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USACE / NAVFAC / AFCESA / NASA | **UFGS-41 22 13.14 (April 2008)**

Preparing Activity: NAVFAC | **Superseding**
UFGS-41 22 13.13 20 (April 2006)
UFGS 41 22 15.00 10 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2012
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DIVISION 41 - MATERIAL PROCESSING AND HANDLING EQUIPMENT

SECTION 41 22 13.14

BRIDGE CRANES, OVERHEAD ELECTRIC, TOP RUNNING

04/08

-- End of Section Table of Contents --

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USACE / NAVFAC / AFCESA / NASA	UFGS-41 22 13.14 (April 2008)
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SECTION 41 22 13.14

BRIDGE CRANES, OVERHEAD ELECTRIC, TOP RUNNING
04/08

****
NOTE: This guide specification covers the requirements for top running overhead electric traveling (OET) cranes with top running bridges and trolleys, Crane Manufacturers Association of America (CMAA) 70 Class A, B and C and with capacities less than 9 metric ton 10 ton 9072 kg 20,000 pounds.

This guide specification includes tailoring options for NAVFAC, pounds (per NAVFAC P-307), and tons. Selection or deselection of a tailoring option (select view-tailoring options) will include or exclude that option in the section. Specific project editing is still required for the resulting section.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****

****
Use this guide specification to specify general purpose cranes that are procured as part of a building construction contract for such applications as machine shops, warehouses, and other areas that do not require specialized weight handling equipment.

The crane specified herein will handle loads which average 50 percent of rated capacity with 5 to 10 lifts per hour averaging 5 m 15 feet with not over 50 percent of the lifts at rated capacity. This criteria places the specified crane, per the Crane Manufacturers Association of America (CMAA) as Duty Class A - Standby or Infrequent Service; B - Light Service; or Class C - Moderate Service. Navy Crane Center minimum requirement is Class C.

NOTE: Do not use this guide specification to procure overhead electric traveling (OET) cranes of 9 metric ton 10 ton[9072 kg][20,000 pounds] capacity or greater; cranes that operate in "hazardous locations" as defined in the National Electrical Code; nonstandard cranes; or cranes that handle hot (molten) metals, ordinance or fissionable materials.

Forward all procurement of OET systems at Naval Shore based activities with rated capacities of 9072 kg 20,000 pounds or greater, or for use in specialized applications to Naval Facilities Engineering Command, Navy Crane Center, Building 491, Norfolk Naval Shipyard, Portsmouth, Va., 23709-5000. (See NAVFAC Instruction 11450.1a of 22 January, 1997).

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NOTE: TO DOWNLOAD UFGS GRAPHICS

Go to http://www.wbdg.org/ccb/NAVGRAPH/graphtoc.pdf.

****

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NOTE: Show the following information on the project drawings:

1. Complete details of plan, elevations and sections of crane, including building clearances. [UFGS - 41 22 13.14-1]

2. Maximum span of runway girder.

3. Runway rail size.

4. Runway girder size.

5. Channel cap size.

6. Size and location of crane stops.

7. Electrical junction box location (including mounting height).

****

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA ISO 10064-6	(2010) Code of Inspection Practice - Part 6: Bevel Gear Measurement Methods
AGMA ISO 17485	(2008; Supplement 2008) Bevel Gears - ISO System of Accuracy (Including Supplement - Tolerance Tables 2008)
ANSI/AGMA 2001	(2004D; R 2010) Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
ANSI/AGMA 2011	(1998A; R 2004) Cylindrical Wormgearing Tolerance and Inspection Methods
ANSI/AGMA 2015-1	(2001A; R 2008) Accuracy Classification System - Tangential Measurements for Cylindrical Gears
ANSI/AGMA 6013	(2006A; R 2011) Standard for Industrial Enclosed Gear Drives
ANSI/AGMA 6113	(2006A; R 2011) Standard for Industrial Enclosed Gear Drives (Metric Edition)

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2011) Steel Construction Manual

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2010; Errata 2010) Structural Welding Code - Steel
AWS D14.1/D14.1M	(2005) Specification for Welding Industrial and Mill Cranes and Other Material Handling Equipment

ASME INTERNATIONAL (ASME)

ASME B30.10	(2009) Hooks
ASME B30.2	(2011) Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)
ASME NOG-1	(2010) Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)

ASTM INTERNATIONAL (ASTM)

ASTM A1023/A1023M	(2009) Standard Specification for Stranded Carbon Steel Wire Ropes for General Purposes
ASTM A275/A275M	(2008) Standard Test Method for Magnetic Particle Examination of Steel Forgings
ASTM A668/A668M	(2004; R 2009) Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
ASTM A931	(2008) Standard Test Method for Tension Testing of Wire Ropes and Strand
ASTM E125	(1963; R 2008) Photographs for Magnetic Particle Indications on Ferrous Castings
ASTM E543	(2009) Standard Practice for Agencies Performing Non-Destructive Testing

CRANE MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)

CMAA 70	(2010) Specification for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes, No. 70

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 6	(1993; R 2011) Enclosures

NEMA ICS 8	(2011) Crane and Hoist Controllers
NEMA MG 1	(2011) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; Errata 2 2012) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards
29 CFR 1910.147	Control of Hazardous Energy (Lock Out/Tag Out)
29 CFR 1910.179	Overhead and Gantry Cranes
29 CFR 1910.306	Specific Purpose Equipment and Installations

UNDERWRITERS LABORATORIES (UL)

UL 1004-1	(2008; Corrections 2008) Standard for Safety Rotating Electrical Machines
UL 1449	(2006; Reprint Feb 2011) Surge Protective Devices
UL 489	(2009; Reprint Jun 2011) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 50	(2007; Reprint Apr 2012) Enclosures for Electrical Equipment, Non-environmental Considerations
UL 943	(2006; Reprint May 2010) Ground-Fault Circuit-Interrupters

1.2 DEFINITIONS

a. Crane Bridge: That part of an overhead crane system consisting of girder(s), end trucks, end ties, walkway, and drive mechanism which carries the trolley(s) and travels along the runway rails parallel to the runway.

b. Crane Runway: The track system along which the crane operates horizontally, including track hangar rods, track connection devices, and runway structural supports.

c. Dead Loads: The loads on a structure which remain in a fixed position relative to the structure.

d. Girder: The principal horizontal beam of the crane bridge. It is supported by the crane end trucks.

e. Live Load: A load which moves relative to the structure under consideration.

f. Pendant: A control for a hoist and/or a crane. The pendant hangs from the hoist or the crane by a cable at a height that is easy for the operator to reach.

g. Rated Load: For the purpose of this specification the rated load is defined as the maximum working load suspended under the load hook.

h. Standard Commercial Cataloged Product: A product which is currently being sold, or previously has been sold, in substantial quantities to the general public, industry or Government in the course of normal business operations. Models, samples, prototypes or experimental units do not meet this definition. The term "cataloged" as specified in this section is defined as "appearing" on the manufacturer's published product data sheets. These data sheets must have been published or copyrighted prior to the issue date of this solicitation and have a document identification number or bulletin number.

i. Top Running Crane: An electric overhead traveling crane that runs on rails on top of support girders.

j. Trolley Mounted Hoist: A combined unit consisting of a wheeled trolley that provides horizontal motion along the bridge girder, and a hoist supported by the trolley, that provides lifting and lowering of a freely suspended load.

1.3 REQUIREMENTS

The requirements for the crane runway system and rail supporting structures are specified in Section 05 12 00, STRUCTURAL STEEL, and must conform to AISC 325.

1.4 VERIFICATION OF DIMENSIONS

The Contractor is responsible for the coordination and proper relation of his work to the building structure and to the work of all trades. Verify all dimensions of the building that relate to fabrication of the crane and notify the Contracting Officer of any discrepancy before finalizing the crane order.

1.5 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G". Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within

the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Overhead electric crane[; G][; G, [_____]]

SD-03 Product Data

Gear Reducers[; G][; G, [_____]]

Hook[; G][; G, [_____]]

Trolley[; G][; G, [_____]]

[Radio Controls[; G][; G, [_____]]]

[Inverter Drives[; G][; G, [_____]]]

[Control Parameter Settings[; G][; G, [_____]]]

Hoist[; G][; G, [_____]]

Controls[; G][; G, [_____]]

Couplings[; G][; G, [_____]]

[Pendant pushbutton station[; G][; G, [_____]]]

Electrification[; G][; G, [_____]]

Motors[; G][; G, [_____]]

Brakes[; G][; G, [_____]]

Capacity Overload Protective Device[; G][; G, [_____]]

Limit Switches[; G][; G, [_____]]

SD-05 Design Data

Load and sizing calculations[; G][; G, [_____]]

SD-06 Test Reports

Hook and hook nut magnetic-particle Tests[; G][; G, [_____]]

Wire rope breaking strength[; G][; G, [_____]]

Post-erection inspection[; G][; G, [_____]]

Operational Tests[; G][; G, [_____]]

Hook Proof Test[; G][; G, [_____]]

Hook Tram Measurement[; G][; G, [_____]]

No-load Test[; G][; G, [_____]]

Load Tests[; G][; G, [_____]]

SD-07 Certificates

Overload Test Certificate[; G][; G, [_____]]

Loss of Power (Panic Test) Certificate[; G][; G, [_____]]

Hazardous Material Certificate[; G][; G, [_____]]

Certificate of the Coupling Alignment Verification Record[; G][; G, [_____]]

Brake Setting Record[; G][; G, [_____]]

Certificate of Compliance with Listed Standards[; G][; G, [_____]]

SD-10 Operation and Maintenance Data

Overhead electric crane[; G][; G, [_____]]

Data Package 3[; G][; G, [_____]]

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA, including weekly, monthly, semi-annual, and annual required maintenance items.

1.6 QUALITY ASSURANCE

1.6.1 Manufacturer Qualification

Overhead electric crane system, including sub-system components manufactured by vendors, must be designed and manufactured by a company with a minimum of 10 years of specialized experience in designing and manufacturing the type of overhead crane required to meet requirements of the Contract Documents.

1.6.2 Pre-Delivery Inspections

Contractor is responsible for performance of quality control inspections, testing and documentation of steel castings, hook assembly and trolley as follows.

1.6.2.1 Inspection of Steel Castings

****
NOTE: Navy Crane Center does not require magnetic-particle testing of steel castings. For NASA projects, select both magnetic particle testing and ultrasonic testing. Magnetic testing for USACE projects should be coordinated with the Contracting Officer.
****

Visually inspect [and test]load-carrying steel castings[using the magnetic-particle inspection method][using ultrasonic testing].[Reference allowable degree of discontinuities to ASTM E125, and relationship to service loads and stresses, critical configuration, location and type.] All load bearing components, couplings, shafts, and gears, in the hoist drive train must be rolled or forged steel, except brake drums which may be ductile iron. Methods of repairing the discontinuities is subject to review by the Contracting Officer.

1.6.2.2 Inspection of Hook Assembly

Inspect hook and nut [by a magnetic-particle type inspection per subpart titled Hook and Hook Nut Magnetic-Particle Tests][and X-rayed][and tested ultrasonically] prior to delivery. Furnish documentation of hook inspection to Contracting Officer prior to field operational testing. As part of the acceptance standard, linear indications[greater than 1/16 inch] are not allowed. Welding repairs of hook are not permitted. A hook showing linear indications, damage or deformation is not acceptable and must be replaced immediately.

1.6.2.3 Hook Proof Test

Proof test the load hook per ASME B30.10.

1.6.3 Certificates

Submit an Overload Test Certificate stating that the crane can be periodically load tested to 125 percent (plus 5 minus 0) of rated load.

Submit a Loss of Power (Panic Test) Certificate stating that a test may be performed in which power is removed from the crane while the hoist, bridge, and trolley are in operation to simulate a loss of power.

Submit a Hazardous Material Certificate that the crane does not contain hazardous material, asbestos, lead, cadmium,chromium, PCBs or elemental mercury.

Submit a Certificate of Compliance with Listed Standards.

Submit a Certificate of the Coupling Alignment Verification Record.

Submit a Certificate of the Brake Setting Record

1.6.4 Drawings: Overhead Electric Crane

Submit shop drawings showing the general arrangement of all components in plan, elevation, and end views; hook approaches on all four sides, clearances and principal dimensions, assemblies of hoist, trolley and bridge drives, motor nameplate data, overcurrent protective device ratings, and electrical schematic drawings. Include weights of components and maximum bridge wheel loads and spacing.

Shop drawing quality must be equivalent to the contract drawings accompanying this solicitation. Drawings must be reviewed, signed and sealed by a registered professional engineer.

Provide integral schedule of crane components on each drawing. Provide maximum wheel loads (without impact) and spacing imparted to the crane runway system track beams. Indicate the crane speeds along the runway, the trolley speeds along the bridge girder, and the hoist lifting speeds; all speeds indicated are speeds with hoist loaded with rated crane capacity load.

1.6.5 Design Data: Load and Sizing Calculations

Submit calculations reviewed, signed and sealed by a registered professional engineer verifying the sizing of the bridge girder, end trucks, travel drives, and overcurrent protection for motors, controllers, and branch circuits. [Include seismic analysis of bridge girder and end trucks.]

1.6.6 Welding Qualifications and Procedures

Welding must be in accordance with qualified procedures using AWS D14.1/D14.1M as modified. Written welding procedures must specify the Contractor's standard dimensional tolerances for deviation from camber and sweep and not exceed those specified in AWS D14.1/D14.1M and CMAA 70. Welders and welding operators must be qualified in accordance with AWS D1.1/D1.1M or AWS D14.1/D14.1M. Allowable stress values must comply with CMAA 70.

1.7 CRANE SAFETY

Comply with the mandatory and advisory safety requirements of ASME B30.10, and NFPA 70. Submit data on Capacity Overload Protective Device

1.7.1 Nuclear Safety Analysis

****

NOTE: Certification is required for cranes handling nuclear materials. Results from the Safety Analysis will be utilized by the Using Agency as a basis for bridge crane certification. Delete this paragraph if the crane is not required to handle nuclear materials.

****

[

Nuclear certification, testing, and rules of construction must be in accordance with ASME NOG-1. Submit analysis and test reports to Contracting Officer for approval.

]PART 2 PRODUCTS

2.1 TOP RUNNING CRANE SYSTEM

****
NOTE: For NAVFAC, specify Class C or better.
****

****
NOTE: Specify Class A Crane when there are long idle periods between lifts. Full capacity loads may be handled for initial installation of machinery and for infrequent maintenance.

Specify Class B Crane where service requirements are light and speeds are slow. Loads may vary from no load to full capacity, averaging 50 percent of full capacity, with two to five lifts per hour averaging ten feet per lift. Not over 50 percent of the lifts will be at full capacity.

Specify Class C Crane where service requirements are moderate. Loads may vary from no load to full capacity, averaging 50 percent to full capacity, with 5 to 10 lifts per hour averaging 15 feet. Not over 50 percent of the loads will be at full capacity.
****

****
NOTE: A footwalk is recommended unless: the crane can be safely serviced by another means; or where lack of clearance would prohibit one.
****

Provide top running overhead electric traveling (OET) crane[s] conforming to CMAA 70, [Class A (Standby or Infrequent Service)][Class B (Light Service)][Class C (Moderate Service)] for [indoor] [outdoor] service, ASME B30.2, with a vertical lift of [_____] feet and as specified herein. The crane span must be [_____] feet, and be designed to operate in an ambient temperature between [_____] and [_____] degrees Fahrenheit.

[Provide a footwalk on the drive girder side, and idler girder side with crossovers on the end trucks to allow access to all maintainable features of the crane.] The crane must be [pendant] [radio controlled] and operate in the spaces and within the loading conditions indicated.[The pendant controller must be mounted on a separate festooned cable system from the trolley power supply.][Submit product data for radio controls.] The crane must operate on [_____]-volts AC, 60 Hz, [single] [three] phase power source. Maximum crane wheel loads (without impact) due to dead and live loads, with the trolley in any position, must not cause a more severe loading condition in the runway support structure than that produced by the design wheel loads and spacing indicated.

Submit Overhead electric crane, Data Package 3, including recommended maintenance items on a weekly, monthly, semi-annual, and annual basis.

2.1.1 Capacity

****
NOTE: Indicate on the drawings the required capacity. Specifier must coordinate thoroughly with the designer to ensure that the crane capacity specified below agrees with the crane capacity indicated on the drawings. Typical cranes of this type have capacities of 5 tons or less than 10 tons.
****

Provide a crane with a minimum rated capacity of [_____] metric ton ton ([_____] kg pounds). Mark the rated capacity in both kilogram and pound units printed in different colors on both sides of the crane on the bridge girders. Capacity marks must be clearly visible to the operator at ground level.

2.1.2 Speeds

****
NOTE: For NAVFAC add the last bracketed sentence.
****

****

1. Hoist: Select hoist speed which conforms to the recommendations of CMAA 70 or ASME tables, based on capacity.

2. Trolley: Trolley travel speed must conform to the recommendations of CMAA 70, based on capacity.

3. Bridge: Bridge travel speed must conform to the suggested speeds per minute for floor controlled cranes as stipulated in CMAA 70.
****

OET crane must have the following full load speeds(plus or minus 10 percent):

a. Hoist - rated speed of[6.1 meters per minute 20 feet per minute][[_____]meters per minute [_____] feet per minute]

b. Trolley - rated speed of[36.6 meters per minute 120 feet per minute][[_____]meters per minute [_____] feet per minute]

c. Bridge - rated speed of[45.7 meters per minute150 feet per minute][[_____]meters per minute [_____] feet per minute]

[For two speed motions, provide the low speeds at less than half of the specified rated speeds.]

****
NOTE: : Use the following applicable sections for infinitely variable drive control
****

[d. Hoist - minimum speed of [_____][meters per minute][feet per minute]]

[e. Trolley - minimum speed of [_____][meters per minute][feet per minute]
]
[f. Bridge - minimum speed of [_____][meters per minute][feet per minute]
]

2.1.3 Hoist

Provide hoist conforming to ASME B30.2 and CMAA 70 Class C or better, double reeved, except as modified and supplemented in this section. Equip hoist with a spring set, electro-mechanically released brake plus a mechanical load brake.

2.1.4 Crane Safety

Comply with the mandatory and advisory safety requirements of ASME B30.2, CMAA 70,29 CFR 1910.147, 29 CFR 1910.179, 29 CFR 1910.306, and all applicable provisions of 29 CFR 1910 and NFPA 70.

2.2 STRUCTURAL REQUIREMENTS

****
NOTE: Specify welded box girders for bridge spans of 15 m 50 feet or more.
****

Structural requirements must be in accordance with CMAA 70, Section 3.

[2.2.1 Seismic Forces (SF)

****
NOTE: Seismic forces should be considered in the design of all cranes in Seismic Zones 3 and 4. Enter the appropriate factor in the formula for SF as determined below:

Seismic Zone	Factor
3	0.45
4	0.60

****

Consider seismic forces in the design of the crane. Apply seismic forces laterally, parallel to the bridge girders and parallel to the runway girders as two separate load cases. Apply seismic forces concurrently with the dead load (DL) and trolley load (TL). Locate the concentrated load in the same positions as when calculating vertical shears and bending moments. Consider torsion due to eccentric horizontal forces. Allowable combined stresses must be 133 percent of Stress Level One in CMAA 70. Calculate combined stresses due to seismic forces for the following load combination:

Seismic Loading = DL + TL + SF

where SF = [_____] DL (distributed) + [_____] TL (concentrated)]

2.3 MECHANICAL EQUIPMENT

Provide steel shafts, gears, keys, and couplings. Cast iron and aluminum used to support components of the hoist power transmission train must be ductile.

All bearings, except those subject only to small rocker motion, must be anti friction type.

2.3.1 Drives

2.3.1.1 Bridge Drives

****
NOTE: If the span is less than 12 m (40 feet) and the application is CMAA Class "A" or "B", then A-1 drive may be included as an option.
****

Bridge drives must be [either the A-1 or] [A-4] drive arrangement as specified in CMAA 70.

[Provide bridge drive consisting of a single electric motor mechanically connected through gear reduction and drive shafts to the drive wheels or separate drive motors at each end of bridge.]

Acceleration and deceleration must meet the requirements specified in this section. Gears must conform to applicable AGMA standards. Provide oil tight fully enclosed gear reducers with pressure or splash type lubrication. Bridge-travel limit-switches are optional. Submit product data on inverter drives and control parameter settings.

2.3.1.2 Trolley Drives

Provide trolley complete with a drive arrangement with a minimum of two wheels driven by an integral electric motor. Drive mechanism must run in totally enclosed oil bath. Limit switches are optional for drive mechanism. Acceleration and deceleration controls must meet requirements specified in this section.

[2.3.1.3 Micro-Drives

****
NOTE: Current industry standards use Variable Frequency Alternating Current Drives (VFAC) in lieu of micro-drive motors. The following paragraph is included in this section for instances where the micro-drive motors will not be replaced with newer VFAC drives. If micro-drives are not to be used, delete this paragraph.
****

****
NOTE: Include those motions where a micro-drive is required. If micro-drive is not specified, delete these paragraphs. Micro-drives are generally required when slow speeds are required for an extended amount of time. If precision movement is required for limited time for final positioning of

loads, use adjustable frequency or dc variable voltage crane controls instead of micro-drives.

****

Provide the following crane motions with a separate micro-drive: [main hoist], [auxiliary hoist], [trolley drive] [and] [bridge drive]. The micro-drives are used to precisely position loads. Each micro-drive must consist of an electric motor, gear reducer, magnetic coupling clutch and necessary controls. Connect the output shaft of the reducer to an extension of the primary drive high-speed shafting with a magnetic coupling clutch. Coupling must normally be disengaged and engage only if the micro-drive is required. Electrical clutch components required for proper operation must conform to the requirements specified in paragraph ELECTRICAL COMPONENTS. provide magnetic coupling type CLUTCHES, which engage and disengage the micro-drives from the high speed shafts of the main drive arrangement. The clutch must be engaged by electromagnet and released by springs. Provide clutch ratings not less than 150 percent of the micro-motor rated torque as amplified by the intervening gearing. Clutch enclosures must facilitate easy access for wear inspection of the friction elements and visual examination of the clutch assemblies.

]2.3.2 Load Block and Hook Assembly

****

NOTE: For NAVFAC, add bracketed paragraph.

****

Construct the load block of steel. Provide an unpainted single barbed forged steel hook complying with ASTM A668/A668M. Hook dimensions must be as shown on the drawings. Fit hook with safety latches designed to preclude inadvertent displacement of slings from the hook saddle. Provide hook nut with a removable type set screw or other similar fastener, installed in a plane parallel to the longitudinal axis of the hook shank. Do not weld hook nut. Hook must be free to rotate through 360 degrees when supporting the test load up to 131.25 percent of the rated capacity. Provide only hooks which are designed and commercially rated in accordance with CMAA and conforming to ASME B30.10, and CMAA 70.

[Each hook and hook nut must be capable of complete disassembly which enables access to all surfaces of hook, including shank and hook nut for inspection purposes. Make provisions for the hook nut, or other hook-to-block fastener, to be keyed to hook shank by means of a set screw or similar, easily removable, securing device.]

[2.3.2.1 Hook and Hook Nut Magnetic-Particle Tests

****

NOTE: Delete this paragraph if selected agency does not require magnetic particle testing.

****

****

NOTE: For NAVFAC, substitute bracketed paragraph.

****

Magnetic-particle inspect the hook and nut over the entire area in accordance with ASTM A275/A275M. Acceptance standard is no defects. A defect is defined as a linear indication that is greater than [3 mm 1/8

inch][1.5 mm 1/16 inch] long.

[Inspect each hook, including shank and hook nut, over the entire surface areas by magnetic particle inspection. If hook nut is not used, any device that functions the same as the hook nut must be inspected by magnetic particle inspection.

a. Procedure: Conduct magnetic particle inspection in accordance with ASTM A275/A275M with the following restrictions: Do not use DC yokes (including switchable AC/DC yokes used in the DC mode) or permanent magnet yokes. Do not use automatic powder blowers or any other form of forced air other than from a hand-held bulb for the application or removal of dry magnetic particles. Remove arc strikes. Equipment ammeters must have an accuracy of plus or minus 5 percent of full scale (equipment ammeter accuracy other than that stated is acceptable provided the MT procedure states that a magnetic field indicator is used to establish and verify adequate field strength for all aspects of the inspection.)

b. Acceptance Criteria: Defects found on the hook or hook nut will result in rejection of defective items for use on furnished hoist. For this inspection, a defect is defined as a linear or non-linear indication for which the largest dimension is greater than[3 mm 1/8 inch][1.5 mm 1/16 inch]. Weld repairs for defects on hook or hook nut will not be permitted.

c. Test Report: Submit a test report of the magnetic particle inspection of each hook and hook nut provided the Contracting Officer for approval prior to final acceptance of hoist installation. Certify test reports by the testing organization.

The performing organization must provide a written statement of certification to ASTM E543, have the procedures used for testing of the hook and hook nut reviewed and approved by an independent Level III examiner, and submit the approved procedures and certification to the Contracting Officer with the test report.

d. Weld Repair: Weld repairs for defects on hooks or hook nuts are not acceptable.]

]2.3.3 Hoisting Ropes

****
NOTE: For NAVFAC, add bracketed paragraph section.
****

Wire ropes must conform to ASTM A1023/A1023M and be tested as required by ASTM A931. Provide 6 by 37 class construction hoisting ropes, with improved or extra improved plow steel, as a minimum, and an independent wire rope core. Maximum hoisting rope fleet angles must be 4 degrees for drums and 4.75 degrees for sheaves. Hoisting rope end connections, other than drum connections, must be speltered sockets with forged steel terminals or swaged fittings installed in a fashion that provides 100 percent of the breaking strength of the wire rope. Provide proof of wire rope breaking strength. Wedge sockets or aluminum swages are not permitted on wire rope end connections.

[Provide wire rope minimum safety factor of 5 to 1 based on the ratio of actual minimum wire rope breaking load to the calculated load on rope when

hoist is assumed loaded to rated capacity. Submit certification from rope manufacturer verifying provided wire rope breaking strength, to the Contracting Officer and secure approval prior to final acceptance of hoist. No paint or coatings are allowed on the wire rope. Minimum length of the wire rope must enable the load hook to operate through its full hook lift range and still have a minimum of two full wraps of wire rope around the rope drum.]

2.3.4 Sheaves

****
NOTE: Select 16 rope diameters for a class A or B crane, and 18 rope diameters for a class C crane.
****

Provide steel sheaves. Minimum pitch diameters must be [16] [18] times the rope diameter for running sheaves, and 12 times the rope diameter for equalizer sheaves. Sheave surfaces which contact wire rope are not to be painted.

2.3.5 Hoist Drum

****
NOTE: Select 16 rope diameters for a class A or B crane, and 18 rope diameters for a class C crane.
****

Provide drum made of steel. Design drum so that not less than two dead wraps of hoisting rope remain on each anchorage when the hook is in its extreme low position. Drum grooving must be right and left hand beginning at the ends and grooving toward the center of the drum. Minimum drum groove depth, must be 0.375 times the rope diameter. Minimum drum groove pitch must be either 1.14 times the rope diameter, or the rope diameter plus 3 mm 1/8 inch, whichever is smaller. Minimum drum pitch diameter must be [16] [18] times the rope diameter. Do not paint, coat, or galvanize the surface of the drum which comes in contact with wire rope.

For wire rope drums installed directly onto the output shaft of the hoist speed reducer without an intermediate flexible coupling, the drum to shaft connection must be a barrel coupling.

2.3.6 Gearing

Provide gearing of the enclosed gear reducers type. Provide spur, helical, or herringbone type gears and pinions only, forged, cast or rolled steel. Open-type gearing is not acceptable, except for final drives. Gears and pinions must have adequate strength and durability for the crane service class and be manufactured to ANSI/AGMA 2001 Quality Class 6 or better precision per [AGMA ISO 10064-6] [AGMA ISO 17485] [ANSI/AGMA 2011] [ANSI/AGMA 2015-1].

2.3.7 Gear Reducers

Gear reducers must be standard items of manufacturers regularly engaged in the design and manufacture of gear reducers for integral components of standard hoists or hoist/trolley units of manufacturers regularly engaged in the design and manufacture of hoists or hoist/trolley units for Class A, B or C cranes. Gear reducers must be designed, manufactured and rated in accordance with ANSI/AGMA 6113ANSI/AGMA 6013 (for trolley drives only), as

applicable. Except for final reduction, the gear reduction units must be fully enclosed in oil-tight housing. Gearing must be designed to AGMA standards and operate in an oil bath. Operation must be smooth and quiet.

2.3.8 Open Gearing

Provide all gears and pinions with adequate strength and durability for the crane service class and manufactured to ANSI/AGMA 2001 quality class 6 or better precision per [AGMA ISO 10064-6] [AGMA ISO 17485] [ANSI/AGMA 2011] [ANSI/AGMA 2015-1]. Open gears must be enclosed with safety guards provided with openings with covers for inspection and access for grease lubrication.

2.3.9 Wheels

Provide double flanged trolley and bridge travel wheels of rolled-to-shape wrought or forged steel. Rim toughen wheels to not less than 320 Brinell Hardness Number (BHN). Wheel sizing and flange-to-rail head clearances must be in accordance with CMAA 70 recommendations.

2.3.10 Bridge and Trolley Brakes

Provide bridge and trolley drives with electro-mechanical brakes capable of stopping the motion of the bridge or trolley within a distance in feet equal to 10 percent of the full load speed in feet per minute when traveling at full speed with a full load. Brakes must have an externally accessible means to manually defeat the brake.

2.3.11 Hoist Brakes

Equip hoist with both a spring set, electro-mechanically or thruster released shoe or disc brake, plus a mechanical load brake. The mechanical load brake and the electro-mechanical or thruster brake must each, independently, stop and hold 131.25 percent of rated capacity. The electro-mechanical or thruster brake must be adjustable to 50 percent of its rated capacity, and must have an externally accessible means of manual release.

2.3.12 Bumpers

Provide bumpers on the bridge and trolley per CMAA 70 guidelines.

2.3.13 End Trucks

Configure bridge and trolley trucks with a feature that limits load movement to 1" in the event of wheel or shaft failure.

2.4 ELECTRICAL COMPONENTS

2.4.1 Motors

****

NOTE:Inverter duty motor are required for Variable frequency drives (VFD).

Select two speed motors for bridge and trolley drives if magnetic controls are specified in paragraph entitled "Controls"; select single speed motors if electronic controls are specified in paragraph entitled "Controls."

****

Motors must meet all applicable requirements of NEMA MG 1and UL 1004-1.[Provide insulated inverter duty motors for Variable Frequency Drives (VFD). Motor insulation must be Class H, but with a Class B temperature rise.][Provide [two] [single] speed AC squirrel cage induction type motors for the bridge and trolley drives.][Provide two speed, AC squirrel cage induction type motor for the hoist.] Provide Class F motor insulation for motors with magnetic controls. Provide motor overload protection utilizing a thermal sensitive device embedded in it's windings.

2.4.2 Controls

****

NOTE: Use the first paragraph to select electronic controls for the hoist, bridge or trolley. Use the second paragraph to select one or two speed control for the hoist, bridge, or trolley. Selections can be made using a combination of electronic controls and one or two speed motor control.

When the two-speed bridge and trolley motor is specified, the slow speed will be 1/3 to 1/4 of rated travel speed. Reduced voltage starting, acceleration, and deceleration, serve to reduce the acceleration rate that is normal for squirrel-cage motors. Squirrel-cage motors with two-speed magnetic controls provide satisfactory results with slow bridge and trolley speeds, and should be specified when short travel distances are involved and where fine positioning is not required.

For faster bridge and trolley speeds or finer positioning requirements, specify electronic controls.

****

[Provide static reversing, adjustable frequency controllers for the [hoist], [bridge] [and] [trolley] electric drives. Provide dynamic braking for all electric drives. Speed control must be of the [three step infinitely variable type for the hoist function] [and] [two step infinitely variable type for the bridge and trolley functions]. The [hoist], [trolley] [and] [bridge] brakes must set only after the associated controller decelerates the motor to a controlled stop. All motors must run smoothly, without torque pulsations at the lowest speed and be energized at a frequency not exceeding 60 HZ at the highest speed. [The hoist controller must enable the drive motor to develop full torque continuously at zero speed.]]

"[Provide [one][two]-speed magnetic controls for the [bridge drive], [trolley drive], [and] [hoist] drive. Ensure that an energized drive motor initially rotates only in the direction selected by the operator by activating the corresponding direction; i.e., is not overhauled. The motor control systems must be provided with resistive or reactive reduced voltage starting, acceleration, and deceleration utilizing, for each, separate banks of voltage reducing resistors or reactors and timing relays.

On deceleration, resistors or reactors must be inserted into the motor's high speed leads prior to de energization of the high speed contactor.

Acceleration and deceleration must be smooth. [Provide the bridge and trolley motor control systems with a drift point between OFF and the first speed control point in each direction.] The use of definite purpose contactors is prohibited. All contactors must be NEMA rated.]

Feed control circuits from a single phase, air cooled, double wound transformer with a grounded metal screen between the primary and secondary windings of the transformer

2.4.3 Protection

Protection must not be less than that required by NEMA ICS 3, NEMA ICS 8, CMAA 70, NFPA 70,UL 1004-1, UL 1449, UL 489, UL 50, UL 943, 29 CFR 1910.147, 29 CFR 1910.179, 29 CFR 1910.306 and all applicable provisions of 29 CFR 1910. Provide enclosed type circuit breaker readily accessible to the crane operator for crane disconnect. Provide an On/Off button that removes power from the motors, brakes and control circuit on the operator's control pendant station or radio controller. Provide for lockout/tagout of all hazardous energy sources.

2.4.4 Resistors

****
NOTE: Include "125 percent of" only if electronic controls have been selected previously.
****

Provide resistors rated for continuous duty operation based upon [125 percent of] the motor nameplate amperes and fabricated of corrosion resistant metal; the use of "wire wound" type resistors is prohibited for segments of 8 ohms or less. Mount resistors in substantial, ventilated enclosures constructed entirely of non-combustible materials. Provide resistors with terminals fitted in the coolest position in the enclosure.

2.4.5 Reactors

****
NOTE: The following items are required only for VFD.
****

Provide line reactors rated for continuous duty operation based upon the motor nameplate amperes. Select reactors for 60 Hz operation and having taps for field adjustment of inductance so as to permit achievement of the optimum acceleration characteristics for the drive. For a drive motor branch circuit that exceeds 100 feet in length, the reactor must also be connected in series with the controller load (output) terminals to provide standing wave protection.

2.4.6 Limit Switches

Provide primary upper and lower geared limit switches. Geared limits must allow reversing direction to back out of the limit without resetting. Provide a backup mechanical hook block activated upper limit switch wired independent of the directional controllers and the primary upper limit switch that removes power from the hoist motor, hoist brake and hoist controls conforming to UL 1449. The backup limit must require hoist resetting prior to operation of the hoist in any direction. Provide a three position keyed switch on the pendant control with positions for bypass of the primary upper limit (to allow testing of the backup upper

limit) and bypass of the backup upper limit in the lower direction only

[2.4.6.1 Radio Control

Provide radio control system conforming to FCC Part 15 (unlicensed frequencies). The remote radio control system must be designed to meet the requirements of NEMA ICS 8, Part 9.

]2.4.7 Pendant Pushbutton Station

Suspend the pendant pushbutton station from an independent festooned messenger track system, operating the length of the bridge. Locate the pendant pushbutton station [1200 mm] [4 feet] [_____] above the finished floor. Clearly mark all controls for identification of functions. Provide directional contactors with both mechanical and electrical interlocks.

2.4.8 Bridge and Runway Electrification

Provide festooned type or enclosed safety bar type bridge electrification. Provide enclosed safety bar type runway electrification. Power collectors must be a fully redundant dual shoe.

[2.4.9 Overload Protection

Provide overload protection for bridge, runway, and hoist systems. Hoist overload protection must be adjustable between 80 and 150 percent of hoist capacity.

][2.4.10 Warning Devices

****
NOTE: A warning horn or light is required for all radio controlled cranes and recommended for all others.
****

[Provide a warning horn that is operable from a push button at the [pendant pushbutton] [radio control] station.][Provide a warning [strobe][rotating beacon] that is illuminated at all times during movement of the hoist, trolley, or bridge function.]

][2.4.11 Floodlights

Provide evenly spaced floodlights along the bridge. Select floodlights to provide an illumination level of 40 lumens at three feet above the finished floor. All lights must be vibration resistant and designed to prevent any material from falling from the fixture. Switch the floodlights from the [pendant pushbutton] [radio controlled] station.

]2.4.12 Indicator Lights

Provide Indicator Lights mounted in an enclosure on the bottom of the bridge with lights sized and positioned to be visible from the ground. The lights must be the dual-lamp type. Provide a white light to indicate that power is available on the load side of the crane disconnect and a blue light to indicate that the main contactor is energized. Light voltage must be 115 VAC. Provide nameplates that are legible from ground level. The nameplates must read, in their respective order, "POWER AVAILABLE" and "CRANE ENERGIZED". The POWER AVAILABLE light must be supplied by a

separate, fused transformer for its energization.

2.5 ENCLOSURES

Provide enclosures for control panels, controls, and brakes in accordance with NEMA 250 and NEMA ICS 6, Classification Type [1 indoor, general purpose] [2 indoor, drip-proof] [3 outdoor, dust-tight, rain-tight, sleet-resistant] [_____].

Provide a non-resettable hour meter, connected across the main line contactor, readable from the exterior of the main control panel, to indicate the elapsed number of hours the crane is energized.

2.6 CRANE PAINTING

****
NOTE: For NAVFAC, add final bracketed sentence.
****

****
NOTE: Select blast cleaning, zinc-rich primer, and alkyd finish coat for outdoor cranes. For corrosive atmospheres, specify appropriate protective requirements.
****

Paint exposed portions of the crane and girders in accordance with CMAA 70. Desired color is brilliant yellow.

Coat faying surfaces of bolted connections per AISC 325, but do not apply finish paint.

Paint the load block brilliant yellow with black diagonal striping, 25 mm one inch wide diagonal black stripes located on 50 mm 2 inch centers. [Paint, coatings, or galvanizing on the following items or areas is not acceptable: hoist wire ropes, hooks, hook nuts, or areas on sheaves or rope drums in contact with the wire ropes.]

Factory paint electrical and mechanical equipment in accordance with the manufacturer's best standard practice (for the specified environment), except that electrical equipment doors, which expose current-carrying electrical conductors when opened, must be orange.

2.7 IDENTIFICATION PLATES

Furnish and install identification plates. Provide non-corrosive metal identification plates with clearly legible permanent lettering giving the manufacturer's name, model number, serial number, capacity in both kilogram and pound units printed in different colors, and other essential information or identification.

2.7.1 Markings on Crane, Trolley, and Hook

****
NOTE: Select pounds for all NAVFAC projects.
****

Markings include: bridge motion direction arrows on both sides of the bridge; and trolley motion direction arrows on both sides of trolley.

Markings must be visible from push button station and from the loading point, corresponding to the push button labeling on the pendant pushbutton station. Mark the hook rated capacity in [pounds][tons] on both sides of the hoist load block.

2.8 RUNWAY SYSTEM AND CRANE RAIL

Provide structural steel and crane rail as specified in Section 05 12 00 STRUCTURAL STEEL, and is not within the scope of this section.

PART 3 EXECUTION

3.1 ERECTION AND INSTALLATION

Erect and install the crane, complete in accordance with the approved submittals and in condition to perform the operational and acceptance tests.

3.2 ERECTION SERVICES

The crane manufacturer must provide supervisory erection services.

3.3 FIELD QUALITY CONTROL

3.3.1 Post-Erection Inspection

After erection, the Contractor and the Contracting Officer[, and the Activity Crane Certifying Official] must jointly inspect the crane bridge and hoist systems and components to determine compliance with specifications and approved submittals. Notify the Contracting Officer [_____] days before the inspection. Provide a report of the inspection indicating the crane is considered ready for operational tests.

3.3.2 Operational Tests

****
NOTE: For NAVFAC, delete sentence beginning, "Perform the 125 percent", and add the bracketed sentence.
****

****
NOTE: Determine if Government furnished test loads are available at the site. If not they must be provided by the Contractor.
****

Check the clearance envelope of the entire crane prior to picking or traversing any load to ensure there are no obstructions. Test the systems in service to determine that each component of the system operates as specified, is properly installed and adjusted, and is free from defects in material, manufacture, installation, and workmanship. Rectify all deficiencies disclosed by testing and retest the system or component to prove the crane is operational. [The Contractor must furnish test loads, operating personnel, instruments, and other apparatus necessary to conduct field tests on each crane.]

3.3.3 Test Data

Record test data on appropriate test record forms suitable for retention

for the life of the crane. Record operating and startup current measurements for electrical equipment (motors and coils) using appropriate instrumentation (i.e., clamp-on ammeters). Compare recorded values with design specifications or manufacturer's recommended values; abnormal differences (i.e., greater than 10 percent from manufacturer's or design values) must be justified or appropriate adjustments performed. In addition, note, investigate, and correct any high temperatures or abnormal operation of any equipment or machinery. Record hoist, trolley, and bridge speeds during each test cycle.

3.3.4 Hook Tram Measurement

Establish a throat dimension base measurement by installing two tram points and measuring the distance between these tram points (plus or minus 0.4 mm 1/64 inch). Record this base dimension. Measure the distance between tram points before and after load test. An increase in the throat opening from the base measurement is cause for rejection.

3.3.5 No-Load Test

Raise and lower the hook through the full range of normal travel at rated speed for three complete cycles. Raise and lower the hook, testing other speeds of the crane. Verify proper operation of hoist limit switches. Operate the bridge and trolley in each direction the full distance between end stops. Operate through the entire speed range and verify proper brake operation.

3.3.6 Load Tests

Perform the following tests, as specified, with test loads of 100 percent (plus 0 minus 10) or 125 percent (plus 5 minus 0) of rated load.

3.3.6.1 Hoist

Disconnect or adjust the overload limit device to allow the hoist to lift the test load. Proof test the overload limit device after it is reconnected.

a. Static Load Test [125 percent only] [_____]): Check entire structure, holding brake and hoisting components as follows: With the trolley in the center of the bridge span, raise the test load approximately 300 mm one foot. Hold the load for 10 minutes. Rotate the load and hook 360 degrees to check bearing operation with no binding. Observe lowering that may occur which indicates a weakness in the structure or malfunction of hoisting components or brakes. Verify that maximum beam and girder deflections do not exceed CMAA 70 design limits.

****
NOTE: For NAVFAC, change "10 cycles" to "5 cycles." Insert required test load percentages if other than 125 percent.
****

b. Raise and lower and test load through the full lift range.[Lower the load to the floor, wait 5 minutes, then raise and lower the load through two more cycles.][Operate continuously for a minimum of 5 minutes.] As a minimum, operate in each speed for each test load. In addition, the dynamic test of test load sequence number 2 (125 percent of rated load) must be repeated for 10 cycles at rated speed, in order

to demonstrate proper operation and repeatability of all functions without component overheating or malfunction. Completely stop the machinery at least once in each direction during each cycle to ensure proper brake operation. Do not stop hoist for more than 15 seconds prior to commencing the next cycle.

c. Hoist Load Brake ([125 percent only][_____]): Raise test load approximately 1500 mm 5 feet. With the hoist controller in the neutral position, release (by hand) the holding brake. Document the method used to release the holding brake. The load brake must hold the test load. Again with the holding brake in the released position start the test load down (first point) and return the controller to the "off" position as the test load lowers. The load brake must stop and hold the test load.

d. Hoist Loss of Power Test [125 percent only][_____]: Raise the test load to approximately 2400 mm 8 feet. While slowly lowering the test load (first point), disconnect the crane's power source. Verify that the test load does not lower and that the brake is set.

3.3.6.2 Trolley

Operate the trolley the full distance of the bridge rails in each direction with a test load of [125][_____] percent of rated load on the hook (one cycle). Check proper functioning of all drive speed control points. Verify proper brake action.

3.3.6.3 Bridge

With a test load of [125][_____] percent of rated load on the hook, operate the bridge for the full length of the runway in one direction with the trolley at the extreme end of the bridge, and in the opposite direction with the trolley at the opposite extreme end of the bridge (one cycle). Check proper functioning of all drive speed control points. Check for any binding of the bridge end trucks and verify proper brake action. Record deficiencies. Secure from testing if deficiencies are found.

3.3.6.4 Rated Travel Tests

Repeat travel tests for trolley and bridge with a test load of 100 percent of rated load. Repeat the test for 5 cycles at rated speed to demonstrate proper operation and repeatability of all functions without the overheating or malfunction of any components. Completely stop the machinery at least once in each direction during each cycle to ensure proper brake action. Do not stop machinery for more than 15 seconds prior to commencing the next cycle.

3.3.6.5 Trolley Loss of Power Test

With a test load of 100 percent of rated load, raise the test load approximately midway between the trolley and any permanent obstruction on the operating floor. Starting at a safe distance from walls or other obstructions, attain a slow speed (first point) of trolley travel. While maintaining a safe distance from obstructions, disconnect the main power source at the wall mounted safety switch (disconnect) to simulate a power failure. Verify that the trolley stops and that the brake sets properly. Measure the distance required for the trolley to stop.

3.3.6.6 Bridge Loss of Power Test

With a test load of 100 percent of rated load, raise the test load approximately midway between the trolley and any permanent obstruction on the operating floor. Starting at a safe distance from walls or other obstructions, attain a slow speed (first point) of bridge travel. While maintaining a safe distance from obstructions, disconnect the main power source at the wall mounted safety switch (disconnect) to simulate a power failure. Verify that the bridge stops and that the brake sets properly. Measure the distance required for the bridge to stop.

-- End of Section --