Table 12.1
Service-condition factors, K_{SF}, for connections
(See Clauses 12.2.1.7.2, 12.3.2, and A.12.6.5.4.)

	Moisture content of wood when connection is fabricated					
	Dry (≤ 19%)		Green (> 19%)			
Service conditions	Dry	Wet	Dry	Wet	Connection detail	Angle of load to grain
Timber rivets						
Lateral loads	1.00	0.80	0.90	0.80	All	All
Withdrawal loads	1.00	*	0.60	*	—	—
Split-ring and shear-plate connectors, and truss plates	1.00	0.67	0.80	0.67	All	All
Bolts, dowels, drift pins, and lag screws†	1.00	0.67	1.00	0.67	A	All
	1.00	0.67	1.00	0.67	B	0°
	1.00	0.67	0.40	0.27	B	90°
	1.00	0.67	0.40	0.27	C	All
Nails, spikes, and wood screws						
Lateral loads	1.00	0.67	0.80	0.67	All	All
Withdrawal loads	1.00	0.67	0.40	0.40	All	90°

Legend:

A = a single fastener or single row parallel to grain with steel splice plates

B = a single row parallel to grain with wood splice plates, two rows parallel to grain not more than 127 mm apart with a common wood splice plate, or multiple rows with separate wood or steel splice plates for each row

C = all other arrangements

* *No data available for this condition.*

† *In calculations of the lateral resistance of bolts and dowels, K_{SF} shall be applied to yielding (see Clause 12.4.4.3) and perpendicular-to-grain splitting (see Clause 12.4.4.7) failure modes. For failure modes involving shear and tension parallel to grain, the corresponding service-condition factors, K_{Sv} and K_{St}, shall be applied (see Clauses 12.4.4.4 to 12.4.4.6).*

Note: *See the CWC* Commentary on CSA O86 *for further information on connection details.*

12.2.2 Split-ring and shear-plate connectors, bolts, dowels, and lag screws

Note: *Clause 12.2.2 provides general requirements for connections with split-ring and shear-plate connectors, bolts, dowels, and lag screws. Specific requirements are provided in Clause 12.3 for connections with split-ring and shear-plate connectors, in Clause 12.4 for connections with bolts and dowels, and in Clause 12.6 for connections with lag screws.*

12.2.2.1 Inspection and tightening

Structures that have been assembled with unseasoned or partially seasoned wood members shall be inspected regularly at intervals not exceeding six months until it becomes apparent that further wood

shrinkage will not be appreciable. At each inspection, the fasteners shall be tightened to bring the faces of the connected members into close contact without deformation.

12.2.2.2 Grooves, daps, and holes

12.2.2.2.1 Grooves, daps, and holes in wood members

Grooves, daps, and holes in wood members shall be fabricated and oriented accurately in the contacting faces. Bolt holes in wood members shall be accurately aligned and drilled not less than 1.0 mm and not more than 2.0 mm larger than the bolt diameter. Pre-drilled holes in connections with dowels shall have a diameter not greater than the dowel diameter. Lag-screw holes shall be drilled in accordance with Clause 12.6.2.5.

12.2.2.2.2 Holes in steel plates

Holes in steel plates shall be accurately placed to line up with holes in the adjoining wood and shall not be more than 2 mm larger than the diameter of the fastener.

12.2.2.3 Group of fasteners

12.2.2.3.1 General

A group of fasteners consists of one or more rows of fasteners of the same type and size arranged symmetrically with respect to the axis of the load (see Clauses 12.3.3, 12.4.3, and 12.6.2).

12.2.2.3.2 Row of fasteners

A row of fasteners consists of one or more fasteners of the same type and size aligned with the direction of the load.

12.2.2.3.3 Multiple rows of fasteners

When fasteners in adjacent rows are staggered and the spacing between adjacent rows is less than one-quarter the spacing between the closest fasteners in adjacent rows measured parallel to the rows, the adjacent rows shall be considered as one row to determine the resistance of the group. For a group of fasteners having an even number of rows, this principle shall apply to each pair. For a group of fasteners having an odd number of rows, the more conservative interpretation shall apply.

12.2.2.3.4 Group action factor, J_G

The group action factor, J_G, for split-ring, shear-plate, and lag-screw connections shall be as specified in Tables 12.2 and 12.3.

12.2.2.4 Washers

12.2.2.4.1 General

A standard cut washer or its equivalent (see Table 12.4), or a metal strap of the same thickness as the washer, shall be placed between the wood and the fastener head and between the wood and the nut.

12.2.2.4.2 Steel plates

When a bolt or lag-screw head or nut bears directly on a steel plate, washers may be omitted.

12.2.2.4.3 Washers for axially loaded fasteners

Bolts or lag screws in axial tension or with a calculated tension component shall be provided with steel plate washers, standard ogee washers, or malleable iron washers under heads and nuts. The area of these washers shall be such that the bearing stress on the wood under the washer does not exceed the factored resistance in compression perpendicular to grain. If steel washers are used, the thickness shall not be less than one-tenth the diameter or one-tenth the length of the longer side of the washer.

12.2.2.5 Net section

12.2.2.5.1 General

The net section of wood members in connections made using bolts, dowels, lag screws, and split-ring and shear-plate connectors shall be checked in accordance with Clause 5.3.8.

12.2.2.5.2 Staggered bolts, dowels, and lag screws

For a connection under parallel-to-grain loading, staggered adjacent bolts, dowels, or lag screws shall be considered to be placed at the critical section unless their spacing centre-to-centre parallel to grain is more than $8d_F$.

12.2.2.5.3 Split-ring and shear-plate connectors

For connections using timber split-ring and shear-plate connectors, the area deducted from the gross section shall include the projected area of that portion of the connectors within the member and that portion of the bolt hole not within the connector projected area, located at the critical plane. Where connectors are staggered, adjacent connectors shall be considered as occurring in the same critical transverse plane unless their spacing parallel to grain is more than two connector diameters.

Table 12.2
Group action factor, J_G, for split-ring, shear-plate, and lag-screw connections with wood side plates

(See Clauses 12.2.2.3.4, 12.3.6, 12.6.5.1.1, and A.12.6.5.4.)

Area ratio*	The lesser of A_m† or A_s‡	No. of fasteners in a row										
		2	3	4	5	6	7	8	9	10	11	12
0.5	< 8000	1.00	0.92	0.84	0.76	0.68	0.61	0.55	0.49	0.43	0.38	0.34
	8001–12 000	1.00	0.95	0.88	0.82	0.75	0.68	0.62	0.57	0.52	0.48	0.43
	12 001–18 000	1.00	0.97	0.93	0.88	0.82	0.77	0.71	0.67	0.63	0.59	0.55
	18 001–26 000	1.00	0.98	0.96	0.92	0.87	0.83	0.79	0.75	0.71	0.69	0.66
	26 001–42 000	1.00	1.00	0.97	0.94	0.90	0.86	0.83	0.79	0.76	0.74	0.72
	> 42 000	1.00	1.00	0.98	0.95	0.91	0.88	0.85	0.82	0.80	0.78	0.76
1.0	< 8000	1.00	0.97	0.92	0.85	0.78	0.71	0.65	0.59	0.54	0.49	0.44
	8001–12 000	1.00	0.98	0.94	0.89	0.84	0.78	0.72	0.66	0.61	0.56	0.51
	12 001–18 000	1.00	1.00	0.97	0.93	0.89	0.85	0.80	0.76	0.72	0.68	0.64
	18 001–26 000	1.00	1.00	0.99	0.96	0.92	0.89	0.85	0.83	0.80	0.78	0.75
	26 001–42 000	1.00	1.00	1.00	0.97	0.94	0.91	0.88	0.85	0.84	0.82	0.80
	> 42 000	1.00	1.00	1.00	0.99	0.96	0.93	0.91	0.88	0.87	0.86	0.85

* *Area ratio = the lesser of A_m/A_s or A_s/A_m*

† *A_m = gross cross-sectional area of main member, mm²*

‡ *A_s = sum of gross cross-sectional areas of side members, mm²*

Note: *For area ratios between 0.5 and 1.0, interpolate between tabulated values. For area ratios less than 0.5, extrapolate from tabulated values.*

Table 12.3
Group action factor, J_G, for split-ring, shear-plate, and lag-screw connections with steel side plates

(See Clauses 12.2.2.3.4, 12.3.6, 12.6.5.1.1, and A.12.6.5.4.)

Area ratio*	A_m	No. of fasteners in a row										
		2	3	4	5	6	7	8	9	10	11	12
2–12	16 000–26 000	1.00	0.94	0.87	0.80	0.73	0.67	0.61	0.56	0.51	0.46	0.42
	26 001–42 000	1.00	0.96	0.92	0.87	0.81	0.75	0.70	0.66	0.62	0.58	0.55
	42 001–76 000	1.00	0.98	0.95	0.91	0.87	0.82	0.78	0.75	0.72	0.69	0.66
	76 001–130 000	1.00	0.99	0.97	0.95	0.92	0.89	0.86	0.84	0.81	0.79	0.78
12–18	26 001–42 000	1.00	0.98	0.94	0.90	0.85	0.80	0.75	0.70	0.67	0.62	0.58
	42 001–76 000	1.00	0.99	0.96	0.93	0.90	0.86	0.82	0.79	0.75	0.72	0.69
	76 001–130 000	1.00	1.00	0.98	0.95	0.94	0.92	0.89	0.86	0.83	0.80	0.78
	> 130 000	1.00	1.00	1.00	0.98	0.97	0.95	0.93	0.91	0.90	0.88	0.87
18–24	26 001–42 000	1.00	1.00	0.96	0.93	0.89	0.84	0.79	0.74	0.69	0.64	0.59
	42 001–76 000	1.00	1.00	0.97	0.94	0.92	0.89	0.86	0.83	0.80	0.76	0.73
	76 001–130 000	1.00	1.00	0.99	0.98	0.96	0.94	0.92	0.90	0.88	0.86	0.85
	> 130 000	1.00	1.00	1.00	1.00	0.98	0.96	0.95	0.93	0.92	0.92	0.91
24–30	26 001–42 000	1.00	0.98	0.94	0.90	0.85	0.80	0.74	0.69	0.65	0.61	0.58
	42 001–76 000	1.00	0.99	0.97	0.93	0.90	0.86	0.82	0.79	0.76	0.73	0.71
	76 001–130 000	1.00	1.00	0.98	0.96	0.94	0.92	0.89	0.87	0.85	0.83	0.81
	> 130 000	1.00	1.00	0.99	0.98	0.97	0.95	0.93	0.92	0.90	0.89	0.89
30–35	26 001–42 000	1.00	0.96	0.92	0.86	0.80	0.74	0.68	0.64	0.60	0.57	0.55
	42 001–76 000	1.00	0.98	0.95	0.90	0.86	0.81	0.76	0.72	0.68	0.65	0.62
	76 001–130 000	1.00	0.99	0.97	0.95	0.92	0.88	0.85	0.82	0.80	0.78	0.77
	> 130 000	1.00	1.00	0.98	0.97	0.95	0.93	0.90	0.89	0.87	0.86	0.85
35–42	26 001–42 000	1.00	0.95	0.89	0.82	0.75	0.69	0.63	0.58	0.53	0.49	0.46
	42 001–76 000	1.00	0.97	0.93	0.88	0.82	0.77	0.71	0.67	0.63	0.59	0.56

(Continued)

Table 12.3 (Concluded)

Area ratio*	A_m	No. of fasteners in a row										
		2	3	4	5	6	7	8	9	10	11	12
	76 001–130 000	1.00	0.98	0.96	0.93	0.89	0.85	0.81	0.78	0.76	0.73	0.71
	> 130 000	1.00	0.99	0.98	0.96	0.93	0.90	0.87	0.84	0.82	0.80	0.78

* *Area ratio* = A_m/A_s

where

A_m = *gross cross-sectional area of main member, mm²*

A_s = *sum of gross cross-sectional area of steel side plates, mm²*

Δ

Table 12.4
Minimum washer sizes for connections with bolts, lag screws, and split-ring and shear-plate connectors

(See Clause 12.2.2.4.1.)

		Bolts or lag screws			Split-ring and shear-plate connectors					
					2-1/2 in split ring with 1/2 in bolt		4 in split ring with 3/4 in bolt		2-5/8 in shear plate and 4 in shear plate with 3/4 in bolt*	
Washer type	**Use**	**Diameter of fastener, d_F, mm**	**Outside dimension, d_o, mm**	**Thickness, t, mm**	**t, mm**	**d_o, mm**	**t, mm**	**d_o, mm**	**t, mm**	**d_o, mm**
Standard cut (steel)	For bolts and lag screws only; too thin to resist any tensile loads	12.7	35	3	Cut washers shall not be used with connectors	—	—	—	—	—
		15.9	45	4	—	—	—	—	—	—
		19.1	50	4	—	—	—	—	—	—
		22.2	60	4	—	—	—	—	—	—
		25.4	65	4	—	—	—	—	—	—
Square plate (steel)	For connector or tensile load	12.7	65	5	3.2	50	4.8	75	6.4	75
		15.9	70	6	—	—	—	—	—	—
		19.1	75	6	—	—	—	—	—	—
		22.2	85	9	—	—	—	—	—	—
		25.4	90	8	—	—	—	—	—	—
Round plate (steel)	For any use, unless tensile loading develops enough stress to crush wood	12.7	65	5	3.2	50	4.8	75	6.4	75
		19.1	75	6	—	—	—	—	—	—
		22.2	85	8	—	—	—	—	—	—
Ogee (cast iron)	Thicker and wider than normal or malleable iron washers (for increased stiffness	12.7	65	13	3.2	55	4.8	75	6.4	75
		15.9	75	16	—	—	—	—	—	—
		19.1	90	19	—	—	—	—	—	—

(Continued)

Table 12.4 (Concluded)

Washer type	Use	Bolts or lag screws			Split-ring and shear-plate connectors					
		Diameter of fastener, d_F, mm	Outside dimension, d_o, mm	Thickness, t, mm	2-1/2 in split ring with 1/2 in bolt		4 in split ring with 3/4 in bolt		2-5/8 in shear plate and 4 in shear plate with 3/4 in bolt*	
					t, mm	d_o, mm	t, mm	d_o, mm	t, mm	d_o, mm
	and bearing strength)	22.2	100	22	—	—	—	—	—	—
		25.4	100	25	—	—	—	—	—	—
Malleable iron	Wider than normal washers (for added bearing strength)	12.7	65	6	3.2	55	4.8	75	6.4	75
		15.9	70	8	—	—	—	—	—	—
		19.1	75	11	—	—	—	—	—	—
		22.2	90	11	—	—	—	—	—	—
		25.4	100	13	—	—	—	—	—	—

* *For 4 in shear plates used with 7/8 in bolts, d_o is 90 mm.*

Note: *Square or round plate bevelled washers can be necessary when bolts project at an angle to the wood.*

12.3 Split-ring and shear-plate connectors

12.3.1 General

12.3.1.1 Connector unit

For specifying connection resistance in this Standard, a connector unit shall consist of one of the following, in any connection of any number of members:

a) one split ring with a bolt or a lag screw;
b) one shear plate with a bolt or a lag screw, used with a steel strap or plate in a wood-to-metal connection; or
c) two shear plates used back-to-back in the contact faces of a wood-to-wood connection with a bolt or a lag screw.

12.3.1.2 Split-ring connectors

The tabulated resistances and design methods for split-ring connectors specified in Clause 12.3 are for split rings that have dimensions in accordance with Table 12.5A and are manufactured from hot-rolled carbon steel, SAE 1010, meeting the requirements of the *SAE Handbook.* Each ring shall form a closed true circle with the principal axis of the cross-section of the ring metal parallel to the geometric axis of the ring. The ring shall be beveled from the central portion toward the edges to a thickness less than that at midsection so that it will fit snugly in a precut groove; alternatively, another means that achieves equivalent performance may be used. The ring shall be cut through in one place in its circumference to form a tongue and slot.

12.3.1.3 Shear-plate connectors

The tabulated resistances and design methods are for shear-plate connectors specified in Clause 12.3 are for shear plates that have dimensions in accordance with Table 12.5B and meet the requirements of Item a) or b):

a) Pressed steel type: pressed steel shear plates manufactured from hot-rolled carbon steel, SAE 1010, meeting the requirements of the *SAE Handbook.* Each plate shall be a true circle with a flange around the edge, extending at right angles to the face of the plate from one face only. The plate portion shall have a central hole and two small perforations on diametrically opposite sides of the hole, each midway from the centre and circumference.
b) Malleable iron type: malleable iron shear plates manufactured in accordance with ASTM A47, Grade 32510 (or ASTM A47M, Grade 22010). Each casting shall consist of a perforated round plate with a flange extending at right angles to the face of the plate and projecting from one face only. The plate portion shall have a central bolt hole, reamed to size where required, with an integral hub concentric to the bolt hole and extending from the same face as the flange.

Table 12.5A
Split ring dimensions, mm
(See Clauses 12.3.1.2 and 12.3.1.3.)

Dimensions	2-1/2 in	4 in
Inside diameter at centre when closed	63.5	101.6
Thickness of steel at centre	4.1	4.9
Depth of steel	19.0	25.4

Table 12.5B
Shear plate dimensions, mm
(See Clauses 12.3.1.2 and 12.3.1.3.)

Dimensions	2-5/8 in	4 in	
		3/4 in bolt	7/8 in bolt
Diameter of plate	66.5	102.1	102.1
Diameter of bolt hole	20.6	20.6	23.9
Thickness of plate	4.3	5.1	5.1
Depth of flange	10.7	15.7	15.7

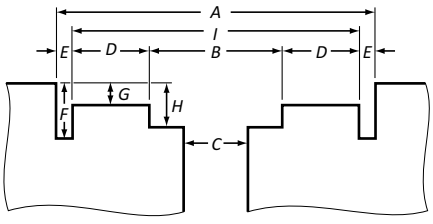
12.3.1.4 Connector grooves

Connector grooves shall have the dimensions specified in Tables 12.6A and 12.6B for split rings and shear plates respectively.

Table 12.6A
Groove dimension for split rings, mm
(See Clause 12.3.1.4.)

Dimensions	2-1/2 in split ring	4 in split ring
Bolt hole diameter	14.3	20.6
Inside diameter	65.0	103.6
Width	4.6	5.3
Depth	9.8	13.1

Table 12.6B
Groove dimension for shear plates, mm
(See Clause 12.3.1.4.)

Dimensions	2-5/8 in shear plate	4 in shear plate	
		3/4 in bolt	7/8 in bolt
	*A* = 66.8	102.4	102.4
	B = not applicable	39.4	39.4
	C = 20.6	20.6	23.8
	D = not applicable	24.6	24.6
	E = 4.5	5.3	5.3
	F = 11.4	16.3	16.3
	G = 6.4	5.6	5.6

(Continued)