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# AISI Standard for Cold-Formed Steel Framing -- Header Design

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# STANDARD FOR COLD-FORMED STEEL FRAMING – HEADER DESIGN

December 17, 2001

**American Iron and Steel Institute**

1101 17th Street, NW Suite 1300 Washington, DC 20036-4700

## DISCLAIMER

The material contained herein has been developed by the American Iron and Steel Institute Committee on Framing Standards. The Committee has made a diligent effort to present accurate, reliable, and useful information on cold-formed steel framing design and installation. The Committee acknowledges and is grateful for the contributions of the numerous researchers, engineers, and others who have contributed to the body of knowledge on the subject. Specific references are included in the *Header Standard* document.

With anticipated improvements in understanding of the behavior of cold-formed steel framing and the continuing development of new technology, this material may eventually become dated. It is anticipated that AISI will publish updates of this material as new information becomes available, but this cannot be guaranteed.

The materials set forth herein are for general purposes only. They are not a substitute for competent professional advice. Application of this information to a specific project should be reviewed by a design professional. Indeed, in many jurisdictions, such review is required by law. Anyone making use of the information set forth herein does so at their own risk and assumes any and all liability arising there from.

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# PREFACE

The American Iron and Steel Institute (AISI) Committee on Framing Standards (COFS) has developed this *Standard for Cold-Formed Steel Framing – Header Design [Header Standard]* to provide technical information and specifications for designing headers made from cold-formed steel.

The Committee acknowledges and is grateful for the contributions of the numerous engineers, researchers, producers and others who have contributed to the body of knowledge on the subjects. The Committee wishes to also express their appreciation for the support and encouragement of the Steel Framing Alliance.

All terms in this Standard written in italics are defined in the AISI-COFS *Standard for Cold-Formed Steel Framing – General Provisions.*

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## STANDARD FOR COLD-FORMED STEEL FRAMING – HEADER DESIGN

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# STANDARD FOR COLD-FORMED STEEL FRAMING – HEADER DESIGN

## A. GENERAL

### A1 Scope

The design and installation of cold-formed steel box and back-to-back *headers*, and double L-*headers* used in single-span conditions for load carrying purposes in buildings shall be in accordance with the *Specification for the Design of Cold-Formed Steel Structural Members* [*Specification*] and *the Standard for Cold-Formed Steel Framing-General Provisions* [*General Provisions*] except as modified by the provisions of this *Header Standard*. This *Header Standard* shall not preclude the use of other materials, assemblies, structures or designs not meeting the criteria herein, when the other materials, assemblies, structures or designs demonstrate equivalent performance for the intended use to those specified in this *Standard*. Where there is a conflict between this *Header Standard* and other reference documents the requirements contained within the *Header Standard* shall govern.

This *Header Standard* shall include Sections A through C inclusive.

#### A1.1 Limitations

##### A1.1.1 Back-to-Back and Box Headers

The design provisions of Sections B1 and B2 of this *Header Standard* shall be limited to back-to-back and box *headers* that are installed using cold-formed steel *C-shape* sections, as shown by Figures A1.1.1-1 and A1.1.1-2.

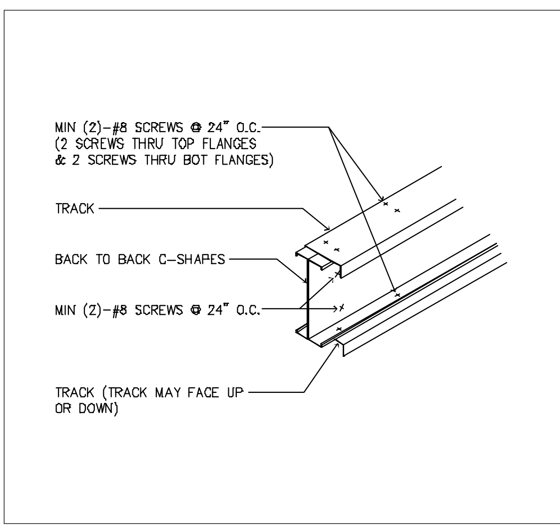


Figure A1.1.1-1 Back-to-Back Header

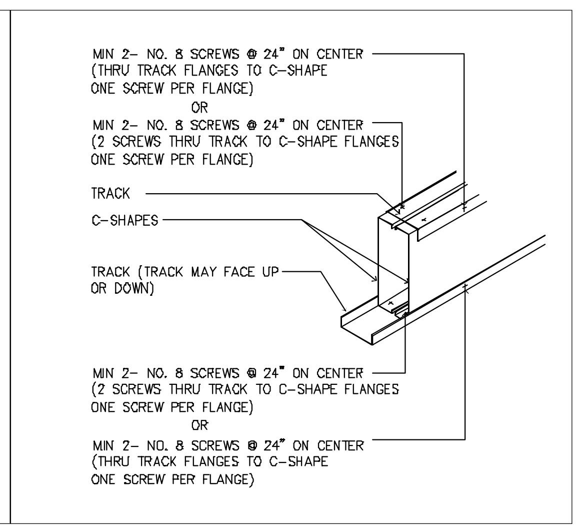


Figure A1.1.1-2 Box Header

### A1.1.2 Double L-Headers

The design provisions of Section B3 of this *Header Standard* shall be limited to double L-*headers* that are installed using cold-formed steel angles, as shown by Figure A.1.1.2, having the following limitations:

Minimum top *flange* width = 1.5 inches (38.1 mm)

Maximum vertical leg dimension = 10 inches (254 mm)

Minimum base metal steel thickness = 0.033 inches (0.838 mm)

Minimum design *yield strength*, $F_y$ = 33 ksi (230 MPa)

Maximum design *yield strength*, $F_y$ = 50 ksi (345 MPa)

*Cripple stud* located at all load points

Minimum bearing length 1.5 inches (38.1 mm) at load points

Minimum wall width = 3.5 inches (88.9 mm)

Maximum span = 16'-0" (4.88 m)

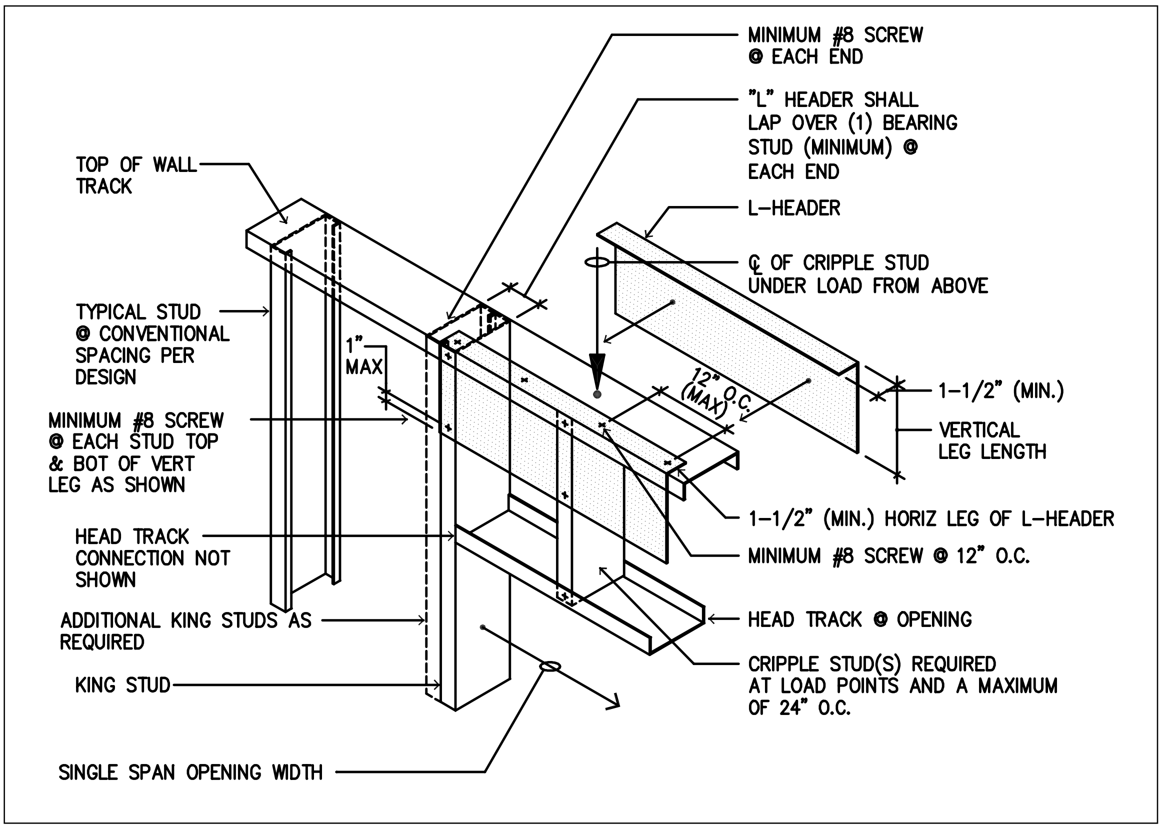


Figure A1.1.2 Double L-Header

## A2 Loads and Load Combinations

Buildings or other structures and all parts therein shall be designed to safely support all loads that are expected to affect the structure during its life. These loads shall be as established by the local building code. In the absence of such a code, the loads, forces, and combinations of loads shall be in accordance with accepted engineering practice for the geographical area under consideration as specified by the appropriate sections of ASCE 7.

## A3 Referenced Documents

The following documents are referenced in this *Header Standard*:

1. AISI, *Specification for the Design of Cold-Formed Steel Structural Members*, 1996 Edition with 1999 Supplement, American Iron and Steel Institute, Washington, DC.
2. AISI, *Standard for Cold-Formed Steel Framing–General Provisions*, 2001 Edition, American Iron and Steel Institute, Washington, DC.
3. ASCE 7-98, *Minimum Design Loads for Buildings and Other Structures*, American Society of Civil Engineers, Reston, VA.

# B. DESIGN

## B1 Back-to-Back Headers

The provisions of this section are limited to back-to-back *header* beams as defined in Section A.1.1.1.

### B1.1 Moment Capacity

Flexure alone shall be evaluated by using Section C3.1.1 of the *Specification*.

### B1.2 Shear Capacity

Shear alone need not be considered for the design of back-to-back *header* beams that are fabricated and installed in accordance with this *Header Standard*.

### B1.3 Web Crippling Capacity

Web crippling alone shall be evaluated by using Section C3.4 of the *Specification*. For back-to-back *header* beams the equations for I-sections or similar sections shall be used.

### B1.4 Bending and Shear

The combination of bending and shear need not be considered for the design of back-to-back *header* beams fabricated and installed in accordance with this *Header Standard*.

### B1.5 Bending and Web Crippling

*Webs* of back-to-back *header* beams subjected to a combination of bending and web crippling shall be designed using Section C3.5 of the *Specification*. For back-to-back *header* beams the equations for I-sections or similar sections shall be used.

## B2 Box Headers

The provisions of this section are limited to box *header* beams as defined in Section A.1.1.1.

### B2.1 Moment Capacity

Flexure alone shall be evaluated by using Section C3.1.1 of the *Specification*.

### B2.2 Shear Capacity

Shear alone need not be considered for the design of box *header* beams that are fabricated and installed in accordance with this *Header Standard*.

### B2.3 Web Crippling Capacity

Web crippling alone shall be evaluated by using Section C3.4 of the *Specification*. For box *header* beams the equations for shapes having single *webs* shall be used. $P_n$ shall be permitted to be modified as follows, where α accounts for the increased strength due to the *track*:

$$P_a = P_n'$$ (*Eq*. B2.3-1)

where

$P_n' = \alpha P_n$

$P_n$ = web crippling capacity for shapes having single *webs* from Section C3.4 of the *Specification*.

α = parameter defined by equation B2.3-2 or B2.3-3

$t_t$ = *design thickness* of the *track* section = 0.033 in. (0.84 mm)

$t_c$ = *design thickness* of the C-section

Ω = 1.85

ϕ = 0.85

When the *track* section thickness ≥ 0.033 in. (0.84 mm), the *track flange* width ≥ 1 in. (25.4 mm), the C-section depth ≤ 12 in. (305 mm) and the C-section thickness ≥ 0.033 in. (0.84 mm):

$$\alpha = 2.3\frac{t_t}{t_c} \geq 1.0$$ (*Eq*. B2.3-2)

When the above limits are not met:

$$\alpha = 1.0$$ (*Eq*. B2.3-3)

### B2.4 Bending and Shear

The combination of bending and shear need not be considered for the design of box *header* beams fabricated and installed in accordance with this *Header Standard*.

### B2.5 Bending and Web Crippling

*Webs* of box *header* beams subjected to a combination of bending and web crippling shall be designed using the following equations:

(a) For ASD:

$$\frac{P}{P_n'} + \frac{M}{M_n} \leq \frac{1.5}{\Omega}$$ (*Eq*. B2.5-1)

where

P = required compressive axial strength for ASD

M = required flexural strength for ASD

$P'_n$ = web crippling capacity computed by Eq. B2.3-1

Ω = 1.85

$M_n$ is defined in the *Specification*.

(b) For LRFD:

$$\frac{P_u}{P_n^{'}} + \frac{M_u}{M_n} \le 1.5\phi \qquad (Eq.\ B2.5\text{-}2)$$

where

$P_u$ = required compressive axial strength for LRFD
$M_u$ = required flexural strength for LRFD
$P'_n$ = web crippling capacity computed by Eq. B2.3-1
$\phi$ = 0.85
$M_n$ is defined in the *Specification*.

## B3 Double L-Headers

The provisions of this section are limited to double L-*headers* as defined in Section A.1.1.2.

### B3.1 Moment Capacity

#### B3.1.1 Gravity Nominal Moment Capacity

(a) For a double L-*header* beam having a vertical leg dimension of 8 inches (203 mm) or less, the design shall be based on the flexural capacity of the L-sections alone. The nominal gravity flexural strength, $M_{ng}$, shall be determined as follows:

$$M_{ng} = S_{ec}\, F_y \qquad (Eq.\ B3.1.1\text{-}1)$$

where

$F_y$ = *yield strength* used for design
$S_{ec}$ = elastic section modulus of the effective section calculated at $f = F_y$ in the extreme compression fibers

(b) For a double L-*header* beam having a vertical leg dimension greater than 8 inches (203 mm), and having a span-to-vertical leg dimension ratio greater than or equal to 10, design shall be based on the flexural capacity of the L-sections alone (Eq. B.3.1.1-1).

(c) For a double L-*header* beam having a vertical leg dimension greater than 8 inches (203 mm) and having a span-to-vertical leg dimension ratio less than 10, the nominal gravity flexural strength, $M_{ng}$, shall be determined as follows:

$$M_{ng} = 0.9\, S_{ec}\, F_y \qquad (Eq.\ B3.1.1\text{-}2)$$

where

$F_y$ = *yield strength* used for design
$S_{ec}$ = elastic section modulus of the effective section calculated at $f = F_y$ in the extreme compression fibers

### B3.1.2 Uplift Nominal Moment Capacity

For a double L-*header* beam, the nominal uplift flexural strength, $M_{nu}$, shall be determined as follows:

$$M_{nu} = R\, M_{ng} \qquad (Eq.\ B3.1.2\text{-}1)$$

where

$M_{ng}$ = gravity moment capacity determined by Eq. B.3.1.1-1

$R$ = uplift reduction factor

= 0.25 for $L_h/t \leq 150$

= 0.20 for $L_h/t \geq 170$

= use linear interpolation for $150 < L_h/t < 170$

$L_h$ = vertical leg dimension of the angle

$t$ = *base metal thickness*

### B3.1.3 Design Moment Capacity.

(a) For ASD, the allowable design moment shall be determined as follows:

For gravity,

$$M_a = M_{ng}/\Omega \qquad (Eq.B3.1.3\text{-}1)$$

$\Omega$ = 1.67 for beams with $L_h \leq 8$ inches (203 mm)

$\Omega$ = 2.26 for beams with $L_h > 8$ inches (203 mm)

For uplift,

$$M_a = M_{nu}/\Omega \qquad (Eq.\ B3.1.3\text{-}2)$$

$\Omega$ = 2.0

(b) For LRFD, the design moment capacity shall be determined as follows:

For gravity,

$$M_u = \phi M_{ng} \qquad (Eq.\ B3.1.3\text{-}3)$$

$\phi$ = 0.90 for beams with $L_h \leq 8$ inches (203 mm)

$\phi$ = 0.71 for beams with Lh > 8 inches (203 mm)

For uplift,

$$M_u = \phi M_{nu} \qquad (Eq.\ B3.1.3\text{-}4)$$

$\phi$ = 0.80

### B3.2 Shear Capacity

Shear alone need not be considered for the design of L-*header* beams that are fabricated and installed in accordance with this *Header Standard*.

### B3.3 Web Crippling Capacity

Web crippling alone need not be considered for the design of L-*header* beams that are fabricated and installed in accordance with this *Header Standard*.

### B3.4 Bending and Shear

The combination of bending and shear need not be considered for the design of L-*header* beams fabricated and installed in accordance with this *Header Standard*.

### B3.5 Bending and Web Crippling

The combination of bending and web crippling need not be considered for the design of L-*header* beams fabricated and installed in accordance with this *Header Standard*.

## C. INSTALLATION

*Headers* shall be installed in accordance with the *General Provisions* and Figures A1.1.1-1 & -2 and A1.1.2.

# COMMENTARY
# ON THE
# STANDARD
# FOR
# COLD-FORMED
# STEEL FRAMING –
# HEADER DESIGN

December 17, 2001

**American Iron and Steel Institute**

1101 17th Street, NW Suite 1300 Washington, DC 20036-4700

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The material contained herein has been developed by the American Iron and Steel Institute Committee on Framing Standards. The Committee has made a diligent effort to present accurate, reliable, and useful information on cold-formed steel framing design and installation. The Committee acknowledges and is grateful for the contributions of the numerous researchers, engineers, and others who have contributed to the body of knowledge on the subject. Specific references are included in the *Commentary on the Header Standard* document.

With anticipated improvements in understanding of the behavior of cold-formed steel framing and the continuing development of new technology, this material may eventually become dated. It is anticipated that AISI will publish updates of this material as new information becomes available, but this cannot be guaranteed.

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# PREFACE

Box and back-to-back header beams have been commonly used in cold-formed steel framing. The geometry is fabricated using two C-shaped cold-formed steel members. Design practice for such header beams can be based on the AISI *Specification* (1999). Recent research has determined that the application of the AISI design provisions is conservative. This led to the development of an improved design methodology.

L-header beam geometries are gaining popularity in cold-formed steel framing. The geometry is fabricated using two L-shaped cold-formed steel members connected to a top track section. This geometry is commonly referred to as a double L-header because two angle shapes are used to create the header. Design practice for header beams has been based on the AISI *Specification* (1999). However, application of the AISI design provisions often results in limited span capability for the header beam. To better define the appropriate design methodology, the Steel Framing Alliance funded an experimental study at the National Association of Home Builders' (NAHB) Research Center (National 1998). An evaluation of the NAHB test results has determined that the application of the AISI design provisions is conservative. A design methodology has been developed and is presented herein. The design methodology is based on the flexural capacity of the L-sections alone and ignores any potential composite action provided by track members and/or sheathing.

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## COMMENTARY ON THE STANDARD FOR COLD-FORMED STEEL FRAMING – HEADER DESIGN

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# COMMENTARY ON THE STANDARD FOR COLD-FORMED STEEL FRAMING – HEADER DESIGN

## A. GENERAL

### A1 Scope

#### A1.1.2 L-Headers

The NAHB Research Center study tested both single and double L-*header* beams. The tests consisted of either a single point load or a two-point load. All angles had a 1.5 inch (38.1 mm) top *flange*. The vertical leg dimensions were either 6, 8, or 10 inches (152, 203 or 254 mm). Thicknesses ranged from nominally 0.033 to 0.068 inches (0.84 to 1.73 mm). Test span lengths ranged from 36 to 192 inches (914 to 4880 mm).

An analysis of the data indicated that the behavior of the L-*header*s differed for single versus double angle geometries. Also, the single point load produced test results that differed from the two-point load. At present, there is insufficient data to develop design guidelines for single angle L-*header*s. Thus, the data analysis has not considered data for the single angle sections nor for the single point loading.

## B. DESIGN

### B1 & B2 Box and Back-to-Back Headers

The design methodology is based on the review and analysis of the data presented in the NAHB report *Cold-Formed Steel Back-To-Back Header Assembly Tests* (1997) and the study of Stephens (2000, 2001). The test results were evaluated and compared with the strength equations contained in the AISI *Specification* (1996).

Stephens and LaBoube (2000) concluded that web crippling or a combination of bending and web crippling is the primary factor in *header* beam design for the IOF (interior-one-*flange*) loading condition. Neither pure shear nor combined bending and shear were failure modes in the test program. The research study showed that using the AISI *Specification* web crippling equations for shapes having single *webs* for the design of box or back-to-back *header* beams will give conservative results.

Based on additional studies conducted by Stephens (2001), a modification factor was derived that enable the computation of the interior-one-*flange* web crippling capacity of a box *header* assembly as defined by Figure A1.1.1-2 of the *Header Standard.* The increased web crippling capacity is attributed to the interaction of the *track* section and the C-section, thus it is imperative that the *track* section be attached with the *flanges* as shown in Figure A1.1.1-2. This interaction is quantified by the ratio of *track* thickness to C-section thickness in

Eq. B2.3-1. When computing the web crippling capacity for a *header* assembly, the nominal capacity computed using the AISI *Specification* is to be multiplied by 2 to reflect that there are two *webs* in the assembly and then the capacity for the two *webs* is used in Eq. B2.3-1. In addition to a modification to the pure web crippling strength, the *Header Standard* also contains an interaction equation for bending and web crippling of box *header* assemblies that differs from the AISI *Specification*. This interaction equation is based on the research of Stephens (2001). The research of Stephens (2001) included test specimens having standard perforations. Thus, the provisions of the 1999 Supplement to the AISI *Specification* are appropriate for *header* design.

If the top *track* section of a box *header* assembly is attached with the *flanges* up, as would be the case when the *header* beam is located directly above the opening and beneath the *cripple studs*, Eq. B2.3-1 would not apply. Web crippling capacity and the combination of bending and web crippling should be evaluated by using Sections C3.4 and C3.5 of the *Specification* and the equations for shapes having single unreinforced *webs* should be used.

The procedure to calculate the vertical deflection of a box or back-to-back *header* may be accomplished by using a composite assembly calculation which would include the two C-sections and the top and bottom *tracks*. However, to achieve full composite action using this type of calculation would require an extensive (cost prohibitive) fastener requirement between the *tracks* and the C-sections, and therefore, it is more common to use a conservative estimate of the vertical deflection based on the full moment of inertia of the two C-sections alone.

## B3 L-Headers

The available test data (Elhajj and LaBoube, 2000) indicated that the failure mode was flexure or combination of flexure and web crippling. Neither pure shear nor combined bending and shear were failure modes in the test program. The tested moment capacity, $M_t$, was determined and compared with the computed moment capacity as defined by Section C3.1.1(a) of the AISI *Specification*. The nominal moment capacity was computed using the following equation:

$$M_n = S_{xc} F_y$$

where

$F_y$ = measured yield stress

$S_{xc}$ = elastic section modulus of the effective section computed at $f = F_y$. The section modulus of the compression *flange* was used for all computations.

For L-*header*s having a geometry as defined by the limitations of Section 1, the performance of full-scale double L-*header* beam tests (Elhajj and LaBoube, 2000) has shown that the limit states of shear, web crippling, bending and shear, and bending and web crippling need not be considered when designing an L-

*header* beam.

The procedure to calculate the vertical deflection of an L-*header* is undefined because the L-*header* is an indeterminate assembly consisting of two angles, *cripple studs*, and *track* sections interconnected by self-drilling screws. However, the test results indicate that the measured deflections at an applied load that equal to the design load was less than L/240. Further analytical work, based on test data, would be necessary in order to develop a calculation procedure to determine the deflection of L-*header* beams.

### B3.1.1 Gravity Moment Capacity

The test results summarized by Elhajj and LaBoube (2000) are considered to be confirmatory tests that show the AISI *Specification* Section C3.1.1 provides an acceptable determination of the design moment capacity. Thus, the factor of safety of 1.67 is prescribed by the *Standard*.

For the 10 inch (254 mm) deep L-*header* beams having the span to vertical leg dimension, $L/L_h$, greater than 10, the tested *header* sections had tested moment capacities greater than the computed moment capacity defined by *Header Standard* Eq. B3.1.1-1. However, for 10 inch (254 mm) deep beams having $L/L_h$ ratios less than 10, the tested moment capacity was on the average ten percent less than the computed moment capacity (Elhajj and LaBoube, 2000). Thus, the application of Eq. B3.1.1-1 is questionable for full range of the 10 inch (254 mm) L-*header*. A review of the data indicates that the application of Eq. B3.1.1-1 is valid for test specimens having a span to vertical leg dimension, $L/L_h$, of 10 or greater. For the specimens having $L/L_h$ ratios less than 10 it is proposed that the results obtained by using Eq. B3.1.1-1 be multiplied by 0.9.

### B3.1.2 Uplift Moment Capacity

A comparison of the tested to computed moment capacity ratios ranged from 0.141 to 0.309 with a mean of 0.215 (Elhajj and LaBoube, 2000). Further analysis of the tested to computed moment ratios indicated that the behavior was influenced by the ratio of $L_h / t$. Therefore, uplift reduction factors, R, in the *Header Standard* were developed as a function of the $L_h / t$ ratio.

Based on the provisions of Chapter F of the AISI *Specification*, the factor of safety was computed to be 2.0.

## REFERENCES


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5. *Specification for the Design of Cold-Formed Steel Structural Members*, 1996 edition with 1999 Supplement (1999), American Iron and Steel Institute, Washington, D.C.