Crane Data Sheets and Drawings

The specific requirements for each crane are described on the 456-2022 Crane Data Sheets and drawings which accompany this specification.

GENERAL SPECIFICATIONS

1.0 SCOPE

This specification describes the requirements for supply and installation of new Under Running Single Girder Overhead Bridge Cranes for repair shops owned by the City of Winnipeg located at 215 Tecumseh and 195 Tecumseh.

The cranes shall include all hoists, bridge beams, end trucks and controls as described in this specification, drawings and Crane Data Sheets.

Cranes shall be installed on existing crane runway beams.

Parts of this Specification refer to certain portions of other applicable Specifications, Codes or Standards.

AGMA American Gear Manufacturers Association
1001 N. Fairfax Street, Suite 500
Alexandria, VA 22314-1587

ANSI/AGMA 2001-D01 (R2010) Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth

ANSI/AGMA 2000-A88 Gear Classification and Inspection Handbook – Tolerances and Measuring Methods for Unassembled Spur and Helical Gears

ANSI/AGMA 2015-1-A01 Accuracy Classification System – Tangential Measurements for Cylindrical Gears

AISC American Institute of Steel Construction
One East Wacker Drive, Suite 700
Chicago, IL 60601-1802

AISC 9th Edition ASD

ANSI American National Standards Institute
25 West 43rd Street
New York, NY 10036

ANSI A14.3-2008 – Safety Requirements for Fixed Ladders and Workplace Surfaces.

ANSI B17.1-1967 – Keys and Keysets

ANSI C84.1-2011 – Electric Power Systems and Equipment Voltage Ratings (60 Hz)

ASCE The American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, VA 20191

ASCE/SEI 7-10 – Minimum Design Loads for Buildings and Other Structures

ASME American Society for Mechanical Engineers
B30.16 -Overhead Hoists -Under Hung

CSA Canadian Standards Association
178 Rexdale Blvd.
Toronto, ON, M9W 1R3

W47.1 – Certification of Companies for Fusion Welding of Steel

W59 – Welded Steel Construction
CSA B167 - Overhead Cranes
CSA C22 – Canadian Electrical Code

CMAA Crane Manufacturers Association of America, Inc.
8720 Red Oak Blvd., Suite 201
Charlotte, NC 28217-3996

Specification No. 74 -2020 Single Girder Cranes

NEMA National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Arlington, VA 22209

ICS 1-2000 (R2005, R2008) – Industrial Control Systems and Electrical Requirements

NEMA MG-1-2011 Motors and Generators

2.0 INSTALLATION AND GENERAL CONSIDERATIONS

Clearance

The crane supplier shall survey the entire length of the crane runways to ensure proper clearance may be maintained for all motions and operations.

Where items are discovered which may be relocated to improve crane operations, the crane supplier shall bring these to the attention of the owner to determine whether relocations are permissible to improve crane mounting height.

Clearance shall be maintained between the crane and the building, as well as cranes operating at different elevations, under all normal operating conditions. In the design of the new cranes, all factors that influence clearance, such as roof/ceiling deflection, girder camber, trolley positions and configurations shall be considered. As a minimum, the clearance between the highest point of the crane and the lowest overhead obstruction shall not be less than 3 inches with the crane unloaded. Pipes, conduits, lights, etc., must not reduce this clearance.

Clearance shall be maintained between the crane and the building, as well as parallel running cranes, under all normal operation conditions. In the design of the new cranes, all factors that influence clearance, such as wheel float, bridge skewing, or trolley positions and configurations shall be considered. As a minimum, the clearance between the end of the crane and the closest side obstruction shall not be less than 2 inches with crane centered on runway beams. Pipes, conduits, lights etc., must not reduce this clearance.

Runway Conductors

The runway conductors shall be furnished and installed by the crane supplier.

Contact conductors shall be guarded in a manner that person cannot inadvertently touch energized current-carrying parts. Flexible conductor systems shall be designed and installed in a manner to minimize the effects of flexing, cable tensions, and abrasion.

The conductors shall be properly supported and aligned horizontally and vertically with the runway rail.

Rated Load Capacity

The rated load capacity of a crane bridge shall be specified by the manufacturer. This capacity shall be marked on each side of the crane bridge and shall be legible from the operating floor.

Individual hoist units shall have their rated load capacity marked on their bottom block. In addition, capacity label shall be marked on the hoist body.

The total lifted load shall not exceed the rated load capacity of the crane bridge. Load on the individual hoists or hooks shall not exceed their rated capacity.

When determining the rated load capacity of a crane, all accessories below the hook, such as load bars, magnets, grabs, etc., shall be included as part of the load to be handled.

Design Stresses

Materials shall be properly selected for the loading, stresses and duty cycles to which they are subjected.

Structural and mechanical components shall be designed according to the appropriate limits as per CMAA No. 74 and section of this Specification, All other components within the lifted load path shall be designed so that the calculated stresses while handling the design rated load (without dynamic load factors) do not exceed 20 percent of the materials' average (or typical) ultimate strength. Unless otherwise published, the compressive ultimate strength shall be taken as equal to the ultimate strength in tension, and the ultimate strength in shear shall be taken as equal to 57.74 percent (1/√3) of the ultimate strength in tension.

Unless otherwise stated, the design requirements and allowable stresses in this Specification are based on Allowable Stress Design (ASD) using classical "Mechanics of Materials / Strength of Materials' methodologies.

Painting

Crane components shall be prime painted then receive two coats of enamel in "Safety Yellow"

Crane rated load capacity shall be labelled on each facing surface of the bridge beam in black letters, minimum 10 inches high.

Assembly and Preparation for Shipment

The crane should be assembled in the manufacturer's plant according to the manufacturer's standard. When feasible, the trolley should be placed on the assembled crane bridge; the hoisting rope is not normally reeved unless otherwise specified.

All parts of the crane should be carefully match-marked.

All exposed finished parts and electrical equipment are to be protected for shipment. If storage is required, arrangements should be made with the manufacturer for extra protection.

Load Testing

After a crane is installed on the runway and before it is placed into service, it shall be fully inspected and tested to ensure compliance with the applicable requirements of this specification and applicable standards.

Load testing shall be performed at 125% of the rated load capacity.

Operation and Maintenance Manuals

The crane manufacturer shall provide two (2) copies of all manuals and drawings describing the installation, electrification operation and maintenance of the cranes including spare parts information.

Two (2) copies of the manufacturer's clearance diagrams shall be submitted for approval, one of which is approved and returned to the crane manufacturer.

Erection

The crane supplier shall include all assembly, field wiring, installation and starting up procedures.

Lubrication

The crane shall be provided with all necessary lubrication fittings. Before putting the crane in operation, the erector of the crane shall assure that all bearing, gears, etc. are lubricated in accordance with the crane manufacturer's recommendations.

Inspection, Maintenance and Crane Operator Training

For inspection and maintenance of cranes, refer to CMAA – Specification No. 78, and CMAA – Overhead Crane Inspection and Maintenance Checklist.

For operator responsibility and training, refer to CMAA – Crane Operator's Training Video and CMAA – Crane Operator's Manual – Specification No. 79.

- END -

3.0 STRUCTURAL DESIGN

3.1 MATERIAL

All structural steel should conform to CSA G40.21 Grade 350W Specifications or shall be an accepted alternate for the purpose for which the steel is to be used and for the operations to be performed on it.

3.2 WELDING

All welding designs and procedures shall conform to CSA Standard W47.1 – Certification of Companies for Fusion Welding of Steel; W59 – Welded Steel Construction. Weld stresses determined by load combination Case 1, Sections 3.3.5, shall not exceed that shown in the applicable Table 3.4.4. Allowable weld stresses for load combination Cases 2 and 3, are to be proportioned in accordance with Section 3.4.3.

3.3 STRUCTURE

3.3.1 General

The crane girder shall be welded structural steel box section, wide flange beam, standard I beam, reinforced beam or a section fabricated from structural plates and shapes. The manufacturer shall specify the type and the construction to be furnished. Camber and sweep should be measured by the manufacturer prior to shipment.

3.3.2 Loadings (Per CMAA 74)

The crane structures are subjected, in service, to repeated loading varying with time which induces variable stresses in members and connections through the interaction of the structural system and the cross-sectional shapes. The loads acting on the structure are divided into three different categories. All the loads having an influence on engineering strength analysis are regarded as principal loads, namely the dead loads, which are always present; the hoist load, acting during each cycle; and the inertia forces acting during the movements of cranes, crane components, and hoist loads.

3.3.3 Principal Loads and Hoist Load Factors

- Dead Load (DL)

  The weight of all effective parts of the bridge structure, the machinery parts and the fixed equipment supported by the structure.

- Trolley Load (TL)

  The weight of the trolley and the equipment attached to the trolley.

- Lifted Load (LL)

  The lifted load consists of the working load and the weight of the lifting devices used for handling and holding the working load such as the load block, lifting beam and the other supplemental devices.

- Vertical Inertia Forces (VIF)

The vertical inertia forces (VIF) include those due to the motion of the cranes or the crane components and those due to lifting or lowering of the hoist load. These additional loadings may be included in a simplified manner by the application of a separate factor for the dead load (DLF) and for the hoist load (HLF) by which the vertical acting loads, the member forces or the stresses due to them must be multiplied.

- Dead Load Factor (DLF)

This factor covers only the dead loads of the crane, trolley and its associated equipment and shall be taken according to:

$$DLF = 1.1 \leq 1.05 + \frac{Travel\ Speed\ (ft/min)}{2000} \leq\ 1.2$$

- Hoist Load Factor (HLF)

The hoist load factor shall be applied to the lifted load (LL) in the vertical direction, and is the result of normal operating inertia forces, loads due to the sudden lifting of the load, and other loading uncertainties that occur during normal crane operation.

The HLF for normal operating cranes, including cranes using permanent magnets or other devices that do not result in abrupt handling of the load, shall be 0.5 percent of the hoisting speed in feet per minute, but not less than 15 percent nor more than 50 percent.

$$HLF = 0.15 \leq 0.005 \times Hoist\ Speed\ (ft/min) \leq\ 0.5$$

The HLF for cranes used for loads that are abruptly engaged shall be at least 50% of the lifted load (LL). Examples of such applications include {but are not limited to) cranes used with buckets, electromagnets, or grapples.

- Inertia Forces From Drives (IFD)

Travel drive inertia forces result from the acceleration or deceleration of the crane bridge or trolley and depend on the magnitude of torque applied to the drive wheels. This force shall be determined by applying an IFD factor to the lifted load and weight of the crane components, including attachments, and shall be imposed on the crane in the direction of bridge and trolley travel.

The IFD factor shall be 7.8% of the acceleration or deceleration rate (ft/s^2), but not less than 2.5%. The resulting drive inertia force is based on 250% of the nominal acceleration or deceleration rate produced by either the drive motor or brake. Additional consideration should be given to a cab operated crane which is equipped with a pedal operated or power assist braking system. Due to the nature of these braking systems, the deceleration rates are limited by the frictional force between the braked wheels and rail {i.e., maximum force when sliding occurs).

IFD Factor = (2.50/32.2) x Acceleration or Deceleration Rate (ft/s^2) ≥ 0.025

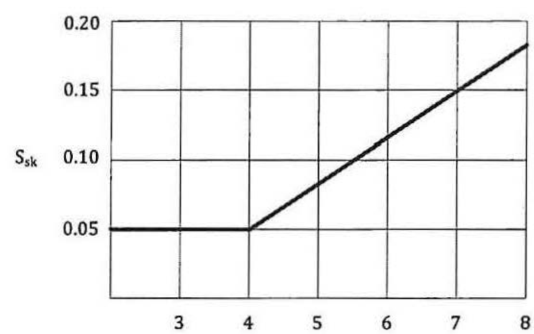
= 0.078 x Acceleration or Deceleration Rate (ft/s^2) ≥ 0.025

For polar cranes, the / FD factor corresponding to the trolley and lifted load that results from either the acceleration or deceleration of the bridge and may be adjusted by the ratio of the location of the trolley and lifted load to the radius of the crane runway rail, both relative to the center of bridge rotation. However, in order to account for possible load swing, the inertia force that corresponds to the lifted load and weight of the load block, shall not be less than 1.5% of these loads. Further, the inertia force that corresponds to bridge component weights, including distributive weight of the girders, may be adjusted by the ratio of the location of the component relative to the center of bridge rotation, to the radius of the crane runway rail. The resulting forces at each end of the polar crane bridge are in opposite directions.

3.3.4 Additional Loads

- Forces due to Skewing (SK)

When wheels roll along a rail, the horizontal forces normal to the rail tend to skew the structure and shall be taken into consideration. The horizontal forces shall be obtained by multiplying the vertical load exerted on each wheel by coefficient S_{sk} which depends upon the ratio of the span to the wheelbase. The wheelbase is the distance between the outermost wheels.



$$RATIO = \frac{SPAN}{WHEEL\ BASE}$$

- Collision Forces (CF)

Special loading of the crane structure resulting from the bumper stops shall be calculated with the crane at 0.4 times the rated speed assuming the bumper system is capable of absorbing the energy within its design stroke. Load suspended from the lifting equipment and free oscillating load need not be taken into consideration. Where the load cannot swing, the bumper effect shall be calculated in the same manner taking into account the value of the load. The kinetic energy released on the collision of two cranes with the moving masses of M_1, M_2, and a 40 percent maximum traveling speed of V_{T1} and V_{T2} shall be determined from the following equation:

$$E = \frac{M_1 M_2 (0.4V_{T1} + 0.4V_{T2})^2}{2(M_1 + M_2)}$$

The bumper forces shall be distributed in accordance with the bumper characteristics and the freedom of the motion of the structure with the trolley in its worst position.

Should the crane application require that maximum deceleration rates and/or stopping forces be limited due to suspended load or building structure considerations, or if bumper impact velocities greater than 40% of maximum crane velocity are to be provided for, such conditions should be defined at the time of the crane purchase.

- Torsional Forces and Moments
  a. Due to the Starting and Stopping of the Bridge Motors

     The twisting moment due to the starting and stopping of bridge motors shall be considered as the starting torque of the bridge motor at 200 percent of full load torque multiplied by the gear ratio between the motor and cross shaft.

  b. Due to Vertical Loads:

     Torsional moment due to vertical forces acting eccentric to the vertical neutral axis of the girder shall be considered as those vertical forces multiplied by the horizontal distance between the centerline of the forces and the shear center of the girder.

  c. Due to Lateral Loads:

     The torsional moment due to the lateral forces acting eccentric to the horizontal neutral axis of the girder shall be considered as those horizontal forces multiplied by the vertical distance between the centerline of the forces and the shear center of the girder.

3.3.5 Load Combination

The combined stresses shall be calculated for the following design cases:

Case 1: Crane in regular use under principal loading

DL(DLF_B) + TL(DLF_T) + LL(1+HLF) + IFD

Case 2: Crane in regular use under principal and additional loading

DL(DLF_B) + TL(DLF_T) + LL(1+HLF) + IFD + WLO + SK

Case 3: Extraordinary Loads

Crane in collision

DL + TL + LL + CF + WLO

3.3.6 Local Bending of Flanges Due to Wheel Loads

Each wheel load shall be considered as a concentrated load applied at the center of wheel contact with the flange (CMAA No. 74 Figure 3.3.2.6-1). Local flange bending stresses in the lateral (x) and longitudinal (y) direction at certain critical points may be calculated from the following formulas:

Underside of flange at flange-to-web transition-Point 0:

$$\sigma_{XO} = C_{X0}\frac{P}{(t_a)^2}$$

$$\sigma_{YO} = C_{YO}\frac{P}{(t_a)^2}$$

Underside of flange directly beneath wheel contact point-Point 1:

$$\sigma_{X1} = C_{X1}\frac{P}{(t_a)^2}$$

$$\sigma_{Y1} = C_{Y1}\frac{P}{(t_a)^2}$$

Topside of flange at flange-to-web transition-Point 2:

$$\sigma_{X2} = -\sigma_{X0}$$

$$\sigma_{Y2} = -\sigma_{Y0}$$

For tapered flange sections (CMAA No.74 Figure 3.3.2.6-2)

$$C_{XO} = -1.096 + 1.095\lambda + 0.192e^{-6.0\lambda}$$

$$C_{X1} = 3.965 - 4.835\lambda - 3.965e^{-2.675\lambda}$$

$$C_{YO} = -0.981 - 1.479\lambda + 1.120e^{1.322\lambda}$$

$$C_{Y1} = 1.810 - 1.150\lambda + 1.060e^{-7.70\lambda}$$

$t_a = t_f - \left[\frac{b}{24}\right] + \left[\frac{a}{6}\right]$ For standard ‘S’ section

Where: t_f= published flange thickness for standard ‘S’ section (in)

For parallel flange section (CMAA No 74 Figure 3.3.2.6-3 & 3.3.2.6-4)

$$C_{XO} = -2.110 + 1.977\lambda + 0.0076e^{6.53\lambda}$$

$$C_{X1} = 10.108 - 7.408\lambda - 10.108e^{-1.364\lambda}$$

$$C_{YO} = 0.050 - 0.580\lambda + 0.148e^{3.015\lambda}$$

$$C_{Y1} = 2.230 - 1.49\lambda + 1.390e^{-18.33\lambda}$$

For single web symmetrical sections (CMAA No 74 Figure 3.3.2.6-2 & 3.3.2.6-3)

$$\lambda = \frac{2a}{b - t_w} \leq 0.65$$

b = section width across flanges (in)

For other cases (CMAA No 74 Figure 3.3.2.6-4)

$$\lambda = \frac{a}{b' - \frac{t_w}{2}} \leq 0.65$$

b' = distance from centerline of web to edge of flange (in)

where: P = Load per wheel including HLF (*lbs*)

t_a = Flange thickness at point of load application (*in*)

t_w = Web thickness (*in*)

a = Distance from edge of flange to point of wheel load application (*in*)
(Center of wheel contact)

e = Napierian base = 2.71828 ...

- The localized stresses due to local bending effects imposed by wheel loads calculated at points O and 1 are to be combined with the stresses due to the Case 2 loading.

  When calculating the combined stress, the flange bending stresses for single web girders are to be diminished to 75% of the value calculated per Section 3.3.6.

  The combined stress, as determined in Section 3.4.1, shall not exceed the Load Case 2 allowable stress in Table 3.4-1.

- Additionally, in the case of welded plate girders only, the localized stresses on the topside of the flange at the flange-to-web transition (Point 2) are to be combined with the stresses due to the Case 2 loading of this Specification.

  The combined stresses, in both the base metal of the welded joint and the weld metal at Point 2, shall not exceed the allowable stresses specified in Table 3.4-1. Nor shall the stress range exceed the allowable shown in Table 3.4.4 for joint category E.

  The use of internal diaphragms within welded box girders that are loaded on the bottom flange may create stress concentration points in the weld between the bottom flange and the web plate. Consideration should be given to the lower flange weld near the locations of any internal diaphragms.

- The local flange bending criteria is to be met in addition to the general criteria of Section 3.4.
- At load transfer points, consideration should be given to lower flange stresses which are not calculable by the formulas.

3.4 ALLOWABLE STRESSES

TABLE 3.4-1

LOAD COMBINATION	ALLOWABLE COMPRESSION STRESS* σ_{CALL}	ALLOWABLE TENSION STRESS σ_{TALL}	ALLOWABLE SHEAR STRESS* τ_{ALL}	ALLOWABLE BEARING STRESS σ_{BrgALL}
Case 1	$0.60\sigma_{yp}$	$0.60\sigma_{yp}$	$0.36\sigma_{yp}$	$0.80\sigma_{yp}$
Case 2	$0.66\sigma_{yp}$	$0.66\sigma_{yp}$	$0.40\sigma_{yp}$	$0.90\sigma_{yp}$
Case 3	$0.75\sigma_{yp}$	$0.75\sigma_{yp}$	$0.45\sigma_{yp}$	$1.00\sigma_{yp}$

3.4.1 Combined Stresses

When loading conditions of a component or weld produce both tensile and compressive stresses in two orthogonal directions, stresses shall be combined as appropriate, and the resulting stress limited to the respective allowable stress. Note that standard sign convention of stresses must be used.

Combined stresses within a component:

$$\sigma_{COMB} = \sqrt{(\sigma_x)^2 + (\sigma_y)^2 - \sigma_x\sigma_y + 3(\tau_{xy})^2} \leq \sigma_{TALL}$$

(Ref. Table 3.4-1)

Combined stresses within the base metal of a welded joint:

$$\sigma_{COMB} = {}^1/_2\,[\sigma_x + \sigma_y] \pm {}^1/_2\sqrt{(\sigma_x - \sigma_y)^2 + 4(\tau_{xy})^2} \leq \sigma_{TALL}$$

(Ref. Table 3.4- 1)

Combined stresses within the weld metal:

$$\sigma_{COMB} = {}^1/_2\,[\sigma_x + \sigma_y] \pm {}^1/_2\sqrt{(\sigma_x - \sigma_y)^2 + 4(\tau_{xy})^2} \leq \sigma_{WeldALL}$$

3.4.2 Buckling Analysis

Local buckling, lateral and torsional buckling of the web plate and local buckling of the rectangular plates forming part of the compression member, shall be made in accordance with a generally accepted theory of the strength of materials. (See Section 3.4.8).

3.4.3 Compression Member

- The average allowable compression stress on the cross-section area of axially loaded compression members susceptible to buckling shall be calculated when KL/r (the largest effective slenderness ratio of any segment) is less than C_c:

$$\sigma_A = \frac{\left[1 - \frac{(KL/r)^2}{2(C_c)^2}\right]\sigma_{yp}}{\left[\frac{5}{3} + \frac{3(KL/r)}{8C_c} - \frac{(KL/r)^3}{8(C_c)^3}\right]}$$

Where: $C_c = \sqrt{\frac{2\pi^2 E}{\sigma_{yp}}}$

- The average allowable compression stress on the cross-section area of axially loaded compression members susceptible to buckling shall be calculated when KL/r (the largest effective slenderness ratio of any segment) exceeds C_c :

$$\sigma_A = \frac{12\pi^2 E}{23(KL/r)^2 N}$$

- Members subjected to both axial compression and bending stresses shall be proportioned to satisfy the following requirements:

$$\frac{\sigma_a}{\sigma_A} + \frac{C_{mx}\sigma_{bx}}{\left[1 - \frac{\sigma_a}{\sigma_{ex}}\right]\sigma_{BX}} + \frac{C_{my}\sigma_{by}}{\left[1 - \frac{\sigma_a}{\sigma_{ey}}\right]\sigma_{BY}} \le 1.0$$

$$\frac{\sigma_a}{\sigma_A} + \frac{\sigma_{bx}}{\sigma_{BX}} + \frac{\sigma_{by}}{\sigma_{BY}} \le 1.0$$

When $\frac{\sigma_a}{\sigma_A} \le 0.15$ the following formula may be used:

$$\frac{\sigma_a}{\sigma_A} + \frac{\sigma_{bx}}{\sigma_{BX}} + \frac{\sigma_{by}}{\sigma_{BY}} \le 1.0$$

where:

K = effective length factor

L = Unbraced length of compression member

r = radius of gyration of member

E = Modulus of elasticity

σ_{yp} = yield point

σ_a = computed axial stress (*ksi*)

σ_b = computed compressive bending stress at the point under consideration (*ksi*)

σ_A = allowable axial stress that will be permitted if axial force alone existed (*ksi*)

σ_B = allowable compressive bending stress that will be permitted if bending moment alone existed (*ksi)*

$$\sigma_e = \frac{12\pi^2 E}{23(KL/r)^2 N}$$

N = 1.1 Case 1

N = 1.0 Case 2

N = 0.89 Case 3

C_{mx} and C_{my} = a coefficient whose value is taken to be:

1. For compression members in frames subject to joint translation (sideway), C_m = 0.85.

2. For restrained compression members in frames braced against joint translation and not subject to transverse loading between their supports in the plane of bending:

$C_m = 0.6 - 0.4\left[\frac{M_1}{M_2}\right]$ but not less than 0.4

where M_1/M_2 is the ratio of the smaller to larger moments at the ends of that portion of the member unbraced in the plane of bending under consideration. M_1/M_2 is positive when the member is bent in reverse curvature, negative when bent in single curvature.

3. For compression members in frames braced against joint translation in the plane of loading and subjected to transverse loading between their supports, the value of C_m may be determined by rational analysis. However, in lieu of such analysis, the following values may be used:

(a) For members whose ends are restrained C_m = 0.85

(b) For members whose ends are unrestrained C_m = 1.0

3.4 Allowable Stress Range - Repeated Load

Members and fasteners subject to repeated load shall be designed so that the maximum stress does not exceed allowable values for various categories as listed in Table 3.4.4. The minimum stress is considered to be negative if it is opposite in sign to the maximum stress. The categories are described in CMAA Specification No. 74, Table 3.4.7-2A with sketches shown in Figure 3.4.7-28. The allowable stress range is to be based on the condition most nearly approximated by the description and sketch. See CMAA No 74 Figure 3.4.7-3 for typical box girders.

TABLE 3.4.4

ALLOWABLE STRESS RANGE - ksi

CMAA SERVICE CLASS	JOINT CATEGORY					
	A	B	C	D	E	F
A	63	49	35	28	22	15
B	50	39	28	22	18	14
C	37	29	21	16	13	12
D	31	24	17	13	11	11

Stress range values are independent of material yield strength.

3.4.5 Buckling

- Local Buckling or Crippling of Flat Plates

  The structural design of the crane must guard against local buckling and lateral torsional buckling of the web plates and cover plates of the girder. For purposes of assessing buckling, the plates are subdivided into rectangular panels of length '*a*' and width '*b*'. The length '*a*' of these panels corresponds to the center distance of the full depth diaphragms or transverse stiffeners welded to the panels.

  In the case of compression flanges the length '*b*' of the panel indicates the distance between web plates or the distance between web plates and/or longitudinal stiffeners. In the case of web plates, the length '*b*' of the panel indicates the depth of the girder, or the distance between compression flanges or tension flanges and/or horizontal stiffeners.

- Critical buckling stress shall be assumed to be a multiple of the Euler Stress σ_e.

  $\sigma_k = K_\sigma \sigma_e; \quad \tau_k = K_\tau \sigma_e$

  Where: K_σ = buckling coefficient compression

  K_τ = buckling coefficient shear

  The buckling coefficient K_σ and K_τ are identified for a few simple cases for plates with simply supported edges in CMAA Specification No. 74 Table 3.4.8.2- 1 and depend on:

  - ratio α = *a/b* of the two sides of the plate

  - manner in which the plate is supported along the edges

  - type of loading sustained by the plate

  It is not the intention of this Specification to enter into further details of this problem. For a more detailed and complex analysis such as evaluation of elastically restrained edges, continuity of plate, and determination of the coefficient of restraint, reference should be made to specialized literature.

  $\sigma_e = Eurler\ buckling\ stress\ which\ can\ be\ determined\ from\ the\ following\ formula$:

$$\sigma_e = \frac{\pi^2 E}{12(1-v^2)}\left[\frac{t}{b}\right]^2 = [26.21x10^6]\left[\frac{t}{b}\right]^2$$

where: *E* = modulus of elasticity (for steel *E* = 29,000,000 *psi*)

v = Poisson's ratio (for steel v = 0.3)

t = thickness of plate (*in*)

b = width of plate (in) perpendicular to the compression force.

If compression and shear stresses occur simultaneously, the individual critical buckling stresses σ_k and τ_k and the calculated stress values σ and t are used to determine the critical comparison stress.

$$\sigma_{1k} = \frac{\sqrt{\sigma^2 + 3\tau^2}}{\left[\frac{1+\psi}{4}\right]\left[\frac{\sigma}{\sigma_k}\right] + \sqrt{\left[\frac{3-\psi}{4}\frac{\sigma}{\sigma_k}\right]^2 + \left[\frac{\tau}{\tau_k}\right]^2}}$$

$\sigma = actual\ compression\ stress$

$\tau = actual\ shear\ stress$

$\sigma_k = critical\ compression\ stress$

$\tau_k = critical\ shear\ stress$

$\psi = stress\ ration\ (see\ table\ No.\ 3.4.8.2 - 1)$

In the special case where $\tau = 0$ it is simply $\sigma_{1k} = \sigma_k$ and in the special case where $\sigma = 0$ than $\sigma_{1k} = \tau_k(k\sqrt{3})$

Refer to CMAA Specification No. 74 Table 3.4.8.2-1

If the resulting critical stress is below the proportional limit σ_p, buckling is said to be elastic. If the resulting value is above the proportional limit σ_p, buckling is said to be inelastic. For inelastic buckling, the critical stress shall be reduced to:

$$\sigma_{1kR} = \frac{\sigma_{yp}(\sigma_{1k})^2}{0.1836\left(\sigma_{yp}\right)^2 + (\sigma_{1k})^2}$$

$\sigma_{yp} = yield\ point$

$\sigma_p = proportional\ limit\ (assumed\ at\ \sigma_{yp}/1.32)$

- Design Factors

The safety factor is ϑ_B calculated with the aid of the formulas:

In the case of elastic buckling: $\vartheta_B = \frac{\sigma_{1k}}{\sqrt{\sigma^2 + 3\tau^2}} \geq DFB$

In the case of inelastic buckling: $\vartheta_B = \frac{\sigma_{1kR}}{\sqrt{\sigma^2 + 3\tau^2}} \geq DFB$

The design factor DFB requirements of buckling are as follows:

LOAD COMBINATION	DESIGN FACTOR DFB
Case 1	$1.7 + 0.175\,(\psi - 1) \geq 1.35$
Case 2	$1.5 + 0.125\,(\psi - 1) \geq 1.25$
Case 3	$1.35 + 0.075\,(\psi - 1) \geq 1.20$

3.5 DESIGN REQUIREMENTS

3.5.1 Proportions for Welded Box Girders

The girder span to section element ratios shall not exceed the following:

$L/d \leq 25$

$L/b \leq 2340/\sigma_{yp}$, or $1404\ F_{LC}/\sigma_{cbm}$

The web height to thickness ratio (h/t) shall not exceed the greater of:

1) when longitudinal web stiffeners are not provided

$1000/\sqrt{\sigma_{yp}}, \quad or \quad 775\sqrt{F_{LC}/\sigma_{bm}};\ or$

2) when longitudinal web stiffeners are provided

$2000/\sqrt{\sigma_{yp}}, \quad or \quad 1550\sqrt{F_{LC}/\sigma_{bm}}$

$L = span\ (in)$

$b = distance\ between\ web\ plates\ at\ the\ compression\ flange\ (in)$

$d = depth\ of\ beam\ (in)$

$h = web\ height; depth\ of\ web\ plate\ (in)$

$t = thickness\ of\ web\ (in)$

$\sigma_{cbm} = maximum\ value\ of\ compression\ bending\ stress\ (ksi)$

$\sigma_{bm} = maximum\ value\ of\ compression\ or\ tension\ bending\ stress\ (ksi)$

$\sigma_{yp} = minimum\ yield\ stress\ of\ web\ plates\ (ksi)$

$F_{LC} = load\ case\ factor$

$= 1.0\ for\ Load\ Case\ 1$

$= 1.1\ for\ Load\ Case\ 2$

$= 1.25\ for\ Load\ Case\ 3$

The slenderness ratio of the section elements (i.e., flanges & webs), shall also be substantiated for plate bucking stability per Section 3.4.5.

3.5.2 Longitudinal Stiffeners

- When one longitudinal stiffener is used, it should be placed so that its centerline is approximately 0.4 times the distance from the inner surface of the compression flange plate to the neutral axis. It shall have a moment of inertia no less than:

  $$I_{\circ} = 1.2[0.4 + 0.6\, a/h + 0.9[a/h]\text{^}2 + 8\frac{A_s a}{h^2 t}]\, ht^3$$

- When two longitudinal stiffeners are used, they should be placed so that their centerlines are approximately 0.25 and 0.55 times the distance, respectively, from the inner surface of the compression flange plate to the neutral axis. They shall each have a moment of inertia no less than:

  $$I_{\circ} = 1.2\left[0.3 + 0.4\frac{a}{h} + 1.3\left[\frac{a}{h}\right]^2 + 14\frac{A_s a}{h^2 t}\right] ht^3$$

  a
  $= longitudinal\ distance\ between\ full\ depth\ diaphragms\ or\ transverse\ stiffeners\ (in)$

  $h = web\ height;depth\ of\ web\ plate\ (in)$

  $t = thickenss\ of\ web\ (in)$

  $A = area\ of\ one\ stiffener\ (in^2)$

  $I_{\circ} = distance\ between\ web\ plates\ at\ the\ compression\ flange\ (in^4)$

  If the stress within the plate is predominately compressive, the depth of the web shall be considered as twice the distance from the inner surface of the compression flange to the neutral axis of the section, when determining the required moment of inertia of the stiffener.

- The moment of inertia of longitudinal stiffeners welded to one side of a plate shall be calculated about the interface of the plate adjacent to the stiffener. For elements of the stiffeners supported along one edge, the maximum width to thickness ratio shall not be greater than 12.7, and for elements supported along both edges, the maximum width to thickness ratio shall not be greater than 42.2. If the ratio of 12.7 is exceeded for the element of the stiffener supported along one edge, but a portion of the stiffener element conforms to the maximum width-thickness ratio and meets the stress requirements with the excess considered as removed, the member is considered acceptable.

3.5.3 Stiffened Plates in Compression

- When one, two or three longitudinal stiffeners are added to a plate in compression, dividing it into segments having equal unsupported widths, full edge support will be provided by the longitudinal stiffeners. and the provisions of Section 3.5.2 may be applied to the design of the plate when stiffeners meet minimum requirements as follows:

For one longitudinal stiffener at the center of the compression plate, where *b/2* is the unstiffened width, the moment of inertia of the stiffener shall be no less than:

$$I_{\circ} = \left[0.6\frac{a}{b} + 0.2\left[\frac{a}{b}\right]^2 + 3\frac{A_s a}{b^2 t}\right] bt^3$$

The moment of inertia need not be greater in any case than as given by the following equation:

$$I_{\circ} = \left[2.2 + 10.3\frac{A_s}{bt}\left[1 + \frac{A_s}{bt}\right]\right] bt^3$$

- For two longitudinal stiffeners, each one at the third points of the compression plate, where *b/3* is the unstiffened width, the moment of inertia of each of the two stiffeners shall be no less than:

  $$I_{\circ} = \left[0.4\frac{a}{b} + 0.8\left[\frac{a}{b}\right]^2 + 8\frac{A_s a}{b^2 t}\right] bt^3$$

  The moment of inertia need not be greater in any case than:

  $$I_{\circ} = \left[9 + 56\frac{A_s}{bt} + 90\left[\frac{A_s}{bt}\right]^2\right] bt^3$$

- For three longitudinal stiffeners, each one spaced equidistant at the one fourth width locations where *b/4* is the unstiffened width, and limited to $a/b < 3$, the moment of inertia of each of the three stiffeners shall be no less than:

  $$I_{\circ} = \left[0.35\frac{a}{b} + 1.10\left[\frac{a}{b}\right]^2 + 12\frac{A_s a}{b^2 t}\right] bt^3$$

  $a = longitudinal\ distance\ between\ \ diaphragms\ or\ transverse\ stiffeners\ (in)$

  $b = total\ width\ of\ stiffened\ plate; distance\ between\ web\ plates\ (in)$

  $t = thickenss\ of\ stiffened\ plate\ (in)$

  $A_s = longitudinal\ distance\ between\ full\ depth\ diaphragms\ or$

  $transverse\ stiffeners\ (in^2\ )$

  $I_{\circ} = required\ moment\ of\ inertia\ of\ one\ stiffener\ (in^4)$

  Stiffeners shall also meet the slenderness requirements of Section 3.5.2.

3.5.4 Diaphragms, Transverse Stiffeners, and Longitudinal Stiffeners used for shear buckling stability of web.

- Structural box members shall have at least one full depth diaphragm at each end. When the web height to thickness ratio of any structural member exceeds the following, or when required for plate buckling stability requirements per Section 3.4.5, additional full depth diaphragms or transverse stiffeners shall be used:

$$h/t > 240/\sqrt{\tau_V};\ or\ \ > 150$$

- When additional full depth diaphragms or transverse stiffeners are required, they shall be spaced so that all web panels are in compliance with the plate buckling stability requirements per Section 3.4.5. Also, the spacing shall not exceed the web height or 72 inches, whichever is greater, nor the distance established by the following:

$$a \leq h[260/(h/t)]^2$$

- Furthermore, the spacing of these stiffeners at each end, and in locations where the web plate panels contain large holes, shall not exceed the depth of the web, nor the distance established by the following:

$$a \leq 350t/\sqrt{\tau_V}$$

$$h = web\ height; depth\ of\ web\ (in)$$

$$a = spacing\ of\ full\ depth\ diagragms\ or\ transverse\ stiffeners\ (in)$$

$$t = thickness\ of\ web\ (in)$$

$$\tau_V = average\ shear\ stress\ in\ web, per\ Load\ Case\ 1 (ksi)$$

- Either full depth diaphragms or transverse stiffeners may be used to meet the spacing requirements.
- The moment of inertia, about the interface of the web plate, of a transverse or longitudinal stiffener when used for the purpose of shear buckling stability requirements, shall not be less than:

$$I \geq 1.2h^3t^3/a^2$$

$$h = web\ height; depth\ of\ web, for\ transverse\ stiffeners\ (in)$$

or

$$= length\ of\ stiffened\ panel\ edge, for\ longitudinal\ stiffeners\ (in)$$

$$a = spacing\ of\ transverse\ stiffeneers, for\ transverse\ stiffeners\ (in)$$

or

$$= average\ width\ of\ adjacent\ panels\ to\ be\ stiffened, but\ no\ greater$$

$than\ 125\%\ of\ smaller\ pannel\ width\ for\ longitudinal\ stiffeners\ (in)$

$t = thickenss\ of\ web\ (in)$

$I = minimum\ moment\ of\ inertia\ of\ transverse\ stiffener\ (in^4)$

Stiffeners shall also meet the slenderness requirements of Section 3.5.2.

When additional loading conditions exist (e.g., localized loads imposed by drive units, motor supports, walk supports, etc.), special design considerations may be needed for sizing the required stiffener.

- Webs shall be reinforced with full depth diaphragms, transverse stiffeners, or other suitable means, at locations of major load attachments.

3.5.5 Deflection and Camber

- Deflection

For rolled sections, the maximum vertical deflection of crane girders produced by the dead load, the weight of the hoist, trolley and the rated load shall not exceed L/600 of span.

For fabricated plate girders, the maximum vertical deflection of crane girders shall not exceed L/888 of span based on weight of the hoist, trolley and the rated load.

- Camber

Rolled section girders need not be cambered. However, beams with rolling induced camber should be placed with positive camber up.

Fabricated plate girders should be cambered an amount equal to the dead load deflection plus 50% of the weight of the hoist, trolley and the rated load deflection.

The maximum lateral deflection of the girder resulting from the travel drive inertia forces shall not exceed 1/ 400 of the span.

3.5.6 Single Web Girders

Single web girders include wide flange beams, standard I beams, or beams reinforced with plate, or other structural configurations having a single web. Where necessary, an auxiliary girder or other suitable means should be provided to support overhanging loads to prevent undue torsional and lateral deflections.

In addition to other applicable design criteria for structural members (i.e.; loadings, allowable stresses, fatigue, buckling and deflection) the maximum compression stress shall not exceed the following:

$$\sigma_{CompALL}(ksi) = \frac{12{,}000}{\frac{Ld}{A_f}} \times F_{LC} \leq \sigma_{CALL}$$

(Ref. Table 3.4-1)

$L = span(unbraced\ length\ of\ top\ flange)(in)$

$d = depth\ of\ beam\ (in)$

$A_f = area\ of\ compression\ flange\ (in^2)$

$F_{LC} = load\ case\ factor\ (in)$

$= 1.0\ for\ load\ Case\ 1$

$= 1.1\ for\ load\ Case\ 2$

$= 1.25\ for\ load\ Case\ 3$

3.5.7 Box Section Girder Built of Two Beams

Box section girder built up of two beams, either with or without reinforcing flange plates, shall be designed according to the same design data as for box section girder cranes for stress and deflection values only.

3.6 BRIDGE END TRUCK

- The crane bridge shall be carried on end trucks designed to carry the rated load when lifted at one end of the crane bridge. The wheelbase of the end truck shall be 1/8 of the span or greater.
- End trucks may be of the rotating axle or fixed axle type as specified by the crane manufacturer.
- The bridge end trucks should be constructed of structural steel or other suitable material. Provision shall be made to prevent the end truck from dropping more than one inch in case of axle failure. Rail sweeps shall be provided in front of each outside wheel and shall project below the top of the runway rail.
- Load combinations and basic allowable stresses are to be in accordance with Sections 3.3.5 and 3.4. End trucks shall be designed so that the deflection in the end truck will not impair the functional operation of the crane or machinery.
- When appropriate, equalizer bridge trucks are to be incorporated to promote sharing of bridge wheel loads. Equalizing pins are to be provided between equalizer truck and equalizer beams and/or rigid bridge structures.

3.8 STRUCTURAL BOLTING

Structural connections in the primary load path shall conform to AISC "Specification for Structural Joints Using ASTM A325 or A490 Bolts," including tensile fatigue loading requirements as applicable (cyclic shear need not be considered). Provision should be made in structural connections for maintaining structural and machinery alignment. Zinc (galvanizing) causes stress corrosion in A490 bolts and therefore galvanized A490 bolts shall not be used.

- END -

4.0 MECHANICAL DESIGN

4.1 BRIDGE DRIVES

- The bridge drive will consist of motor or motors driving through a suitable reduction unit or units to the wheels located at each end of the bridge.
- When called for on the information sheets, a cushioned drive may be provided for starting the bridge.

4.2 GEARING

- The types of gearing shall be specified by the crane manufacturer. When worm gearing is used for travel drives, consideration should be given to its back driving characteristics.
- All gears and pinions shall be constructed of material of adequate strength and durability to meet the requirements for the intended class of service, and manufactured to quality class (Qv) 5 or better per ANSI/AGMA 2000-A88 "Gear Classification and Inspection Handbook - Tolerances and Measuring Methods for Unassembled Spur and Helical Gears" or to the equivalent transmission accuracy level (Av) per ANSI/AGMA 2015-1-A01 "Accuracy Classification System - Tangential Measurements for Cylindrical Gears". For the purpose of this Specification, hoist gearing strength and durability shall be based on the horsepower required to lift the rated load. Travel gearing strength and durability shall be based on the motor name plate rating. Due consideration shall be given to the maximum brake torque which can be applied to the drive. Also, consideration shall be given to the fact that gearing for travel drives transmit a larger portion of the available motor torque than gearing for hoist drives.
- The horsepower rating for all spur, helical and herringbone gearing shall be based upon AGMA Standard 2001-004 "Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth". For the purpose of this Specification, the horsepower formula may be written:

  Allowable strength horsepower:

$$P_{at} = \left[\frac{\pi N_p d}{396{,}000\ K_v}\right]\left[\frac{F S_{at} J}{K_m P_d S_{fs} K_B}\right]$$

  Allowable durability horsepower:

$$P_{at} = \left[\frac{\pi N_p F I}{396{,}000\ K_v K_m S_{fd}}\right]\left[\frac{S_{ac} d C_h}{C_p}\right]^2$$

$P_{at} = allowable\ strength\ horsepower$

$P_{av} = allowable\ durability\ horespower$

$N_p = pinion\ spreed\ (r/\min\ )$

$d = pitch\ diameter\ of\ pinion\ (in)$

$K_v = dynamic\ factor\ (strength\ and\ durability)$

$F = net\ face\ width\ of\ the\ narrowest\ of\ the\ mating\ gears\ (in)$

$K_m = load\ distribution\ factor\ (strength\ and\ durability)$

$C_p = elastic\ coefficient$

$C_h = hardness\ factor\ (durability)$

$J = geometry\ factor\ (strength)$

$I = geometry\ factor\ (durability)$

$P_d = transverse\ diametral\ pitch\ (in^{-1})$

$K_B = rim\ thickness\ factor$

$S_{at} = allowable\ bending\ stress\ for\ material\ (psi)(strength)$

$S_{ac} = allowable\ allowable\ contact\ stress\ for\ material\ (psi)(durability)$

$S_{fd} = crane\ class\ factor\ (strenght)$

$S_{fs} = crane\ class\ factor\ (durability)$

Note: Due to the differences in geometry factors and material properties, the ratings of both the pinion and gear must be evaluated.

Values for $K_v, K_m, C_p, C_h, J, I, K_B, S_{at}, and\ S_{ac}$ Sat and Sac can be determined from the tables and curves in AGMA Standard 2001-004. Crane class factor S_{fs} is tabulated in Table 4 .2.3-2 and S_{fd} shall be the product of the machinery service factor (C_d) and the mechanical mean effective load factor $K_{w,}$ $[S_{fd} = C_d \times K_w]$. For$C_d$, refer to Table 4.2.1 and for K_w , refer to the equation below. The remaining values pertain to gear size and speed.

$$K_w = \frac{2(Maximum\ Load) = (Minimum\ Load)}{3(Maximum\ Load)}$$

TABLE 4.2.1

MACHINERY SERVICE FACTORS *Cd*

CRANE CLASS	C_d
A	0.64
B	0.72
C	0.80
D	0.90

These factors are not to be used in sizing any commercial gearboxes. All commercial gearboxes are to be sized according to gearbox manufacturer's recommendations.

- Means shall be provided to insure adequate and proper lubrication on all gearing.
- All gearing not enclosed in gear cases which may constitute a hazard under normal operating conditions shall be guarded with provision for lubrication and inspection.

a) Guards shall be securely fastened.
b) Each guard shall be capable of supporting the weight of a 200 pound person without permanent distortion, unless the guard is located where it is impossible to step on.

4 .3 BEARINGS

- The type of bearing shall be specified by the crane manufacturer.
- Anti-friction bearings shall be selected to give a minimum life expectancy based on full rated speed as follows:

TABLE 4.3.1

AFBMA L_{10} BEARING LIFE

Class A	1250 Hours
Class B	2500 Hours
Class C	5000 Hours
Class D	10000 Hours

Use the appropriate K_w load factor for the applications as determined in Section 4.3.1 of this Specification.

Due consideration shall be given to the selection of the bearing in the event a crane is used for a limited time at an increased service class (i.e. during a construction phase).

- Sleeve bearing shall have a minimum allowable unit bearing pressure as recommended by the bearing manufacturer.
- All bearings shall be provided with proper lubrication. Bearing enclosures should be designed as far as practicable to exclude dirt and prevent leakage of oil or grease.

4.4 BRIDGE BRAKES

- A bridge brake or non-freecoasting mechanical drive shall be provided capable of stopping the motion of the bridge within a distance in feet equal to 10% of the full load speed in feet per minute when traveling at rated speed with rated load.
- Bridge braking means shall have thermal capacity for the frequency of operation required by the service.
- If bridge parking brake(s) are provided on an indoor crane, it should have a torque rating of at least 50 percent of the rated motor torque. Bridge parking brake(s) provided on outdoor cranes shall have a torque rating of at least 100 percent of the rated motor torque.
- If parking brakes are provided, they shall not prohibit the use of a drift point in the control circuit.

4.5 WHEELS

Under Running Bridge Wheels

- Wheels shall be constructed of suitable material. Wheels shall be heat treated only if specified. All under running bridge truck wheels shall be designed to suit the surface on which they run. Drive wheels shall be the same diameter within a tolerance of 0.010 inch.
- When flangeless wheels are used, they and the side roller arrangement shall be the crane manufacturer's standard.
- Wheels shall be designed to carry the maximum wheel load under normal conditions. Design shall meet the requirements of CMAA Specification No. 74 Tables 4.7.1-1 through 4.7.1-4.

*Where wheel tread matches the rolling surface of the lower flange of the track beam. Note: Charted values are based on wheels with Brinell hardness of 200. Larger wheel loads are obtainable with suitable material and with greater Brinell hardness.

4.6 BUMPERS AND STOPS

- When provided, bridge bumpers shall be rigidly mounted in such a manner that the attaching bolts are not in shear and they shall be designed and installed to minimize parts falling from the crane in the event of breakage. Bumpers and their mountings shall be of sufficient length that no other parts of either crane shall come in contact when the two cranes come together.
- Bumpers shall have the energy absorbing (or dissipating) capacity to stop the crane when traveling with power off in either direction at a speed of at least 40% of the rated load speed. The bumpers shall also be capable of stopping the crane (not including load block and lifted load) at a rate of deceleration not to exceed an average of three (3 feet per second per second) when traveling with power off in either direction at 20% of rated load speed.
- The size and location of the bridge bumpers shall be specified by the crane manufacturer.
- Runway stops engaging top running wheels are not recommended.
- Runway stops are normally designed and provided by owner or specifier and are located at the limits of the bridge travel.
- Runway stops shall be attached to resist the force applied when contacted.

- END -

5.0 ELECTRICAL EQUIPMENT

5.1 GENERAL

- The electrical equipment Section of this Specification is intended to cover tQ1W under running bridge type single girder electric overhead traveling cranes for operation with alternating current or direct current power supplies.
- The proposal of the crane manufacturer shall include the rating and description of all motors, brakes, control and protective and safety features.
- The crane manufacturer shall furnish and mount all electrical equipment, conduit, and wiring, unless otherwise specified. If it is necessary to partially disassemble the crane for shipment, all conduit and wiring affected shall be cut to length and identified to facilitate reassembly. Bridge conductors, runway collectors and other accessory equipment may be removed for shipment.
- Wiring and equipment shall comply with the Canadian Electrical Code.

5.2 MOTORS

- Motors shall be designed specifically for crane and hoist duty and shall conform to NEMA Standard MG1 or AISE Standard No. 1 or 1A, where applicable. Designs shall conform to CMAA Specification No. 74.

5.2.1 Motor Time Ratings

Single speed motors shall be rated on no less than a 30 minute basis with temperature rise in accordance with the latest NEMA standards for the class of insulation and enclosure used, unless otherwise specified.

- VFD Drive and multispeed motors may be rated less than 30 minutes on the low speed winding so long as the crane builder data sheets so indicate.
- Under unusual conditions, such as long lifts at reduced speeds, abnormal inching or jogging requirements, short, repeated travel drive movements, altitudes over 3,300 feet above sea level, abnormal ambient temperatures, etc., the motor time rating must be increased accordingly.

5.2.2 Bridge Motor Size Selection

The bridge motor rating is basically the mechanical horsepower with considerations for the effect of control, and ambient temperature.

- Indoor bridge motor required horsepower

  Required Motor Horsepower:

  The bridge motor shall be selected so that the horsepower rating is not less than that given by the following formula:

  $HP = K_a \times W \times V \times K_s$

  $K_a = Acceleration\ factor\ for\ type\ of\ motor\ used$

  $K_s = service\ factor\ which\ accounts\ for\ the\ type\ of\ drive\ and\ duty\ cycle.$

$1.2 \ for \ AC \ magnetic \ and \ DC \ adjustable \ voltage \ controls. \ For \ other$

$types \ of \ control \ consult \ control \ manufature$

$W \ = total \ weight \ to \ be \ removed \ including \ all \ dead \ and \ live \ loads \ (tons)$

$V \ = rated \ drive \ speed \ (ft/min)$

For general case of bridge drives:

$$K_a = \frac{f + \frac{2000_a \times C_r}{g \times E}}{33{,}000 \times K_t} \times \frac{N_r}{N_f}$$

$f = rolling \ friction \ of \ drive \ (including \ transmission \ losses) in \ pounds \ per \ ton$

$a = average \ or \ equivalent \ uniform \ acceleration \ rate \ in \ feet \ per \ second$

$per \ second \ up \ to \ rated \ motor$ RPM.

$C_r = rotational \ inertia \ factor$

$$= \frac{WK^2 \ of \ crane \ \& \ load + WK^2 \ of \ rotating \ mass}{WK^2 \ of \ crane \ \& \ load}$$

$or \ 1.05 + (a/7.5) \ if \ WK^2 is \ unknown$

$g = 32.2 \ feet \ per \ second \ per \ second$

$E = mechanical \ efficiency \ of \ drive \ machinery \ expressed \ as \ per \ unit \ decimal$

$N_r = rated \ speed \ of \ motor \ in$ "RPM" $at \ full \ load$

$N_f = free \ running$ RPM$of \ motor \ when \ driving \ speed \ is \ V$

$K_t = equivellent \ steady \ state \ torque \ relative \ to \ reated \ motor \ torque \ which \ results$

$accelerating \ up \ to \ rated \ motor'RPM'(N_r) in \ the \ same \ time \ as \ the \ actual \ variable$

$torque \ speed \ characteristic \ of \ motor \ and \ control \ characteristic \ used.$

5.2.3 Bridge Drive Gear Ratios

$$Bridge \ drive \ gear \ ratio = \frac{N_f \times D_w \times \pi}{R \times V \times 12}$$

$N_f = free \ running$ "RPM" $of \ the \ motor, after \ the \ drive \ has \ acceleerated, with \ rated \ load$

$to \ the \ steady \ state \ speed \ V \ \left(\frac{ft}{\min}\right). \ The \ value \ of \ N_f \ \ is \ established \ from \ the \ motorcontrol \ speed$
$- torque \ curves \ at \ free \ running \ horsepower \ (HP_{FR})$

$$HP_{FR} = \frac{W \times V \times f}{33000}$$

$W = Total\ load\ (ton)$

$f = rolling\ friction\ (lb/$

- Variations from the calculated gear ratio is permissible to facilitate the use of standard available ratios, provided that motor heating and operational performance is not adversely affected. The actual full load drive speed may vary a maximum of ± 10 percent of the specified full load speed.

5.3 BRAKES

- Types of electrical brakes for the bridge when provided shall be specified by the crane manufacturer.
- Hoists shall be equipped with a mechanical load brake
- Refer to Section 4.4 of this Specification for bridge brake selection and rating.
- Holding brakes if provided shall be applied automatically when power to the brake is removed.
- On direct current shunt brakes, it may be desirable to include a forcing circuit to provide rapid setting and release.
- Brake coil time rating shall be selected for the duration and frequency of operation required by the service.
- . Brake for the trolley is recommended with use of an inverter when proper braking and three phase monitoring is not provided in the VFD.

5.4 CONTROLLERS

- Scope - This Section covers requirements for selecting and controlling the direction, speed, acceleration and electrical braking of the bridge and travel motors. other control requirements such as protection and master switches are covered in other Sections. This Section also covers the requirements for hoist and trolley travel controls if not supplied as an integral part of the monorail hoist.
- On cranes with a combination of cab with master switches, and pendant floor control, the applicable Specifications for cab-controlled cranes shall apply. On floor operated cranes where the pendant master is also used in a "skeleton" cab, the applicable Specifications for floor-controlled cranes shall apply.
- On remote controlled cranes, such as by radio or carrier signal, the applicable floor control Specifications shall apply, unless otherwise specified.
- Control systems may be manual, magnetic, static, variable frequency or variable voltage DC or in combination as specified.
- Hoists shall be furnished with a control braking means, either mechanical or power. Typical mechanical means include mechanical load brakes or self-locking worm drives. Typical power means include dynamic lowering, eddy-current braking, counter-torque, regenerative braking.

5.4.1 Bridge and Trolley Travel

All bridges and trolleys shall be furnished with reversing control systems incorporating plugging protection. Typical plugging protection includes a magnetic plugging contactor, ballast resistors, slip couplings, motor characteristics, or static controlled torque.

5.4.2 Enclosures

- Control panels should be enclosed and shall be suitable for the environment and type of control. A typical non-ventilated enclosure may be in accordance with Type 12 – Industrial use, dust-tight and drip-tight Indoor NEMA Standards publication ICS6 Classification.
- Unless otherwise specified, enclosures for electrical equipment other than controls shall be suitable for the environment, and in accordance with the following practices:

  (a) Auxiliary devices such as safety switches, junction boxes, transformers, pendant masters, lighting panels, main line disconnects, accessory drive controls, brake rectifier panels, limit switches, etc., may be supplied in enclosures other than specified for the control panel.

  (b) Resistor covers for indoor cranes, required to prevent accidental contact under normal operating conditions, shall include necessary screening and ventilation. Resistor covers for outdoor cranes shall be adequately ventilated.

  (c) Brake covers:

  1. Brakes, for indoor cranes, may be supplied without covers.
  2. Brakes, for outdoor cranes, shall be supplied with covers.

- The electrical control system shall be marked with the following information that is plainly visible after installation:

  (a) Manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product can be identified.

  (b) Supply voltage, number of phases, frequency, and full load current calculated in accordance with the Canadian Electrical Code.

  (c) Arc Flash warning label, as per Canadian Electrical Code.

Wiring Practice inside enclosures

- Separate power and control wires and cross at 90 degree angle as much as possible. Low voltage signal wires can be run with control wiring or separately. If they are susceptible to EMC (Electromagnetic Compatibility), they should be wired with shielded cable.
- Any conductors that are energized after the main disconnect has been turned off hall be orange or orange/white stripe (for a grounded neutral AC system).

- Use High Temperature Wire when connecting DB resistors in the panel. Proper spacing will be required around the resistor if it is mounted in the enclosure. Wires should be twisted to limit common mode noise.
- Follow the manufacturer torque specifications on all terminals and fastening hardware.
- For conductor support, non-metallic ducts can be used as long as they are non-fire propagating material. Conductors can also be supported by cable fasteners.
- Terminal blocks should be used for conductors that enter or leave the enclosure except where the main supply comes into a disconnect. Plug connectors are also permissible for conductors entering/leaving the enclosure. Wiring entering/leaving an enclosure shall maintain enclosure integrity.
- Encoder cables (or any other low signal cable) should be connected directly to the device and should not go through a relay, contactor or terminal blocks unless the component to which it is connected is suited for the signal.
- Power cords shall be permitted as long as they are part of the Original Equipment Manufacturer's power supply.
- The enclosure and components should be designed around a temperature range of 32°F to 104"F (O"C to 40°C) unless a means of environmental control is utilized, or all the components are suitable for an expanded temperature range.
- . Wires attached to doors shall have abrasion protection and allow for full movement of the door without abrasion/damage to the wires. Wires or wire bundles shall be anchored at the door and frame such that the wires are not stressed. If the doors are removable, a disconnect means should be provided for these conductors.

Wiring Practice outside enclosures

When configuring the crane or hoist interconnecting electrical system, consider the following design features and guidelines for proper operation and personnel/equipment protection.

- Mechanical Protection of Crane Electrical Conductors

  Electrical conductors should be protected from inadvertent damage due to physical contact or exposure (i.e. conduit, wire way, cable duct, insulated bus-bar, jacketed conductors, or armored cables). Where non-insulated conductors are exposed, mechanical guards shall be provided to prevent accidental contact (i.e. collector shoe wiring behind cab).

- Electrical Conductor Segregation

  Conductors voltage levels are defined as power, control and low-level.

  Conductors in the same conduit/wire trough shall be insulated for the highest voltage applied to any one of the wires, and ratings shall comply with NEC.

  Select the interconnecting power, control, and low level wire conductor insulation I routing to suit the application. As possible, increase the separation distance between parallel conductor runs, and when possible, physically separate the various power, control, and low level conductors from each other, to maintain signal integrity. Overall shielded cables and shielded twisted paired cables will also improve signal level integrity, ensuring EMC. Refer to applicable manufacturer's instructions for details on proper cabling of motor starter, VFD, and control components.

- Environmental Suitability

  Crane wiring and mounting hardware shall consider the operating environment.

  Wiring methods should prevent excessive degradation of wiring/cabling and its associated hardware as well as prevent intrusion of foreign materials. If intrusion of foreign materials cannot be prevented, means of draining should be provided (i.e. condensation in conduits on an outside crane).

- Flexible Interconnecting Conductors or Cables

  Flexible stranded conductors shall be protected from snagging, abrasion or cuts.

  Runs of unprotected wire, cable or flexible conduit should be minimized to prevent mechanical damage.

  When continuous flexing is required, proper selection of cable type shall be considered (i.e., festoon, chain carrier cable, etc.) and follow manufacturer's recommendations.

- Grounding/bonding

  Proper grounding/bonding techniques shall be followed for interconnection cabling as per the CEC and City of Winnipeg bylaws.

- Suppression devices

  Surge Suppressors should be used across all control circuit coils or inductive devices in a machine control panel.

  When a RF type radio system or PLC is used, according to manufacturer's recommendation, suppressors shall be used across all control circuit coils or inductive devices.

5.5 RESISTORS

- Resistors (except those in permanent sections) shall have a thermal capacity of not less than NEMA Class 150 series for CMAA crane service C.
- Resistors shall be designed to provide the proper speed and torque as required by the control system used.
- Resistors shall be installed with adequate ventilation, and with proper supports to withstand vibration and to prevent broken parts or molten metal falling from the crane.
- When using resistors where conductive dust may be present in the atmosphere and can affect resistor insulation performance, double insulated Nema 3R resistors should be used, unless the resistors are located inside suitable control enclosure. As an alternate to the DB resistors, AC Line Regeneration Units may be used.

5.6 PROTECTION AND SAFETY FEATURES

- A crane disconnecting means, either a current-rated circuit breaker or motor rated switch, lockable in the open position, shall be provided in the leads from the runway contact conductors or other power supply.
- The continuous current rating of the switch or circuit breaker shall not be less than 50 percent of the combined short time motor full load currents, nor less than 75 percent of the sum of the short time full load currents of the motors required for any single crane motion, plus any additional loads fed by the device.
- The disconnecting device shall have an opening means located where it is readily accessible to the operator's station, or a mainline contactor connected after the may be furnished and shall be operable from the operator's station.
- Power circuit fault protection devices shall be furnished in accordance with CEC Interrupting Rating. The user shall state the available fault current or the crane manufacturer shall state in the Specification the interrupting rating being furnished.
- Branch circuit protection shall be provided per CEC.
- Magnetic Mainline contactors, when used, shall be as shown in Tables 5.6.6-1 per CMAA No.74. The size shall not be less than the rating of the largest primary contactor used on any one motion.
- Motor running overcurrent protection shall be provided in accordance with CEC.
- Control circuits shall be protected in accordance with CSA C22.
- Undervoltage protection shall be provided as a function of each motor controller, or an enclosed protective panel, or a magnetic mainline contactor, or a manual-magnetic disconnect switch.
- An emergency stop I stop switch shall be provided on each operator control device and shall be within reach of the operator in any operating position. The stop switch shall open or de-energize a power device (i.e. mainline contactor) that is not required to open and close during normal run - stop operations. A fail- safe circuit shall be utilized to implement this provision. Except for wireless control devices (such as radio or infrared remote control), the stop circuitry shall be hardwired and not dependant on programmable logic devices. All equipment motion stopped by the stop controls shall be capable of being re-started only by deliberate action or sequence of actions by the operator.

5.8 FLOOR OPERATED PENDANT PUSHBUTTON STATIONS

- The arrangement of pendant pushbutton stations should conform to CMAA No. 74 Figure 5.8.1 unless otherwise agreed between the manufacturer and owner.
- Pushbuttons shall return to the "off" position when pressure is released by the crane operator.
- Pendant pushbutton stations shall have a grounding conductor between a ground terminal in the station and the crane.
- The maximum voltage in pendant pushbutton stations shall be 120 Volts AC.
- Pushbuttons shall be guarded or shrouded to prevent accidental actuation of crane motions.
- "Stop" pushbuttons shall be colored red.

- Pendant pushbutton stations shall be supported in a manner that will protect the electrical conductors against strain.
- Minimum wire size of multiconductor flexible cords for pendant pushbutton stations shall be #16 AWG.

In each user location, the relative arrangement of units on crane Pendant pushbutton stations should be standardized. In the absence of such standardization, suggested arrangement is shown in CMAA No. 74 Figure 5.8.1.

5.9 LIMIT SWITCHES

- The hoist motion of all cranes shall be equipped with an overtravel limit switch in the raising direction to stop hoisting motion. If a geared or other limit switch or device that operates in relation to drum turns is used, an additional limit switch or device that operates independent of drum turns shall be provided.
- Interruption of the raising motion shall not interfere with the lowering motion. Lowering of the block shall automatically reset the limit switch unless otherwise specified.
- The upper limit switch shall be power circuit type, control circuit type or as specified by the purchaser. The manufacturer's proposal shall state which type is being furnished.
- Power circuit limit switches are required, an interrupting device that cuts power to the hoist motor shall be used. Provision shall be made to set the brake upon activation of the interrupting device.
- Upon activation, the power circuit limit switch shall prevent any raising motion.
- When using a power interrupting device between an inverter and the motor, the following should be considered:
  a) A reactor should be used at the output of the AC inverter.
  b) A control contact, that opens prior to the power contacts, should be wired to the permissive input of the AC inverter to turn off the power output stage (i.e. early breaking contact).
- Lower limit switches shall be provided where the hook can be lowered beyond the rated hook travel under normal operating conditions and shall be of the control circuit type.

5.10 INSTALLATION

- Electrical equipment shall be so located or enclosed to prevent the operator from accidental contact with live parts under normal operating conditions.
- Electrical equipment shall be installed in accessible locations and protected against ambient environmental conditions as agreed to by the purchaser and the crane manufacturer.

5.11. RUNWAY/BRIDGE CONDUCTOR SYSTEM

- The runway/bridge conductors shall be insulated duct-u-bar system.
- The crane manufacturer shall state the type of conductors to be furnished.
- The conductors shall have sufficient ampacity to carry the required current to the crane, or cranes, when operating with rated load. The conductor ratings shall be selected in accordance Canadian Electrical Code. For manufactured conductor systems with published ampacities, the intermittent ratings may be used.

- The published crane intermittent ratings of manufactured conductor systems shall not be less than the ampacity required for the circuit in which they are used.
- Current collectors, if used, shall be compatible with the type of contact conductors furnished and shall be rated for the ampacity of the circuit in which they are used.
- For grounding purposes, when a new conductor bar system is installed, a separate grounding conductor should be provided.

5.12 REMOTE CONTROL

- Remote control may be by means of radio or infrared transmission or an off-crane control station connected to the crane through wiring. The control station may consist of pushbuttons, master switches, computer keyboards or combination thereof. For definition of remote control, see the applicable ANSI / ASME standards.
- The selection and application of the remote-control system should be done to assure compatibility between the remote control and the crane control system and eliminate interference.
- When more than one control station is provided, electrical interlocks shall be included in the system to permit operation from only one station at a time. Electrical interlock is defined as effective isolation of the control circuits with the use of rotary switch contacts, relay contacts or with the use of a programmable logic controller and its input/output modules.
- Due consideration should be given to elimination of interference between electronic signals and power circuits. This includes physical and electrical separation, shielding, etc.
- Due consideration should be given to the following:

  (a) Operating range of the remote-control equipment.

  (b) Operating speeds of the crane.

  (c) Application of end travel limit switches.

  (d) Wiring of magnet and vacuum circuits to the line side of the disconnecting means and use of latching controls.

- Power disconnecting circuits and warning device shall be provided.

5.13 WIRELESS DATA EXCHANGE BETWEEEN CRANE TO CRANE AND/OR CRANE TO BUILDING

- Wireless systems shall meet FCC requirements or local regulatory bodies.
- General wireless transmission of crane status to building
- Frequency should be chosen to minimize interference from existing wireless devices.
- Antennas should be in line of sight.
- Transmission gain should be evaluated when crane/building wireless devices are closest and furthest from each other.
- Transmission frequency range should have a possibility of selecting a channel out of multiple channels or have a way to automatically switch channels (via automatic channel switching or spread spectrum).

- Wireless transmission for data exchange (ex. Interlocks)
- Communication protocol shall include a way to determine that the wireless communication is lost (i.e. handshaking between crane/building or incorporated in communication protocol).
- Loss of communication shall bring the process interlocks to a safe state. States shall be programmed so that a value of zero corresponds to the safe state of the equipment.
- Channel switching time (if automatic channel switching is provided) shall be less than the time allowed to detect communication loss.

5.14 COLLISION AVOIDANCE

- All collision avoidance requirements shall be specified by the owner I purchaser of the crane. In all cases, the environment, obstacles, and other such items must be considered by the owner I purchaser to properly select a collision avoidance system.
- Collision avoidance system(s) between cranes on the same runway should be designed to prevent unintentional contact between the cranes. These may be of an electrical or mechanical means, or a combination of electrical and mechanical. In some cases, the design may permit intentional controlled contact.
- End of travel collision avoidance should be designed to prevent unintentional contact of the crane or trolley with mechanical end stop(s) or other equipment.

5.15 LED LIGHTING

- Each crane bridge shall have 4 LED lighting fixtures with minimum 8000 lumens per fixture. Lights shall be located in line with the existing shop ceiling fixtures to maintain light levels when crane is operating or parked beneath ceiling fixtures.
- LED lights to operate on 120 volts, with on / off switch located on the pendant.
- LED lights to be rigidly mounted to the bridge girder to avoid shaking during travel.

- End -