i6 to ¾ , incl	0.020
7/8	0.022
1.0 to 11⁄4 , incl	0.024
13%,11⁄2	0.027
1¾ to 4.0, incl	0.050
1¾ to 4.0, incl	0.050

<sup>A</sup> These values are the same as the overtapping required for zinc-coated nuts in Specification A563.

#### 8. Workmanship

8.1 Surface discontinuity limits shall be in accordance with Specification F788/F788M.

#### 9. Number of Tests

9.1 Testing Responsibility:

9.1.1 Each lot shall be tested by the manufacturer prior to shipment in accordance with the lot identification control quality assurance plan in 9.2 through 9.6.

9.1.2 When fasteners are furnished by a source other than the manufacturer, the responsible party as defined in 12.1 shall be responsible for ensuring that all tests have been performed and the fasteners comply with the requirements of this specification.

9.2 *Purpose of Lot Inspection*—The purpose of a lot inspection program is to ensure that each lot conforms to the requirements of this specification. For such a plan to be fully effective it is essential that secondary processors, distributors,

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#### TABLE 3 Tensile Requirements for All Full-Size Fasteners-Inch-Pound Units

Bolt	Threads	Stress		Grade BC			Grade BD	
size, in.	per inch	Area,~ in. <sup>2</sup>	Tensile Strength, min, Ibf <sup>ø</sup>	Proof Load, min, Ibf <sup>C</sup>	Yield Strength (0.2 % offset), min, lbf <sup>D</sup>	Tensile Strength, min, lbf <sup>£</sup>	Proof Load, min, Ibf <sup>F</sup>	Yield Strength (0.2 % offset), min, lbf <sup>a</sup>
1	2	3	4	5	6	7	8	9
1/4	20	0.0318	4 000	3 350	3 450	4 750	3 800	4 100
1/4	28	0.0364	4 550	3 820	3 950	5 450	4 350	4 700
5⁄16	18	0.0524	6 550	5 500	5 700	7 850	6 300	6 800
5⁄16	24	0.0580	7 250	6 090	6 300	8 700	6 950	7 500
3/8	16	0.0775	9 700	8 150	8 450	11 650	9 300	10 075
% 7/	24	0.0878	11 000	9 220	9 550	13 200	10 500	11 400
16 7/16	14	0.1063	13 300	12 470	12 000	17 950	12 750	13 850
1/2	13	0.1419	17 750	14 900	15 450	21 300	17 050	18 500
1/2	20	0 1599	19 990	16 790	17 400	24 000	19 200	20 750
9/16	12	0.182	22 750	19 100	19 850	27 300	21 850	23 600
9/16	18	0.203	25 400	21 400	22 100	30 400	24 400	26 350
5⁄8	11	0.226	28 250	23 750	24 650	33 900	27 100	29 400
5⁄8	18	0.256	32 000	26 800	27 900	38 400	30 700	33 250
3/4	10	0.334	41 750	35 050	36 400	50 100	40 100	43 400
9/4 7/	16	0.373	46 600	39 100	40 650	56 000	44 800 EE 4E0	48 450
76	9	0.462	63 600	48 500	55 450	76400	61 100	66 150
70	140	0.000	00 000	00 400	00 400	70 +00	01 100	00 100
1	8	0.606	75 750	63 650	66 050	90 900	72 700	78 800
1	12	0.663	82 900	69 700	72 250	99 400	79 600	86 150
1	14 UNS	0.679	84 900	71 300	74 400	101 900	81 500	88 250
11/8	7	0.763	95 400	80 100	83 150	114 450	91 550	99 200
11/8	8	0.790	98 /50	82 950	86 200	118 500	94 800	102 700
1 1/8	12	0.856	107 000	101 750	93 300	128 400	116 200	111 250
1 74	8	1.000	125 000	105 000	109 000	150 000	120 000	130.000
11/4	12	1.073	134 100	112 600	116 950	161 000	128 800	139 450
1%	6	1,155	144 400	121 300	125 900	173 250	138 600	150 200
13⁄8	8	1.233	154 150	129 450	134 400	185 000	148 000	160 300
<b>1</b> 3⁄8	12	1.315	164 400	138 100	143 300	197 200	157 800	170 950
11/2	6	1.405	175 650	147 550	153 150	210 750	168 600	182 500
11/2	8	1.492	186 500	156 650	162 250	233 800	175 050	194 000
1 1/2	12	1.581	197 600	166 000	172 300	237 200	189 700	205 500
194	9	2.08	267 500	218 400	207 100	265 000	220 000	247 000
174	0	2.00	200 000	210400	220 700	012 000	249 000	210 000
2	41/2	2.50	312 500	262 500	272 500	375 000	300 000	325 000
2	8	2.77	346 250	290 850	301 950	415 000	332 400	360 000
21/4	41/2	3.25	406 250	341 250	354 250	487 000	390 000	422 500
21/4	8	3.56	445 000	373 800	388 050	534 000	422 200	462 800
21/2	4	4.00	500 000	420 000	436 000	600 000	480 000	520 000
2 1/2	8	4.44	550 000	466 200	483 950	600 200	532 800	577 200
23/4	4	5.43	624 450	515 850	537 550	750 200	570 150	624 450
<b>H</b> 67		0.10	021100	010 000		100 200	010100	0211100
3	4	5.97	686 550	567 150	591 050	835 800	626 850	686 550
3	8	6.51	748 650	618 450	644 500	911 400	683 550	748 650
31/4	4	7.10	816 500	674 500	702 900	994 000	745 500	816 500
31/4	8	7.69	884 350	730 550	761 300	1 076 600	807 650	884 350
3 1/2 21/4	4 8	0.33 202	907 900	791 300 851 200	024 600 887 050	1 254 400	074 000 074 000	1 030 400
33/4	0 4	08.0 88.0	1 110 900	917 700	956 350	1 352 400	1 014 300	1 110 900
33/4	8	10.34	1 199 100	983 300	1 023 650	1 447 600	1 085 700	1 189 100
			• •					
4	4	11.08	1 274 200	1 052 600	1 096 900	1 551 200	1 163 400	1 274 200
4	8	11.81	1 358 200	1 122 000	1 169 200	1 653 400	1 240 050	1 358 150

<sup>A</sup> Stress Area, in.<sup>2</sup>= 0.7854 [D = 0.9743/n]<sup>2</sup> where D = nominal diameter, in., and n = threads/in.

<sup>a</sup>Based on 125 000 psi for sizes ¼ to 2½ in., inclusive, and on 95 000 psi for sizes over 2½ to 4 in., inclusive. <sup>b</sup>Based on 105 000 psi for sizes ¼ to 2½ in., inclusive, and on 95 000 psi for sizes over 2½ to 4 in., inclusive.

<sup>E</sup>Based on 150 000 psi for sizes  $\frac{1}{4}$  to  $\frac{21}{2}$  in., inclusive, and on 140 000 psi for sizes over  $\frac{21}{2}$  to 4 in., inclusive. <sup>F</sup>Based on 120 000 psi for sizes  $\frac{1}{4}$  to  $\frac{21}{2}$  in., inclusive, and on 105 000 psi for sizes over  $\frac{21}{2}$  to 4 in., inclusive.

<sup>G</sup> Based on 130 000 psi for sizes 1/4 to 21/2 in., inclusive, and on 115 000 psi for sizes over 21/2 to 4 in., inclusive.

TABLE 4 Mechanical	Requirements for	Machined	Specimens
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Grade	Size, in.	Tensile Strength min, psi	Yield Strength (0.2 % offset), min, psi	Elonga- tion in 2 in. min, %	Reduc- tion of Area, min, %
BC	1/4 to 21/2 , incl	125 000	109 000	16	50
BC	Over 21/2	115 000	99 000	16	45
BD	1/4 to 21/2 , incl	150 000	130 000	14	40
BD	Over 21/2	140 000	115 000	14	40

and purchasers maintain the identification and integrity of each lot until the product is installed.

9.3 Lot Processing—All fasteners shall be processed in accordance with a lot identification-control quality assurance plan. The manufacturer, secondary processors, and distributors shall identify and maintain the integrity of each lot of fasteners from raw-material selection through all processing operations and treatments to final packing and shipment. Each lot shall be assigned its own lot-identification number, each lot shall be tested, and the inspection test reports for each lot shall be retained.

9.4 Lot Definition—A lot is a quantity of a uniquely identified fastener product of the same nominal size and length produced consecutively at the initial operation from a single mill heat of material and heat treatment lot and processed at one time, by the same process, in the same manner so that statistical sampling is valid. The identity of the lot is maintained throughout all subsequent operations and packaging.

9.5 *Number of Tests*—The minimum number of tests from each production lot for the tests specified below shall be in accordance with Guide F1470.

Hardness	Coating Weight/Thickness
Tensile	Workmanship (Surface Disconti
	nuities Section 8)

#### Proof Load

9.5.1 The number of tests for dimensional and thread fit compliance shall be in accordance with the quality assurance provisions of the referenced dimensional standards.

9.6 If any test specimen shows defective machining it may be discarded and another specimen substituted.

#### 10. Test Methods

10.1 Test methods shall be conducted in accordance with Test Methods F606.

10.2 Proof load, rather than yield strength determination is preferred and shall be the arbitration method for fasteners  $1\frac{1}{4}$  in. and under in diameter.

10.3 Hexagon bolts shall be tested by the wedge tension method. Fracture shall be in the body or threads of the bolt without any fracture at the junction of the head and body.

10.3.1 At the option of the manufacturer, the yield strength test (Method 2, Yield Strength paragraph of Test Methods F606) and the wedge tension test (Wedge Tension Testing of Full-Size Product paragraph, both from the Test Method section of Test Methods F606) may be accomplished concurrently to satisfy 10.2 and 10.3.

10.4 Studs and bolts other than those in 10.3 shall be tested by the axial tension method.

10.4.1 At the option of the manufacturer, the yield strength test and the axial tension test may be accomplished concurrently to satisfy 10.2 and 10.4.

10.5 The speed of testing determined with a free running crosshead shall be a maximum of  $\frac{1}{8}$  in. (3.2 mm)/min for the bolt proof load (or yield strength) determination and a maximum of 1 in. (25.4 mm)/min for the tensile strength determination.

#### 11. Inspection

11.1 If the inspection described in 11.2 is required by the purchaser, it shall be specified in the inquiry and contract or purchase order.

11.2 The inspector representing the purchaser shall have free entry to all parts of the manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests and inspections required by the specification that are requested by the purchaser's representative shall be made before shipment, and shall be conducted as not to interfere unnecessarily with the operation of the works.

#### 12. Responsibility

12.1 The party responsible for the fastener shall be the organization that supplies the fastener to the purchaser.

#### 13. Rejection and Rehearing

13.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

#### 14. Certification

14.1 When specified on the purchase order, the manufacturer or supplier, whichever is the responsible party in accordance with Section 12, shall furnish the purchaser a test report which includes the following:

14.1.1 Product description, grade, quantity, ASTM Specification Number and issue date,

14.1.2 Alloy grade (AISI, SAE, UNS, etc.), heat analysis, and heat number, and type of quench,

14.1.3 Results of hardness, tensile, and proof load tests, as applicable,

14.1.4 Statement of compliance to Protective Coating Specification (if applicable),

14.1.5 Statement of compliance with the surface discontinuity requirements of Specification F788/F788M,

14.1.6 Statement of compliance dimensionally,

14.1.7 Report, describe, or illustrate manufacturer's markings and their location,

14.1.8 Lot number, purchase order number, and date shipped,

14.1.9 Country of origin, and

14.1.10 Title and signature of the individual assigned certification responsibility by the company officers, with complete mailing address.

Licensee=Dept of Transportation/5950087001 Not for Resale, 01/18/2013 17:16:59 MST 14.2 Failure to include all the required information on the test report shall be cause for rejection.

#### 15. Product Marking

15.1 *Manufacturers Identification*—All products shall be marked by the manufacturer with a unique identifier to identify the manufacturer or private label distributor, as appropriate.

15.2 Grade Identification:

15.2.1 All Grade BC products shall be marked "BC".

15.2.2 All Grade BD products shall be marked "BD". In addition to the "BD" marking, the product may be marked with 6 radial lines  $60^{\circ}$  apart if manufactured from alloy steel conforming to the requirements of this specification.

15.3 Marking Location and Methods:

15.3.1 Bolts shall be marked on the top of the bolt head.

15.3.2 Where studs have both coarse and fine threads, all markings shall appear on the coarse thread end or, if preferred, the manufacturer's identification shall appear on the fine thread end and the grade marking on the coarse thread end.

15.3.3 Continuous thread studs may be marked on either end.

15.3.4 All markings may be raised or depressed at the manufacturer's option.

15.3.5 Grade and manufacturer's or private label distributor's identification shall be separate and distinct. The two identifications shall preferably be in different locations and when on the same level shall be separated by at least two spaces.

#### 16. Packaging and Package Marking

#### 16.1 Packaging:

16.1.1 Unless otherwise specified, packaging shall be in accordance with Practice D3951.

16.1.2 When special packaging requirements are required, they shall be defined at the time of the inquiry and order.

16.2 Package Marking:

16.2.1 Each shipping unit shall include or be plainly marked with the following information:

16.2.1.1 ASTM designation and grade,

16.2.1.2 Size,

16.2.1.3 Name and brand or trademark of the manufacturer,

16.2.1.4 Number of pieces,

16.2.1.5 Purchase order number, and

16.2.1.6 Country of origin.

#### 17. Keywords

17.1 alloy steel; bolts; steel; studs

#### SUPPLEMENTARY REQUIREMENTS

#### S1. Marking

S1.1 Studs that are continuously threaded with the same class of thread shall be marked on each end with the marking in accordance with Section 15.

S1.2 Marking small sizes (customarily less than 0.375 in. (9.525 mm) may not be practical. Consult the producer for the minimum size that can be marked.

#### SUMMARY OF CHANGES

Committee F16 has identified the location of selected changes to this standard since the last issue (A354-07a) that may impact the use of this standard. (Approved Dec. 15, 2011.)

(1) Revised—Table 1.

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## Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength<sup>1</sup>

This standard is issued under the fixed designation A490; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\varepsilon$ ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

#### 1. Scope\*

1.1 This specification covers two types of quenched and tempered, alloy steel, heavy hex structural bolts having a tensile strength of 150 to 173 ksi.

1.2 These bolts are intended for use in structural connections. These connections are covered under the requirements of the Specification for Structural Joints Using Specification A325 or A490 bolts, approved by the Research Council on Structural Connections; endorsed by the American Institute of Steel Construction and by the Industrial Fastener Institute.<sup>2</sup>

1.3 The bolts are furnished in sizes  $\frac{1}{2}$  to  $\frac{1}{2}$  in., inclusive. They are designated by type denoting chemical composition as follows:

Туре	Description
Type 1	Medium carbon alloy steel
Type 2	Withdrawn in 2002
Туре З	Weathering steel

1.4 This specification provides that heavy hex structural bolts shall be furnished unless other dimensional requirements are specified on the purchase order.

1.5 Terms used in this specification are defined in Terminology F1789 unless otherwise defined herein.

1.6 For metric bolts, see Specification A490M Classes 10.9 and 10.9.3

1.7 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.8 The following safety hazards caveat pertains only to the Test Methods portion, Section 12 of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user* 

of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

#### 2. Referenced Documents

- 2.1 ASTM Standards:<sup>3</sup>
- A194/A194M Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
- A325 Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
- A354 Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
- A490M Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric)
- A563 Specification for Carbon and Alloy Steel Nuts
- A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
- D3951 Practice for Commercial Packaging
- E384 Test Method for Knoop and Vickers Hardness of Materials
- E709 Guide for Magnetic Particle Testing
- E1444 Practice for Magnetic Particle Testing
- F436 Specification for Hardened Steel Washers
- F606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
- F788/F788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series
- F959 Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners
- F1136 Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners
- F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

\*A Summary of Changes section appears at the end of this standard.

<sup>&</sup>lt;sup>1</sup>This specification is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.02 on Steel Bolts, Nuts, Rivets and Washers.

Current edition approved April 1, 2012. Published April 2012. Originally approved in 1964. Last previous edition approved in 2011 as A490 - 11. DOI: 10.1520/A0490-12.

<sup>&</sup>lt;sup>2</sup> Available from American Institute of Steel Construction (AISC), One E. Wacker Dr., Suite 700, Chicago, IL 60601-2001, http://www.aisc.org.

<sup>&</sup>lt;sup>3</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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F1789 Terminology for F16 Mechanical Fasteners

F2328 Test Method for Determining Decarburization and Carburization in Hardened and Tempered Threaded Steel Bolts, Screws and Studs

- F2833 Specification for Corrosion Protective Fastener Coatings with Zinc Rich Base Coat and Aluminum Organic/Inorganic Type
- G101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

2.2 ASME Standards:<sup>4</sup>

**B1.1** Unified Screw Threads

B18.2.6 Fasteners for Use in Structural Applications

B18.24 Part Identification Number (PIN) Code System Standard for B18 Fastener Products

2.3 IFI Standard:<sup>5</sup>

IFI 144 Test Evaluation Procedures for Coating Qualification Intended for Use on High-Strength Bolts

#### 3. Ordering Information

3.1 Orders for heavy hex structural bolts under this specification shall include the following:

3.1.1 Quantity (number of pieces of bolts and accessories ); 3.1.2 Size, including nominal bolt diameter, thread pitch, and bolt length. The thread length shall not be changed;

3.1.3 Name of product: heavy hex structural bolts, or other such bolts as specified;

3.1.4 Type of bolt (Type 1 or 3). When type is not specified, either Type 1 or Type 3 shall be furnished at the supplier's option;

3.1.5 ASTM designation and year of issue,

3.1.6 Other components such as nuts, washers, and washertype direct tension indicators, if required;

3.1.7 Test Reports, if required (see Section 15); and

3.1.8 Protective coating per Specification F1136, Grade 3, if required. See 4.3.

3.1.9 Protective coating per Specification F2833, Grade 1, if required. See 4.3.

3.1.10 Special requirements.

3.1.11 For establishment of a part identifying system, see ASME B18.24.

NOTE 1—A typical ordering description follows: 1000 pieces 1–8 in. dia  $\times$  4 in. long heavy hex structural bolt, Type 1, *ASTM A490 – 02*; each with two hardened washers, ASTM F436 Type 1; and one heavy hex nut, ASTM A563 Grade DH.

3.2 Recommended Nuts:

3.2.1 Nuts conforming to the requirements of Specification A563 are the recommended nuts for use with Specification A490 heavy hex structural bolts. The nuts shall be of the class and have a surface finish for each type of bolt as follows:

Bolt Type and Finish Nut Class and Finish

1, plain (uncoated)

A563—DH, DH3 plain (uncoated)

<sup>4</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http:// www.asme.org.

<sup>5</sup> Available from Industrial Fastener Institute, (IFI), 6363 Oak Tree Boulevard, Independence, OH 44131. http://www.industrial-fasteners.org.

1, coated in accordance with Specification F1136, Grade 3 or Specification F2833, Grade 1. A563—coated in accordance with Specification F1136, Grade 5 or Specification F2833, Grade 1.

3, weathering steel

A563—DH3, weathering steel

3.2.2 Alternatively, nuts conforming to Specification A194/ A194M Gr. 2H plain (uncoated) are considered a suitable substitute for use with Specification A490 Type 1 heavy hex structural bolts.

3.3 *Recommended Washers*—Washers conforming to Specification F436 are the recommended washers for use with Specification A490 heavy hex structural bolts. The washers shall have a surface finish for each type of bolt as follows: Bolt Type and Finish Washer Finish

1, plain (uncoated) plain (uncoated)

 1, coated in accordance
 plain, coated in accordance

 with F1136, Grade 3 or F2833, Grade 1.with F1136, Grade 3 or F2833, Grade 1.

3, weathering steel

weathering steel

3.4 *Other Accessories*—When compressible washer type direct tension indicators are specified to be used with these bolts, they shall conform to Specification F959 Type 490.

#### 4. Materials and Manufacture

4.1 *Heat Treatment*—Type 1 and Type 3 bolts shall be heat treated by quenching in oil from the austenitic temperature and then tempered by reheating to a temperature of not less than 800°F.

4.2 *Threading*—The threads shall be cut or rolled.

4.3 Protective Coatings:

4.3.1 When a protective coating is required and specified, the bolts shall be coated with Zinc/Aluminum Corrosion Protective Coatings in accordance with Specification F1136, Grade 3 or Specification F2833, Grade 1. These coatings have been qualified based on the findings of an investigation founded on IFI 144. <sup>6</sup>

4.3.2 No other metallic coatings are permitted unless authorized by Committee F16. Future consideration of any coating will be based on results of testing performed in accordance with the procedures in IFI 144, and submitted to Committee F16 for review (See note 2).

NOTE 2—For more detail see the H. E. Townsend Report "Effects of Zinc Coatings on Stress Corrosion Cracking and Hydrogen Embrittlement of Low Alloy Steel," published in Metallurgical Transactions, Vol. 6, April 1975.

#### 5. Chemical Composition

5.1 Type 1 bolts shall be alloy steel conforming to the chemical composition specified in Table 1. The steel shall contain sufficient alloying elements to qualify it as an alloy steel (see Table 1, footnote A.).

5.2 Type 3 bolts shall be weathering steel conforming to the chemical composition requirements in Table 2. See Guide G101 for methods of estimating the atmospheric corrosion resistance of low alloy steel.

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<sup>&</sup>lt;sup>6</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:F16-1001.

TABLE 1 Chemical Requirements for Type 1 Bolts

Alloy Steel					
Element	Heat Analysis, %	Product Analysis, %			
Carbon					
For sizes through 1% in.	0.30-0.48	0.28-0.50			
For size 11/2 in.	0.35-0.53	0.33-0.55			
Phosphorus, max	0.040	0.045			
Manganese, min	0.60	0.57			
Sulfur, max	0.040	0.045			
Alloying Elements	А	А			
Alloy Stee	el with Boron Addition				
Element	Heat Analysis, %	Product Analysis, %			
Carbon					
For sizes through 1% in.	0.30-0.48	0.28-0.50			
For size 11/2 in.	0.35-0.53	0.35-0.55			
Manganese, min	0.60	0.57			
Phosphorus, max	0.040	0.045			
Sulfur, max	0.040	0.045			
Boron	0.0005-0.003	0.0005-0.003			
Alloying Elements	А	Α			

<sup>A</sup>Steel, as defined by the American Iron and Steel Institute, shall be considered to be alloy when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits: Manganese, 1.65 %; silicon, 0.60 %; copper, 0.60 % or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, chromium up to 3.99 %, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other alloying elements added to obtain a desired alloying effect.

TABLE 2 Chemical Requirements for Type 3 Bolts

Element	Heat Analysis, %	Product Analysis, %
Carbon		
Sizes 0.75 in. and smaller	0.20-0.53	0.19-0.55
Sizes larger than 0.75 in.	0.30-0.53	0.28-0.55
Manganese, min	0.40	0.37
Phosphorus, max	0.035	0.040
Sulfur, max	0.040	0.045
Copper	0.20-0.60	0.17-0.63
Chromium, min	0.45	0.42
Nickel, min	0.20	0.17
or		
Molybdenum, min	0.15	0.14

5.3 Product analyses made on finished bolts representing each lot shall conform to the product analysis requirements specified in Tables 1 and 2, as applicable.

5.4 Heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be used for bolts furnished to this specification. Compliance with this requirement shall be based on certification that steels having these elements intentionally added were not used. 5.5 Chemical analyses shall be performed in accordance with Test Methods, Practices, and Terminology A751.

#### 6. Mechanical Properties

6.1 *Hardness*—The bolts shall conform to the hardness specified in Table 3.

6.2 Tensile Properties:

6.2.1 Except as permitted in 6.2.1.1 for long bolts and 6.2.1.2 for short bolts, sizes 1.00 in. and smaller having a nominal length of  $2\frac{1}{4}D$  and longer and sizes larger than 1.00 in. having a nominal length of 3D and longer shall be wedge tested full size and shall conform to the minimum and maximum wedge tensile load, and proof load or alternative proof load specified in Table 4. The load achieved during proof load testing shall be equal to or greater than the specified proof load.

6.2.1.1 When the length of the bolt makes full-size testing impractical, machined specimens shall be tested and shall conform to the requirements specified in Table 5. When bolts are tested by both full-size and machined specimen methods, the full-size test shall take precedence.

6.2.1.2 Sizes 1.00 in. and smaller having a nominal length shorter than  $2\frac{1}{4}D$  down to 2D, inclusive, that cannot be wedge tensile tested shall be axially tension tested full size and shall conform to the minimum tensile load and proof load or alternate proof load specified in Table 4. Sizes 1.00 in. and smaller having a nominal length shorter than 2D and sizes larger than 1.00 in. with nominal lengths shorter than 3D that cannot be axially tensile tested shall be qualified on the basis of hardness.

6.2.2 For bolts on which hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence in the event of low hardness readings.

#### 7. Carburization/Decarburization

7.1 This test is intended to evaluate the presence or absence of carburization and decarburization as determined by the difference in microhardness near the surface and core.

7.2 Requirements:

7.2.1 *Carburization*—The bolts shall show no evidence of a carburized surface when evaluated in accordance with 12.2.

7.2.2 *Decarburization*—Hardness value differences shall not exceed the requirements set forth for decarburization in Test Method F2328 materials when evaluated in accordance with 12.2.

#### 8. Dimensions

8.1 Head and Body:

TABLE	3	Hardness	Requirements	for	Bolts
		1/2 to 11/2 in	. Nominal Size		

Size,		Nominal Length,	Brinell		Rockwell C	
	in.	in.	min	max	min	max
	1/2 to 1, incl.	Less than 2D	311	352	33	38
		2D and longer	3 10	352	479 12	38
	Over 1 to 11/2, incl.	Less than 3D	311	352	33	38
	<i>∽</i>	3D and longer	3.43	352	408 F)	38

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#### TABLE 4 Tensile Load Requirements for Bolts Tested Full-Size

Bolt Size, Threads per Inch, and	Stress Area, <sup>4</sup> in. <sup>2</sup>	Tensile I	_oad, <sup>B</sup> lbf	Proof Load, <sup>B</sup> Ibf	Alternative Proof Load, <sup>8</sup> Ibf
Series Designation	annorma constructo acou	min	max	Length Measure- ment Method	Yield Strength Method
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
1/2-13 UNC	0.142	21 300	24 600	17 050	18 500
5%-11 UNC	0.226	33 900	39 100	27 100	29 400
3/4-10 UNC	0.334	50 100	57 800	40 100	43 400
7∕a-9 UNC	0.462	69 300	79 950	55 450	60 100
1-8 UNC	0.606	90 900	104 850	72 700	78 800
11/8-7 UNC	0.763	114 450	132 000	91 550	99 200
11/4-7 UNC	0.969	145 350	167 650	116 300	126 000
13%-6 UNC	1.155	173 250	199 850	138 600	150 200
11/2-6 UNC	1.405	210 750	243 100	168 600	182 600

A The stress area is calculated as follows:

 $A_s = 0.7854 [D - (0.9743/n)]^2$ 

AA1 IC	10.	
$A_s$	1	stress area, in. <sup>2</sup>
D	$\equiv$	nominal bolt size, and
n	-	threads per inch.

<sup>B</sup>Loads tabulated and loads to be used for tests of full-size bolts larger than 1½ in. in diameter are based on the following:

Bolt Size	Column 3	Column 4	Column 5	Column 6
1/2 to 11/2 in., incl	150 000 psi	173 000 psi	120 000 psi	130 000 psi

#### TABLE 5 Tensile Strength Requirements for Specimens Machined from Bolts

Bolt Size, in.	Tensile Strength, psi		Yield Strength (0.2 %	Elongation in 2 in. or 50 mm,	Reduction of Area,
	min	max	min, psi	min, %	111111, 76
½ to 1½ in., incl	150 000	173 000	130 000	14	40
i.					

8.1.1 Unless otherwise specified, bolts shall conform to the dimensions for heavy hex structural bolts specified in ASME B18,2.6.

8.1.2 The thread length shall not be changed from that specified in ASME B18.2.6 for heavy hex structural bolts. Bolts requiring thread lengths other than those required by this specification shall be ordered under Specification A354 Gr. BD.

8.2 *Threads*—Threads shall be the Unified Coarse Thread Series as specified in ASME B1.1 and shall have Class 2A tolerances.

#### 9. Workmanship

9.1 The allowable limits, inspection, and evaluation of the surface discontinuities, quench cracks, forging cracks, head bursts, shear bursts, seams, folds, thread laps, voids, tool marks, nicks, and gouges shall be in accordance with Specification F788/F788M.

# 10. Magnetic Particle Inspection for Longitudinal Discontinuities and Transverse Cracks

#### 10.1 Requirements:

10.1.1 Each sample representative of the lot shall be magnetic particle inspected for longitudinal discontinuities and transverse cracks.

10.1.2 The lot, as represented by the sample, shall be free from nonconforming bolts, as defined in Specification F788/ F788M, when inspected in accordance with 10.2.1-10.2.3.

10.2 Inspection Procedure:

10.2.1 The inspection sample shall be selected at random from each lot in accordance with Practice F1470 and examined for longitudinal discontinuities and transverse cracks.

10.2.2 Magnetic particle inspection shall be conducted in accordance with Guide E709 or Practice E1444. Guide E709 shall be used for referee purposes. If any nonconforming bolt is found during the manufacturer's examination of the lot selected in 10.2.1, the lot shall be 100 % magnetic particle inspected, and all nonconforming bolts shall be removed and scrapped or destroyed.

10.2.3 Eddy current or liquid penetrant inspection shall be an acceptable substitute for the 100 % magnetic particle inspection when nonconforming bolts are found and 100 % inspection is required. On completion of the eddy current or liquid penetrant inspection, a random sample selected from each lot in accordance with Practice F1470 shall be reexamined by the magnetic particle method. In case of controversy, the magnetic particle test shall take precedence.

10.2.4 Magnetic particle indications of themselves shall not be cause for rejection. If in the opinion of the quality assurance

representative the indications may be cause for rejection, a sample taken in accordance with Practice F1470 shall be examined by microscopic examination or removal by surface grinding to determine if the indicated discontinuities are within the specified limits.

#### 11. Number of Tests and Retests

#### 11.1 Testing Responsibility:

11.1.1 Each lot shall be tested by the manufacturer prior to shipment in accordance with the lot identification control quality assurance plan in 11.2-11.5.

11.1.2 When bolts are furnished by a source other than the manufacturer, the Responsible Party as defined in 16.1 shall be responsible for assuring all tests have been performed and the bolts comply with the requirements of this specification.

11.2 Purpose of Lot Inspection—The purpose of a lot inspection program shall be to ensure that each lot as represented by the samples tested conforms to the requirements of this specification. For such a plan to be fully effective, it is essential that secondary processors, distributors, and purchasers maintain the identification and integrity of each lot until the product is installed.

11.3 Lot Method—All bolts shall be processed in accordance with a lot identification-control quality assurance plan. The manufacturer, secondary processors, and distributors shall identify and maintain the integrity of each lot of bolts from raw-material selection through all processing operations and treatments to final packing and shipment. Each lot shall be assigned its own lot-identification number, each lot shall be tested, and the inspection test reports for each lot shall be retained.

11.4 Lot Definition—A lot shall be a quantity of uniquely identified heavy hex structural bolts of the same nominal size and length produced consecutively at the initial operation from a single mill heat of material and processed at one time, by the same process, in the same manner, so that statistical sampling is valid. The identity of the lot and lot integrity shall be maintained throughout all subsequent operations and packaging.

#### 11.5 Number of Tests:

11.5.1 The minimum number of tests from each lot for the tests specified below shall be as follows:

Tests Specified below shall be as follows: Tests Number of Tests in Accordance with

j.	
Hardness, tensile strength, proof load	Practice F1470
Surface discontinuities	Specification F788/F788M
Magnetic particle inspection	Specification F788/F788M
Dimensions and thread fit	ASME B18.2.6

11.5.2 For carburization and decarburization tests, not less than one sample unit per manufactured lot shall be tested for microhardness.

#### 12. Test Methods

12.1 Tensile, Proof Load, and Hardness:

12.1.1 Tensile, proof load, and hardness tests shall be conducted in accordance with Test Methods F606.

12.1.2 Tensile strength shall be determined using the Wedge or Axial Tension Testing Method of Full Size Product Method or the Machined Test Specimens Method, depending on size and nominal length as specified in 6.2.1-6.2.2. Fracture on

full-size tests shall be in the body or threads of the bolt without a fracture at the junction of the head and body.

12.1.3 Proof load shall be determined using Method 1, Length Measurement, or Method 2, Yield Strength, at the option of the manufacturer.

12.2 *Carburization/Decarburization*—Tests shall be conducted in accordance with Test Method F2328 Hardness Method.

12.3 *Microhardness*—Tests shall be conducted in accordance with Test Method E384.

12.4 *Magnetic Particle*—Inspection shall be conducted in accordance with Section 10.

#### 13. Inspection

13.1 If the inspection described in 13.2 is required by the purchaser, it shall be specified in the inquiry and contract or order.

13.2 The purchaser's representative shall have free entry to all parts of manufacturer's works or supplier's place of business that concern the manufacture of the material ordered. The manufacturer or supplier shall afford the purchaser's representative all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests and inspections required by the specification that are requested by the purchaser's representative shall be made before shipment, and shall be conducted as not to interfere unnecessarily with the operation of the manufacturer's works or supplier's place of business.

#### 14. Rejection and Rehearing

14.1 Disposition of nonconforming material shall be in accordance with Practice F1470 section titled "Disposition of Nonconforming Lots."

#### 15. Certification

15.1 When specified on the purchase order, the manufacturer or supplier, whichever is the responsible party as defined in Section 16 shall furnish the purchaser a test report that includes the following:

15.1.1 Heat analysis, heat number, and a statement certifying that heats having bismuth, selenium, tellurium, or lead intentionally added were not used to produce the bolts;

15.1.2 Results of hardness, tensile, and proof load tests;

15.1.3 Results of magnetic particle inspection for longitudinal discontinuities and transverse cracks;

15.1.4 Results of tests and inspections for surface discontinuities including visual inspection for head bursts;

15.1.5 Results of carburization and decarburization tests;

15.1.6 Statement of compliance with dimensional and thread fit requirements;

15.1.7 Lot number and purchase order number;

15.1.8 Complete mailing address of responsible party; and

15.1.9 Title and signature of the individual assigned certification responsibility by the company officers.

15.2 Failure to include all the required information on the test report shall be cause for rejection.

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#### 16. Responsibility

16.1 The party responsible for the fastener shall be the organization that supplies the fastener to the purchaser.

#### 17. Product Marking

17.1 Manufacturer's Identification—All Type 1 and Type 3 bolts shall be marked by the manufacturer with a unique identifier to identify the manufacturer or private label distributor, as appropriate.

17.2 Grade Identification:

17.2.1 Type 1 bolts shall be marked "A490."

17.2.2 Type 3 bolts shall be marked "A490" underlined.

17.3 Marking Location and Methods-All marking shall be located on the top of the bolt head and shall be either raised or depressed at the manufacturer's option.

17.4 Acceptance Criteria-Bolts that are not marked in accordance with these provisions shall be considered nonconforming and subject to rejection.

17.5 Type and manufacturer's or private label distributor's identification shall be separate and distinct. The two identifications shall preferably be in different locations and, when on the same level, shall be separated by at least two spaces.

#### 18. Packaging and Package Marking

#### 18.1 Packaging:

18.1.1 Unless otherwise specified, packaging shall be in accordance with Practice D3951.

18.1.2 When special packaging requirements are required. they shall be defined at the time of the inquiry and order.

18.2 Package Marking:

18.2.1 Each shipping unit shall include or be plainly marked with the following information:

18.2.1.1 ASTM designation and type,

18.2.1.2 Size,

18.2.1.3 Name and brand or trademark of the manufacturer,

18.2.1.4 Number of pieces,

18.2.1.5 Lot number,

18.2.1.6 Purchase order number, and

18.2.1.7 Country of origin.

#### 19. Keywords

19.1 bolts; alloy steel; steel; structural; weathering steel

(4) Revised—3.3 to include protective coating F2833 grade 1.

#### SUMMARY OF CHANGES

Committee F16 has identified the location of selected changes to this standard since the last issue (A490–11) that may impact the use of this standard. (Approved April 1, 2012.)

(1) Revised—Section 2 to include protective coating F2833 grade 1.

(2) *Revised*—3.1 to include protective coating F2833 grade 1. (3) Revised—3.2.1 to include protective coating F2833 grade 1.

> Committee F16 has identified the location of selected changes to this standard since the last issue (A490–10a<sup>e1</sup>) that may impact the use of this standard. (Approved Dec. 15, 2011.)

1.

(1) Revised—Table 1.

Committee F16 has identified the location of selected changes to this standard since the last issue (A490–10) that may impact the use of this standard. (Approved Dec. 1, 2010.)

(1) Revised—In Table 3, reduced maximum Rockwell C hardness from 39 to 38 HRC

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