



Run Smart™

COLUMBIA WORKSHOP MANUAL

**Models: CL112
CL120**

Foreword

The purpose of this manual is to assist the service technician when the vehicle is serviced. Major drivetrain component service information is not included in this manual, but is located in each manufacturer's service manual.

Instructions and procedures are those recommended by Freightliner Trucks or the component manufacturer.

Maintenance schedules and additional service information are included in the *Columbia™ Maintenance Manual*.

IMPORTANT: Descriptions and specifications in this manual were in effect at the time of printing. Freightliner Trucks reserves the right to discontinue models, and to change specifications or design at any time without notice and without incurring obligation. Descriptions and specifications contained in this publication provide no warranty, expressed or implied, and are subject to revision and editions without notice.

Refer to www.Daimler-TrucksNorthAmerica.com and www.FreightlinerTrucks.com for more information, or contact Daimler Trucks North America LLC at the address below.

Environmental Concerns and Recommendations

Whenever you see instructions in this manual to discard materials, you should attempt to reclaim and recycle them. To preserve our environment, follow appropriate environmental rules and regulations when disposing of materials.

NOTICE: Parts Replacement Considerations

Do not replace suspension, axle, or steering parts (such as springs, wheels, hubs, and steering gears) with used parts. Used parts may have been subjected to collisions or improper use and have undetected structural damage.

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Descriptions of Service Publications

Daimler Trucks North America LLC distributes the following major service publications in paper and electronic (via ServicePro®) formats.

Workshop/Service Manual	Workshop/service manuals contain service and repair information for all vehicle systems and components, except for major components such as engines, transmissions, and rear axles. Each workshop/service manual section is divided into subjects that can include general information, principles of operation, removal, disassembly, assembly, installation, specifications, and troubleshooting.
Maintenance Manual	Maintenance manuals contain routine maintenance procedures and intervals for vehicle components and systems. They have information such as lubrication procedures and tables, fluid replacement procedures, fluid capacities, specifications, and procedures for adjustments and for checking the tightness of fasteners. Maintenance manuals do not contain detailed repair or service information.
Driver's/Operator's Manual	Driver's/operator's manuals contain information needed to enhance the driver's understanding of how to operate and care for the vehicle and its components. Each manual contains a chapter that covers pretrip and post-trip inspections, and daily, weekly, and monthly maintenance of vehicle components. Driver's/operator's manuals do not contain detailed repair or service information.
Service Bulletins	<p>Service bulletins provide the latest service tips, field repairs, product improvements, and related information. Some service bulletins are updates to information in the workshop/service manual. These bulletins take precedence over workshop/service manual information, until the latter is updated; at that time, the bulletin is usually canceled. The service bulletins manual is available only to dealers. When doing service work on a vehicle system or part, check for a valid service bulletin for the latest information on the subject.</p> <p>IMPORTANT: Before using a particular service bulletin, check the current service bulletin validity list to be sure the bulletin is valid.</p>
Parts Technical Bulletins	Parts technical bulletins provide information on parts. These bulletins contain lists of parts and BOMs needed to do replacement and upgrade procedures.

Web-based repair, service, and parts documentation can be accessed using the following applications on the AccessFreightliner.com website.

ServicePro	ServicePro® provides Web-based access to the most up-to-date versions of the publications listed above. In addition, the Service Solutions feature provides diagnostic assistance with Symptoms Search, by connecting to a large knowledge base gathered from technicians and service personnel. Search results for both documents and service solutions can be narrowed by initially entering vehicle identification data.
PartsPro	PartsPro® is an electronic parts catalog system, showing the specified vehicle's build record.
EZWiring	EZWiring™ makes Freightliner, Sterling, Western Star, Thomas Built Buses, and Freightliner Custom Chassis Corporation products' wiring drawings and floating pin lists available online for viewing and printing. EZWiring can also be accessed from within PartsPro.

Descriptions of Service Publications

Warranty-related service information available on the AccessFreightliner.com website includes the following documentation.

Recall Campaigns

Recall campaigns cover situations that involve service work or replacement of parts in connection with a recall notice. These campaigns pertain to matters of vehicle safety. All recall campaigns are distributed to dealers; customers receive notices that apply to their vehicles.

Field Service Campaigns

Field service campaigns are concerned with non-safety-related service work or replacement of parts. All field service campaigns are distributed to dealers; customers receive notices that apply to their vehicles.

Page Description

For an example of a *Columbia Workshop Manual* page, see **Fig. 1**.

The diagram shows a page from a workshop manual. At the top left, 'Threaded Fasteners' is the section title (A). To its right is the section number '00.04' (B). Below the section number is the text 'General Instructions' (C). The page contains several sections: 'Fastener Replacement', 'Fastener Selection and Installation', and 'Thread Locking Compound Application'. Each section has detailed instructions. At the bottom left, the manual title 'Columbia Workshop Manual, April 2000' is shown (D). Below that is the date '11/02/1999' (E). At the bottom right, the subject number '100/1' is shown (F), and below it is the subject page number '277' (G).

Threaded Fasteners **00.04**

General Instructions

Fastener Replacement

When replacing fasteners, use only identical bolts, washers, and nuts; they must be the same size, strength, and finish as originally specified. See the Freightliner Service Parts Catalog for fastener specifications.

When replacing graded (or metric class) bolts and capscrews, use only fasteners that have the manufacturer's trademark or identification on the bolt head; do not use substandard bolts. Inferior, counterfeit fasteners are difficult to identify; buy your fasteners from a reputable supplier.

Fastener Selection and Installation

When using nuts with bolts, use a grade (or class) of nut that matches the bolt.

When installing non-flanged fasteners, use hardened steel flatwashers under the bolt (capscrew) head, and under the hexnut or locknut.

For bolts 4 inches (100 mm) or less in length, make sure that at least 1-1/2 threads and no more than 5/8-inch (16-mm) bolt length extends through the nut after it has been tightened. For bolts longer than 4 inches (100 mm), allow a minimum of 1-1/2 threads and a maximum of 3/4-inch (19-mm) bolt length.

Never hammer or screw bolts into place. Align the holes of the parts being attached, so that the nut and bolt surfaces are flush against the washers, and the washers are flush against the parts.

When installing fasteners in aluminum or plastic parts with threaded holes, start the fasteners by hand, to ensure straight starting and to prevent damaged threads.

Do not use lockwashers (split or toothed) next to aluminum surfaces.

When installing studs that do not have an interference fit, install them with thread locking compound, as instructed in this subject.

When installing parts that are mounted on studs, use free-spinning (non-locking) nuts and helical-spring (split) lockwashers or internal-tooth lockwashers. Do not use locknuts, because they tend to loosen the studs during removal. Do not use plain washers (flatwashers).

Do not use lockwashers and flatwashers in combination (against each other); each defeats the other's purpose.

Use stainless steel fasteners against chrome plating, unpainted aluminum, or stainless steel.

Fastener Tightening

Before installing fasteners, clean all fastener (and parts) threads, and all surfaces being clamped.

To ensure they are always torqued accurately, Freightliner recommends that all fasteners be lubricated with oil (unless specifically instructed to install them dry), then torqued to the values for lubricated- and plated-thread fasteners. When locking compound or antiseize compound is recommended for a fastener, the compound acts as a lubricant, and oil is not needed.

Bring parts and fasteners into contact, with no gaps between them, before using a torque wrench to tighten fasteners to their final torque values.

Tighten the nut, not the bolt head. This will give a truer torque reading by eliminating bolt body friction.

Always use a torque wrench to tighten fasteners, and use a slow, smooth, even pull on the wrench. Do not overtighten fasteners; overtightening causes permanent stretching of the fasteners, which can result in breakage of the parts or fasteners.

If specific torque values are not given for countersunk bolts, use the torque value for the corresponding size and grade of regular bolt, as given in **Subject 400**.

Always follow the torque sequence or torque interval when provided, to ensure that clamping forces are even, and parts and fasteners are not distorted.

Thread Locking Compound Application

When the use of thread locking compound is recommended or desired, for studs, capscrews, and bolts with a thread diameter of 1 inch (25 mm) or less, use Loctite® 271 or Perma-Lok® HM-128.

For thread diameters over 1 inch (25 mm), use Loctite 277.

Columbia Workshop Manual, April 2000

11/02/1999

100/1

277

11/02/1999

f020045a

A. Section Title
B. Section Number (made up of the Group Number—first two digits, followed by a sequence number—last two digits)
C. Subject Title
D. Manual Title
E. Release (Supplement) Date
F. Subject Number
G. Subject Page Number

Fig. 1, Example of a Columbia Workshop Manual Page

Group No.	Group Title
00	General Information
01	Engine
09	Air Intake
13	Air Compressor
15	Alternators and Starters
20	Engine Cooling/Radiator
25	Clutch
26	Transmission
30	Throttle Control
31	Frame and Frame Components
32	Suspension
33	Front Axle
35	Rear Axle
40	Wheels and Tires
41	Driveline
42	Brakes
46	Steering
47	Fuel
49	Exhaust
54	Electrical, Instruments, and Controls
60	Cab
72	Doors
82	Windshield Wipers and Washer
83	Heater and Air Conditioner
88	Hood, Grille, and Cab Fenders
91	Seats and Restraint Systems
98	Paint

List of Abbreviations

The following is a list of definitions for abbreviations and symbols used in Freightliner publications.

A	amperes	BBC	bumper-to-back-of-cab	CUM	Cummins
AAVA	auxiliary air valve assembly	BHM	bulkhead module	CVSA	Commercial Vehicle Safety Alliance
ABS	antilock braking system	BOC	back-of-cab	CWS	collision warning system
ABS	acrylonitrile-butadiene-styrene	BOM	bill of material	DC	direct current
A/C	air conditioner	BTDC	before top dead center	DCA	diesel coolant additive
AC	alternating current	Btu(s)	British thermal unit(s)	DCDL	driver-controlled differential lock
acc	accessories	C	common (terminal)	DDA	Detroit Diesel Allison (obs)
ACM	aftertreatment control module	CAC	charge air cooler	DDC	Detroit Diesel Corporation
ACPU	air conditioning protection unit	CAN	controller area network	DDDL	Detroit Diesel Diagnostic Link
ADLO	auto-disengagement lockout	CARB	California Air Resources Board	DDE	Detroit Diesel Engines
AGM	absorbed glass mat	CAT	Caterpillar	DDEC	Detroit Diesel Electronic (engine) Control
AGS	automated gear shift	CB	circuit breaker	DDR	diagnostic data reader
AG2	Aluminum Generation 2	CB	citizens' band	DDU	driver display unit
a.m.	<i>ante meridiem</i> (midnight to noon)	CBE	cab behind engine	def	defrost
AM	amplitude modulation	CCA	cold cranking amperes	DEF	diesel exhaust fluid
amp(s)	ampere(s)	CCR	California Code of Regulations	DFI	direct fuel injection
AMT	automated mechanical transmission	CD-ROM ..	compact-disc/read-only memory	DGPS	differential global positioning system
AMU	air management unit	CDTC	constant discharge temperature control	DHD	dealer help desk
ANSI	American National Standards Institute	CEL	check-engine light	dia.	diameter
API	American Petroleum Institute	CFC	chlorofluorocarbons (refrigerant-12)	DIAG	diagnosis
API	application programming interface	cfm	cubic feet per minute	DIP	dual inline package (switch)
ARI	Air Conditioning and Refrigeration Institute	CFR	Code of Federal Regulations	DIU	driver interface unit
ASA	American Standards Association	CGI	clean gas induction	DLA	datalink adaptor
ASF	American Steel Foundries	CGW	central gateway	DLM	datalink monitor
ASR	automatic spin regulator	CHM	chassis module	DLU	data logging unit
assy.	assembly	CIP	cold inflation pressure	DMM	digital multimeter
ASTM	American Society for Testing and Materials	CLDS	cab load disconnect switch	DOC	diesel oxidation catalyst
ATC	automatic temperature control	CLS	coolant level sensor	DOT	Department of Transportation
ATC	automatic traction control	cm	centimeters	DPF	diesel particulate filter
ATC	automatic transmission control	cm³	cubic centimeters	DRL	daytime running lights
ATD	aftertreatment device	CMVSS	Canadian Motor Vehicle Safety Standard	DRM	dryer reservoir module
ATF	automatic transmission fluid	Co.	company	DSM	district service manager
ATS	aftertreatment system	COE	cab over engine	DTC	diagnostic trouble code
attn	attention	Corp.	corporation	DTC	discharge temperature control
aux.	auxiliary	CPC	common powertrain controller	DTNA	Daimler Trucks North America
av	<i>avoirdupois</i> (British weight system)	CPU	central processing unit	DVOM	digital volt/ohm meter
AWD	all-wheel drive	CRT	cathode ray tube	ea.	each
AWG	American wire gauge	cSt	centistokes (unit of measurement for describing the viscosity of general liquids)	EBS	electronic braking system
AWS	American Welding Society	cu ft	cubic feet	ECA	electric clutch actuator
BAT	battery	cu in	cubic inches	ECAP	electronic control analyzer programmer
				ECAS	electronically controlled air suspension

List of Abbreviations

ECI	electronically controlled injection	FM	frequency modulation	HVLP	high velocity, low pressure
ECL	engine coolant level	FMCSA	Federal Motor Carrier Safety Administration	H/W	hardware
ECM	electronic control module	FMEA	failure mode effects analysis	Hz	hertz
ECT	engine coolant temperature	FMI	failure mode indicator	IAD	interaxle differential
ECU	electronic control unit	FMSI	Friction Materials Standards Institute	ICS	integrated child seat
EDM	electronic data monitor	FMVSS	Federal Motor Vehicle Safety Standard	ICU	instrumentation control unit
EEPROM ..	electrically erasable programmable read-only memory	FRP	fiberglass reinforced plastic	i.d.	inside diameter
EFG	electric fuel gauge	FSA	field service authorization	ID	identification
EFPA	electronic foot pedal assembly	FSM	fleet service manager	IFI	Industrial Fasteners Institute
EGR	exhaust gas recirculation	ft	feet	IFS	independent front suspension
ELC	extended-life coolant	ft³	cubic feet	IGN	ignition
EMC	electromagnetic compatibility	ft³/min	cubic feet per minute	ILB	intelligent lightbar
EMI	electromagnetic interference	FTL	Freightliner	ILO	<i>in lieu of</i> (in the place of)
EOA	electric over air	F.U.E.L.	fuel usage efficiency level	in	inches
EP	extreme pressure (describes an antiwear agent added to some lubricants)	g	grams	in³	cubic inches
EPA	Environmental Protection Agency	gal	gallons	Inc.	incorporated
EPS	engine position sensor	GAWR	gross axle weight rating	inH₂O	inches of water
ESC	electronic stability control	GHG	greenhouse gas	inHg	inches of mercury
ESC	enhanced stability control	GHG14	greenhouse gas and fuel efficiency regulations	I/O	input/output
ESD	electrostatic discharge	GL	gear lubricant	IP	instrument panel
ESS	engine syncro shift (transmission)	GND	ground	ISO	International Organization for Standardization
etc.	<i>et cetera</i> (and so forth)	gpm	gallons per minute	IVS	idle validation switch
ETEC	electronic truck engine control	GPS	global positioning system	k	kilo (1000)
EUI	electronic unit (fuel) injectors	GVWR	gross vehicle weight rating	kg	kilograms
EVA	electronic vibration analyzer	HBED	hard-braking event data	km	kilometers
EXM	(chassis) expansion module	HCM	hybrid control module	km/h	kilometers per hour
E85	85% ethanol fuel	HCOE	high cab over engine	kPa	kilopascals
FAS	Freightliner air suspension	HCU	hydraulic control unit	kW	kilowatts
FCCC	Freightliner Custom Chassis Corporation	HD	heavy-duty	L	liters
FCU	forward control unit	HDU	hybrid drive unit	lb	pounds
FET	field effect transistor	HEPA	high-efficiency particulate air (filter)	LBCU	lightbar control unit
Fig.	figure	HEST	high exhaust system temperature	lbf-ft	pounds force feet
fl oz	fluid ounces	HEV	hybrid electric vehicle	lbf-in	pounds force inches
FLA	post-1984 advancements Freightliner COE	HFC	hydrogenated fluorocarbons (refrigerant-134a)	LCD	liquid crystal display
FLB	enhanced Freightliner FLA COE	hp	horsepower	LCOE	low cab over engine
FLC	steel-cab Freightliner 112 Conventional	hp	high pressure	LED	light-emitting diode
FLD	post-1984 advancements Freightliner 112/120 aluminum-cab Conventional	HRC	Rockwell "C" hardness	LFL	lower flammability limit
FLR	forward-looking radar	hr(s)	hour(s)	LH	left-hand
		HSA	hill start aid	LHD	left-hand drive
		HSD	high-side driver	LH DR	left-hand-drive
		htr.	heater	LHK	liters per hundred kilometers
		HVAC	heating, ventilating, and air conditioning	LHS	low-hydrogen steel
				LIN	Local Interconnect Network
				LLC	limited liability company
				L/min	liters per minute
				LNG	liquefied natural gas
				LPG	liquefied petroleum gas

List of Abbreviations

LPG	liquid propane gas	NO	normally open (terminal or switch)	POE	polyol ester
LPI	liquid propane injection	NOAT	Nitrited Organic Acid Technology	PRD	pressure relief device
LPR	low pressure reservoir	NOx	nitrogen oxides	PRD	product requirements document
LRR	low-rolling resistance	no.	number	PSA	pressure-sensitive adhesive
LSD	low-side driver	NPT	national pipe thread	PSG	pressure sensor governor
LVD	low-voltage disconnect	NPTF	national pipe thread fitting	psi	pounds per square inch
m	meters	NT	nylon tube or nylon tubing	psia	pounds per square inch, atmosphere
max.	maximum	NTSB	National Transportation Safety Board	psig	pounds per square inch, gauge
M-B	Mercedes-Benz	OAT	Organic Acid Technology	pt	pints
MCM	motor control module	OBd(s)	on-board diagnostic(s)	PTCM	pressure time control module
MESA	Mining Enforcement Safety Act	obs	obsolete	PTO	power takeoff
mfr.	manufacturer	OC	open circuit	PTP	powertrain protection
mi	miles	OCV	open circuit voltage	PTPDM	powertrain power distribution module
MID	message identifier	o.d.	outside diameter	pvc	polyvinyl chloride
MIL	malfunction indicator lamp (light)	O.D.	overdrive	PWM	pulse width modulation
MIL	military specification	OEM	original equipment manufacturer	pwr	power
min.	minutes	OPD	overflow protection device	qt	quarts
min.	minimum	OSHA	Occupational Safety and Health Administration	qty.	quantity
misc.	miscellaneous	oz	ounces	R & O	rust inhibitors and oxidants
mL	milliliters	ozf-in	ounces force inches	R-12	refrigerant-12 (CFC)
mm	millimeters	p	positive (front axle wheel alignment specification)	R-134a	refrigerant-134a (HFC)
mod.	module	PACE	programmable electronically controlled engine	RAM	random access memory
mpg	miles per gallon	PAG	polyalkylene glycol (oil)	RC	reserve capacity
mph	miles per hour	parm	parameter	recirc.	recirculation
MSF	modular switch field	PAS	passenger advisory system	Ref(s)	reference(s)
MMT	methylcyclopentadienyl manganese tricarbonyl	PC	personal computer	regen	regeneration
MSHA	Mining Safety and Health Administration	PCB	printed circuit board	RELS	reduced engine load at stop
MVDA	Motor Vehicle Dealers Association	PDC(s)	parts distribution center(s)	RFI	radio frequency interference
n	negative (front axle wheel alignment specification)	PDI	pre-delivery inspection	RH	right-hand
N	nitrogen	PDM	power distribution module	RHD	right-hand drive
N/A	not applicable	PEC	power electronics carrier	RH DR	right-hand-drive
N-cm	Newton-centimeters	PEEC	programmable electronic engine control	R/I	removal and installation
NC	normally closed (terminal or switch)	PID	parameter identifier	RMA	return material authorization
NCG	noncondensable gases	PKP	Purple-K powder	ROM	read-only memory
NHTSA	National Highway Traffic Safety Administration	PLC	power line carrier	rpm	revolutions per minute
NIOSH	National Institute for Occupational Safety and Health	PLD	<i>Pumpe-Linie-Düse</i> (pump-line-nozzle)	R/R	removal and replacement
NITE	no idle thermal environment	PNDB	power-net distribution box	RSA	roll-stability advisor
NLA	no longer available	PM	particulate matter	RSG	road speed governor
NLGI	National Lubricating Grease Institute	p.m.	<i>post meridiem</i> (noon to midnight)	RSM	regional service manager
N-m	Newton-meters	p/n	part number	RTS	ready-to-spray
		PO	purchase order	RTV	room temperature vulcanizing
				RV	recreational vehicle
				SA	source address
				S-ABA	self-setting automatic brake adjusters

List of Abbreviations

SAE	Society of Automotive Engineers	°C	degrees Celsius (centigrade)
SB	service bulletin	°F	degrees Fahrenheit
SBT	seat back thickness	#	number
SBW	shift-by-wire	%	percent
SCA(s)	Supplemental Coolant Additive(s)	&	and
SCR	selective catalytic reduction	©	copyright
SCU	system control unit (speedometer)	™	trademark
SD	severe-duty	®	registered trademark
SDU	step deployment unit		
SEL	shutdown engine light		
SEM	switch expansion module		
SEO	stop engine override		
SHM	switch hub module		
SI	service information		
SI	<i>Système International</i>		
SID	subsystem identifier		
SM	system malfunction		
SMC	sheet molded compound		
S/N	serial number		
SOC	state-of-charge		
SPACE	seat pretensioner activation for crash survival enhancement		
SPG	special purpose grease		
SPN	suspect parameter number		
sq in	square inches		
SRP	seating reference point		
SRS	supplemental restraint system		
SRS	synchronous reference sensor		
SRT	standard repair time		
SSD	side sensor display		
SSID	smart switch identification		
SST	stainless steel		
std.	standard		
S/W	software		
SW	switch		
TAM	thermocouple amplifier module		
TBB	Thomas Built Buses		
TBS	turbo boost sensor		
TCM	transmission control module		
TCU	transmission control unit		
TDC	top dead center		
TDR	technician diagnostic routine		
TEM	truck equipment manufacturer		
temp	temperature		
TIG	tungsten inert gas		
TIR	total indicator reading		
TMC	Technology and Maintenance Council		
TPMS	tire pressure monitoring system		
TPS	thermal protection switch		
TPS	throttle position sensor		
TRS	timing reference sensor		
TSO	truck specification order		
TSU	transmission shift unit		
TXV	thermal expansion valve		
U.D.	underdrive		
ULSD	ultralow-sulfur diesel		
UNC	unified national coarse		
UNF	unified national fine		
U.S.	United States		
U.S.A.	United States of America		
USC	United States customary (measures)		
V	volts		
VCU	vehicle control unit		
VDC	vehicle data computer		
Vdc	volts, direct current		
VIMS	vehicle information management system		
VIN	vehicle identification number		
VIP	vehicle instrumentation and protection (Kysor)		
VIW	vehicle interface wiring (connector)		
VOC	volatile organic compounds		
VOM	volt-ohmmeter		
VRS	variable resistance sensor		
VSG	variable speed governor		
VSS	vehicle speed sensor		
VSU	vehicle security unit		
WB	wire braid		
WI	work instructions		
WIF	water-in-fuel		
WOT	wide open throttle		
-	minus or negative		
+	plus or positive		
±	plus-or-minus		
>	greater than		
<	less than		
x	by (used in fastener size descriptions)		
"	inches		
°	degrees (of an angle)		

General Information

U.S. Customary to Metric			Metric to U.S. Customary		
When You Know	Multiply By	To Get	When You Know	Multiply By	To Get
Length					
inches (in)	25.4	millimeters (mm)	0.03937		inches (in)
inches (in)	2.54	centimeters (cm)	0.3937		inches (in)
feet (ft)	0.3048	meters (m)	3.281		feet (ft)
yards (yd)	0.9144	meters (m)	1.094		yards (yd)
miles (mi)	1.609	kilometers (km)	0.6215		miles (mi)
Area					
square inches (in ²)	645.16	square millimeters (mm ²)	0.00155		square inches (in ²)
square inches (in ²)	6.452	square centimeters (cm ²)	0.15		square inches (in ²)
square feet (ft ²)	0.0929	square meters (m ²)	10.764		square feet (ft ²)
Volume					
cubic inches (in ³)	16387.0	cubic millimeters (mm ³)	0.000061		cubic inches (in ³)
cubic inches (in ³)	16.387	cubic centimeters (cm ³)	0.06102		cubic inches (in ³)
cubic inches (in ³)	0.01639	liters (L)	61.024		cubic inches (in ³)
fluid ounces (fl oz)	29.54	milliliters (mL)	0.03381		fluid ounces (fl oz)
pints (pt)	0.47318	liters (L)	2.1134		pints (pt)
quarts (qt)	0.94635	liters (L)	1.0567		quarts (qt)
gallons (gal)	3.7854	liters (L)	0.2642		gallons (gal)
cubic feet (ft ³)	28.317	liters (L)	0.03531		cubic feet (ft ³)
cubic feet (ft ³)	0.02832	cubic meters (m ³)	35.315		cubic feet (ft ³)
Weight/Force					
ounces (av) (oz)	28.35	grams (g)	0.03527		ounces (av) (oz)
pounds (av) (lb)	0.454	kilograms (kg)	2.205		pounds (av) (lb)
U.S. tons (t)	907.18	kilograms (kg)	0.001102		U.S. tons (t)
U.S. tons (t)	0.90718	metric tons (t)	1.1023		U.S. tons (t)
Torque/Work Force					
inch-pounds (lbf-in)	11.298	Newton-centimeters (N-cm)	0.08851		inch-pounds (lbf-in)
foot-pounds (lbf-ft)	1.3558	Newton-meters (N-m)	0.7376		foot-pounds (lbf-ft)
Pressure/Vacuum					
inches of mercury (inHg)	3.37685	kilo Pascals (kPa)	0.29613		inches of mercury (inHg)
pounds per square inch (psi)	6.895	kilo Pascals (kPa)	0.14503		pounds per square inch (psi)

When You Know	Subtract	Then Divide By	To Get	When You Know	Multiply By	Then Add	To Get
degrees Fahrenheit (°F)	32	1.8	degrees Celsius (°C)	degrees Celsius (°C)	1.8	32	degrees Fahrenheit (°F)

Vehicle Receipt

Prior to signing for vehicle delivery from a transporter company, the dealer is responsible for checking for transporter-related shortages or damages, and noting these discrepancies on the transporter's delivery receipt.

The dealer is also responsible for ensuring that the vehicle was built according to the Truck Sales Order/ Invoice.

Refer to Section 3 of the Daimler Trucks North America LLC *Warranty Manual* for details.

Vehicle Storage

There may be times when a vehicle is stored for long periods before customer delivery. To protect all vehicles from deterioration and weather, they must be properly maintained. Adequate protection and storage of new vehicles is the responsibility of the dealer.

Claims arising from loss and damage to improperly stored vehicles will not be reimbursed.

See Section 3 of the Daimler Trucks North America LLC *Warranty Manual* for instructions on storage of new vehicles.

Pre-Delivery Information

All pre-delivery inspections and services must be performed at an authorized Daimler Trucks North America LLC facility, assigned to fully qualified service personnel and recorded on the "New Vehicle Pre-Delivery Inspection" form.

Refer to Section 3 of the Daimler Trucks North America LLC *Warranty Manual* for details.

It is recommended the pre-delivery inspection be performed within 30 days of vehicle receipt.

Hoses and Electrical Wiring Routing Standards

Cooling System

1. Cooling system hoses must clear all moving parts by a minimum of 1/4 inch (6 mm).
2. The 1-inch (25-mm) hose from the surge tank to the engine must be free of sumps and have allowance for engine torque.
3. All hoses from the engine hard pipes must be wrapped in convoluted tubing.
4. Hoses that are protected with convoluted tubing may be secured with tie straps to clear the inner fenders.
5. Cooling system hoses should not be twisted or kinked.
6. Cooling system hoses must be routed at least 6 inches (152 mm) from a heat source if the heat source does not have a heat shield. If a heat shield is provided, the hose must be routed at least 3 inches (76 mm) from the heat source.

HVAC System

1. Cushion clamps are required to support all A/C lines. Butterfly or figure-8 clamps (two cushion clamps) may be used to prevent rubbing or chafing.
2. Heater hoses that are protected with convoluted tubing may be fastened with tie straps. If not protected with convoluted tubing, only cushion clamps or butterfly clamps may be used for heater hoses.
3. A/C lines cannot be secured to air lines, fuel lines, or electrical wires.
4. HVAC hoses should be protected from damage by routing them away from hazards of heat, wheel splash (water, gravel, ice), human traffic, and moving parts of the vehicle.
5. HVAC hoses should be routed away from sharp points and edges (such as nuts, bolts, brackets, and frame rail edges), moveable parts, and sources of abrasion, cutting, pinching, or crushing.

NOTE: If hoses are covered with convoluted tubing, they may touch any of the above.

6. Hoses that are protected with convoluted tubing may come in contact with the bends on frame rails and filters.
7. HVAC hoses must be routed at least 6 inches (152 mm) from a heat source if the heat source does not have a heat shield. If a heat shield is provided, the hose must be routed at least 3 inches (76 mm) from the heat source.
8. All HVAC hoses must be routed so that regularly serviced components, such as fuel filters, fuel/water separators, oil filters, air filters, belts, and fill and drain plugs, are readily accessible for adjustment or replacement without the need to relocate or remove the hoses.
9. All A/C hoses in the engine compartment must have convoluted tubing.
10. If cushion clamps are used over convoluted tubing at existing clamp points, no additional tie straps or tape is needed.
11. When convoluted tubing is installed on the heater hose where it routes past the splash shield on the front right-hand side of the firewall, and if it uses existing clamps, no additional tie straps or tape is needed.

Auxiliary Heater

All auxiliary heater lines are deck-mounted hard piping with rubber hose at both ends. No additional tie straps are required.

Engine Plumbing

1. On vehicles equipped with the Cummins ISM engine and power steering, no additional tie straps or tape are needed if convoluted tubing is installed on the power steering hose where it routes under the frame rail.
2. The engine oil pressure line should not rub or chafe against the Teflon® discharge line.

Electrical Wiring

1. Wires that are bundled together should be fastened at 8- to 12-inch (203- to 305-mm) intervals. If anchor clamps are more than 12 inches (305

Hoses and Electrical Wiring Routing Standards

mm) apart, a tie strap must be used between the anchor clamps.

2. Bundles of wires that are located in an exposed area, such as under the cab or outside the frame rail, need to be fastened with heavy-duty cable ties.
3. Any wiring that will be exposed to water or heat must be covered with either loom or convoluted tubing. Loom or convoluted tubing need not butt up against Weather Pack® connectors.
4. Any wiring routed across the vehicle, on the engine crossmember, or across the rear of the engine, must be secured with a clamp or tie strap, and covered with either convoluted tubing or a loom.
5. Any wiring that may come into contact with sharp points and edges (such as nuts, bolts, brackets, and frame rail edges), moveable parts, and sources of abrasion, cutting, pinching, or crushing, must be protected by either a loom or convoluted tubing.
6. Unprotected breakouts (individual wires) of up to 8 inches (203 mm) are acceptable as long as these wires are routed safely away from sharp points and edges, moveable parts, and sources of abrasion, cutting, pinching, or crushing.
7. Gray, flame-retardant convoluted tubing may be used to protect wiring in the cab or the chassis. Black nylon convoluted tubing may only be used in the chassis.
8. All wiring must be routed so that regularly serviced components, such as fuel filters, fuel/water separators, oil filters, air filters, belts, and fill and drain plugs, are readily accessible for adjustment or replacement without the need to relocate or remove any wiring.
9. In exposed locations, such as the road light harness near the headlights, loose loops of wire must be secured with tie straps.
10. All wiring should be routed a minimum of 4 inches (102 mm) from the exhaust. In situations where the wiring is less than 4 inches (102 mm) from the exhaust, a heat shield must be placed between the wiring and the exhaust.

Battery Cables

1. Battery cables must be routed along an unobstructed path from the starter to the battery box. The cables must **not** rub or chafe on brackets, tanks, air lines, or fuel lines.
2. Battery cables and electrical wiring cannot be tied or secured to fuel lines, discharge lines, or air lines.
3. Battery cables must have support brackets no more than 30 inches (762 mm) apart. Tie straps must be within 6 inches (152 mm) of both sides of the support brackets, and every 12 inches (305 mm) between the brackets.
4. Battery cables must have convoluted tubing from the frame bracket to the batteries, and from the frame bracket to the starter.

Fuel Lines

1. Fuel lines must not be clamped to A/C lines, battery cables, jumper cables, or any other electrical wiring.
2. Stand-off brackets or clamps may be used to prevent fuel lines from rubbing against the frame.
3. Fuel lines must be routed at least 6 inches (152 mm) from a heat source. If a heat shield is provided, the fuel line must be at least 3 inches (76 mm) from the heat source.
4. Fuel lines that are parallel may be fastened together. Fuel lines that cross or that rub on metal, plastic, or electrical parts, need to be separated with butterfly clamps.

Chassis Air Lines and Brake Hoses

1. Hoses may come in contact with each other if they are parallel, or if they are bundled together.
2. If the hoses lie on the curve or flat surface of a bracket or crossmember, they do not need convoluted tubing.
3. Brake hoses may be clamped at the top of the axle housing, and touch or lie against the axle housing in its path to the brake chamber as this assembly moves together.

Hoses and Electrical Wiring Routing Standards

4. Brake hoses must have slack between the last clamping point on the frame rail and the brake chamber to allow for full range of suspension travel.
5. Brake hoses should have butterfly clamps at breakout points.
6. Air lines and brake hoses that are bundled together should be fastened at 8- to 12-inch (203- to 305-mm) intervals. If anchor clamps are more than 12 inches (305 mm) apart, a tie strap must be used between the anchor clamps. Tie straps may be closer than 12 inches (305 mm) apart.
7. Hoses or lines that may come into contact with the sharp edge of a bracket or frame rail are to be protected by convoluted tubing.
8. Air lines and brake hoses that are parallel may be fastened together. Air lines and brake hoses that cross or that rub on metal, plastic, or electrical parts need to be separated with butterfly clamps.
9. Nylon or STX (wire braid) chassis air lines may be fastened together to prevent rubbing, as long as the lines are stationary.

Threaded Fastener Types

The majority of threaded fasteners used throughout the vehicle have U.S. customary threads (diameter and pitch are measured in inches). See **Fig. 1**. However, the engine and some items attached to the cab use metric fasteners (diameter and pitch are measured in millimeters).

Most threaded fasteners used on the vehicle that are 1/2-inch diameter or larger are plain hex-type fasteners (non-flanged); *all* metric fasteners are non-flanged. Special hardened flatwashers are used under the bolt head, and between the part being attached and the hexnut, to distribute the load, and to prevent localized overstressing of the parts. The washers are cadmium- or zinc-plated, and have a hardness rating of 38 to 45 HRC.

Some fasteners smaller than 1/2-inch diameter are flanged fasteners, which have integral flanges that fit against the parts being fastened. The flanges eliminate the need for washers.

NOTE: The standard fasteners used to assemble the vehicle frame and to attach components to the vehicle frame are threaded lockbolts (Spin Hucks). These fasteners are covered in **Section 31.00**.

Fastener Grades and Classes

Fasteners with U.S. customary threads are divided into grades established by the Society of Automotive Engineers (S.A.E.) or the International Fastener Institute (I.F.I.). The fastener grades indicate the relative strength of the fastener; the higher the number (or letter), the stronger the fastener. Bolt (capscrew) grades can be identified by the number and pattern of radial lines forged on the bolt head. See **Fig. 2**. Hexnut (and locknut) grades can be identified by the number and pattern of lines and dots on various surfaces of the nut. See **Fig. 3**. Nearly all of the bolts used on the vehicle are grades 5, 8, and 8.2. Matching grades of hexnuts are always used: grade 5 or grade B hexnuts are used with grade 5 bolts; grade 8, grade C, or grade G (flanged) hexnuts are used with grade 8 or 8.2 bolts.

Fasteners with metric threads are divided into classes adopted by the American National Standards Institute (ANSI). The higher the class number, the

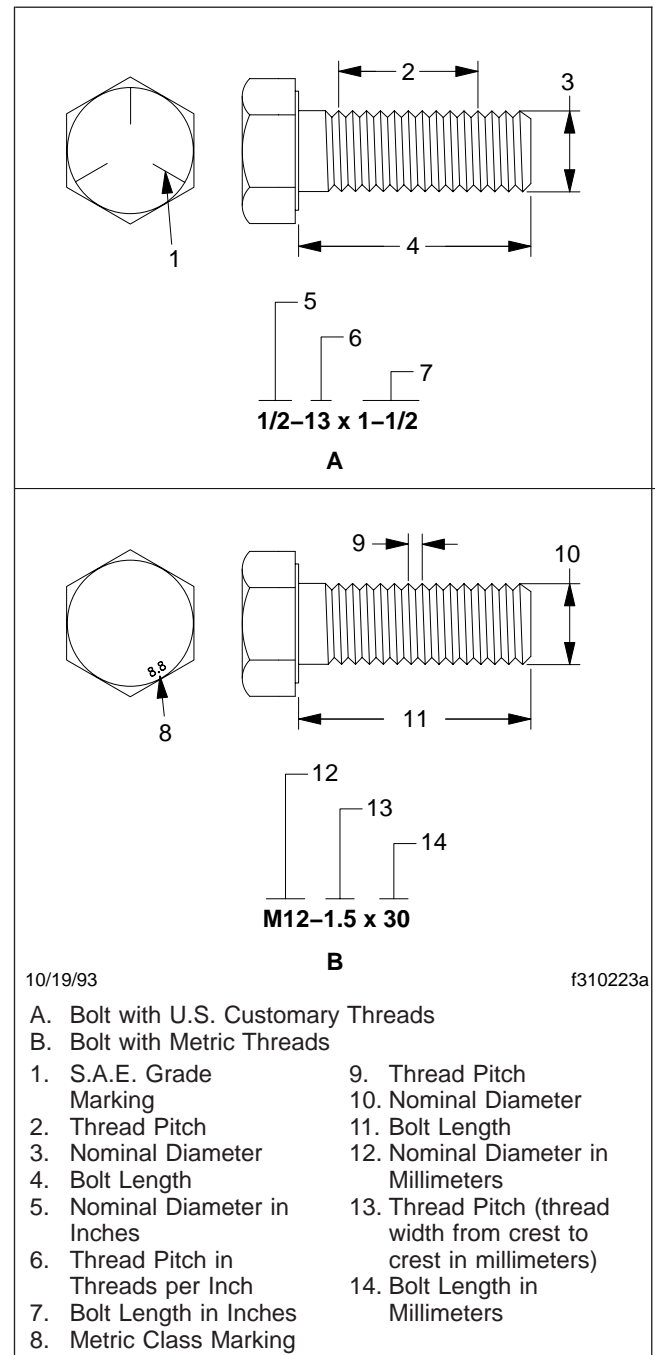


Fig. 1, Fastener Size and Thread Identification

stronger the fastener. Bolt classes can be identified by the numbers forged on the head of the bolt. See **Fig. 4**. Hexnut (and locknut) classes can be identified by the marks or numbers on various surfaces of the

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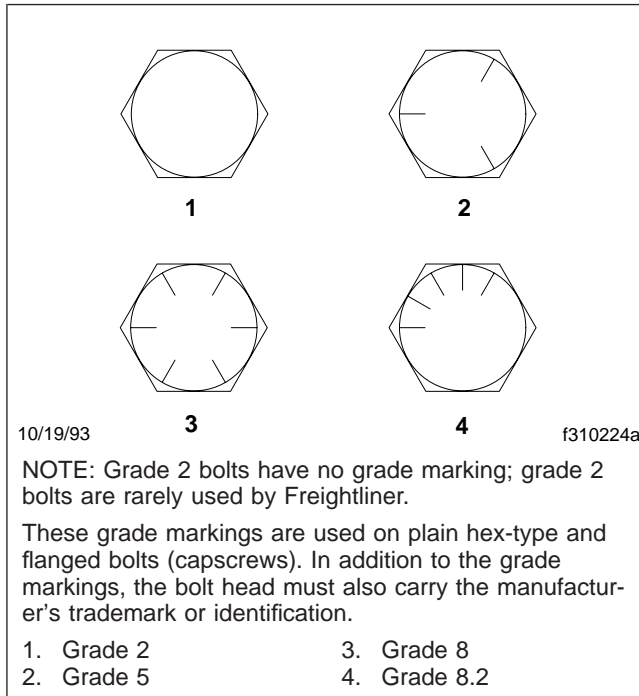


Fig. 2, Bolt Grades

nut. See **Fig. 5**. Class 8 hexnuts are always used with class 8.8 bolts; class 10 hexnuts with class 10.9 bolts.

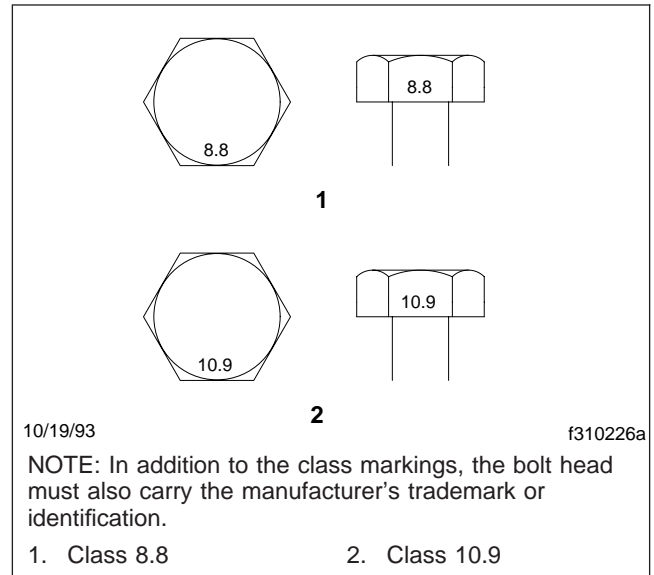


Fig. 4, Bolt Classes

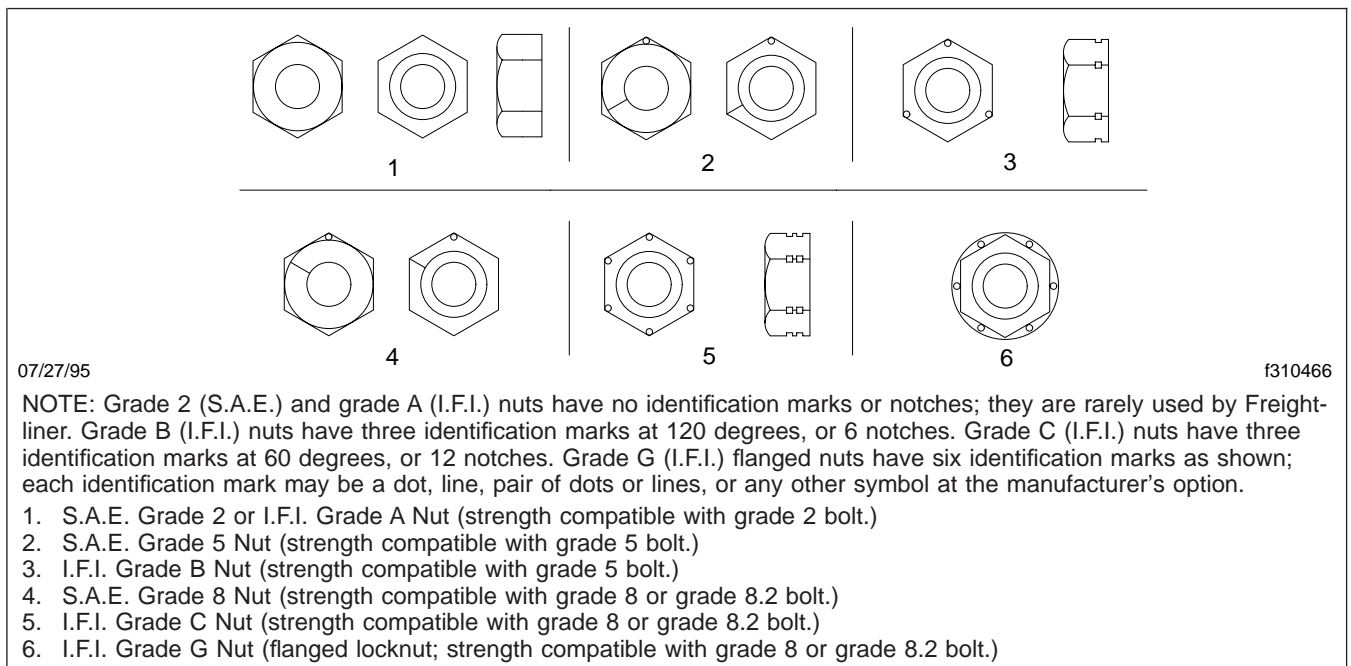


Fig. 3, Nut Grades

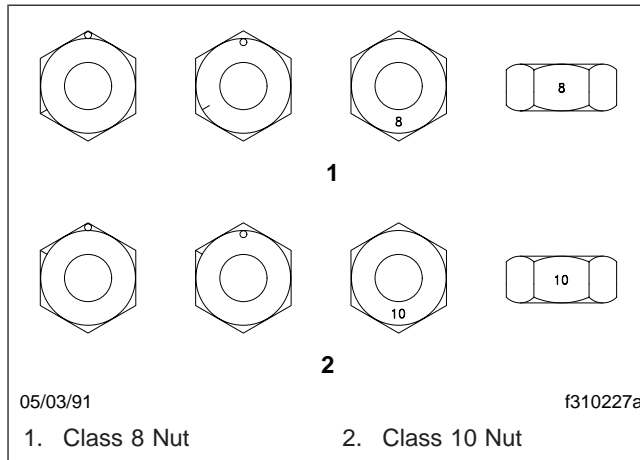


Fig. 5, Nut Classes

Frame Fasteners

The standard fasteners used to assemble the vehicle frame and to attach most components to the vehicle frame are threaded lockbolts (Spin Hucks). These fasteners are covered in [Section 31.00](#).

For some other components attached to the frame, grade 8 and 8.2 phosphate-and oil-coated hexhead bolts and grade C cadmium-plated and wax-coated prevailing torque locknuts are used. The prevailing torque locknuts have distorted sections of threads to provide torque retention. For attachments where clearance is minimal, low-profile hexhead bolts and grade C prevailing torque locknuts are used. See [Fig. 6](#).

Tightening Fasteners

When a capscrew is tightened to its torque value in a threaded hole, or a nut is tightened to its torque value on a bolt, the shank of the capscrew or bolt is stretched slightly. This stretching (tensioning) results in a preload that reduces fatigue of the fasteners. The torque values given in the tables in [Specifications, 400](#) have been calculated to provide enough clamping force on the parts being fastened, and the correct tensioning of the bolt to maintain the clamping force.

Use of a torque wrench to tighten fasteners will help prevent overtensioning them. Overtensioning causes permanent stretching of the fasteners, which can result in breakage of the parts or fasteners.

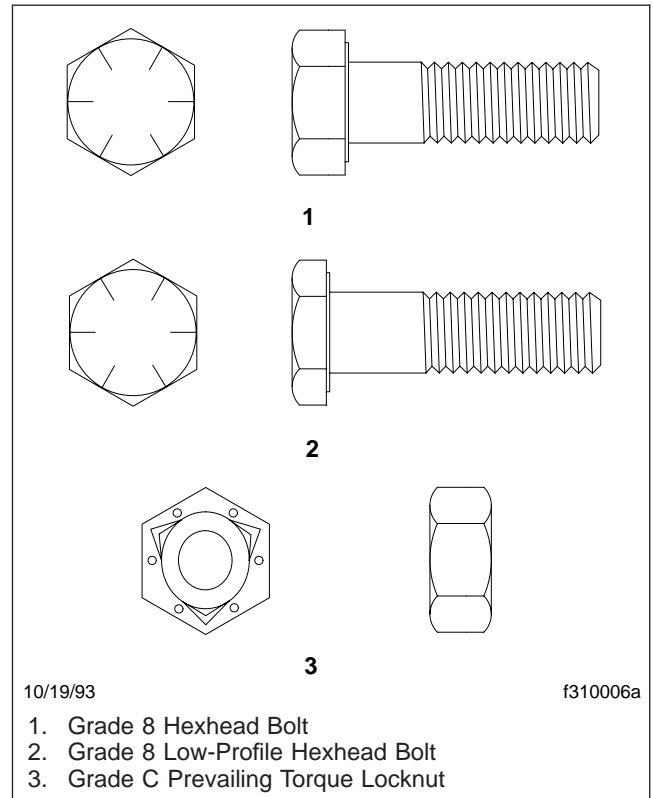


Fig. 6, Frame Fastener Identification

When torquing a fastener, typically 80 to 90 percent of the turning force is used to overcome friction; only 10 to 20 percent is used to stretch the capscrew or bolt. About 40 to 50 percent of the turning force is needed to overcome the friction between the underside of the capscrew head or nut and the washer. Another 30 to 40 percent is needed to overcome the friction between the threads of the capscrew and the threaded hole, or the friction between the threads of the nut and bolt.

The amount of torque required to tighten a fastener is reduced when the amount of friction is reduced. If a fastener is dry (unlubricated) and plain (unplated), the amount of friction is high. If a fastener is wax-coated or oiled, or has a zinc phosphate coating or cadmium plating, the amount of friction is reduced. Each of these coatings and combinations of coatings has a different effect. Using zinc-plated hardened flatwashers under the bolt (capscrew) head and nut reduces the amount of friction. Dirt or other foreign

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Threaded Fasteners

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material on the threads or clamping surfaces of the fastener or clamped part also changes the amount of friction.

Even though each different condition affects the amount of friction, a different torque value cannot be given for each different condition. To ensure they are always torqued accurately, Freightliner recommends that all fasteners be lubricated with oil (unless specifically instructed to install them dry), then torqued to the values for lubricated- and plated-thread fasteners. When locking compound or anti-seize compound is recommended for a fastener, the compound acts as a lubricant, and oil is not needed.