CATERPILLAR®

KENR7661-01
September 2008

Schematic

420E and 430E Backhoe Loader Electrical System

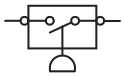
420E:
PRA1-UP
PHC1-UP

430E:
SCD1-UP
RLN1-UP

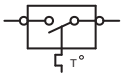
Printed in U.S.A.

Harness And Wire Electrical Schematic Symbols

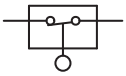
Symbols



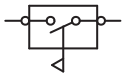
Pressure Symbol



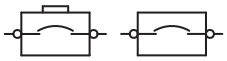
Temperature Symbol



Level Symbol



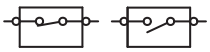
Flow Symbol



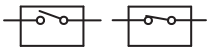
Circuit Breaker Symbol

Symbols and Definitions

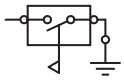
Fuse: A component in an electrical circuit that will open the circuit if too much current flows through it.



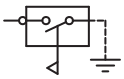
Switch (Normally Open): A switch that will close at a specified point (temp, press, etc.). The circle indicates that the component has screw terminals and a wire can be disconnected from it.



Switch (Normally Closed): A switch that will open at a specified point (temp, press, etc.). No circle indicates that the wire cannot be disconnected from the component.

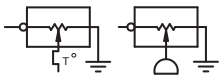


Ground (Wired): This indicates that the component is connected to a grounded wire. The grounded wire is fastened to the machine.

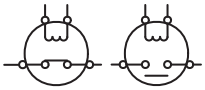


Ground (Case): This indicates that the component does not have a wire connected to ground. It is grounded by being fastened to the machine.

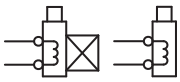
Reed Switch: A switch whose contacts are controlled by a magnet. A magnet closes the contacts of a normally open reed switch; it opens the contacts of a normally closed reed switch.



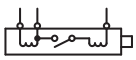
Sender: A component that is used with a temperature or pressure gauge. The sender measures the temperature or pressure. Its resistance changes to give an indication to the gauge of the temperature or pressure.



Relay (Magnetic Switch): A relay is an electrical component that is activated by electricity. It has a coil that makes an electromagnet when current flows through it. The electromagnet can open or close the switch part of the relay.

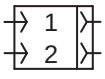


Solenoid: A solenoid is an electrical component that is activated by electricity. It has a coil that makes an electromagnet when current flows through it. The electromagnet can open or close a valve or move a piece of metal that can do work.

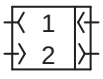


Magnetic Latch Solenoid: A magnetic latch solenoid is an electrical component that is activated by electricity and held latched by a permanent magnet. It has two coils (latch and unlatch) that make electromagnet when current flows through them. It also has an internal switch that places the latch coil circuit open at the time the coil latches.

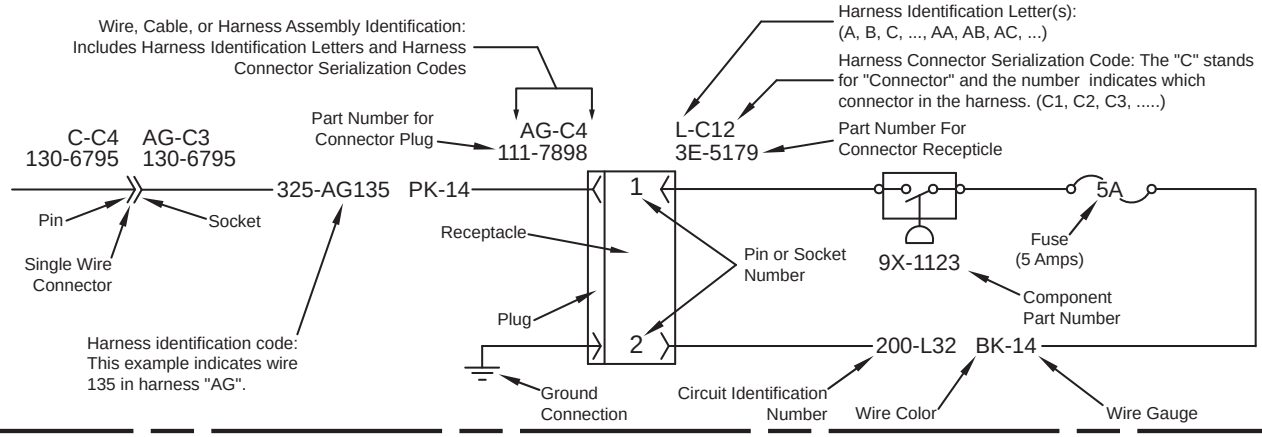
Harness and Wire Symbols



Deutsch connector: Typical representation of a Deutsch connector. The plug contains all sockets and the receptacle contains all pins.



Sure-Seal connector: Typical representation of a Sure-Seal connector. The plug and receptacle contain both pins and sockets.



Component Tables

Cab: Component Location

Component	Schematic Location	Machine Location
Alarm, Accugrade	B-13	B
Antenna	E-12	93
Block, Diode (XMSN)	F-8	A
FNR Shift Handle	F-8	A
Flasher	H-2	86
Fuse Block	D-1:G-1	C
Indicator, AESC	B-13	B
Indicator, Assembly (RH)	C-8	A
Indicator, Deluxe	D-13	B
Indicator Lamp (LH)	D-8	A
Indicator, Wait to Start	B-12	B
Joystick, Loader	F-3	90
Machine ECM	J,6-7:B,6-7	81
Meter, Service	I-8	A
Module, PRM 1	I-2	89
Module, PRM 2	I-2	88
Module, PRM (Engine)	I-1	87
Module, PRM (HVAC)	I-1	3
Motor, Front Wiper	G-12	72
Motor, Rear Wiper	G-14	73
Motor, Seat Group	G-3	94
Power Port #1	E-11	B
Power Port #2	J-8	80
Relay, AWD Brake	D-1	C
Relay, Backup Alarm	G-2	C
Relay, Horn	G-2	C
Relay, Implement Enable	E-1	C
Relay, Position Lamp	G-1	C
Relay, Ride Control	D-2	C
Relay,Start	H-2	84
Relay, Torque Limiter	H-2	85
Resistor, Terminal (#3)	I-13	74
Shifter, Autoshift	E-7	A
Suppressor, Arc	J-2	B
Suppressor, Front	G-8	97
Suppressor, Rear	G-8	97
Switch, AESC	C-13	B
Switch, Autoshift Manual	D-8	A
Switch, AWD	H-8	A
Switch, Beacon	D-13	B
Switch, Brake (LH)	F-8	82
Switch, Brake (RH)	F-8	83
Switch, Control Flow 7-8	E-13	B
Switch, Control Pattern	I-8	A
Switch, Differential Lock	G-8	95
Switch, Front Work Lamp	E-13	B
Switch, Hazard	D-8	A
Switch, Horn (Front Console)	G-8	A
Switch, Horn (Steering Column)	C-8	A
Switch, Implement Lockout	E-13	B
Switch, Key	B-14	B
Switch, Neutral Loader Handle	G-4	96
Switch, Neutral XMSN Handle	G-4	B
Switch, Park Brake	D-11	B
Switch, Rear Wiper	C-13	B
Switch, Rear Work Lamp	D-13	B

Chassis: Component Location

Component	Schematic Location	Machine Location
Alarm, Backup	H-14	56
Alternator	D-2	34
Base, Loader Joystick	I-4	119
Battery, HD	C-1	46
Battery, STD	C-1	46
Control, Gateway	I-6	71
Handle, Operator Left	G-14	51
Handle, Operator Right	I-14	52
Horn, Forward	F-3	35
Injector, Cylinder #1	G-7	47
Injector, Cylinder #2	G-7	47
Injector, Cylinder #3	F-7	48
Injector, Cylinder #4	F-7	48
Motor, Blower	G-11	1
Motor, Front Washer	F-3	29
Motor, Rear Washer	F-3	28
Motor, Starter	C-3	40
Plugs, Glow	C-4	44
Relay, A/C Compressor	H-9	2
Relay, High Speed	G-9	4
Relay, Quick Connect	D-11	105
Resistor, Excitation	D-2	43
Resistor, Motor Speed	G-11	1
Resistor, Terminating (CAN)	D-4	36
Sender, Conv Temperature (Atch)	B-5	7
Sender, Coolant Temperature	F-3	42
Sender, Fuel Level	F-3	39
Sensor, Brake Pressure	G-14	58
Sensor, Bucket Cylinder Position	E-14	110
Sensor, Bucket Position	J-4	118
Sender, Coolant Temperature	F-7	20
Sensor, Fuel Rail Pressure	G-7	27
Sensor, Hydraulic Load	G-14	60
Sensor, Hydraulic Oil Temperature	C-4	31
Sensor, Intake Manifold Pressure	G-7	19
Sensor, Intake Manifold Temperature	E-7	25
Sensor, Oil Pressure	G-7	23
Sensor, Speed (Crankshaft)	E-7	24
Sensor, Speed (Pump Cam)	E-7	22
Sensor, Temperature (Conv) (Std)	I-2	7
Sensor, Throttle	E-3	33
Sensor, Water In Fuel	F-3	38
Sensor, XMSN Output Speed (Atch)	C-7	14
Sensor, XMSN Output Speed (Std)	I-3	14
Solenoid, AC Compressor Clutch	E-2	41
Solenoid, AWD (Atch)	C-5	12
Solenoid, AWD (Std)	I-2	12
Solenoid, Differential Lock As (Atch)	D-5	18
Solenoid, Differential Lock As (Std)	I-1	18
Solenoid, Forward (High) (Atch)	C-5	5
Solenoid, Forward (Low) (Atch)	B-5	10
Solenoid, Forward (Low) (Std)	I-2	10
Solenoid, Fuel Pump	F-7	21
Solenoid, Hoe Aux Valve #1 (7th Function)	I-14	66
Solenoid, Hoe Aux Valve #2 (7th Function)	I-14	68
Solenoid, Hoe Aux Valve #1 (8th Function)	F-14	67

Component Tables Continued

Cab: Component Location

Component	Schematic Location	Machine Location
Switch, Ride Control	H-8	A
Switch, Stalk	C-8	A
Switch, XMSN Lock	I-8	A
Throttle, EH Hand	J-13	75
Timer, Stabilizer	I-12	98
Solenoid, Detent Coil (LH)	I-14	78
Solenoid, Detent Coil (RH)	I-14	79
Switch, Stabilizer (LH)	I-14	76
Switch, Stabilizer (RH)	I-14	77

Accugrade Option: Component Location

Component	Schematic Location	Machine Location
Display, Advisory	E-10	53
Inclinometer	D-13	54
Mast, Laser	D-8	114
Module, Power	E-8	115
Receiver, Laser	D-9	114
Relay, Power Module	F-9	117
Resistor, Terminal (GC)	E-9	116
Sensor, Boom Cylinder Position	E-14	113
Sensor, E-Stick Cylinder Position	E-14	112
Sensor, Stick Cylinder Position	E-14	111
Sensor, Swing Position	F-12	55
Sensor, Bucket Cylinder Position	E-14	110
Sensor, Bucket Position	J-4	118
Solenoid, Loader Aux Valve #1	F-3	91
Solenoid, Loader Aux Valve #2	F-3	92

NOTES: Component Location

Machine locations are repeated for components located close together.

A = Located inside operator dash.

B = Located inside right console.

C = Located around fuse block.

Chassis: Component Location

Component	Schematic Location	Machine Location
Solenoid, Hoe Aux Valve #2 (8th Function)	F-14	69
Solenoid, Hydraulic Torque Limiter (Atch)	D-5	16
Solenoid, Hydraulic Torque Limiter (Std)	J-1	16
Solenoid, Implement Lockout	H-14	59
Solenoid, Pattern Changer #1	H-14	63
Solenoid, Pattern Changer #2	H-14	64
Solenoid, Quick Connect Loader	B-9	98
Solenoid, Reverse As (Atch)	C-5	9
Solenoid, Reverse As (Std)	I-1	9
Solenoid, Ride Control #1	C-8	108
Solenoid, Ride Control #2	C-8	109
Solenoid, Return to Dig Loader Valve	I-4	121
Solenoid, Speed Clutch #1 (Atch)	C-5	13
Solenoid, Speed Clutch #2 (Atch)	C-5	6
Solenoid, Speed Clutch #3 (Atch)	C-5	8
Solenoid, Wastegate Actuator	F-7	26
Suppressor, AWD (Atch)	C-5	15
Suppressor, AWD (Std)	I-2	15
Suppressor, Differential Lock (Atch)	D-5	11
Suppressor, Differential Lock (Std)	I-2	11
Suppressor, HVAC	D-2	41
Suppressor, Hydraulic Torque Limiter (Atch)	D-5	17
Suppressor, Hydraulic Torque Limiter (Std)	I-2	17
Suppressor, Implement Enable #1	H-14	61
Suppressor, Pattern Changer	H-14	62
Suppressor, Quick Coupler #1	D-10	100
Suppressor, Quick Coupler #2	C-10	101
Suppressor, Quick Coupler #3	C-10	102
Suppressor, Quick Coupler #4	C-10	103
Suppressor, Quick Coupler #5	C-10	104
Suppressor, Ride Control	D-8	106
Switch, A/C Refrigerant High Pressure	E-2	50
Switch, A/C Refrigerant Low Pressure	E-2	49
Switch, Air Filter	E-3	37
Switch, Battery Disconnect	C-2	45
Switch, Blower Speed	G-10	B
Switch, Broom Angle	B-14	99
Switch, Cont Flow	C-14	99
Switch, Heater A/C	H-10	B
Switch, Hydraulic Oil Filter Bypass	C-4	32
Switch, Power (External Electrical)	C-13	99
Switch, Pressure (Ride Control)	C-8	107
Switch, Quick Connect Loader Pins	C-13	99
Switch, Return to Dig	I-4	120
Switch, Thermostat	G-10	1
Switch, Vent	H-10	B
Control, Engine	F-1	30
Radio, Product Link	J-8	70
Switch, Pressure (Boosted Brake)	H-14	57

Connector Tables

Cab: Connector Location	
Connector Number	**Schematic Location**
CONN 1	I-12
CONN 2	H-12
CONN 3	H-12
CONN 4	F-12
CONN 5	F-12
CONN 6	B-11
CONN 7	B-11
CONN 8	C-11
CONN 9	C-11
CONN 10	C,D-11
CONN 11	D-11
CONN 12	E-11
CONN 13	E-11
CONN 14	E-8
CONN 15	E-8
CONN 16	J-4
CONN 17	I-4
CONN 18	I-4
CONN 19	I-4
CONN 20	H-4
CONN 21	H-4
CONN 22	G-4
CONN 23	G-4
CONN 24	G-4
CONN 25	G-4
CONN 26	F-4
CONN 27	F-4
CONN 28	E-4
CONN 29	E-4
CONN 30	E-4
CONN 31	E-4
CONN 32	J-2
CONN 50	G-8

Chassis: Connector Location	
Connector Number	**Schematic Location**
CONN 1	E-12
CONN 2	D-12
CONN 3	H-12
CONN 11	G-9
CONN 12	I-11
CONN 13	I-11
CONN 16	I-8
CONN 18	D-7
CONN 19	C-7
CONN 20	G,H-6
CONN 21	G-5
CONN 22	F-5
CONN 23	F-5
CONN 24	C-10
CONN 28	C-10
CONN 30	J-6
CONN 31	I-5
CONN 32	H-5
CONN 33	E-13
CONN 34	E-12
CONN 35	E-12
CONN 36	C-12
CONN 37	E-10
CONN 38	E-10
CONN 39	B-10
CONN 40	B-9
CONN 41	D-9
CONN 42	E-9
CONN 43	E-9
CONN 44	J-7
CONN 45	J-7
CONN 46	E,F-6
CONN 47	J-4
CONN 48	I-4
CONN 49	E-4
CONN 52	E-14

The connectors shown in this chart are for harness to harness connectors. Connectors that join a harness to a component are generally located at or near the component. See the Component Location Chart.

Wire Table

Wire Description

Wire Number	Wire Color	Description
Power Circuits		
101	RD	Bat (+) (Not Application Specific)
103	RD	PRM Module #1
105	RD	Key Switch
110	RD	Flasher
111	RD	Rear Horn Relay
112	PU	PRM Module #2
115	RD	ACC Power Port
116	BR	Rear Flood Lamp
117	YL	Rear Flood Lamp (ATCH)
118	GY	Front Wiper
119	PK	Rear Wiper
121	YL	Backup Alarm To Lamp
122	BU	Heater/AC Switch
123	WH	Quick Coupler
124	GN	A/C Compressor
126	RD	Grade Check ECM
127	OR	Laser Grade Check
133	OR	PHS Solenoid
136	GN	Differential Lock Relay
143	BR	Differential Lock/AWS
144	GN	Beacon
146	GY	PRM Module #1
150	OR	Batt (+)
157	YL	Front Flood Lamp (ATCH)
158	BR	Front Flood Lamp
180	GN	Operator Seat
181	GY	Engine Speed Control (+)
182	PU	Engine Underspeed Control
Ground Circuits		
200	BK	Main Chassis
202	BK	XMSN Control
207	BK	Start Relay
Basic Machine Circuits		
304	WH	Starter Relay No. 1 Output
306	GN	Starter Relay Coil Or Key Switch
307	OR	Key Switch To Shifter
308	BK	Keyswitch Power (+)
309	GY	Alternator Regulator Terminal
310	PU	Start Aid Switch To Start Aid Solenoid
320	OR	Horn Relay Coil To Switch
321	BR	Backup Alarm Lamp Travel Alarm
322	GY	Warning Horn (Forward)
324	BU	Differential Lock Solenoid
331	OR	Backup Alarm Relay Coil
384	BU	Relay To Glow Plugs
A347	GN	MSS Start Condition Indicator
Monitoring Circuits		
403	GN	Alternator (R) Terminal
404	YL	Opr Mon Hydraulic Oil Temperature
405	GY	Opr Mon Oil Pressure (Low)
420	OR	Opr Mon Fuel Filter/Low Accum Pressure
432	PK	Opr Mon Brake Pressure (Oil)
439	YL	Water in Fuel Indicator
441	OR	Engine Coolant Temp Gage
442	GY	Hydraulic Oil Temperature Sensor
447	PK	Fuel Level Gage
450	YL	Tach Sender (+)
452	PU	Torque Converter
483	BR	Brake Fluid Level
E455	BR	Hydraulic Oil Filter

Wire Number	Wire Color	Description
Control Circuits (Continued)		
945	BR	CAT Data Link -
973	BR	CST Autoshift- Auto/Manual Switch 2
975	WH	CST Autoshift- Sol Return
976	OR	Ride Control Solenoid #1
977	YL	CST Autoshift- Auto/Manual Switch #1
994	GY	Oil Pressure (Filtered)
995	BU	Coolant Temperature
996	GN	Engine/Speed Timing (Crankshaft)
A755	PK	Throttle Switch 1
A756	BU	Throttle Switch 2
A757	GY	Throttle Switch 3
A758	BR	Throttle Switch 4
C720	BU	Interlock Relay
C743	PK	Parking Brake
C949	YL	Brake Pressure Sensor
C967	BU	Inlet Air Temperature
E455	BR	Hydraulic Oil Filter Switch
E540	PK	Aux Hydraulic Interlock
E543	WH	Aux Hyd. Return Solenoid (Close)
E544	GN	Aux Hyd. Return Solenoid (Open)
E701	PK	Auto Ride Control Switch
E750	PU	Body Position Sensor (Load Switch)
E803	YL	Right Ind Steer Solenoid
E804	BU	Left Ind Steer Solenoid
E885	OR	Bucket Dump Exchange
E900	WH	ECPC Trans Output Speed +
E901	GN	ECPC Trans Output Speed -
E917	WH	Implement Lockout Switch To Ground (N.O.)
E918	GN	Implement Lockout Switch To Ground (N.C.)
E965	BU	Engine Speed/Timing Sensor (Camshaft)
E991	GY	Implement Lock out Switch
F420	GN	Warning Lamp
F702	GN	Throttle Position
F711	GN	CAN Link +
F712	GY	CAN Link -
F738	WH	Active Ride Control Switch (N.C.)
F739	GN	Active Ride Control Switch (N.O.)
F748	WH	Ride Control Switch
G423	PK	Hydraulic Filter Bypass
G750	BU	XMSN Forward Switch To Ground
G755	GY	XMSN Reverse Switch To Ground
G962	OR	Pilot Cutout Solenoid
H416	GN	Lamp Indicator
H705	BR	Pump Relay
H707	YL	Impl Cont Pump Torque Solenoid
H730	BR	Reverse Output - Shuttle Control
H731	GY	Forward Output - Shuttle Control
H771	BR	Side Shift Lock Solenoid
H783	GN	AESC Control Indicator Lamp
H901	OR	LVDT Signal - Boom 1
H902	YL	LVDT Signal - Bucket
H903	PK	LVDT Signal - EStick
H904	GY	LVDT Signal - Swing
H907	GN	LVDT Signal - Stick 2 Bypass
J764	BR	Switch/Sensor Return #1
J765	BU	Switch/Sensor Return #2
J766	PU	Switch/Sensor Return #3
J878	YL	Switch/Sensor Return #5
J984	PK	Analog 1
K753	OR	Power Mod Relay (+)

Wire Table (Continued)

Wire Descriptions (Continued)

Wire Number	Wire Color	Description
Monitoring Circuits (Continued)		
F420	GN	Warning Lamp (General)
G423	PK	High Pressure Implement Filter - Rear
H416	GN	Lamp Indicator
Accessory Circuits		
500	BR	Wiper - Front (Park)
501	GN	Wiper - Front (Low)
502	OR	Wiper - Front (Hi)
503	BR	Wiper - Rear (Park)
506	PU	Washer - Front
507	WH	Washer - Rear
508	PU	Radio Speaker - Left
509	WH	Radio Speaker - Left (Commom)
511	BR	Radio Speaker - Right
512	GN	Radio Speaker - Right (Common)
513	OR	A/C Compressor/Refrigerant Pressure Sw.
515	GY	Blower Motor (HI)
516	GN	Blower Motor (Medium)
517	BU	Blower Motor (Low)
518	OR	Hazard Flasher To Switch
519	PK	A/C Refrigerant High Pressure
520	WH	A/C Switch To Thermostat Switch
537	GN	Turn Signal Switch To Flasher
552	WH	Four Wheel Drive Solenoid
564	GY	Rear Wiper Interrupt Switch To Wiper Sw.
568	GN	Parking Brake Warning Buzzer To Diodes
569	PK	A/C Switch Jumper #2
578	BU	Auxiliary Washer
585	YL	Aux Hydtraulic - Open
586	BR	Aux Hydtraulic - Closed
597	PU	A/C High Press. Cutout Switch
A510	OR	A/C Low Press. Cutout Switch
C506	WH	High Speed Relay
C510	WH	A/C Compressor Relay Switch
E528	PU	HVAC On/Off Switch To Blower Switch
E529	YL	Blower Switch Jumper
E540	PK	Aux Hydraulic Interlock
E543	WH	Aux Hydraulic Return Solenoid - Close
E544	GN	Aux Hydraulic Return Solenoid - Open
Lighting Circuits		
603	PK	Rotary Beacon
604	OR	Stop Lamp
605	YL	Turn Lamp - Left
606	GY	Turn Lamp - Right
607	PK	Flood Lamp - Front
608	GN	Flood Lamp - Rear
614	PU	Park/Tail/Dash/Lamp
617	BR	Tail/Position Lamp - Left (Road Package)
618	YL	Tail/Position Lamp - Right (Road Package)
620	WH	Flood Lamp - Front
630	GY	Flood Lamp Rear (ATCH)
668	BU	Backlight Relay
Control Circuits		
702	OR	XMSN Brake Switch LH
708	YL	XMSN Neutral Lock Switch
720	PU	XMSN Brake Switch RH
751	GN	XMSN Shift Solenoid (No. 1 OR 3)
752	YL	XMSN Shift Solenoid (No. 2 - Reverse)
754	BU	XMSN Shift Sol (No. 3 Or No. 1 - Forward)
762	YL	Bucket Positioner Solenoid Switch
766	GN	XMSN Disconnect Solenoid

Wire Number	Wire Color	Description
Control Circuits (Continued)		
K754	PK	Power Mod relay (-)
K973	PK	Hex Engine Speed Control 1
K974	PU	Hex Engine Speed Control 2
K975	WH	Hex Engine Speed Control 3
L730	OR	Analog Sensor Return (+5V)
L731	BR	Analog Sensor Return (+5V)
L740	BR	Analog Sensor Return (+5V)(VCM)
L998	OR	Auxiliary Hydraulic Solenoid B
L999	GN	Auxiliary Hydraulic Solenoid C
M795	WH	Waste Gate Valve (+)
M936	BR	Flow Control Switch
M937	GN	Flow Control Prox Sw #1
M952	BU	LH Joystick
M965	GN	RH Joystick
M968	BU	Coupler Switch Interconnect
M969	YL	Coupler Switch Interconnect
N756	PK	Alarm Horn Output
N939	GN	Ride Control Solenoid
N945	OR	AWD (Signal)
N957	PK	RS-232 RXD - COMM #1
N959	PK	RS-232 RXD - COMM #3
N960	OR	RS-232 TXD - COMM #1
N963	OR	RS-232 TXD - COMM #3
N970	YL	RS-232 DTR - COMM #1
N973	BR	RS-232 DCD - COMM #1
N979	GN	RS-232 Signal Ground - COMM #1
N981	GN	RS-232 Signal Ground - COMM #3
N997	WH	PWM - Freq In #1
P914	GN	XMSN Forward Indicator
P920	BR	EUI Secondary Engine Speed/Timing
P993	OR	Auxiliary Hydraulic Select
R762	GY	Control Pattern Switch
R763	BU	Control Pattern Switch
R912	OR	Hydraulic Pedal Lock Solenoid
R954	BK	Discrete Output 1
R955	GY	Discrete Output 2
R956	BU	Discrete Output 3
R956	BK	Discrete Output 3
R957	GY	Discrete Output 4
R958	GN	Discrete Output 5
R997	OR	Analog Sensor Power (+5v)
T901	YL	MSS Exciter Coil In
T902	PK	MSS Exciter Coil Out
T904	BU	RH Stabilizer Up - Switch To Solenoid
T907	GN	LH Stabilizer Down - Switch To Solenoid
T969	YL	Aux Circuit 1
T970	GY	Stick Extend Solenoid (+)
T971	OR	Aux Circuit 3
T972	GN	Stick Extend Solenoid (+)
T993	BR	Analog Sensor Return
T997	OR	Analog Sensor Power (+5v)
X731	BU	Boost Pressure to Controller
X740	BU	Seat Forward to Controller
X750	OR	Fwd/Rev Solenoid Return From Controller
X800	OR	+8V Sensor Power
X920	BR	Injector 1 Hi Side
X921	PK	Injector 2 Hi Side
X922	WH	Injector 3 Hi Side
X923	OR	Injector 4 Hi Side
X926	GY	Injector 1 Return

Wire Table (Continued)

Wire Descriptions (Continued)					
Wire Number	**Wire Color**	**Description**	**Wire Number**	**Wire Color**	**Description**
Control Circuits (Continued)			**Control Circuits (Continued)**		
774	YL	AETA Solenoid - Left	X927	YL	Injector 2 Return
779	WH	Coupler Engage Solenoid	X928	GN	Injector 3 Return
799	WH	Sensor Power	X929	BU	Injector 4 Return
852	GN	Continuious Flow Sensor (signal)	Y794	OR	Expanded CAN Data Link +
892	BR	Cat Data Link (-)	Y795	GN	Expanded CAN Data Link -
893	GN	Cat Data LInk (+)	Y946	BU	Fuel Rail Pressure
900	PU	XMSN Shift Sol No. 5 Or 4	Y947	BR	Analog Sensor Return
902	BR	XMSN Shift Sol No. 7	Y948	BR	Analog Sensor Return
903	GY	XMSN Shift Sol No. 8	Y950	YL	Fuel Pump Solenoid (+)
911	YL	AWD Mode Relay Switch Jumper	Y951	PU	Fuel Pump Solenoid (-)
944	OR	CAT Data Link +			

Harness, Cable and Wire Table

IDENT	PART NO.	CHG		LOC	NOTE	DESCRIPTION
HARNESS AS.						
AE	290-6727	02	SH 2	C-2	J	HVAC AIR CONDITION - ENGINE
AC	290-6728	02	SH 2	F-10	J	HVAC - CONSOLE
AF	263-9498	01	SH 1	H-13	J	TERMINATING RES JUMPER
AV	246-8046	02	SH 2	D-11	J	ACCUGRADE CHECK - BASIC (DISPLAY)
AW	268-7761	03	SH 2	D-11	J	ACCUGRADE READY BASIC
AX	246-8044	03	SH 2	C-11	J	ACCUGRADE CHECK - ADVANCED
AY	290-6804	02	SH 2	D-13	J	ACCUGRADE READY - SWING CASTING
EN	290-6751	03	SH 2	F-1	N/A	ENGINE (ELEK)
ER	290-6806	02	SH 2	D-15	J	E-STICK JUMPER (14FT)
ER	290-6811	02	SH 2	D-15	J	E-STICK JUMPER (16 FT)
FA	268-7755	01	SH 1	E-4	J	FRONT AUX (3RD FUCNTION)
HL	213-6051	05	SH 1	F-14	H	HEADLINER
KF	213-6075	04	SH 2	A-14	J	QUICK COUPLER - FRONT CONSOLE
KL	213-6077	04	SH 2	A-11	J	QUICK COUPLER - LOADER
KP	213-6076	04	SH 2	A-12	J	QUICK COUPLER - PLATFORM
KT	211-9461	04	SH 2	A-10	J	QUICK COUPLER - BROOM
LN	290-6744	02	SH 1	F-4	J	SEAT HARNESS
MC	290-6741	01	SH 1	D-4	J	MSS TORNADO ECM
PK	225-7959	00	SH 1	D-8	J	AUTOSHIFT FNR
PA	268-7759	02	SH 1	E-1	N/A	POWER DISTRIBUTION
PJ	290-6808	02	SH 2	D-14	J	BUCKET SENSOR W/STD STICK
PJ	290-6809	02	SH 2	D-14	J	BUCKET SENSOR W/14 FT E-STICK
PJ	290-6810	02	SH 2	D-14	J	BUCKET SENSOR W/16 FT E-STICK
PL	290-6721	02	SH 1	F-4	N/A	PLATFORM
PT	290-6805	02	SH 2	D-13	N/A	BACKHOE SENSORS (STD STICK)
PU	290-6800	01	SH 2	I-6	J	RTD - PARALLEL (PLATFM)
PV	290-6801	01	SH 2	H-6	J	RTD - SGL TILT (PLATFM)
PW	246-8047	02	SH 2	I-4	H	RETURN TO DIG - PARALLEL LIFT
PX	233-7977	03	SH 2	H-4	H	RETURN TO DIG - SINGLE TILT
RH	290-6736	02	SH 1	B-14	N/A	CONSOLE - SIDE
RK	246-8038	02	SH 2	B-10	J	RIDE CONTROL
RN	213-6049	07	SH 2	I-12	N/A	ROOF (NACD)
RT	290-6787	01	SH 2	G-13	N/A	REAR (ET3)
WR	256-6803	03	SH 2	I-9	J	PRODUCT LINK - RADIO - 121SR
WV	256-6804	01	SH 2	I-7	J	PRODUCT LINK - GATEWAY - 321SR
XA	290-6755	02	SH 2	B-7	J	AUTOSHIFT XMSN - SOL
XC	225-7984	00	SH 2	D-9	J	ACCUGRADE - POWER MODULE B
XE	225-7985	00	SH 2	C-9	J	ACCUGRADE - POWER MODULE A
XF	225-7986	01	SH 2	C-9	J	ACCUGRADE - LASER MAST
XG	225-7987	01	SH 2	C-14	J	ACCUGRADE - INCLINOMETER
XK	290-6758	02	SH 2	H-2	J	STD XMSN - SOL
CABLE AS.						
AA	246-8053	02	SH 2	B-1	H	POS (BAT TO STARTER)
CC	213-6094	02	SH 2	C-2	H	POS (STARTER TO ALTERNATOR)
EE	290-6791	00	SH 2	B-1	H	NEG (BATTERY TO SWITCH)
FF	290-6792	00	SH 2	A-2	H	NEG (SWITCH TO FRAME)
MM	290-6745	01	SH 2	B-1	H	POWER DISTRIBUTION
GG	213-6091	03	SH 2	A-1	H	POS (HD)
HH	213-6092	03	SH 2	A-1	H	NEG (HD)
WIRE AS.						
FG	217-8058	02	SH 1	B-8	N/A	STEERING COLUMN HORN SW
PY	213-6060	03	SH 1	F-9	J	DIFF LOCK JUMPER

NOTES:		
Note Loc.	**Note**	**Description**
Various	Note: H	Option Harness - Alternate Based on Machine
Various	Note: J	Attachment Harness

CID / FMI Tables

Diagnostic Codes For the Machine ECM Module Identifier (MID 039)	
Perform the procedure that corresponds to the CID and the FMI of the diagnostic code during troubleshooting.	
Component Identifier (CID)	**Component Description**
41	8 VDC Supply
168	Electrical System Voltage
191	Transmission Output Speed Sensor
247	SAE J1939 Data Link
262	5 VDC Supply
367	Ride Control Switch
368	Transmission Auto/Manual Switch
434	Hydraulic Pilot Oil Pressure Sensor
490	Implement Lockout Switch
590	Engine Control Module
600	Hydraulic Oil Temperature Sensor
626	Steering / Transmission Lock Switch
629	Neutralizer Switch
668	Transmission Shift Lever
702	“FNR” Lever Diagnostics
871	“Accugrade” Inclination
1009	Front Facing Position Seat Switch
1037	Display Module
1251	Alternator R-Terminal Signal
1326	Application Location Code
1401	Transmission Solenoid 1
1402	Transmission Solenoid 2
1403	Transmission Solenoid 3
1404	Transmission Solenoid 4
1405	Transmission Solenoid 5
1406	Transmission Solenoid 6
1482	10 Volt Sensor DC Power Supply
1529	Implement Front Aux. Quick Coupler Flow Switch
1834	Ignition Key Switch
1956	Implement Hoe Bucket Position Sensor
1957	Implement Hoe Stick Position Sensor
1958	Implement Hoe Estick Position Sensor
1959	Boom Cylinder Position
1960	MSS_trm Communication Diag
2108	Dev -- Hoe Swing Sensor
2236	Hoe Auxiliary Valve #1 Port A Solenoid
2237	Hoe Auxiliary Valve #1 Port B Solenoid
2242	Loader Auxiliary Valve Port A Solenoid
2243	Loader Auxiliary Valve Port B Solenoid
2244	Hoe Auxiliary Valve #2 Port A Solenoid
2245	Hoe Auxiliary Valve #2 Port B Solenoid
2529	Loader Joystick Thumbwheel Position Sensor
2530	Hoe Left Joystick Thumbwheel Position Sensor
2531	Hoe Right Joystick Thumbwheel Position Sensor
2735	Implement Front Auxiliary Continous flow switch
2736	Hoe Auxiliary Continuous Flow Switch
2977	Low Idle Switch
2997	Implement Valve Load Sense Pressure Sensor
3084	AESC Enable Selection Switch

Failure Mode Identifiers (FMI)[1]	
FMI	**Failure Description**
0	Data valid but above normal operating range
1	Data valid but below normal operating range
2	Data erratic, intermittent or incorrect
3	Voltage above normal or shorted high
4	Voltage below normal or shorted low
5	Current below normal or open circuit
6	Current above normal or grounded circuit
7	Mechanical system not responding properly
8	Abnormal frequency, pulse, or period
9	Abnormal update rate
10	Abnormal rate of change
11	Failure mode not identifiable
12	Bad device or component
13	Out of calibration
14	Special Instruction
15	Data valid but above normal operational range
16	Data valid but above normal operational range
17	Data valid but below normal operational range
18	Data valid but below normal operational range
19	Received network data in error

NOTES:

(1) For the Machine ECM, the MID is 039. This table pertains only to faults with a MID of 039.

The CID is a diagnostic code that indicates which circuit is faulty.

The MID is a diagnostic code that indicates which electronic control module.

Machine ECM Event Codes

Event Codes for the Machine ECM			
EID	**Warning Level**	**Description**	**Activation**
50(1)	1	High Voltage Level 1 Event	1. Start-up delay timer is expired (30 sec) and 2. Engine speed is greater than 800 RPM and 3. System Voltage is greater than 14.8 VDC to activate (less than 14.5 VDC to deactivate) and 4. Debounce status is TRUE.
50(1)	3	High Voltage Level 3 Event	1. System Voltage is greater than 16 VDC to activate (less than 15.8 VDC to deactivate) and 2. Debounce status is TRUE.
153	3	High speed directional shift	1. Ground speed is greater than 16 km/h (10 mph) and 2. A shift in direction is requested by the operator. A “Shift in Direction” is defined as: 1. Shift from Fwd to Rev 2. Shift from Rev to Fwd 3. Shift out of neutral
172	5 min	Air Inlet Restriction	The air filter is restricted.
282(1)	2	Hydraulic Oil Filter Bypass Event	1. Hydraulic oil temperature is greater than 42 °C (108 °F) (Temp Limit) or Hydraulic Oil Temp is unknown or Event is previously active and still in hysteresis(39 °C (102.2 °F)) and 2. The switch for the hydraulic filter is ACTIVE.
360		Low Engine Oil Pressure	The engine oil pressure is low enough to activate the engine oil pressure switch for 3 seconds and the engine is not running.
361		High Engine Coolant Temperature	The engine coolant temperature is greater than 113 °C (235 °F) for 3 seconds.
627(1)	2	Machine Driven with Parking Brake ON	1. The ground speed is greater than 1 km/h (0.6 mph) in forward or reverse and
			2. The Parking Brake switch is closed for 1 second.
797(2)	1	Brake Boost Low Pressure Level 1 Event	1. Fluid level / pressure for the brake is low and 2. Engine speed is less than 800 RPM.
797(1)	3	Brake Boost Low Pressure Level 3 Event	1. Fluid level / pressure for the brake is low and 2. Engine speed is greater than 800 RPM.
861(1)	1	Machine Synchronize clock Manual Alignment	The SYNC Clock requires Manual Adjustment.
875(1)	1	Low Voltage Level 1 Event	1. Start-up delay timer is expired (30 sec) and 2. Engine speed less than 400 RPM and 3. System Voltage is 12.3 -12.5 VDC and 4. Debounce status is TRUE (8 minute debounce on bench test). OR 1. Start-up delay timer is expired (30 sec) and 2. Engine speed greater than 1300 RPM and 3. System voltage is 12.4 -13 VDC and 4. Debounce status is TRUE.
875(1)	2	Low Voltage Level 2 Event	1. Start-up delay timer is expired (30 sec) and 2. Engine is running and 3. Engine speed less than 1300 RPM and 4. System Voltage is 12.4 -13 VDC and 5. Debounce status is TRUE. OR 1. Start-up delay timer is expired (30 sec) and 2. Engine is running and 3. System voltage is 12 -12.3 VDC and 4. Debounce status is TRUE.
875(1)	3	Low Voltage Level 3 Event	1. Start-up delay timer is expired (30 sec) and 2. Engine speed is greater than 800 RPM and 3. System Voltage is 11.5 or 11.8 VDC and 4. Debounce status is TRUE.
878(1)	2	High Hydraulic Oil Temperature Event	1. Hydraulic oil temperature is greater than 110 °C (230. °F) and 2. ON delay timer (3 min) is expired.

(1) logged and active (2) active only

Specifications and Related Manuals

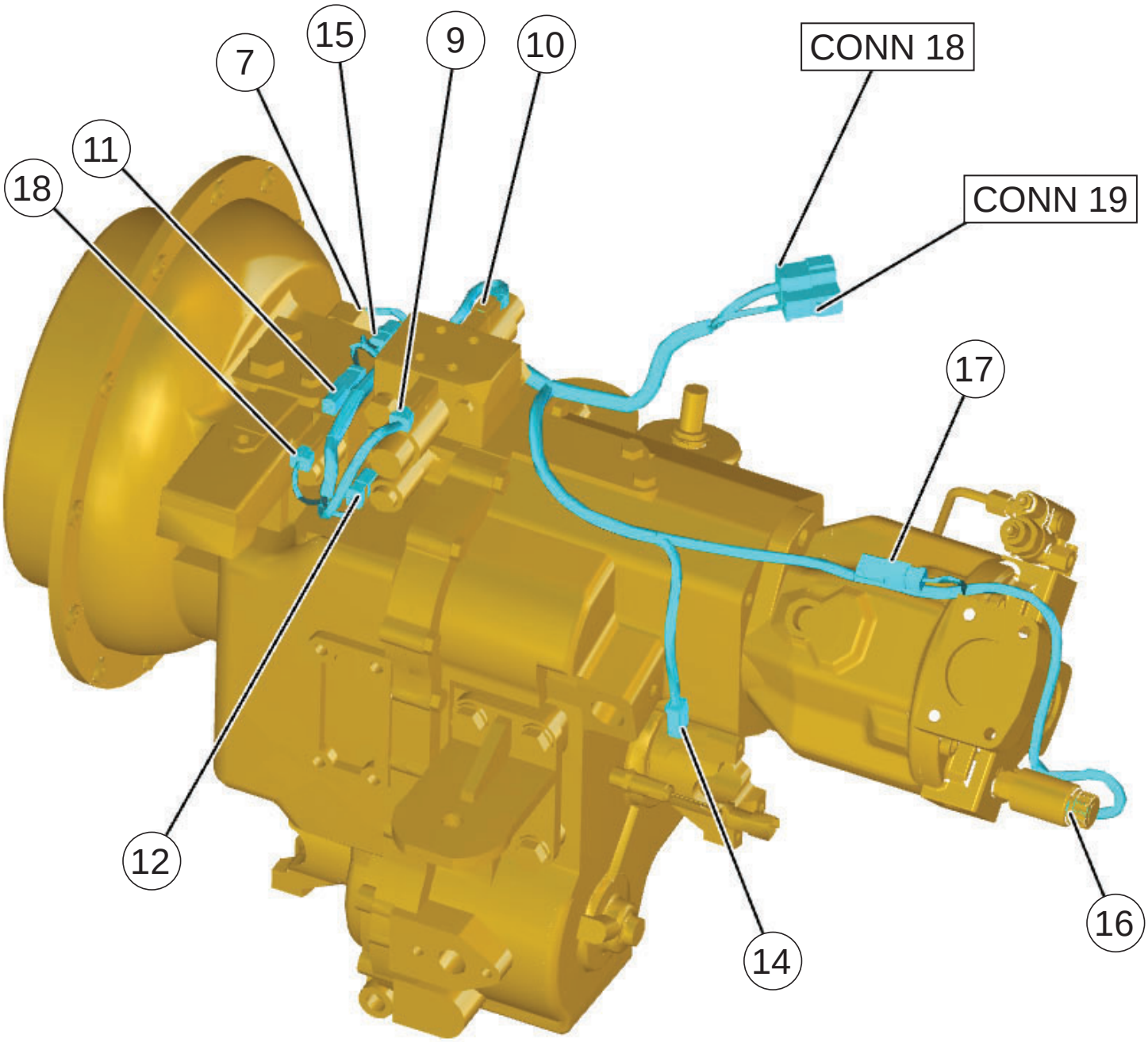
Resistor, Sender and Solenoid Specifications			
Part No.	**Component Description**		**Resistance (Ohms)[1]**
244-3106	Sender:	Coolant Temperature	54°C (130°F) - 560 to 716 110°C (230°F) - 72 to 82
238-9397	Resistor:	Excitation	120±6
4W-9972	Sender:	Converter Temperature	54°C (130°F) - 560 to 716 110°C (230°F) - 72 to 82
3E-8620	Solenoid:	RTD Loader Valve	21.8 ±1
134-2540	Resistor:	Terminating	120
212-3350	Solenoid:	Loader QC	3.2
251-3231	Sender:	Fuel Level (EST)	Empty - 240-250 Full - 28-33

[1] At room temperature unless otherwise noted.

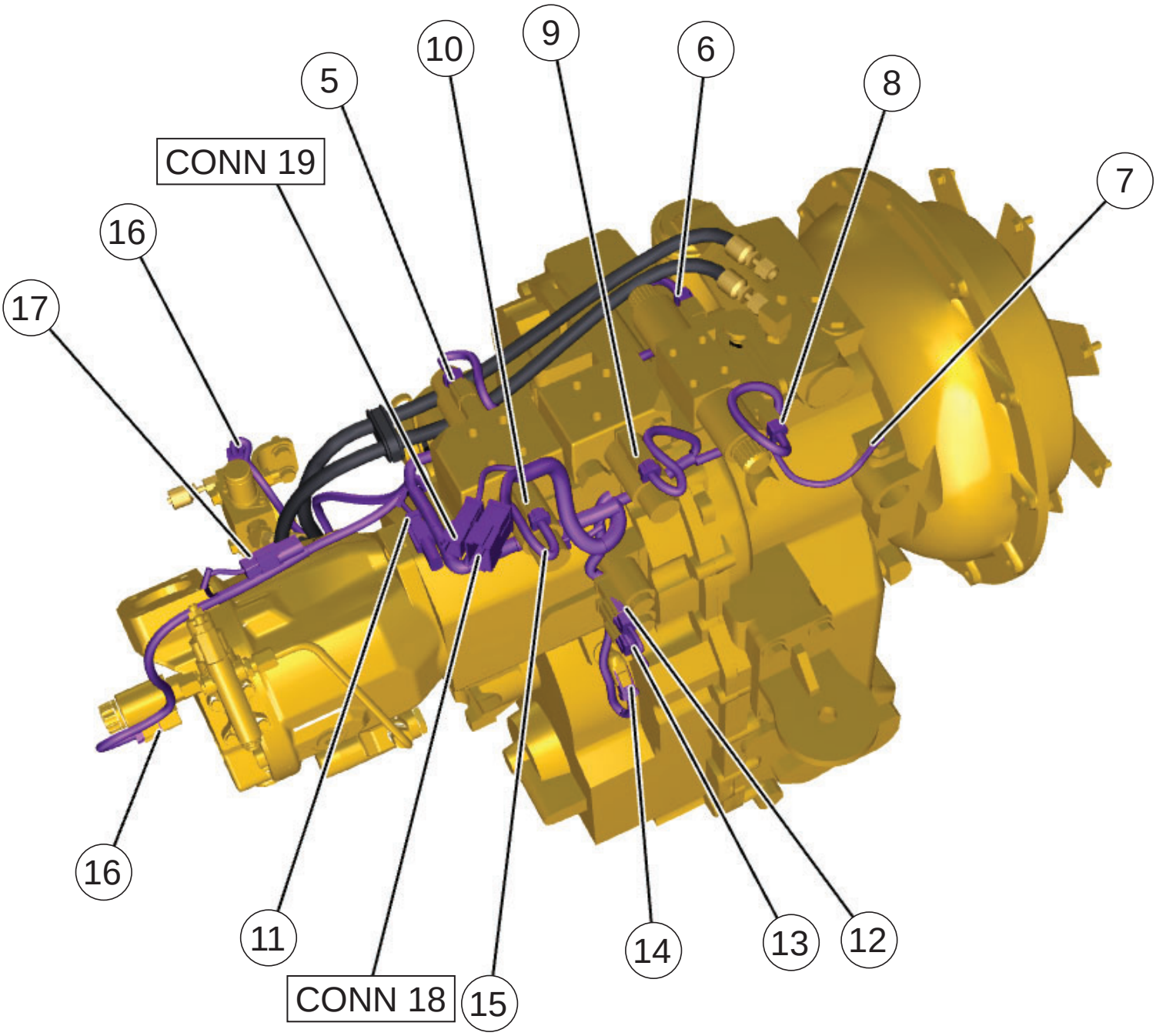
Off Machine Switch Specification				
Part No.	**Function**	**Actuate**	**Deactuate**	**Contact Position**
134-0404	Hydraulic Bypass Oil Filter	276 to 303 kPa MAX (507.6 psi)	207 kPa (30 psi)	Normally Open
3E-7675	Boosted Brake Pressure	2550 kPa MAX (369.8 psi)	1800 ± 175 kPa (261 ± 25.3 psi)	Normally Closed
304-5696	Ride Control Pressure	3500 kPa MAX (507.6 psi)	3137 ± 175 kPa (495.0 ± 25.4 psi)	A-C, Normally Closed A-B, Normally Open

Related Electrical Service Manuals	
Title	**Form Number**
Electric Starting Motor: 143-0539	SENR3828
Machine Troubleshooting:	KENR7663

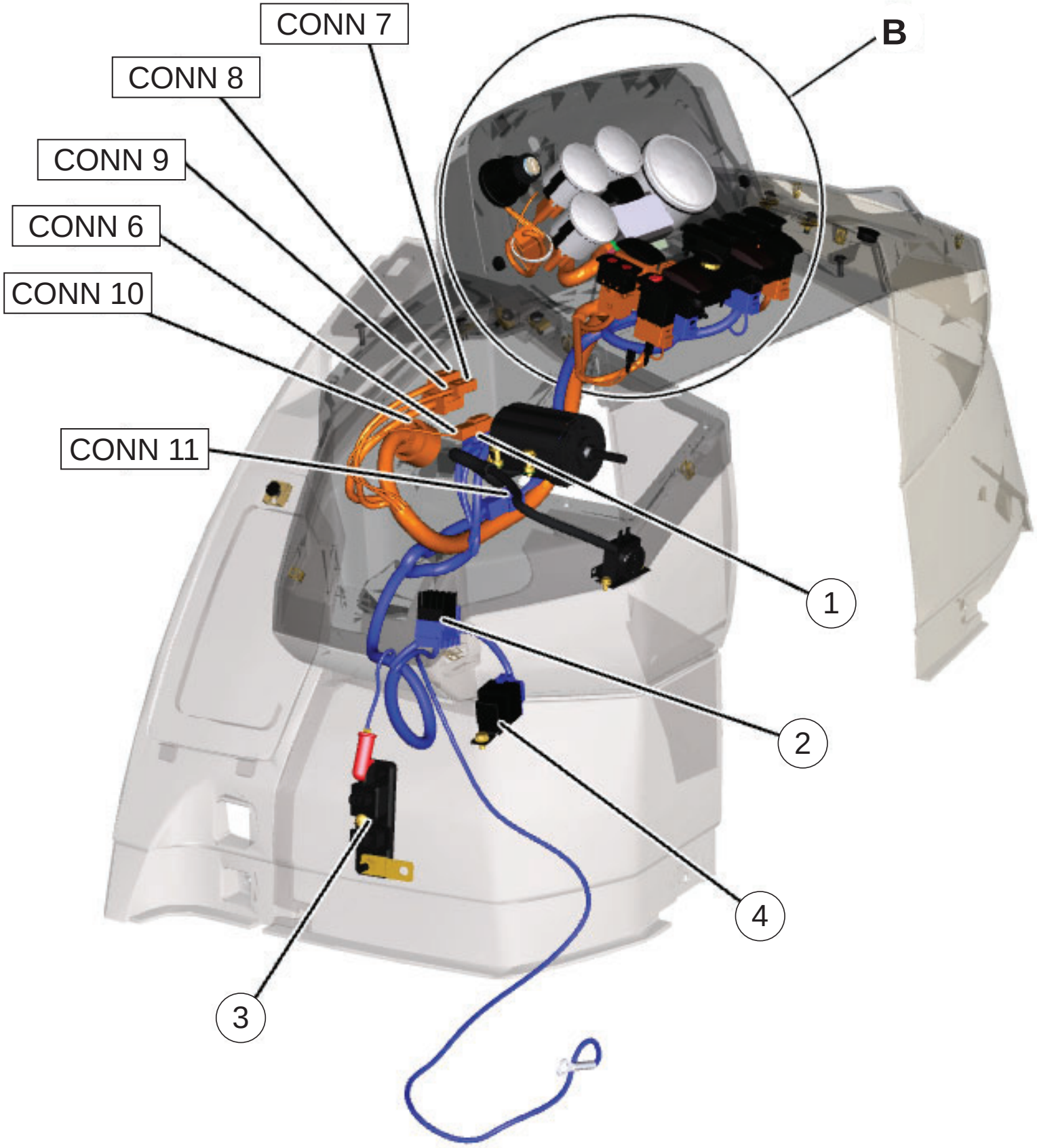
Transmission Harness - Autoshift (STD)



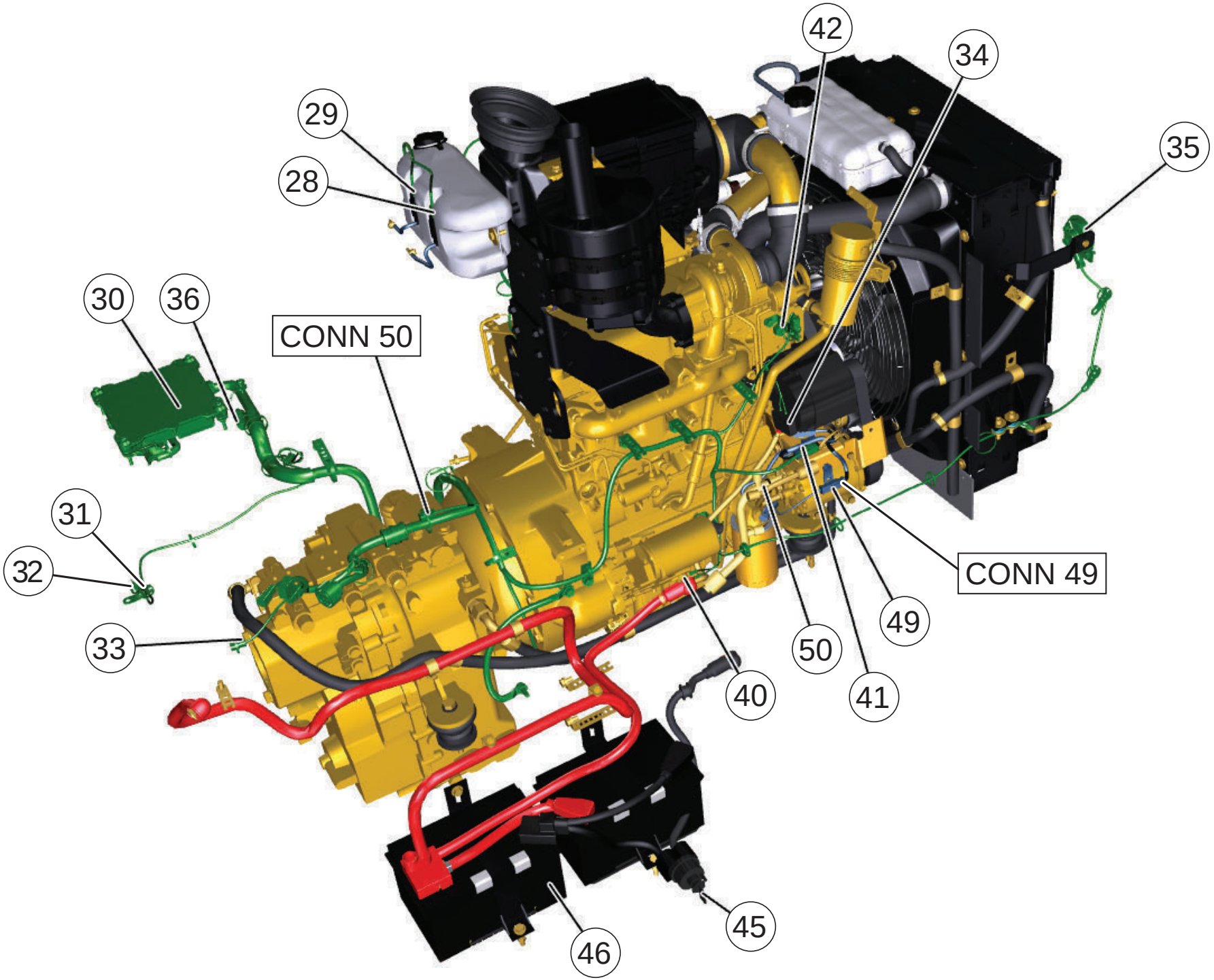
Transmission Harness - Autoshift (ATCH)



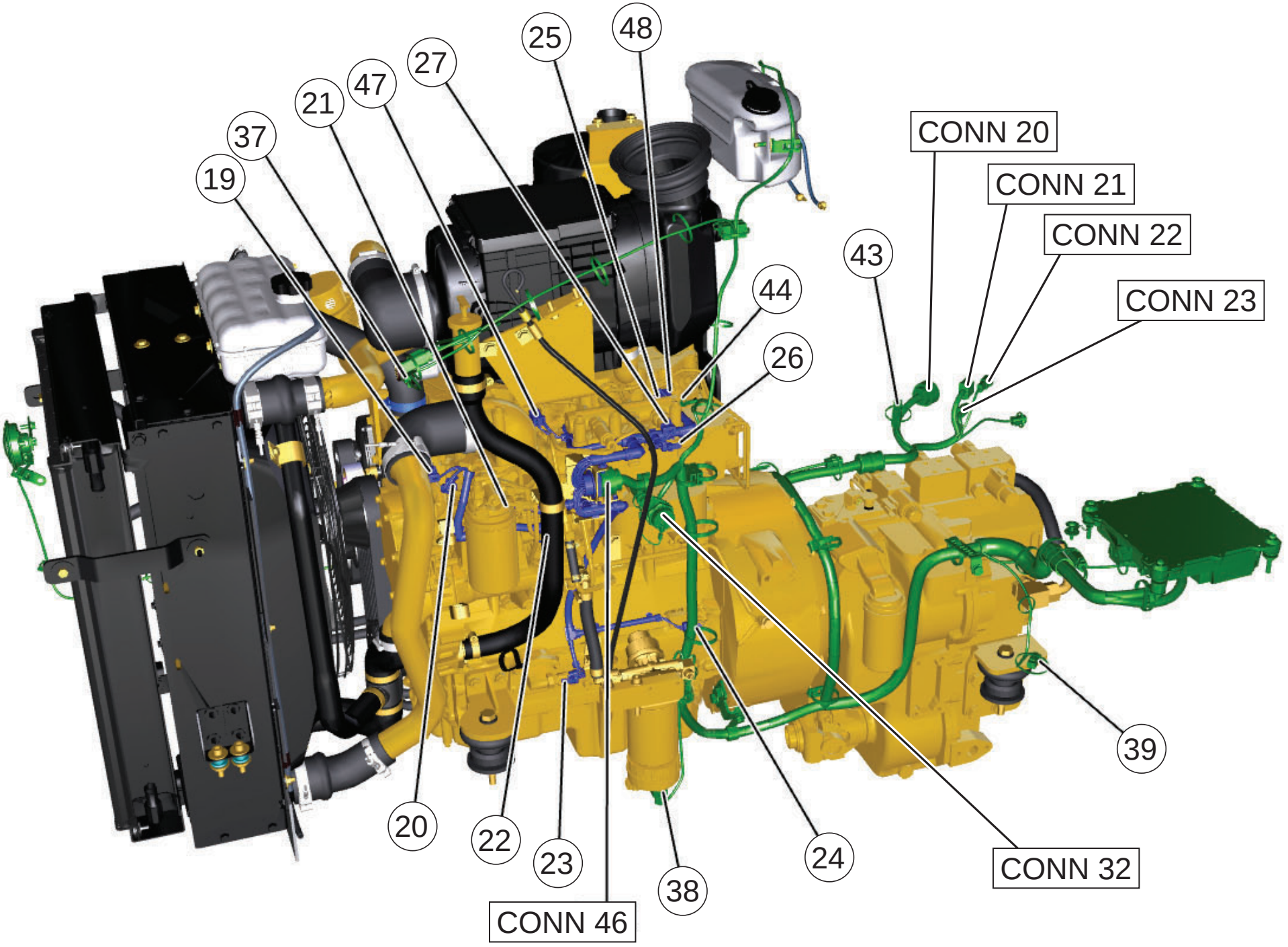
Right Hand Console Wiring



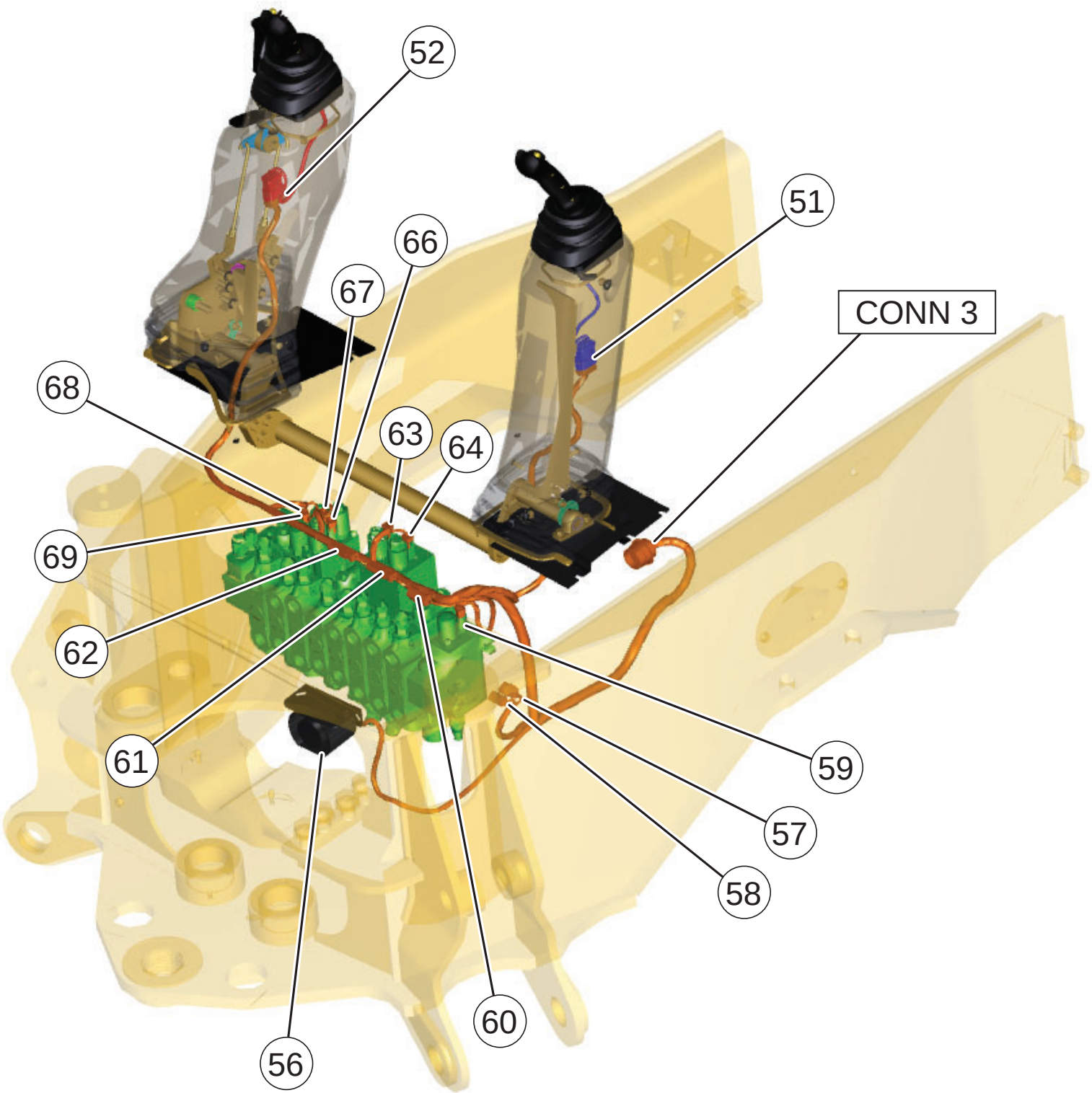
Engine Wiring - Right Side View



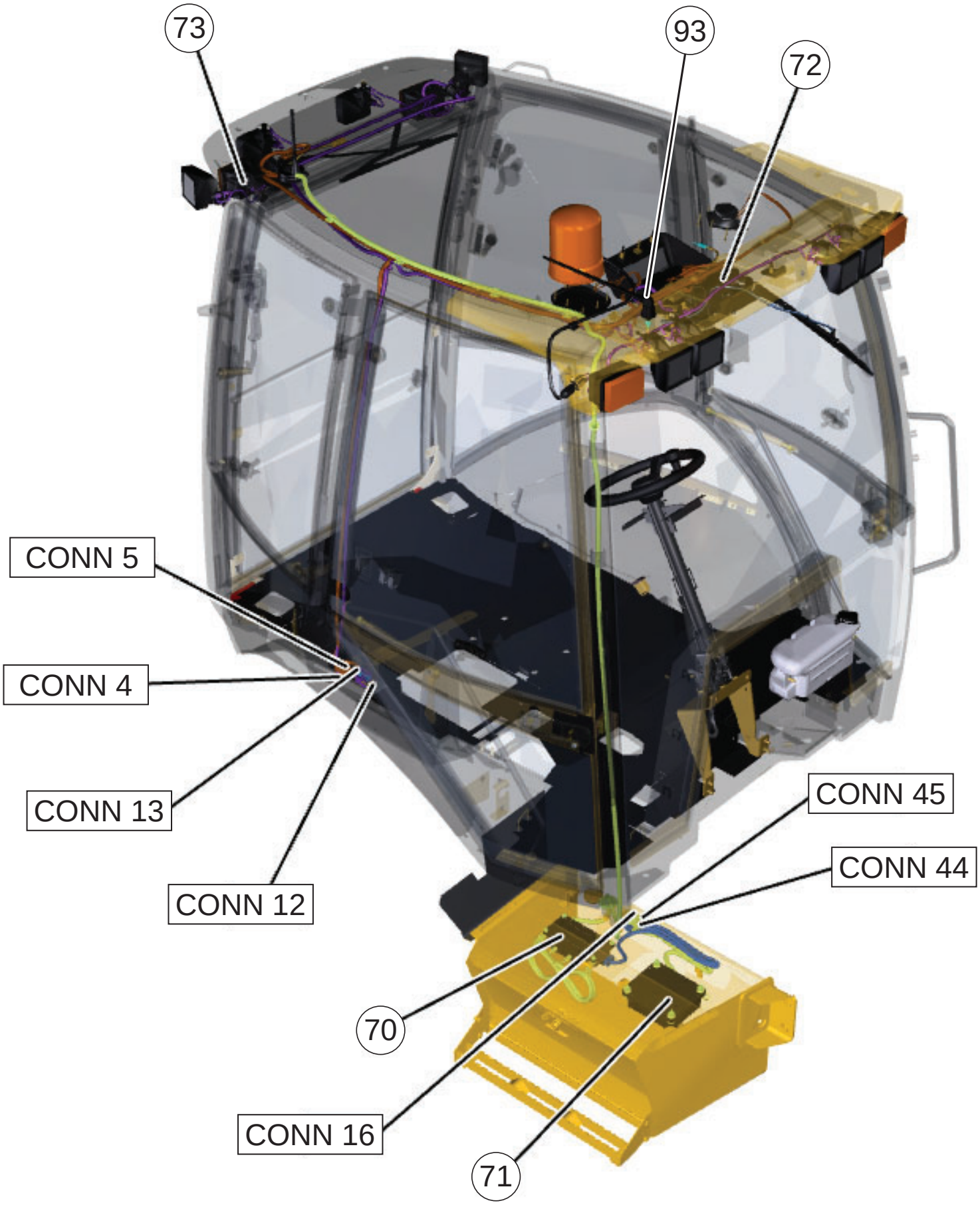
Engine Wiring - Left Side View



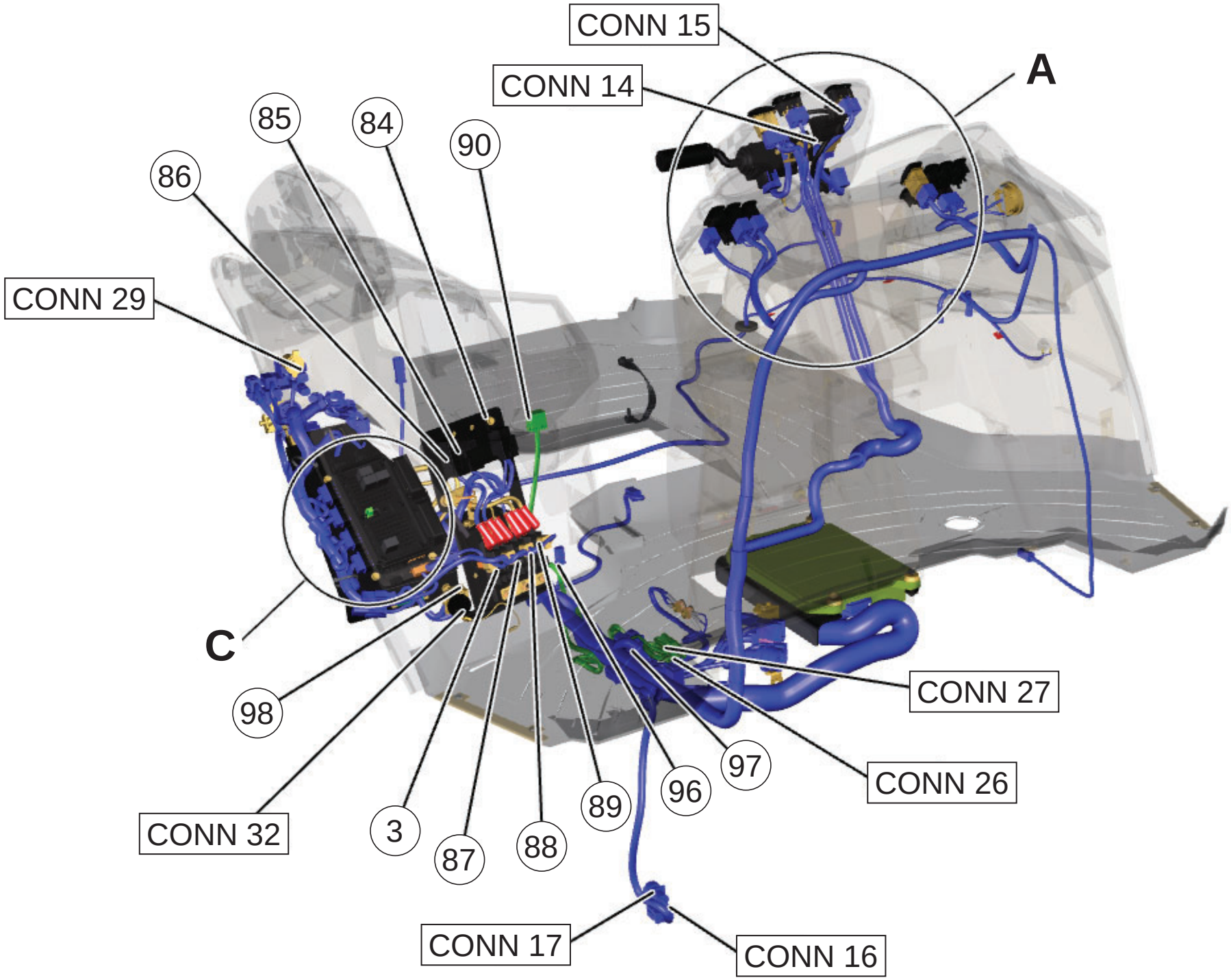
Rear Wiring



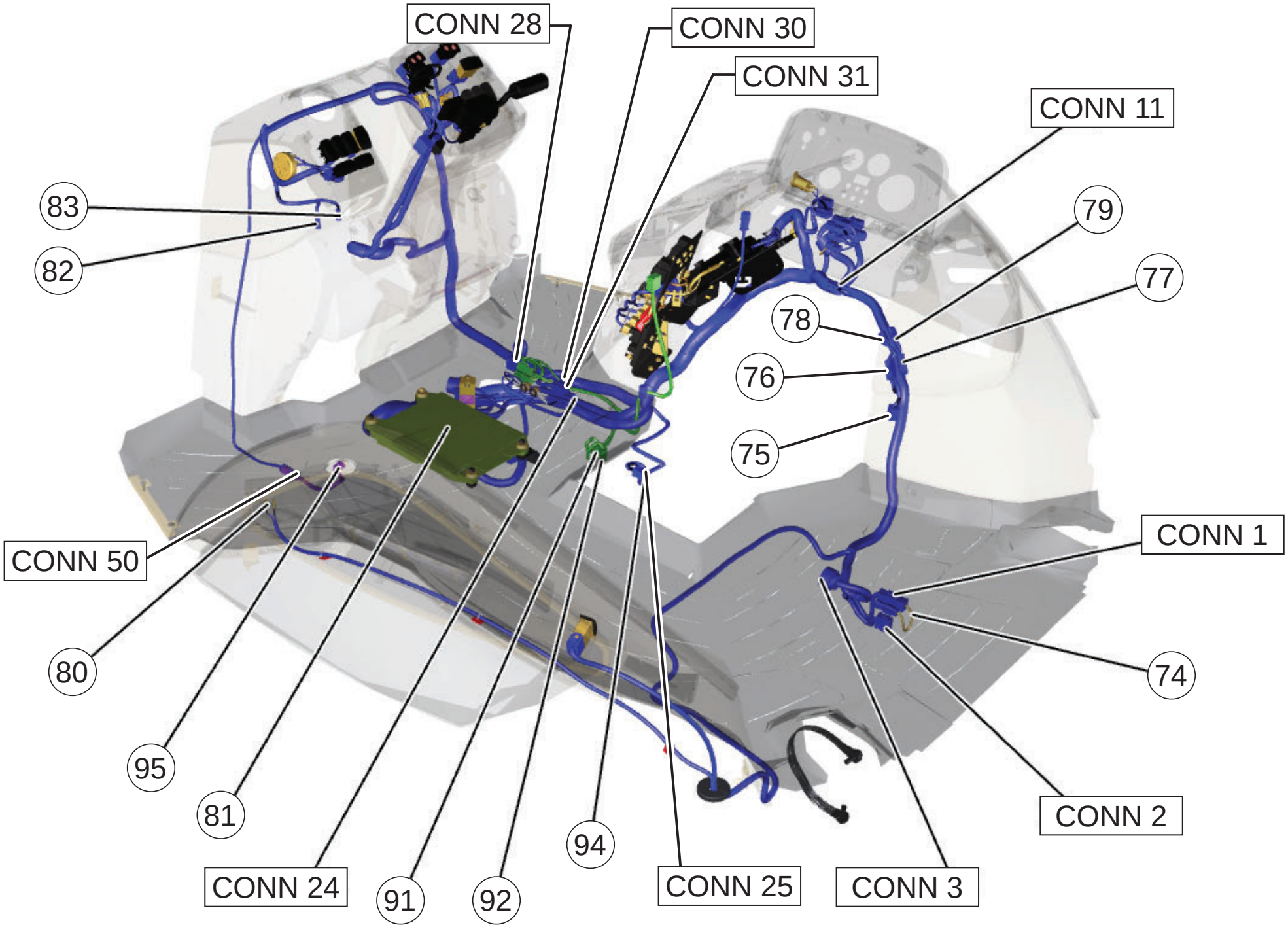
Cab Roof - Rear Wiring



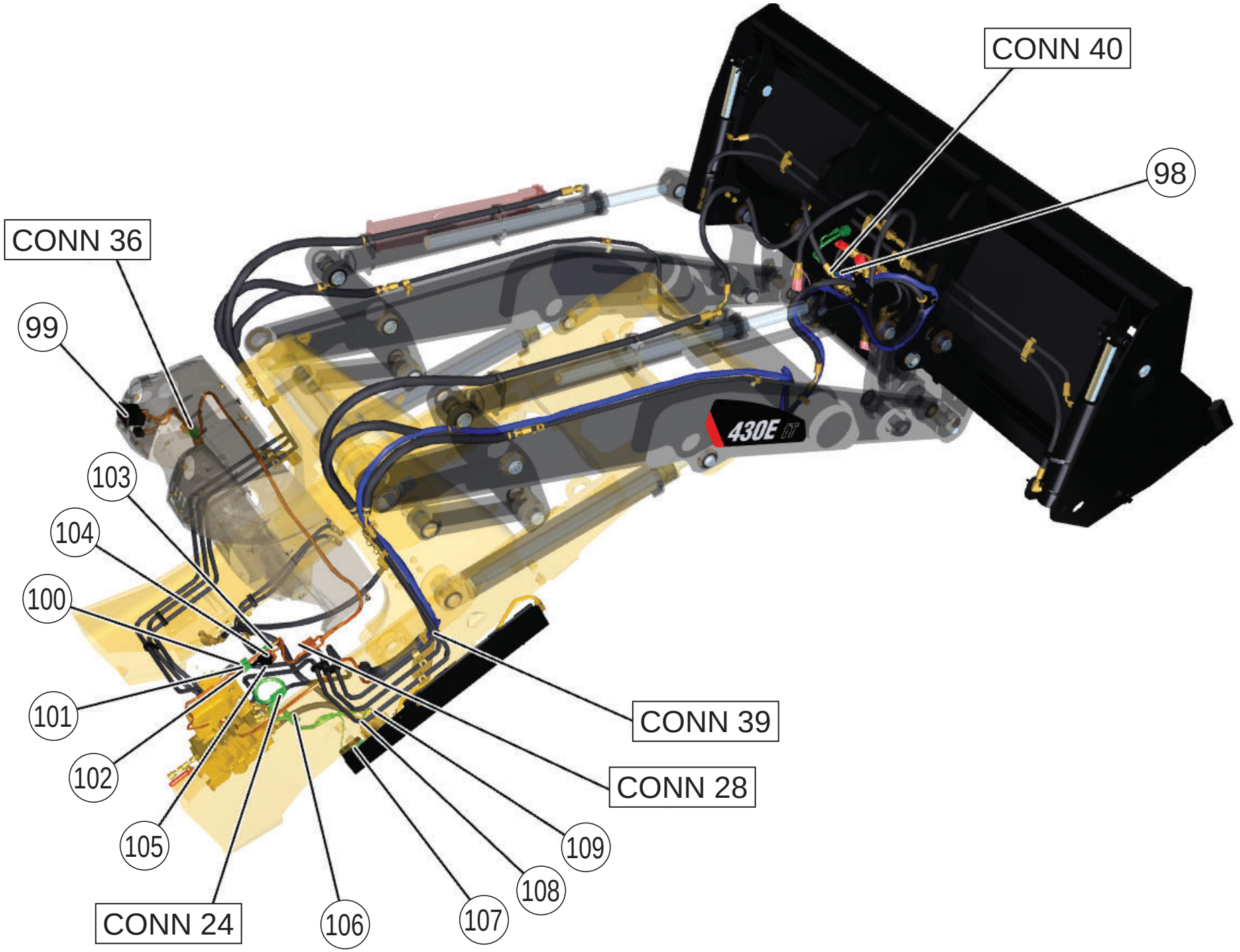
Platform Wiring - Front Right



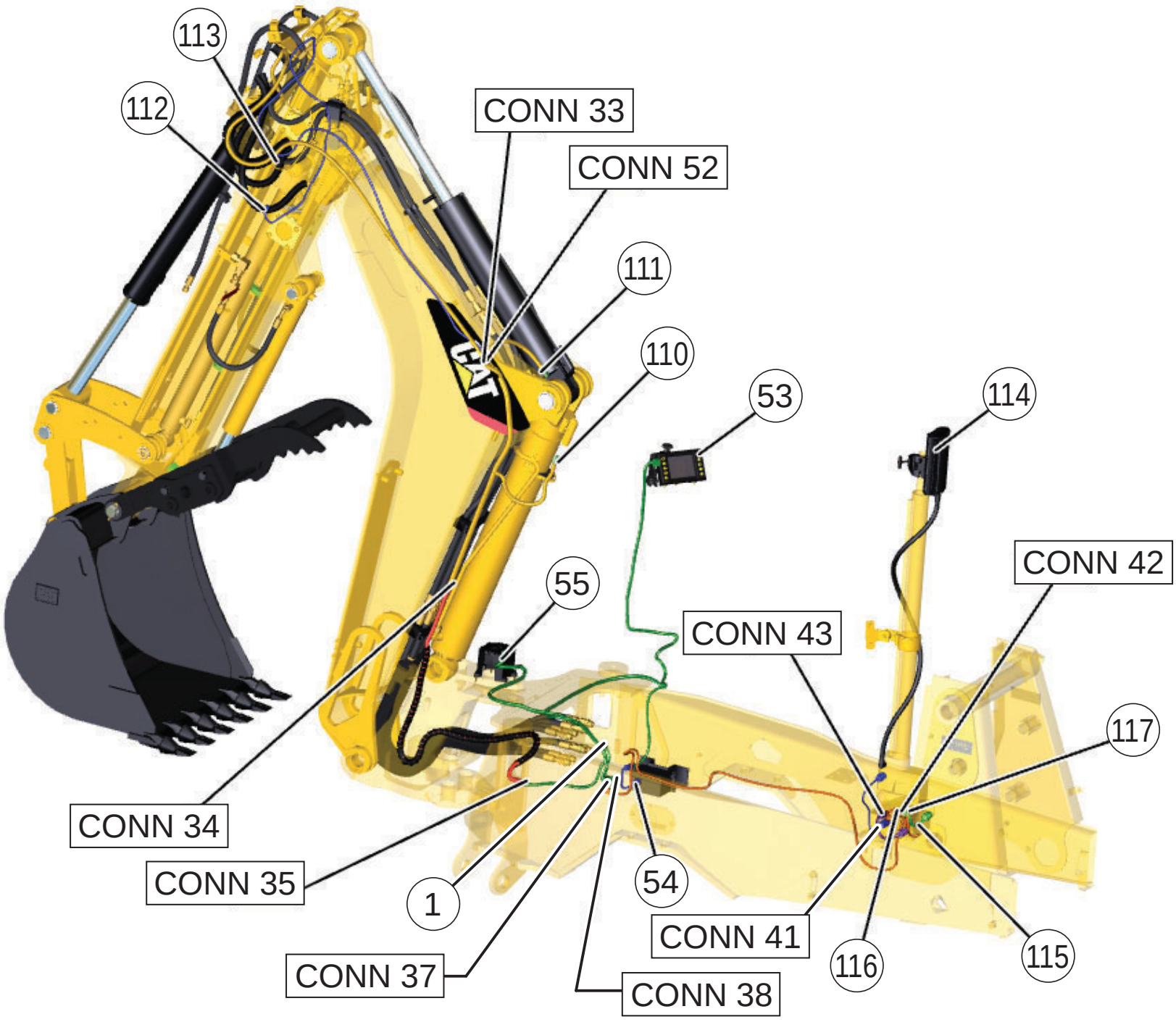
Platform Wiring - Rear Left



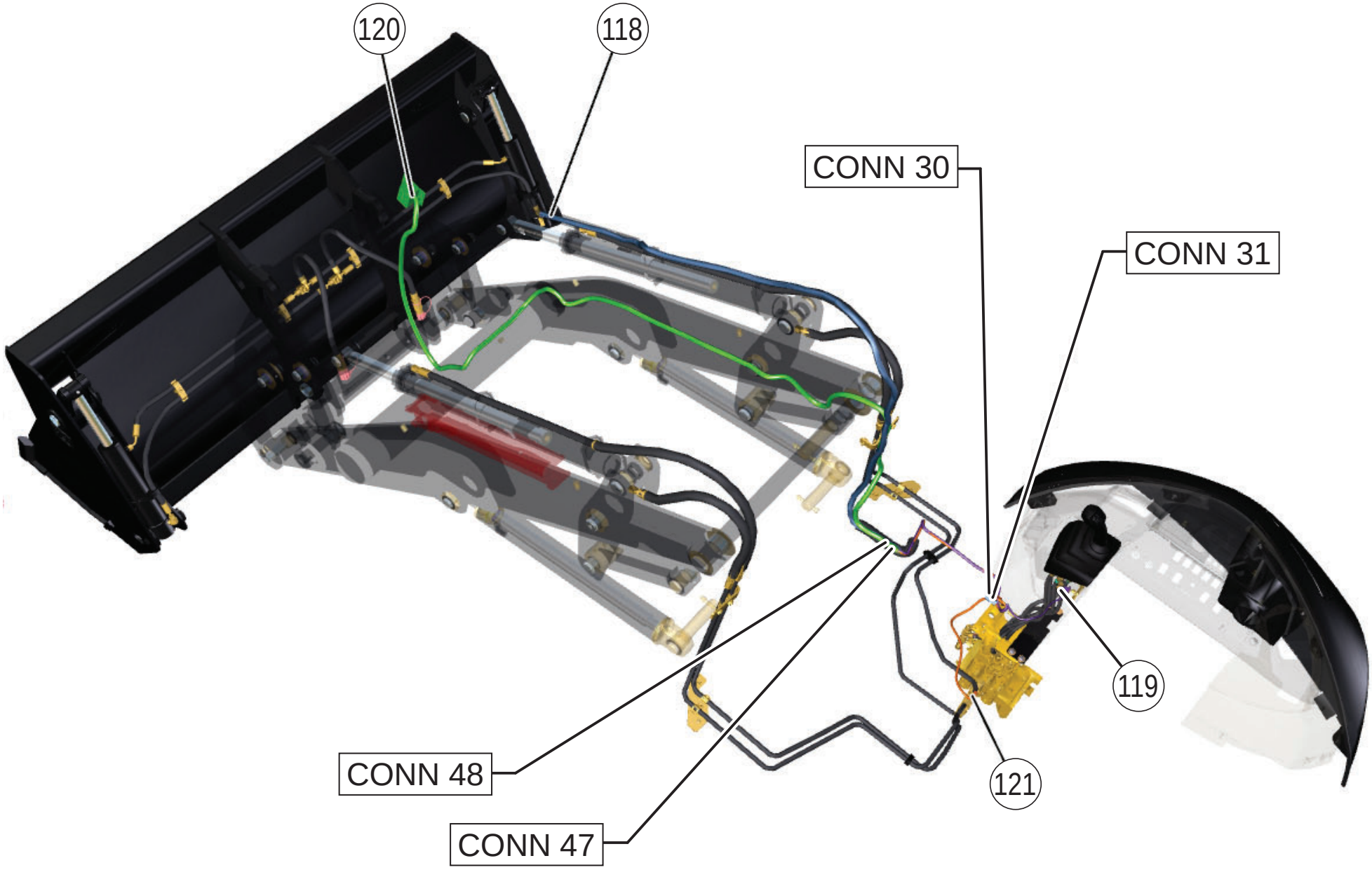
Quick Coupler Wiring

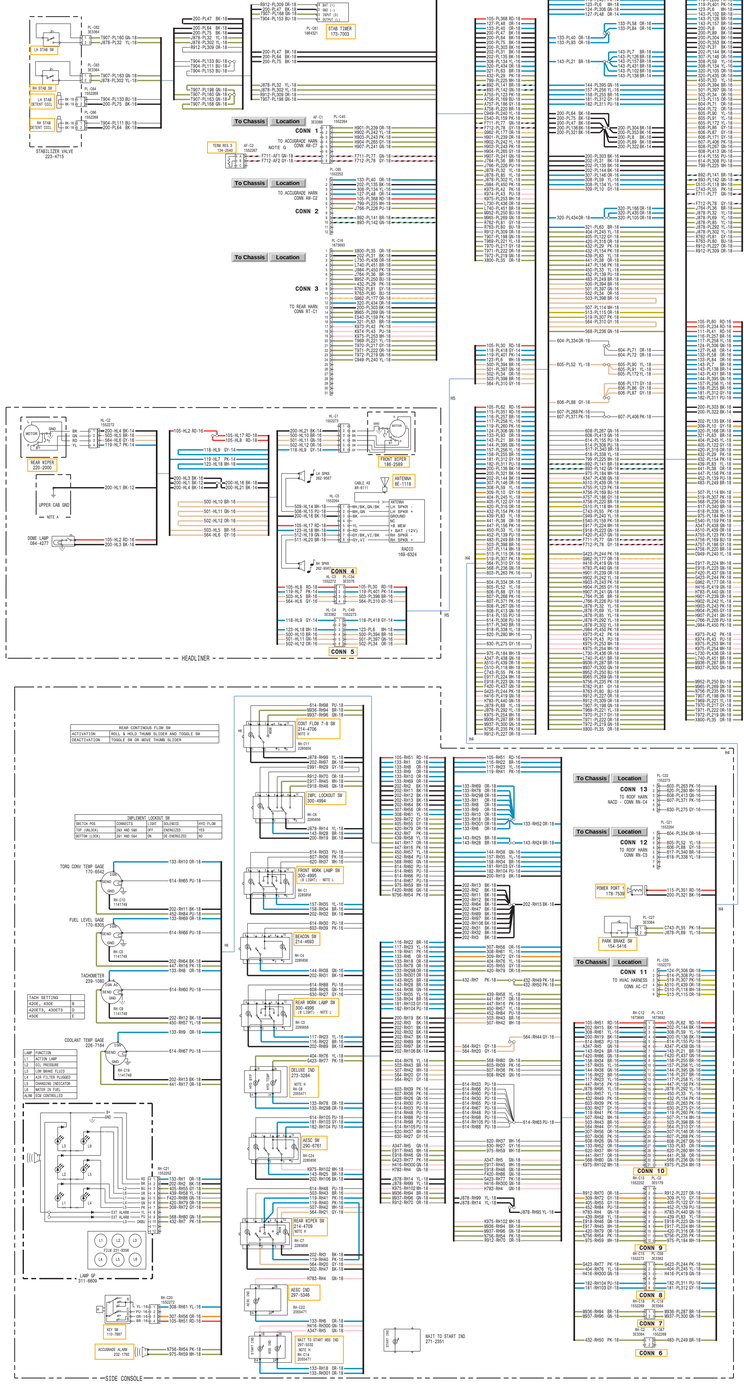


Accugrade Wiring



Return to Dig Wiring





WIRES ARE TWISTED. TWISTED 1 TWIST PER 25mm.
WIRES TO BE TWISTED ARE:
892-BR AND 893-GN
F711-GN AND F712-GY
E900-WH AND E901-GN

IDENT	PART NO.	CHG		LOC	NOTE	DESCRIPTION
				HARNESS AS.		
AE	290-6727	02	SH 2	C-2	J	HVAC AIR CONDITION - ENGINE
AC	290-6728	02	SH 2	F-10	J	HVAC - CONSOLE
AF	263-9498	01	SH 1	H-13	J	TERMINATING RES JUMPER
AV	246-8046	02	SH 2	D-11	J	ACCUGRADE CHECK - BASIC (DISPLAY)
AW	268-7761	03	SH 2	D-11	J	ACCUGRADE READY BASIC
AX	246-8044	03	SH 2	C-11	J	ACCUGRADE CHECK - ADVANCED
AY	290-6804	02	SH 2	D-13	J	ACCUGRADE READY - SWING CASTING
EN	290-6751	03	SH 2	F-1		ENGINE (ELEK)
ER	290-6806	02	SH 2	D-15	J	E-STICK JUMPER (14FT)
ER	290-6811	02	SH 2	D-15	J	E-STICK JUMPER (16 FT)
FA	268-7755	01	SH 1	E-4	J	FRONT AUX (3RD FUCNTION)
HL	213-6051	05	SH 1	F-14	H	HEADLINER
KF	213-6075	04	SH 2	A-14	J	QUICK COUPLER - FRONT CONSOLE
KL	213-6077	04	SH 2	A-11	J	QUICK COUPLER - LOADER
KP	213-6076	04	SH 2	A-12	J	QUICK COUPLER - PLATFORM
KT	211-9461	04	SH 2	A-10	J	QUICK COUPLER - BROOM
LN	290-6744	02	SH 1	F-4	J	SEAT HARNESS
MC	290-6741	01	SH 1	D-4	J	MSS TORNADO ECM
PK	225-7959	00	SH 1	D-8	J	AUTOSHIFT FNR
PA	268-7759	02	SH 1	E-1		POWER DISTRIBUTION
PJ	290-6808	02	SH 2	D-14	J	BUCKET SENSOR W/STD STICK
PJ	290-6809	02	SH 2	D-14	J	BUCKET SENSOR W/14 FT E-STICK
PJ	290-6810	02	SH 2	D-14	J	BUCKET SENSOR W/16 FT E-STICK
PL	290-6721	02	SH 1	F-4		PLATFORM
PT	290-6805	02	SH 2	D-13		BACKHOE SENSORS (STD STICK)
PU	290-6800	01	SH 2	I-6	J	RTD - PARALLEL (PLATFM)
PV	290-6801	01	SH 2	H-6	J	RTD - SGL TILT (PLATFM)
PW	246-8047	02	SH 2	I-4	H	RETURN TO DIG - PARALLEL LIFT
PX	233-7977	03	SH 2	H-4	H	RETURN TO DIG - SINGLE TILT
RH	290-6736	02	SH 1	B-14		CONSOLE - SIDE
RK	246-8038	02	SH 2	B-10	J	RIDE CONTROL
RN	213-6049	07	SH 2	I-12		ROOF (NACD)
RT	290-6787	01	SH 2	G-13		REAR (ET3)
WR	256-6803	03	SH 2	I-9	J	PRODUCT LINK - RADIO - 121SR
WV	256-6804	01	SH 2	I-7	J	PRODUCT LINK - GATEWAY - 321SR
XA	290-6755	02	SH 2	B-7	J	AUTOSHIFT XMSN - SOL
XC	225-7984	00	SH 2	D-9	J	ACCUGRADE - POWER MODULE B
XE	225-7985	00	SH 2	C-9	J	ACCUGRADE - POWER MODULE A
XF	225-7986	01	SH 2	C-9	J	ACCUGRADE - LASER MAST
XG	225-7987	01	SH 2	C-14	J	ACCUGRADE - INCLINOMETER
XK	290-6758	02	SH 2	H-2	J	STD XMSN - SOL
				CABLE AS.		
AA	246-8053	02	SH 2	B-1	H	POS (BAT TO STARTER)
CC	213-6094	02	SH 2	C-2	H	POS (STARTER TO ALTERNATOR)
EE	290-6791	00	SH 2	B-1	H	NEG (BATTERY TO SWITCH)
FF	290-6792	00	SH 2	A-2	H	NEG (SWITCH TO FRAME)
MM	290-6745	01	SH 2	B-1	H	POWER DISTRIBUTION
GG	213-6091	03	SH 2	A-1	H	POS (HD)
HH	213-6092	03	SH 2	A-1	H	NEG (HD)
				WIRE AS.		
FG	217-8058	02	SH 1	B-8		STEERING COLUMN HORN SW
PY	213-6060	03	SH 1	F-9	J	DIFF LOCK JUMPER

NOTE LOC	NOTE	DESCRIPTION
VARIOUS	NOTE A:	ASSEMBLE TERMINALS TO DESIGNATED STUD.
VARIOUS	NOTE D:	NOT USED ON PILOT MACHINE
SH 1 E-8	NOTE E:	CLOSED WHEN BRAKE IS DEPRESSED
SH 1 H-14	NOTE G:	FOR MACHINES WITH ACCUGRADE, REMOVE TERM RES AND CONNECT TO ACCUGRADE HARN
VARIOUS	NOTE H:	OPTION HARNESS - ALTERNATE BASED ON MACHINE CONFIGURATION.
VARIOUS	NOTE J:	ATTACHMENT HARNESS
SH 2 G-11	NOTE M:	WHEN USING A CAB WITH HEATER ONLY, HEATER AC SW IS REPLACED WITH VENT SW.
SH 2 F-11	NOTE N:	NORMALLY CLOSED AT PROPER REFRIGERANT CHARGE
SH 2 B-9	NOTE P:	FOR PARALLEL LIFT MACHINES ONLY, TIE BACK ON ALL SINGLE TILT MACHINES
SH 2 F-10	NOTE T:	FOR HVAC OPTION, CONNECT 122-BU-12 FROM HVAC HARN TO POWER MODULE SB STUD
SH 1 I-1	NOTE U:	FOR MACHINES WITHOUT HVAC, USE 2-BLOCK BUSS BAR 275-0553 FOR MACHINES WITH HVAC OPTION, USE 2-BLOCK BUSS BAR WITH OFFSET 275-0570

SYMBOL	DESCRIPTION
┼	CIRCUIT CONNECTED
+	CIRCUIT NOT CONNECTED
⏚	ELECTRICAL CONNECTION TO MACHINE STRUCTURE
⏚	INTERNAL ELECTRICAL CONNECTION TO SURFACE OF COMPONENT
→)—	CONNECTOR
H#	CIRCUIT GROUPING DESIGNATION
– – –	ATCH WIRE, CABLE, COMPONENT
○–○	CIRCUIT CONNECTED
○	SPLICE
●	BLADE, SPADE, RING OR SCREW TERMINAL

COLOR ABBREVIATIONS

ABBREV	COLOR
RD	RED
WH	WHITE
OR	ORANGE
YL	YELLOW
PK	PINK
BK	BLACK
GY	GRAY
PU	PURPLE
BR	BROWN
GN	GREEN
BU	BLUE

WIRE GROUP COLOR DESCRIPTIONS

■	GROUND CIRCUIT
🟥	WIRES THAT HAVE SYSTEM VOLTAGE WHEN THE KEY SWITCH IS OFF
🟦	WIRES THAT HAVE SYSTEM VOLTAGE WHEN THE KEY SWITCH IS ON
🟧	STARTING CIRCUIT
▨	IMPLEMENT CONTROL CIRCUIT
🟪	TRANSMISSION CIRCUIT
■	MACHINE SECURITY CONTROL CIRCUIT
🟨	HEATER AND AIR CONDITIONER CIRCUIT
■	TURN SIGNAL / WIPER WASHER CIRCUIT
🟩	MACHINE CONTROL CIRCUIT
▨	CAT DATA LINK
▨	RS-232 / RS-485 DATA LINK
▨	CAN DATA LINK A

OTHER COLOR DESCRIPTIONS

🟦	HIGHWAYS

THIS SCHEMATIC IS FOR THE 420E Tier III Backhoe Loader
VOLUME 1 of 2: Cab Wiring
PART NUMBER: 290-6781, CHANGE: 00, VERSION: -

Components are shown installed on a fully operable machine.

Refer to the appropriate Service Manual for Troubleshooting, Specifications and Systems Operations.

SYMBOL	DESCRIPTION
┼•	CIRCUIT CONNECTED
┼	CIRCUIT NOT CONNECTED
⏚	ELECTRICAL CONNECTION TO MACHINE STRUCTURE
⏚ (dashed)	INTERNAL ELECTRICAL CONNECTION TO SURFACE OF COMPONENT
→)—	CONNECTOR
H#	CIRCUIT GROUPING DESIGNATION
– – –	ATCH WIRE, CABLE, COMPONENT
○–○	CIRCUIT CONNECTED
○	SPLICE
●	BLADE, SPADE, RING OR SCREW TERMINAL

COLOR ABBREVIATIONS	
ABBREV	COLOR
RD	RED
WH	WHITE
OR	ORANGE
YL	YELLOW
PK	PINK
BK	BLACK
GY	GRAY
PU	PURPLE
BR	BROWN
GN	GREEN
BU	BLUE

WIRE GROUP COLOR DESCRIPTIONS

(black)	GROUND CIRCUIT
(red)	WIRES THAT HAVE SYSTEM VOLTAGE WHEN THE KEY SWITCH IS OFF
(blue)	WIRES THAT HAVE SYSTEM VOLTAGE WHEN THE KEY SWITCH IS ON
(light blue)	VOLTAGE CONVERTER OUTPUT CIRCUIT
(orange)	STARTING CIRCUIT
(pink)	START AID CIRCUIT
(purple)	TRANSMISSION CIRCUIT
(light pink)	ENGINE CONTROL CIRCUIT
(yellow)	HEATER AND AIR CONDITIONER CIRCUIT
(tan)	TURN SIGNAL / WIPER WASHER CIRCUIT
(olive)	MACHINE CONTROL CIRCUIT
(striped green/black)	CAT DATA LINK
(striped red/black)	RS-232 / RS-485 DATA LINK
(striped orange)	IMPLEMENT CONTROL CIRCUIT
(striped pink/black)	CAN DATA LINK A

OTHER COLOR DESCRIPTIONS

(light blue)	HIGHWAYS

THIS SCHEMATIC IS FOR THE 420E Tier III Backhoe Loader
VOLUME 2 of 2: Engine and Chassis

PART NUMBER: 290-6781, CHANGE: 00, VERSION: -

Components are shown installed on a fully operable machine.

Refer to the appropriate Service Manual for Troubleshooting, Specifications and Systems Operations.