

# T16AMR (Battery)

**Rider-Scrubber** 





Hygenic Fully<sup>®</sup> Cleanable Tanks TennantTrue<sup>®</sup> Parts







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9021276 Rev. 01 (07-2022)

#### INTRODUCTION

This manual is furnished with each new model. It provides necessary operation and maintenance instructions.



Read this manual completely and understand the machine before operating or servicing it.

This machine will provide excellent service. However, the best results will be obtained at minimum costs if:

- The machine is operated with reasonable care.
- The machine is maintained regularly per the machine maintenance instructions provided.
- The machine is maintained with manufacturer supplied or equivalent parts.

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### PROTECT THE ENVIRONMENT

Please dispose of packaging materials, used components such as batteries and fluids in an environmentally safe way according to local waste disposal regulations. Always remember to recycle.

MACHINE DATA         Please fill out at time of machine install for future reference.         Model No	
Serial No	

The T16AMR is an industrial robotic rider scrubber machine. It is designed exclusively to wet scrub both rough and smooth hard surfaces (concrete, tile, stone, synthetic, etc). This machine can be operated in either robotic mode (without operator) or manual mode (with operator). This machine is intended for indoor use only. Do not use this machine on soil, grass, artificial turf, or carpeted surfaces. This machine is not intended for use on public roadways. Do not use this machine other than described in this Service Manual. Only use recommended accessories. The T16AMR Scrubber, powered by BrainOS, should only be used by trained operators in controlled, restricted environments approved by Brain Corp/Tennant Company.

#### **Tennant Company**

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www.tennantco.com

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### **IMPORTANT SAFETY INSTRUCTIONS - SAVE THESE INSTRUCTIONS**

The following precautions are used throughout this manual as indicated in their descriptions:



WARNING: To warn of hazards or unsafe practices that could result in severe personal injury or death.

FOR SAFETY: To identify actions that must be followed for safe operation of equipment.

The following information signals potentially dangerous conditions to the operator. Know when these conditions can exist. Locate all safety devices on the machine. Report machine damage or faulty operation immediately.



WARNING: Lead-acid batteries emit hydrogen gas. Explosion or fire can result. Keep sparks and open flame away. Keep covers open when charging.

WARNING: Flammable materials can cause an explosion or fire. Do not use flammable materials in tank(s).



WARNING: Flammable materials or reactive metals can cause an explosion or fire. Do not pick up.

ESCALATOR WARNING: Always place a cone or other physical barrier at escalator entrances and exits before teaching or running routes.

This machine is equipped with technology that automatically communicates over the cellular network. This machine is equipped with BrainOS software that is accessible via the BrainOS User Interface (UI) Touch Screen. Avoid operating machine in areas where other equipment that may be sensitive to electromagnetic noise is located.

### FOR SAFETY:

- 1. Do not operate machine:
  - Unless trained and authorized.
  - Unless operator manual is read and understood.
  - Under the influence of alcohol or drugs.
  - In Manual Mode: While using a cell phone or other types of electronic devices.
  - Unless mentally and physically capable of following machine instructions.
  - With brake disabled.
  - Without filters in place or with clogged filters.
  - If it is not in proper operating condition.
  - In areas where flammable vapors/liquids or combustible dusts are present.
  - In outdoor areas. This machine is for indoor use only.
  - In areas that are too dark to safely see the controls or operate the machine.
  - In areas with possible falling objects.
- 2. Before Starting Machine:
  - Check machine for fluid leaks.
  - Make sure all safety devices are in place and operate properly.
  - Check brakes and steering for proper operation.
  - In Manual Mode: Adjust seat and fasten seat belt (if equipped).
- 3. When using machine in manual mode:
  - Use only as described in this manual.
  - Use brakes to stop machine.
  - Reduce speed when turning.
  - Go slowly on inclines and slippery surfaces.
  - Do not scrub on ramp inclines that exceed 7% / 4° grade or transport (GVWR) on ramp inclines that exceed 8.75% / 5° grade.
  - Drive slowly through doorways and narrow openings.
  - Be cautious of the squeegee near bystanders and obstacles.
  - Keep all parts of body inside operator station while machine is moving.
  - Always be aware of surroundings while operating machine.
  - Use care when reversing machine.
  - Keep children and unauthorized persons away from machine.
  - Do not allow machine to be used as a toy.
  - Do not carry passengers on any part of the machine.
  - Always follow safety and traffic rules.

- Report machine damage or faulty operation immediately.
- Follow mixing, handling and disposal instructions on chemical containers.
- Place proper floor cleaning signage in areas where the machine is operating and people are present, in accordance with standard floor cleaning practices.
- Follow site safety guidelines concerning wet floors.
- 4. When using machine in robotic mode:
  - Use only as described in this manual.
  - As the machine begins robotic operation, observe scrubbing performance to ensure that all components are functioning properly.
  - Remove the key from the ON/OFF key switch without turning it to the off position. This will not disrupt the robotic route and prevents it from being stolen or lost.
  - Do not attempt to ride machine.
  - Do not grab steering wheel or put hands or arms through the holes of the steering wheel. Steering wheel may move rapidly and unexpectedly while in robotic mode.
  - Do not operate machine in environments requiring fail-safe performance (areas where machine failure could lead to personal injury or property damage).
  - Guard sudden drops, stairs, escalators, or moving platforms in area of machine operation with a physical barrier.
  - Do not use ladders, scaffolds, or other temporary constructed structures in area of machine operation.
  - Only scrub flat, hard surfaces with 2% or less incline.
  - Do not operate machine in low traction environments (ice, oil, etc...).
  - Do not leave electrical cords or low profile items (anything having a height of less than 10 cm from ground) in area of machine operation.
  - Always operate machine in manual mode when going into elevators or through automatic doors. Robotic routes should never include going into elevators or through automatic doors.
  - Keep children and unauthorized persons away from machine.
  - Do not allow machine to be used as a toy.
  - Do not carry passengers on any part of the machine.
  - Always follow safety and traffic rules.
  - Report machine damage or faulty operation immediately.
  - Follow mixing, handling and disposal instructions on chemical containers.

- Place proper floor cleaning signage in areas where the machine is operating and people are present, in accordance with standard floor cleaning practices.
- Follow site safety guidelines concerning wet floors.
- 5. Before leaving or servicing machine:
  - Stop on level surface.
  - Turn off machine and remove key.
- 6. When servicing machine:
  - All work must be done with sufficient lighting and visibility.
  - Keep work area well ventilated.
  - Avoid moving parts. Do not wear loose clothing, jewelry and secure long hair.
  - Block machine tires before jacking machine up.
  - Jack machine up at designated locations only. Support machine with jack stands.
  - Use hoist or jack that will support the weight of the machine.
  - Do not push or tow the machine without an operator in the seat controlling the machine.
  - Do not push or tow the machine on inclines with the brake disabled.
  - Do not power spray or hose off machine. Electrical malfunction may occur. Use damp cloth.
  - Plug the off-board charger into a properly rated outlet only.
  - Do not disconnect the off-board charger's DC cord from the machine's receptacle when the charger is operating. Arcing may result. If the charger must be interrupted during charging cycle, disconnect the AC power supply cord first.
  - Disconnect battery connections before working on machine.
  - Do not disconnect battery connections while machine is charging. Machine electrical damage may occur.
  - Do not pull on battery charger cord to unplug. Grasp plug at outlet and pull.
  - Do not use incompatible battery chargers as this may damage battery packs and potentially cause a fire.
  - Do not charge frozen batteries.
  - Inspect charger cord regularly for damage.
  - Avoid contact with battery acid.
  - Keep all metal objects off batteries.
  - Use a non-conductive battery removal device.
  - Use a hoist and adequate assistance when lifting batteries.
  - Battery installation must be done by trained personnel.

### SAFETY

- Follow site safety guidelines concerning battery removal.
- All repairs must be performed by trained personnel.
- Do not modify the machine from its original design.
- Use Tennant supplied or approved replacement parts.
- Wear personal protective equipment as needed and where recommended in this manual.

For Safety: wear hearing protection.

For Safety: wear protective gloves.

For Safety: wear eye protection.



For Safety: wear protective dust mask.

- 7. When using Lithium-ion Battery model:
  - Battery service to be performed by Tennant Service only.
  - Battery installation requires a specific service kit which includes a hoisting strap and proper lifting instructions. Contact Tennant Service (Lithium Case Battery Only).
  - Do not attempt to lift battery by hand or by any other unauthorized method (Lithium Case Battery Only).
  - Do not disassemble or mistreat battery.
     Do not tear seal tape or will void warranty (Lithium Case Battery Only).
  - Lithium batteries are designed exclusively for specific Tennant machine applications. Do not install battery pack in unapproved machines.
  - Dispose of battery in accordance with local regulations. Contact Tennant Service.
  - Contact Tennant Service or your local regulatory authorities for proper transporting instructions of lithium–ion batteries.
  - Disconnect battery cable connector, battery management system (BMS) connector and charger cord before working on machine.
  - Use only OEM approved battery charger supplied with lithium-ion battery.
  - Do not expose battery to temperatures below -22°F (-30°C), above 140°F (60°C).
  - Do not use machine immediately after longterm extreme temperature storage. Before use, return battery module temperature range to 50°F (10°C)~95°F (35°C)

- Do not operate or store battery in hazardous environment (electrically charged, humidity, extreme temperatures and magnetic fields).
- Do not expose battery to flame or plasma.
- Do not drop, crush or subject battery to impact, as it may cause battery to heat up or catch fire.
- Do not put battery in fire or water to avoid battery explosion.
- Do not touch battery with wet hand, avoid electric shock.
- Stop using or charging the battery immediately if battery has abnormal temperature, leakage or other abnormal conditions.
- 8. When loading/unloading machine onto/off truck or trailer:
  - Use ramp, truck or trailer that will support the weight of the machine and operator.
  - Drain tanks before loading machine.
  - Do not drive on a slippery ramp.
  - Use caution when operating on a ramp.
  - Do not load/unload on ramp inclines that exceed 12.3% / 7° grade.
  - Lower scrub head and squeegee before tying down machine.
  - Turn off machine and remove key.
  - Block machine tires.
  - Use tie-down straps to secure machine.

The following safety labels are mounted on the machine in the locations indicated. Replace damaged/missing labels.



electrical panel.

# SAFETY

Lithium-ion Battery Model (Lithium Case Battery Only): the safety label appears on the lithium-ion battery pack in the location indicated. Replace damaged labels.

### LITHIUM-ION BATTERY CAUTION LABEL -Located on top of the battery pack.

▲ CAUTION	▲ ATTENTION	ATENCIÓN
<ol> <li>Do not expose battery to temperatures below -30° C(-22°F), above 60°C (140°F).</li> <li>Do not disassemble or mistreat battery. Do not crush.</li> <li>Do not drop or subject it to impact.</li> <li>Use only OEM approved charger.</li> <li>Failure to follow these instructions may present risk of explosion, fire, or high temperatures.</li> <li>See owner's manual for additional safety instructions.</li> <li>Recommended torque for stud assembly is; M8 = 9.1Nm / M12 = 24.5Nm.</li> <li>Refer to owner's manual for lifting instructions.</li> <li>Service by Tennant Personnel only.</li> </ol>	<ol> <li>No exponga la batería a temperaturas por debajo de-30 ° C(-22 °F), por encima de 60 ° C (140 ° F).</li> <li>No desarmar ni maltratar la batería. No la aplaste.</li> <li>No deje caer ni la someta a impactos.</li> <li>Use solo el cargador Original aprobado.</li> <li>El incumplimiento de estas instrucciones puede presentar riesgo de explosión, fuego o altas temperaturas.</li> <li>Véase el manual del propietario para instrucciones adicionales de seguridad.</li> <li>El par recomendado de apriete para el poste es de; M8 - 9.1Nm / M12 = 24.5Nm.</li> <li>Consulte el manual del propietario para las instrucciones de elevación.</li> <li>Servicio por técnicos de Tennant exclusivamente.</li> </ol>	<ol> <li>N'exposez pas la batterie à des températures inférieures à -30 ° C (supérieures à 60 ° C).</li> <li>Ne pas démonter ni maltraiter la batterie. Ne pas écraser.</li> <li>Ne la laissez pas tomber et ne la soumettez pas à un impact.</li> <li>Utilisez uniquement un chargeur approuvé par l'OEM.</li> <li>Le non-respect de ces instructions peut présenter un risque d'explosion, d'incendie ou de températures élevées.</li> <li>Voir le manuel du propriétaire pour les consignes de sécurité supplémentaires.</li> <li>Le couple recommandé pour le montage des goujons est de: M8 - 9.1Nm / M12 = 24,5 Nm.</li> <li>Reportez-vous au manuel du propriétaire pour les instructions de levage.</li> <li>Service réservé au personnel Tennant.</li> </ol>
	Tennant Co File Number: MH63465	y Disposal contact Tennant ical Service 1-800-553-8033 1247721



(Lithium-ION Battery Case Only)

# SAFETY

#### MACHINE COMPONENTS





- A. Recovery tank drain hose
- B. Solution tank drain hose
- C. Left perimeter guard
- D. Retractable strap (Anti-Joyride)
- E. User Interface (UI) touchscreen
- F. Control panel
- G. Recovery tank
- H. Recovery tank cover
- I. Backup alarm / flashing light
- J. Operator seat
- K. Batteries
- L. Battery charging connector (Flooded lead battery only)
- M. Solution tank cover

- N. Solution tank
- O. Sensor panel
- P. Brake pedal
- Q. Propel pedal
- R. Front perimeter guard
- S. Side squeegee
- T. Scrub head
- U. Right perimeter guard
- V. Rear squeegee
- W. Squeegee vacuum hose
- X. Steering wheel
- Y. Rear squeegee guard
- Z. Debris tray
- AA. Battery charging connection (Lithium-ion battery)

### CONTROLS AND INSTRUMENTS





- A. ON/OFF key switch
- B. Emergency Stop Button (located on control panel and back of machine)
- C. 1-Step button
- D. Horn button
- E. Brush pressure button
- F. Brush pressure indicator lights
- G. Solution flow indicator lights
- H. Solution flow button (Conventional scrubbing)

- I. Vacuum fan/squeegee button
- J. ec-H2O system indicator light
- K. ec-H2O system on/off button
- L. Directional switch
- M. Blue start/pause button
- N. Operating lights switch
- O. Solution flow button (ec-H2O system)

### **CAMERAS AND SENSORS**



- A. Sensors Upper LIDAR
- B. Signal lights (Front)
- C. Sensors Front 2D camera
- D. Sensors Front 3D camera
- E. Sensors Side 2D camera (located on each side of machine)
- F. Sensors Side 3D camera (located on each side of machine)
- G. Sensors Lower LIDAR

**DPDT Switch** 

Motor

3 Phase AC

Motor Encoder

Sensor

-

 $-\underline{\circ}$ 

0 070

### **ELECTRICAL SCHEMATIC SYMBOLS**



Solenoid Valve

 $\gg$ 













105K/GRN

фр

STEERING COLUMN GROUND













# FASTENER TORQUE

### SAE (STANDARD)

Thread Size	SAE Grade 1	SAE Grade 2 Carriage Bolts	Thread Cutting Thread Rolling	SAE Grade 5 Socket & Stainless Steel	SAE Grade 8	Headless Socket Set Screws	Square Head Set Screws	
4 (.112)	(5) - (6.5)					(4) - (6)		
5 (.125)	(6) - (8)					(9) - (11)		Inch
6 (.138)	(7) - (9)		(20) - (24)			(9) - (11)		Por
8 (.164)	(12) - (16)		(40) - (47)			(17) - (23)		spur
10 (.190)	(20) - (26)		(50) - (60)			(31) - (41)		1
1/4 (.250)	4 - 5	5 - 6	7 - 10	7 - 10	10 - 13	6 - 8	17 - 19	
5/16 (.312)	7 - 9	9 - 12	15 - 20	15 - 20	20 - 26	13 - 15	32 - 38	1
3/8 (.375)	13 - 17	16 - 21		27 - 35	36 - 47	22 - 26	65 - 75	7
7/16 (.438)	20 - 26	26 - 34		43 - 56	53 - 76	33 - 39	106 - 124	of P
1/2 (.500)	27 - 35	39 - 51		65 - 85	89 - 116	48 - 56	162 - 188	oun
5/8 (.625)		80 - 104		130 - 170	171 - 265		228 - 383	ds
3/4 (.750)		129 - 168		215 - 280	313 - 407		592 - 688	]
1 (1.000)		258 - 335		500 - 650	757 - 984		1281 - 1489	]

### METRIC

Thread Size	4.8/5.6	8.8 Stainless Steel	10.9	12.9	Set Screws
М3	43 - 56 Ncm	99 - 128 Ncm	139 - 180 Ncm	166 - 215 Ncm	61 - 79 Ncm
M4	99 - 128 Ncm	223 - 290 Ncm	316 - 410 Ncm	381 - 495 Ncm	219 - 285 Ncm
M5	193 - 250 Ncm	443 - 575 Ncm	624 - 810 Ncm	747 - 970 Ncm	427 - 554 Ncm
M6	3.3 - 4.3 Nm	7.6 - 9.9 Nm	10.8 - 14 Nm	12.7 - 16.5 Nm	7.5 - 9.8 Nm
M8	8.1 - 10.5 Nm	18.5 - 24 Nm	26.2 - 34 Nm	31 - 40 Nm	18.3 - 23.7 Nm
M10	16 - 21 Nm	37 - 48 Nm	52 - 67 Nm	63 - 81 Nm	
M12	28 - 36 Nm	64 - 83 Nm	90 - 117 Nm	108 - 140 Nm	
M14	45 - 58 Nm	102 - 132 Nm	142 - 185 Nm	169 - 220 Nm	
M16	68 - 88 Nm	154 - 200 Nm	219 - 285 Nm	262 - 340 Nm	
M20	132 - 171 Nm	300 - 390 Nm	424 - 550 Nm	508 - 660 Nm	
M22	177 - 230 Nm	409 - 530 Nm	574 - 745 Nm	686 - 890 Nm	
M24	227 - 295 Nm	520 - 675 Nm	732 - 950 Nm	879 - 1140 Nm	

### GENERAL MACHINE DIMENSIONS/CAPACITIES/ PERFORMANCE

Item	Dimension / Capacity
Length	2030 mm (80 in)
Height (to light)	1475 mm (58 in)
Width/rear squeegee	1070 mm (42 in)
Width/frame rollers	1070 mm (42 in)
Cylindrical scrub brush diameter	205 mm (8 in)
Cylindrical brush length	910 mm (36 in)
Scrubbing path width	910 mm (36 in)
Track	900 mm (35.5)
Wheel base	1091 mm (43 in)
Solution tank capacity	190 L (50 gallons)
Recovery tank capacity	225 L (60 gallons)
Demisting tank	38 L (10 gallons)
Weight/net less batteries	528 Kg (1165 lbs)
Weight/with standard battery package	785 Kg (1725 lbs)
weight/with Lithium-ion battery	635 Kg (1400 lbs)
GVWR	1118 Kg (2465 lbs)
Protection Grade	IPX3

Values determined as per IEC 60335-2-72	Measure
Sound pressure level LpA	66 dB(A)
Sound pressure uncertainty KpA	4 dB(A)
Sound power level LWA + Uncertainty KWA	89 dB(A)
Vibration - Hand-arm	<2.50 m/s <sup>2</sup>
Vibration - Whole body	<0.50 m/s <sup>2</sup>

### **GENERAL MACHINE PERFORMANCE**

Item	Measure
Aisle turnaround (Manual)	2110 mm (83 in)
Aisle turnaround (Autonomous)	3430 mm (135 in)
Travel Speed Forward (maximum) - Manual Mode	6.1 Km/h (3.8 mph)
Travel Speed Forward (maximum) - Robotic Mode	3.5 Km/h (2.2 mph)
Travel Speed Reverse - Manual Mode Only	4.0 Km/h (2.5 mph)
Maximum rated climb and descent angle with full tanks (Robotic Mode)	2% / 1°
Maximum ramp incline for scrubbing - (Robotic mode)	2% / 1°
Maximum ramp incline for transporting (GVWR - Manual mode only)	8.75% / 5°
Maximum ramp incline for loading – Empty (Manual mode only)	12.3% / 7°
Maximum ramp incline for scrubbing - (Manual mode)	7.0% / 4°
Maximum ambient temperature for machine operation	40° C (104° F)
Minimum temperature for operating machine scrubbing functions	2° C (36° F)

### POWER TYPE

Туре	Quantity	Volts	Ah Rating	Weight (each)
Batteries (flooded lead acid)	6	36	360@20 hr rate	44 kg (98 lb)
Lithium-ion Battery	6 pack	36	331 / 12.2 kWh	114.5 kg (252.5 lb)

Туре	Use	VDC	kW (hp)
Electric Motors	Scrub brush	36	0.75 kW (1.00 hp)
	Vacuum fan	36	0.6 kW (0.8 hp)
	Propelling	36	1.1 kW (1.5 hp)

Туре	VDC	amp	Hz	Phase	W	VAC
Charger (Lead-acid)	36	21	45-65	1	756	85-265
Charger, lithium-ion	36	90	50-60	1	3240	200-240

#### TIRES

Location	Туре	Size
Front (1)	Solid	90 mm wide x 250 mm OD (3.5 in wide x 10 in OD)
Rear (2)	Solid	102 mm wide x 300 mm OD (4 in wide x 12 in OD)

### CONVENTIONAL SCRUBBING

Item	Measure
Solution pump	36 Volt DC, 12.5 LPM (3.3 GPM) open flow
Solution flow rate	Low: 0.5 gpm
	Medium: 1.0 gpm
	High: 1.5 gpm

#### ec-H2O SYSTEM

Item	Measure
Solution pump	36 Volt DC, 12.5 LPM (3.3 GPM) open flow
Solution flow rate	Low: 0.35 gpm
	Medium: 0.44 gpm
	High: 0.53 gpm

### MACHINE DIMENSIONS





### MAINTENANCE



# **MAINTENANCE CHART**

The table below indicates the Person Responsible for each procedure.

O = Operator. T = Trained Personnel.

Interval	Person Resp.	Key	Description	Procedure	Lubricant/ Fluid	No. of Service Points
Daily	0	1	Side and rear	Check, flip or replace	-	3
			squeegees	Check deflection and leveling	-	6
	0	2	Main brushes	Check for damage, wear, debris	-	2
	0	3	Recovery tank	Clean tank		1
	0	13	Solution tank	Drain and rinse as necessary	-	1
	0	4	Vacuum fan inlet filter	Clean		1
	0	5	Debris tray	Clean		1
	0	6	Front/side 2D and 3D sensors and upper/ lower LIDAR sensors	Check for damage. Clean with provided microfiber cloth.	-	8
	0	7	Perimeter guards (left, right, and front)	Check for debris, damage, and wear	-	3
Weekly	Т	8	Battery cells (Lead-acid)	Check electrolyte level (Lead Acid)	DW	3
50 Hours	0	9	Squeegee caster wheel pivot points	lubricate	SPL	4
	0	2	Main brushes	Rotate brushes from front to rear	-	2
100 Hours	Т	4	Vacuum fan and recovery tank seals	Check for damage and wear	-	3
	0	13	Solution tank seals	Check for damage and wear		2
	0	8	Battery watering system (option)	Check hoses for damage and wear	-	All
200 Hours	Т	8	Battery terminals and cables	Check and clean	-	12
	Т	10	Brush drive belts	Check for damage and wear	-	2
	Т	11	Steering gear chain	Lubricate, check tension, and check for damage and wear.	GL	1

# MAINTENANCE

Interval	Person Resp.	Key	Description	Procedure	Lubricant/ Fluid	No. of Service Points
500 Hours	Т	15	Vacuum fan motor(s)	Check motor brushes (Check every 100 hours after initial 500 hour check)	-	1
	Т	16	Tires	Check for damage and wear	-	3
	Т	10	Scrub brush motors	Check motor brushes (Check every 100 hours after initial 500 hour check)	-	2
	Т	11	Propelling motor	Check motor brushes (Check every 100 hours after initial 500 hour check)	-	1

LUBRICANT/FLUID

DW Distilled water

SPL Special lubricant, Lubriplate EMB grease (Tennant part number 01433-1) SAE 90 weight gear lubricant

GL

# YELLOW TOUCH POINTS

This machine features easy to find yellow touch points for simple service items. No tool are required to perform these maintenance items.



### REAR SQUEEGEE CASTERS

Lubricate the rear squeegee caster pivot point on each squeegee caster after every 50 hours.



### LUBRICATION

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

### **STEERING GEAR CHAIN**

The steering gear chain is located directly above the front tire. Check for damage or wear and lubricate the steering gear chain after every 200 hours.


## BATTERIES

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

The lifetime of the batteries depends on their proper maintenance. To get the most life from the batteries;

### FLOODED (WET) LEAD-ACID BATTERIES

- Do not charge the batteries more than once a day and only after running the machine for a minimum of 15 minutes.
- Do not leave the batteries partially discharged for long period of time.
- Only charge the batteries in a well-ventilated area to prevent gas build up. Charge batteries in areas with ambient temperatures 27C (80F) or less.
- Allow the charger to complete charging the batteries before re-using the machine.
- Maintain the proper electrolyte levels of flooded (wet) batteries by checking levels weekly.

### CHECKING THE ELECTROLYTE LEVEL

The flooded (wet) lead-acid batteries require routine watering as described below. Check the battery electrolyte level weekly.

NOTE: **Do Not** check the electrolyte level if the machine is equipped with a battery watering system.



FOR SAFETY: When servicing machine, keep all metal objects off batteries. Avoid contact with battery acid.

The electrolyte level should be slightly above the battery plates as shown before charging. Add distilled water if low. DO NOT OVERFILL. The electrolyte will expand and may overflow when charging. After charging, distilled water can be added up to about 3 mm (0.12 in) below the sight tubes.



NOTE: Make sure the battery caps are in place while charging. There may be a sulfur smell after charging batteries. This is normal.

### **CHECKING CONNECTIONS / CLEANING**

After every 200 hours of use check for loose battery connections and clean the surface of the batteries, including terminals and cable clamps, with a strong solution of baking soda and water. Replace any worn or damaged wires. Do not remove battery caps when cleaning batteries.



### LITHIUM-ION BATTERY

The lithium-ion battery pack is a maintenancefree battery protected by a battery management system (BMS). To achieve the maximum battery life, carefully follow the instructions below:

- Lithium-Ion batteries must be charged prior to initial use.
- Carefully follow the Important Safety Instructions section in the manual when using the Lithium-ion Battery Model.
- Only use the lithium-ion battery charger supplied with machine.
- Charge battery pack in well-ventilated areas. For best charging performance, charge the battery pack in temperatures below 80F/27C and above 32F/0C. Battery pack may shut down and not take a charge in elevated or freezing temperatures.
- It is recommended to only recharge battery pack when discharge indicator level reaches the last bar. Do not store the machine for an extended period if battery is discharged to the last bar, the battery may further discharge to a level that is unrecoverable.
- When the machine shuts down due to a depleted battery pack, do not repeatedly cycle the key switch on and off. This may cause permanent battery pack damage. Recharge battery pack immediately to avoid damage.
- Allow charge cycle to completely charge battery pack.
- Opportunity charging (i.e. partial charge cycle of a half hour or more) is only recommended if discharge level is below 80%.
- Do not operate machine in temperatures above 110F / 43C or below -4F / -20C. Machine may shutdown if exceed these temperatures.
- When removing or replacing the lithiumion battery pack, a specific lifting kit is recommended. It is important to use nonconductive lifting straps positioned at all four lift points with straps angled at 45° or greater when hoisting battery pack (Lithium Case Battery Only).
- Contact Tennant Service for lithium-ion battery service and replacement (Lithium Case Battery Only).

# BATTERY POWER BUTTON / BATTERY DISCHARGE INDICATOR

Each Lithuim-Ion battery contains a power button to turn on/off the battery power supply. The battery discharge indicator (BDI) displays the current state of the battery.



To display the battery charge status or fault state (while the batteries are active), press and hold the power button of any battery for **one second**. When the batteries are fully charged, all five green indicators are lit. As the battery discharges, the indicator levels decreases. If the indicators flash red the battery is getting very low. If the indicators display solid red along with green, the battery has a fault. Contact Tennant Service to fix the fault.

LED Indicator Status	Battery State of Charge
0	81-100%
	61-80%
	41-60%
	21-40%
	11-20%
	1-10%
	Fault - Contact Tennant Service

To turn off the battery power (while the batteries are active), press and hold the battery power button of any battery for **20 seconds**. The battery discharge indicators will turn off. Turning off one battery will shut down power to all connected batteries. Batteries should be shut down before any service is completed on the battery modules.

To turn on the battery power (when the batteries are shutdown), press and hold the power button on each battery for **5 seconds**. The battery discharge green indicators will illuminate when turned on.

## **CHARGING THE BATTERIES**

The charging instructions in this manual are intended for the battery charger supplied with the machine. The use of other battery chargers that are not supplied and approved by Tennant are prohibited. Refer to the charger owners manual for additional information. Contact distributor or Tennant for battery charger recommendations.

# FOR SAFETY: The use of incompatible battery chargers may damage battery packs and potentially cause a fire hazard.

**IMPORTANT NOTICE:** The battery charger is set to charge the battery type supplied with the machine.

1. Drive the machine to a flat, dry surface in a well-ventilated area.



WARNING: Lead-acid batteries emit hydrogen gas. Explosion or fire can result. Keep sparks and open flame away. Keep covers open when charging.

2. Stop the machine and turn the machine power off.

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

3. Lift the operator seat open, engage the seat support bar.



NOTE: Make sure the batteries have the proper electrolyte levwel before chargng. See CHECKING THE ELECTROLYTE LEVEL.

4. Plug the charger AC power supply cord into a properly grounded outlet.

- 5. On machines equipped with Lithium-ion batteries: Open the remote battery charge connector door.
- 6. Plug the charger connector into the remote battery charge connector.

Flooded lead-acid battery charge connector:



NOTE: The machine will be disabled until the charge plug is removed from the battery charge connector (Lead acid battery)

Lithium-ion battery charge connector:



NOTE: The machine will be disabled until the charge plug is removed and the remote battery charge connector door is closed and latched (Lithium-ion battery).

FOR SAFETY: Do not disconnect battery connections while machine is charging. Machine electrical damage may occur.

NOTE: If the charger "FAULT CODE:" lights flash when the batteries are plugged into the charger, refer to the charger manufacturer manual for fault code definitions.

### TO CHARGE LEAD-ACID BATTERIES



- 1. Once connected, the Tennant charger will start automatically. When the batteries are fully charged, the Tennant charger will automatically turn off.
- 2. After the charger has turned off, unplug the charger connector from the remote battery charge connector.

ATTENTION: Do not disconnect the charger DC cord from the machine receptacle when the charger is operating. Arcing may result. If the charger must be interrupted during the charging, disconnect the AC supply cord first.

3. Close the operator seat.

The table below shows the status of the battery charger.



Pattern	Description	Comments
LED is OFF	No AC Power Connected	Charger not plugged into the wall
Slow Green Blinking	Charging but batteries are less than 80% State of Charge	Charger displays this LED pattern when first plugged into AC power then LED turns off
Fast GREEN Blinking	Charging but batteries are greater than 80% State of Charge	Normal operation. Allow charger to finish charging
Solid GREEN	Charge Complete	Machine ready for use
Blinking RED	Charger internal failure	Contact Service

TO CHARGE LITHIUM-ION BATTERIES WITH 33A (1200W) CHARGER



- 1. Once connected, the Tennant charger will start automatically. When the batteries are fully charged, the Tennant charger will automatically turn off.
- 2. After the charger has turned off, unplug the charger connector from the remote battery charge connector.

ATTENTION: Do not disconnect the charger DC cord from the machine receptacle when the charger is operating. Arcing may result. If the charger must be interrupted during the charging, disconnect the AC supply cord first.

3. Close the operator seat.

The table below shows the status of the battery charger.



LED Pattern	Description	Comments
LED is OFF	No AC Power Connected	Charger not plugged into the wall
LED flashes RED followed by AMBER for few seconds and Turns OFF (and stays OFF)	AC Power Connected to the charger but No Batteries are connected	Charger not plugged into the wall
Slow Green Blinking (1 second ON; 0.2 second OFF)	Charging but batteries are less than 80% State of Charge	Charger displays this LED pattern when first plugged into AC power then LED turns off
Fast GREEN Blinking (0.4 second ON; 0.1 second OFF)	Charging but batteries are greater than 80% State of Charge	Normal operation. Allow charger to finish charging
Solid GREEN	Charge Complete	Machine ready for use
Rapid AMBER flashing (0.5 second ON; 0.5 second OFF)	Issue with Battery Detected	Contact Service
Solid RED	Charger internal failure	Contact Service

# TO CHARGE LITHIUM-ION BATTERIES WITH 90A FAST CHARGER (220V)



1. Turn on the battery charger if required.



NOTE: If there are charger fault codes when the battery is plugged into the battery charger, the fault codes will appear at the bottom of the charger display. Refer to the battery charger manual for fault code definitions



2. Observe the charger display. CHARGE appears on the display when the battery is charging. This is the charger default screen.



NOTE: (Lithium Case Battery Only) The Lithiumlon Battery Pack's battery management system (BMS) is active for five minutes after the machine cable is disconnected. If the charger is not connected and charging within this five minutes, the BMS will shut off and the charger will not be able to charge. Reconnect the machine cable to the battery pack and remove it again to restart the BMS active period.

Charger Display:



- A. Charge profile number
- B. Charger rating (Volts and Current)
- C. Battery voltage (Volts)
- D. Charger current (Amperes)
- E. Ampere hours charged
- F. Time charged (hours / minutes / seconds)
- G. Charging phase (Phase 1 / Phase 2 / Phase 3 / Maintenance)

 If necessary, press the navigation buttons to access additional screens. Press the charger stop / start / enter button to enter selection. The charger will return to the default screen. Refer to manufacturers operator manual for additional information.



NOTE: If the charger cable must be disconnected from the battery before they are fully charged, press the charger stop / start / enter button to stop charging. Be sure STOP appears on the display and the red stop charge light is illuminated before disconnecting the battery charger cable.



9. The charger status indicators will illuminate from left to the right as the battery is charging. COMPLETE will appear in the display, all the charger status indicators will be illuminated, and the Tennant charger will stop charging when the battery is completely charged.



10. After the charger has turned off, unplug the charger connector from the remote battery charge connector.

ATTENTION: Do not disconnect the charger DC cord from the machine receptacle when the charger is operating. Arcing may result. If the charger must be interrupted during the charging, disconnect the AC supply cord first.

11. Close the operator seat.

### MANUAL BATTERY WATERING SYSTEM

The following instructions are for models equipped with the manual battery watering system.



The manual battery watering system provides a safe and easy way to maintain the proper electrolyte levels in your batteries. It is designed exclusively for flooded (wet) lead-acid batteries.

# FOR SAFETY: When servicing machine, wear personal protection equipment as needed. Avoid contact with battery acid.

Before using the battery watering system check hoses and connections for damage or wear.

- 1. Fully charge batteries prior to using the battery watering system. Do not add water to batteries before charging, the electrolyte level will expand and may overflow when charging.
- 2. After charging batteries, check the battery electrolyte level indicators located on the battery covers.



3. If the level indicator has a low white float add water as described in the following instructions.





High Float = Full

4. Locate the battery fill hose coupler inside the battery compartment. Remove the dust cap and connect the hand pump hose.



5. Submerge the other end of the hand pump hose into a bottle of distilled water



6. Squeeze the bulb on the hand pump hose until firm. The white float will rise when full.



7. After adding water, replace the dust cap on the battery fill hose and store the hand pump hose inside the machine's battery compartment for future use.

## **CIRCUIT BREAKERS AND FUSES**

#### **CIRCUIT BREAKERS**

Circuit breakers are resettable electrical circuit protection devices that stop the flow of current in the event of a circuit overload. Once a circuit breaker is tripped, allow breaker to cool and then press the reset button to manually reset the breaker.



If the overload that caused the circuit breaker to trip is still there, the circuit breaker will continue to stop current flow until the problem is corrected.

The circuit breakers are located inside the battery compartment next to the hour meter.

The chart shows the circuit breakers and the electrical components they protect.

Circuit Breaker	Rating	Circuit Protected
CB1	2.5 A	Vehicle Interface board
CB2	2.5 A	Hour meter
CB3	10 A	Brain control module
CB4	10 A	Motor amplifier module
CB5	2.5A	Horn
CB6	2.5A	Reverse alarm
CB7	2.5A	Head lights
CB8	10A	ec-H20

Circuit breaker 20 is located inside the light assembly mounted on top of the recovery tank.

Fuses are one-time protection devices designed to stop the flow of current in the event of a circuit overload. Never substitute higher value fuses than specified.

Circuit Protected	Rating	Location
Traction	125A	Near controller
Main controller	150A	Near main contactor
Scrub motor	60A	Main harness
Vacuum	40A	Main harness
Deck Actuator	20A	Main harness
Squeegee fuse	20A	Main harness
Battery interface board (Lithium 4 pack)	2A	Battery harness

NOTE: Always replace the fuse with a fuse of the same amperage.

### ELECTRIC MOTORS

FUSES

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

The carbon brushes in the vacuum fan motor, the propelling motor, and the scrub brush motors should be inspected after the initial 500 hours of machine operation and then every 100 hours after the initial 500 hours.

### CAMERAS AND SENSORS

#### FRONT AND SIDE 2D AND 3D CAMERAS

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

Check the front and side 2D and 3D cameras for water spots, dirt, dust, smudges, and damage daily (or before each robotic run). Debris, streaks, or smudges could deliver false environmental information to the machine.

Cleaning camera lenses should only be done with microfiber cleaning cloths designed for sensitive optical surfaces (one was included with the home location markers). In extreme cases, a lens cleaning solution formulated for optical polycarbonate lenses may be used. Do not spray camera lenses with solution. If a lens cleaning solution is required, wet the cleaning cloth sparingly - do not spray cleaning solution onto the camera unit.

NOTE: Do not scratch or damage the 2D or 3D camera lenses. Robotic machine performance could be adversely affected if camera lenses are scratched or damaged.



Side 2D and 3D cameras are located on each side of the machine.



### UPPER AND LOWER LIDAR SENSORS

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

Check the upper and lower LIDAR sensors for dirt, dust, smudges, and damage daily (or before each robotic run). Debris, streaks, or smudges could deliver false environmental information to the machine.

Cleaning LIDAR sensors should only be done with microfiber cleaning cloths designed for sensitive optical surfaces (one is included with the home location markers). In extreme cases, a lens cleaning solution formulated for optical polycarbonate lenses may be used. Do not spray LIDAR sensors with solution. If a lens cleaning solution is required, wet the cleaning cloth sparingly - do not spray cleaning solution onto the LIDAR sensors.

NOTE: Do not scratch or damage the upper or lower LIDAR sensor surfaces. Robotic machine performance could be adversely affected if sensor surfaces are scratched or damaged.



NOTE: Due to the lower LIDAR sensor being located near the cleaning surface, pay particular attention to ensure the front, side, back, and bottom surfaces are completely clear of all dirt, smudges, and/or other debris. Use a flashlight to inspect these sensor surfaces and ensure they are thoroughly cleaned.



# SCRUB BRUSHES

Check scrub brushes daily for wire or string tangled around the brush or brush drive hub. Also check brushes for damage and wear.

Rotate the brushes from front -to-rear after every 50 hours of operation.

Replace the brushes when they no longer clean effectively.

REPLACING CYLINDRICAL SCRUB BRUSHES

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

1. Remove the pin from the rear perimeter guard. Lift the guard.



2. Unlatch and open the side squeegee support door.



3. Lift the idler plate retainer handle and unhook the retainer ring from the idler plate hook.



4. Remove the idler plate from the scrub head.



5. Remove the brush from the scrub head.



6. Position the brush with the double row end towards the scrub head opening. Guide the new brush onto the drive hub.

7. If rotating the brushes, always rotate the front with the back so that they wear evenly. they may be rotated end for end as well.



- 8. Reinstall the idler plate onto the scrub head and secure the idler plate into place with the idler plate retainer.
- 9. Close and latch the side squeegee and secure the rear perimeter guard with the pin.
- 10. Repeat for the other brush on the other side of the machine.

NOTE: Do not switch the left or right idler plates or the brushes will need to be readjusted by trained personnel.

## ec-H2O SYSTEM

# ec-H2O WATER CONDITIONING CARTRIDGE REPLACEMENT

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

The water conditioning cartridge is required to be replaced when it reaches its maximum water usage or expiration time of when the cartridge was activated, which ever comes first. The *ec-H2O* system indicator light will blink green/red when it is time to replace cartridge.

Depending on machine usage, on average, a new cartridge can last anywhere from 12 months for heavy machine usage to 24 months for light machine usage.

NOTE: During first time use and after replacing the water conditioning cartridge, the ec-H2O system will automatically override the selected solution flow rate for up to 75 minutes.

- 1. To engage the seat support arm, lift the seat completely open and insert the seat support arm into the hole in the operator seat plate.
- 2. Turn the ec-H2O compartment cover knob counter clock-wise and open the compartment door.





 Disconnect the two hose connectors from cartridge by pressing the gray collars inward and pulling the connectors outward.



4. Remove the 2 screws securing the cartridge mounting bracket and slide out the expired cartridge.



5. Fill in the installation date on the new cartridge label.



6. Slide the new cartridge into the mounting bracket and replace the 2 screws. Reconnect the two hoses. Make sure the hose connectors are fully inserted into new cartridge.

Reset timer for new cartridge.

Carefully read and understand all steps first before performing procedure.

- a. Turn the ON/OFF key switch on.
- b. Press and hold the service switch, located on the *ec-H2O* module, <u>for 10 seconds</u>. After releasing service switch, the three solution flow indicator lights will begin to (ripple) move back and forth.
- <u>Within 5 seconds</u> after releasing the service switch, while the three indicator lights are moving back and forth, quickly press and release the solution flow button located on *ec-H2O* module. The three indicator lights will then blink three times to indicate timer has been reset. Repeat process if the three indicator lights do not blink three times.



7. Close the compartment cover and lower seat.

## SQUEEGEE BLADES

Check the squeegee blades for damage and wear daily. When the blades become worn, rotate the blades end-for-end or top-to-bottom to a new wiping edge. Replace blades when all edges are worn.

Check the deflection of the squeegee blades daily or when scrubbing a different type of surface. Check the leveling of the rear squeegee every 50 hours of operation.

The rear squeegee assembly can be removed from the squeegee pivot to prevent damage during transport of the machine.

# REPLACING (OR ROTATING) THE REAR SQUEEGEE BLADES

1. Lower the scrub head.

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

2. Disconnect the vacuum hose from the rear squeegee assembly.



3. Loosen both squeegee mounting handles.





4. Pull the rear squeegee assembly from the machine.



5. Loosen the retainer latch and remove the retainer from the squeegee assembly.



6. Remove the squeegee from the squeegee assembly.



7. Slide both retainers out away from the squeegee assembly.



8. Remove the inner frame from the outer frame.



9. Remove the squeegee from the outer frame.



10. Install the rotated or new squeegee blade into the outer frame. Be sure the squeegee is completely slid down onto each tab on the outer frame.



11. Install the inner frame over the squeegee and onto the outer frame. Be sure the inner frame is tight against the top of the outer frame.



12. Slide both retainers into the squeegee assembly.



13. Place the rotated or new squeegee blade onto the inner frame. Be sure the squeegee is securely attached on each tab on the inner frame.



14. Insert the hinge end of the retainer into the hooks in the inner frame.



15. Install the retainer along the rest of the squeegee assembly and fasten the latch onto the other end of the squeegee assembly.



#### REPLACING OR ROTATING THE SIDE SQUEE-GEE BLADES

1. If necessary raise the scrub head.

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

2. Remove the pin from the rear perimeter guard. Lift the guard.



3. Unlatch and open the side squeegee support door.



4. Unhook the retaining band latch from the side squeegee assembly.



5. Remove the retaining band from the side squeegee assembly.



6. Remove the squeegee from the side squeegee assembly.



- 7. Install the rotated or new squeegee blade onto the side squeegee blade assembly.
- 8. Hook the retaining band onto the side squeegee assembly.



- 9. Fasten the retaining band latch onto the side squeegee assembly.
- 10. Close and latch the side squeegee and secure the rear perimeter guard with the pin.
- 11. Repeat for the side squeegee on the other side of the scrub head.

### LEVELING THE REAR SQUEEGEE

Leveling of the squeegee assures the entire length of the squeegee is in even contact with the surface being scrubbed. Perform this adjustment on an even and level floor.

1. Lower the squeegee and drive the machine several meters (feet) forward and slowly bring the machine to a stop.

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 2. check the squeegee deflection over the full length of the squeegee blade.
- 3. If the deflection is not the same over the full length of the blade, use the tilt adjust knob to make adjustments.

**DO NOT** disconnect the vacuum hose from the squeegee frame when leveling squeegee.

4. to adjust the squeegee leveling, loosen the tilt lock knob.



5. Turn the squeegee tilt adjust knob counterclockwise to decrease the deflection at the ends of the squeegee blade.

Turn the squeegee tilt adjust knob clockwise to increase the deflection at the end of the squeegee blade.



- 6. Tighten the tilt lock knob.
- 7. Drive the machine forward with the squeegee down to recheck the squeegee blade deflection if adjustments were made.
- 8. Readjust the squeegee blade deflection if necessary.

# ADJUSTING REAR SQUEEGEE BLADE DEFLECTION

Deflection is the amount of curl the overall squeegee blade has when the machine moves forward. The best deflection is when the squeegee wipes the floor dry with a minimal amount of deflection.

NOTE: Make sure the squeegee is level before adjusting the deflection. See LEVELING THE REAR SQUEEGEE.

1. Lower the squeegee and drive the machine several meters (feet) forward and slowly bring the machine to a stop.

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

 Look at the amount of deflection or "curl" of the squeegee blade. The correct amount of deflection is 12 mm (0.50 in) for scrubbing smooth floors and 15 mm (0.62 in) for rough floors.



3. To adjust the overall squeegee blade deflection, loosen the lock knob.



4. Turn the adjustment knobs counter clockwise to increase deflection or clockwise to decrease deflection.



- 5. Retighten the lock knob.
- 6. Drive the machine forward to recheck the squeegee blade deflection.
- 7. Readjust the squeegee blade deflection if necessary.

## SKIRTS AND SEALS

#### SOLUTION TANK SEAL

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

Check the seal for damage and wear after every 100 hours of operation.



#### **RECOVERY TANK SEALS**

Check the seals for damage and wear after every 100 hours of operation.



#### LEFT PERIMETER GUARD, RIGHT PERIMETER GUARD, AND FRONT PERIMETER GUARD

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

Check the left perimeter guard, right perimeter guard, front perimeter guard, and perimeter guard bristles and bumpers for debris, damage, and wear daily.







The bristles on the front, left, and right perimeter guard should be slightly off the floor. Replace damaged and/or worn bristle assemblies.

### BELTS

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

The brush drive belts are located on the cylindrical brush scrub head. Check the belts for damage and wear after every 200 hours of operation.



### TIRES

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

The machine has three solid rubber tires: one tire in front and two are in the rear. Check the tires for damage and wear after every 500 hours of operation.



### PUSHING, TOWING, AND TRANSPORTING THE MACHINE

#### PUSHING OR TOWING THE MACHINE

If the machine becomes disabled, it can be pushed from the front or rear, but only tow it from the front.

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

Before attempting to push or tow the machine, disengage the brake as described below.

To disengage the brake, insert the tip of a small screw driver between the brake release lever and the body of the encoder.



Only push or tow the machine for a very short distance and do not exceed 3.2 kp/h (2 mph). It is NOT intended to be pushed or towed for a long distance or at a high speed.

NOTE: **<u>Do</u>** <u>Not</u> push or tow machine for a long distance or damage may occur to the propelling system.

Immediately after pushing the machine, remove the screw driver from between the brake release lever and the body of the encoder. NEVER operate the machine with the parking brake disabled.

FOR SAFETY: Do not operate machine with the brake disabled.

#### TRANSPORTING THE MACHINE

FOR SAFETY: When transporting Lithium-ion Battery Model, contact Tennant or your local regulatory authorities for proper transporting instructions.

When transporting the machine by trailer or truck, be certain to follow the tie-down procedure below:

# FOR SAFETY: When loading/unloading machine onto/off truck or trailer, drain tanks before loading machine.

- 1. Raise the squeegee and scrub head.
- 2. Remove the rear squeegee from the machine.

NOTE: If necessary, remove the hardware securing the front perimeter guard from the front perimeter guard brackets and remove the front perimeter guard from the machine.

FOR SAFETY: When loading/unloading machine onto/off truck or trailer, use ramp, truck or trailer that will support the weight of the machine and operator.

FOR SAFETY: When loading/unloading machine onto/off truck or trailer, do not load/ unload on ramp inclines that exceed 12.3% / 7° grade.

NOTE: The machine ability to climb a ramp is affected by tire wear, ramp surface, weather conditions, and other factors. Trailering should only be performed by personnel trained on how to safely load a machine. 3. Enclosed trailers: Drive the machine onto the trailer or truck.

Open trailers: Back the machine on to the trailer to ensure that the navigation sensors are protected from any debris such as gravel while the machine is being transported.

Position the machine so the weight of the machine is safely distributed and can be safely strapped down to the trailer or truck.



- 4. Lower the scrub head and squeegee after the machine is positioned on the trailer or truck.
- 5. Turn off the machine.
- 6. Place a block behind each wheel to prevent the machine from rolling.

 Hook the tie-down straps to the stabilizer arms and then secure the tie-downs to the trailer or truck to prevent the machine from tipping. Repeat for other side of machine.

**Do Not** wrap the tie-down straps around the lower LIDAR sensor or route the tie-down straps over the front of the LIDAR sensor.





NOTE: Ensure that the lower lidar is protected from any debris such as gravel if the machine is being transported on a flat trailer.

NOTE: It may be necessary to install tie-down brackets to the floor of the trailer or truck.

FOR SAFETY: When loading/unloading machine onto/off truck or trailer, use tie-down straps to secure machine.

8. Hook the tie down straps to the rear squeegee guard arms and then secure the tie downs to the trailer or truck to prevent the machine from tipping. Repeat for other side of machine.





- 9. Ensure all tie-down straps are fully tightened and machine is completely secure on the trailer or truck.
- 10. Stow/secure all parts removed from the machine in a safe place where they will not be lost or damaged.

### JACKING UP THE MACHINE

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

Empty the recovery and solution tanks before jacking the machine.

Remove the front perimeter guard from the front perimeter guard brackets located at the front of the machine before jacking up the front end of the machine.



Rear jacking locations are located on both sides of the machine.



FOR SAFETY: When servicing machine, block machine tires before jacking machine up. Use a hoist or jack that will support the weight of the machine. Jack machine up at designated locations only. Block machine up with jack stands.



The front jack location is located on the back of the LIDAR bracket. **Do Not** position the jack or jack stand at the front of the LIDAR bracket.



### **STORAGE INFORMATION**

The following steps should be taken when storing the machine for extended periods of time.

- 1. Drain and clean the solution and recovery tanks. Open the recovery tank cover to promote air circulation.
- 2. Charge the batteries before storing machine to prolong the life of the batteries. Recharge batteries once a month.
- 3. Disconnect batteries before storing.
- 4. Park the machine in a cool, dry area. Do not expose the machine to rain. Store indoors.

### FREEZE PROTECTION

FOR SAFETY: When storing Lithium-ion Battery model, do not expose battery to temperatures below -22°F/30°C, above 140°F/60°C. do not use machine immediately after long term extreme temperature storage. Before use, return battery module temperature ranfe to 50°F/10°C ~95°F/35°C.

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Drain the solution tank and recovery tank of all water.
- Pour 2 gallons (8 liters) of full strength Propylene Glycol Based/Recreational Vehicle (RV) antifreeze into the solution tank. Do not dilute.

# FOR SAFETY: Avoid eye contact with antifreeze. Wear safety glasses.

- 3. Turn the machine power on and operate the default ec-H2O solution flow system until antifreeze appears at the scrub head.
- 4. Turn off the ec-H2O system and continue to operate the conventional soultion flow system. Turn off the machine when antifreeze reappears at the scrub head.

After storing machine in freezing temperatures, drain any remaining antifreeze from the solution tank. Add clean water to solution tank and operate the machine to flush system.

#### TROUBLESHOOTING/DIAGNOSTICS

#### INITIAL TROUBLESHOOTING MATRIX

Use the Initial Troubleshooting Matrix to conduct preliminary troubleshooting. Some errors may be caused by a blocked vacuum hose or debris preventing the actuator(s) from moving in the complete range of motion. Always check these items before conducting more labor intensive troubleshooting procedures requiring the machine to be disassembled and the AMR SERVICE CONNECTION diagnostics software application to be used.

Function	Enabled	Disabled
Propel	<ul> <li>Key ON (I)</li> <li>Battery voltage &gt; 31.5V for FLA batteries, or 30.5V for lithium batteries (Samsung), or 2% SOC* for lithium batteries (Inventus)**</li> <li>Operator in seat</li> <li>Propel pedal pressed</li> <li>E-Stops not engaged</li> <li>Charger interlock not engaged</li> <li>No faults on propel motor output</li> </ul>	<ul> <li>Key OFF (O)</li> <li>Battery voltage &lt; 31.5V for FLA batteries, or 30.5V for lithium batteries (Samsung), or 2% SOC* for lithium batteries (Inventus)**</li> <li>Propel pedal not pressed</li> <li>E-Stops engaged</li> <li>Charger interlock engaged</li> <li>Faults on propel motor output</li> </ul>
Vacuum Fan	<ul> <li>Key ON (I)</li> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> <li>1-Step or water-pickup enabled</li> <li>Directional switch set to forward</li> <li>Vacuum fan continues to operate for a period of time after disabling</li> <li>Recovery tank not full</li> <li>E-Stops not engaged</li> <li>Charger interlock not engaged</li> <li>No faults on vacuum fan output</li> </ul>	<ul> <li>Key OFF (O)</li> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> <li>1-Step or water-pickup not enabled</li> <li>Directional switch set to reverse</li> <li>Vacuum off timer expired</li> <li>Recovery tank full</li> <li>E-Stops engaged</li> <li>Charger interlock engaged</li> <li>Faults on vacuum fan output</li> </ul>
Scrub Head Actuator	<ul> <li>Key ON (I)</li> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> <li>1-Step enabled/disabled</li> <li>Lifts until current limits are reached on power-up and end of scrub</li> <li>Lowers for fixed time duration at beginning of scrub</li> <li>Adjusts during scrubbing to maintain down pressure</li> <li>Solution tank not empty</li> <li>Recovery tank not full</li> <li>E-Stops not engaged</li> <li>Charger interlock not engaged</li> <li>No faults on scrub deck actuator output</li> </ul>	<ul> <li>Key OFF (O)</li> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> <li>1-Step not enabled</li> <li>Lifting current limit is reached</li> <li>Machine scrubbing at desired down pressure target</li> <li>E-Stops engaged</li> <li>Charger interlock engaged</li> <li>Faults on scrub deck actuator output</li> </ul>

Function	Enabled	Disabled
Rear Squeegee Actuator	<ul> <li>Key ON (I)</li> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> <li>1-Step or water pickup is enabled/disabled</li> <li>Directional switch set to forward</li> <li>Lifts when directional switch is set to reverse</li> <li>Lifts until internal limit switch is hit on power-up and at end of 1-Step/water pickup</li> <li>Lowers until internal limit switch is hit at beginning of 1-Step/water pickup</li> <li>Recovery tank not full</li> <li>E-Stops not engaged</li> <li>Charger interlock not engaged</li> <li>No faults on squeegee actuator output</li> </ul>	<ul> <li>Key OFF (O)</li> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> <li>1-Step or Water Pickup are not enabled</li> <li>Will not lower if directional switch is set to reverse</li> <li>Internal limit switches are hit</li> <li>Recovery tank full</li> <li>E-Stops engaged</li> <li>Charger interlock engaged</li> <li>Faults on squeegee actuator output</li> </ul>
Scrub Motors	<ul> <li>Key ON (I)</li> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> <li>1-Step enabled</li> <li>Scrub deck lowered</li> <li>Machine is propelling</li> <li>Solution tank not empty</li> <li>Recovery tank not full</li> <li>E-Stops not engaged</li> <li>Charger interlock not engaged</li> <li>No faults on scrub motor output</li> </ul>	<ul> <li>Key OFF (O)</li> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> <li>1-Step disabled</li> <li>Scrub deck raised/raising</li> <li>Machine not propelling</li> <li>Solution tank empty</li> <li>Recovery tank full</li> <li>E-Stops engaged</li> <li>Charger interlock engaged</li> <li>Faults on scrub motor output</li> </ul>
Solution Control (Conventional)	<ul> <li>Key ON (I)</li> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> <li>1-Step enabled</li> <li>ec-H2O not enabled</li> <li>Machine is scrubbing</li> <li>Solution tank not empty</li> <li>Recovery tank not full</li> <li>E-Stops not engaged</li> <li>Charger interlock not engaged</li> <li>No faults on water valve output</li> </ul>	<ul> <li>Key OFF (O)</li> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> <li>1-Step not enabled</li> <li>ec-H2O (if equipped) is enabled</li> <li>Machine not scrubbing</li> <li>Solution tank empty</li> <li>Recovery tank full</li> <li>E-Stops engaged</li> <li>Charger interlock engaged</li> <li>Faults on water valve output</li> </ul>
Solution Control (ec-H2O NanoClean)	<ul> <li>Key ON (I)</li> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> <li>1-Step enabled</li> <li>ec-H2O enabled</li> <li>Machine is scrubbing</li> <li>Solution tank not empty</li> <li>Recovery tank not full</li> <li>E-Stops not engaged</li> <li>Charger interlock not engaged</li> <li>No faults on ec-H2O enable output</li> </ul>	<ul> <li>Key OFF (O)</li> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> <li>1-Step not enabled</li> <li>ec-H2O disabled</li> <li>Machine not scrubbing</li> <li>Solution tank empty</li> <li>Recovery tank full</li> <li>E-Stops engaged</li> <li>Charger interlock engaged</li> <li>Faults on ec-H2O enable output</li> </ul>

\* SOC = State of Charge

\*\* SOC percentages shown when service device is connected to service terminal may not be accurate. Service device must be connected to the lithium battery control board USB cable for accurate SOC percentage. See ACCESS LITHIUM BATTERY SERVICE SCREEN in LITHIUM BATTERIES section.

### SERVICE DIAGNOSTICS TOOL

Machine configuration software is stored in the Kinetek Control Module. It may be necessary to reload the machine configuration software if there are issues/ errors with the machine configuration software requiring the software to be reloaded into the Kinetek Control Module.

Authorized service providers can download the Service Diagnostics software. Tennant Service personnel have this software installed on their service devices.

Use the AMR Service Connector to connect the service device to the Kinetek Control Module. The Kinetek Control Module stores configuration data and communicates via the AMR SERVICE CONNECTOR communication with the Kinetek Control Module.

- VIB (Vehicle Interface Board): The VIB interface module is located in the operator console.
- Kinetek Vehicle Controller: The machine controller is located beneath on the controller mounting panel located at the front of the battery compartment.
- BCM (Brain Control Module): The BCM is located under the shroud on the front of the steering support.
- ec-H2O NanoClean Module: The ec-H2O module is located at the front of the battery compartment.

# ISOLATING THE MACHINE FROM THE AMR SYSTEM

Initial machine troubleshooting is required to determine whether a malfunction/error code is due to an AMR related or non-AMR issue. To begin troubleshooting the machine the machine must first be isolated from the AMR system.

NOTE: Use the AMR bypass switch only when performing machine diagnostics/maintenance procedures. <u>Do Not</u> leave the machine isolated from the AMR system during regular use.

- 1. Turn the ON/OFF key switch OFF.
- 2. Remove the access panel from the instrument shroud.

 Turn the AMR bypass switch clockwise to isolate the machine from the AMR system.



- 4. Turn the ON/OFF key switch ON.
- 5. Operate the machine in the Manual Mode.

Are all scrubbing functions fully operational while the machine is in the manual mode? If yes, there is an issue with the AMR system. Proceed to PREPARE THE MACHINE FOR EXTERNAL TROUBLESHOOTING/DIAGNOSTICS/FILE TRANSFERS.

Are there scrubbing function issues while the machine is in the Manual Mode? If yes there is an issue with the T16 portion of the machine. Troubleshoot the machine to determine possible issues. Make necessary repairs and/ or adjustments. Proceed to PREPARE THE MACHINE FOR TROUBLESHOOTING/ DIAGNOSTICS/FILE TRANSFERS and CHECK THE KINETEK CONTROL MODULE/MACHINE DIAGNOSTICS.

6. Turn the AMR bypass switch counterclockwise to link the machine to the AMR system when finished with diagnostic procedures.



#### PREPARE THE MACHINE FOR TROUBLESHOOTING/DIAGNOSTICS/FILE TRANSFERS

There will be instances when troubleshooting/ diagnostics/file transfers will be necessary to get the machine functioning. The ROC (Robotics Operation Center) allows external entities (Tennant Service/ Brain Corp.) to communicate with the machine to troubleshoot problems, provide diagnostic information, and transfer files that may be required to update/fix malfunctioning robotic functions.

- 1. Turn the ON/OFF key switch ON.
- 2. If necessary, drive the machine to an area where the ROC light located on the user interface touchscreen is illuminated. The ROC light must be illuminated for there to be any external troubleshooting/diagnostics/file transfers completed.



3. Contact the Tennant Customer Service Department for additional troubleshooting/diagnostic guidance.

#### CHECK THE KINETEK CONTROL MODULE/ MACHINE DIAGNOSTICS

SYSTEM REQUIREMENTS: Windows<sup>®</sup> 10 Operating System or newer version.

- 1. Remove the access panel from the steering column.
- 2. Connect the AMR service connector to the service device.
- 3. Connect the AMR SERVICE CONNECTOR to the service terminal above the AMR bypass switch.



- 4. Remove the front perimeter guard from the machine.
- 5. Chock the rear wheels to prevent the machine from rolling.
- Position a jack under the front jack point at the back of the LIDAR bracket. <u>Do Not</u> position the jack at the front of the LIDAR bracket.
- 7. Jack the front end of the machine approximately 12.7 mm (0.50 in) from the floor (high enough so the front drive wheel moves freely when the propel pedal is pressed).

FOR SAFETY: When servicing machine, block machine tires before jacking machine up. Use a hoist or jack that will support the weight of the machine. Jack machine up at designated locations only.

- 8. Turn the ON/OFF key switch ON.
- 9. Disconnect the main wire harness from the seat switch harness.
- 10. Click the desktop icon start menu to open the AMR SERVICE CONNECTION diagnostics software application.

11. Check the ERROR VALUES located at the bottom of the Current and Volts column for an error code. See OUTPUT INFORMATION/CURRENT AND VOLTS.

	20,0		_
HEATSINK V(Tra	): 25,3	v	BF
HEATSINK V(Oth	): 25.3	v	-
MCU Temp:	24.4	c	Dasht
MOSFET Temp:	24.9	c	
VEHICLE STATE	0 X 2	0	
ERROR VALUE	0 X 3	1	BEEPER
•			

- 12. Proceed to FAULT CODES for fault codes, fault code conditions, cause(s) for the fault code(s), and corrective actions to be taken.
- Press the DIAGNOSTIC ON button to activate the Output Check (Diagnostic Test) function of the AMR Diagnostic Test application. See INPUT CHECK/ OUTPUT CHECK (DIAGNOSTIC TEST).

BRUSH & ACT 1 +	DIAGNOSTIC ON	Diagnostic commands are enabled when traction is not running
VACUUM & ACT TEST	Enter Diagnoùtic Bode	Please click button "DIAGNOSTIC ON", ther you can use the test buttons.
HORN TEST		Diagnostic Off Mode
PUMP TEST 5 +		RVS Alarm RVS Alarm
BRAKE TEST	ONE KEY TEST	ECH2O On ECH2O Of
ashboard Check		

- 14. Observe the diagnostics status box for error codes.
- 15. Observe the Output Information column for possible short circuits and open circuits. Check the Current and Volts column to ensure circuits being tested are operating within the correct voltage and amp ranges. See OUTPUT INFORMATION/ CURRENT AND VOLTS.

- 16. If further diagnostic testing is required, conduct a dashboard Check. See DASHBOARD CHECK.
- 17. If necessary, perform diagnostics tests to find where there may be machine operation/ performance issues. See FAULTS CODES for fault codes. See DIAGNOSTIC TOOLS for diagnostic tool information.
- 18. Disconnect the AMR service connector from the Kinetek controller.
- 19. Turn the ON/OFF key switch OFF.
- 20. Reinstall the access panel onto the steering column.
- 21. Reconnect the main wire harness to the operator seat switch cable.

#### **DIAGNOSTIC TOOLS**

The AMR SERVICE CONNECTION diagnostics software application provides detailed information for testing the machine for open circuits, shorts, and current and volt information for all machine operating and scrubbing systems. This information can be used for troubleshooting the various machine circuits and finding any problems that could be adversely affecting machine operation and performance.

# CAN INFORMATION/CONTROLLER GENERAL INFORMATION

Tennant T16 Diagnostic Tool V1.6		- 🗆 X
CAN Information	Controller General Information (Configuration Group: KCGC0237-0028) Firmware Rev 2 30 25 STM32 App Checksum 0xF85D Stu Checksum 0x191A	Output Information           Tract Running         0           Tract Open         0
Current and Volts       TRACT DIRECTION       TRACT CURRENT       0	A Seat SW Dirty Water Clean Water Service Propel Motor Scrub Motor Accel Pedal	Tract Short 0 Brush Running 0 Brush Open 0 Brush Short 0 Vacuum Running 0
TRACTION VOLTAGE0BRUSH CURRENT0BRUSH VOLTAGE-0.4	V         SW         SW         Pedal         Temp SW         Temp SW           A         Output Check (Diagnostic Test)           Diagnostic command           V         BRUSH & ACT         1 ±         Image: Diagnostic command          Diagnostic command           TEST         ON         OFF         OFF         Diagnostic command	Vacuum Open 0 Vacuum Short 0 Squ Act Running 0 Squ Act Open 1 Squ Act Open 1
VACUUM CURRENT 0 VACUUM VOLTAGE -0.2 SQU ACT CURRENT 0	A V VACUUM & ACT TEST A	Scrub Act Running 0 Scrub Act Qpen Scrub Act Short 0 HM Running 0
SCRUB ACT CURRENT     0       ACCEL VOLTAGE     0       BATTERY VOLTAGE     35.1	A HORN TEST V PUMP TEST 5 + V PUMP TEST 5 + On Off	HM Open 1 HM Overload 0 Pump Running 0 Pump Open 0
HEATSINK V(Tra): 35 HEATSINK V(Oth): 34.8	V BRAKE TEST ONE KEY TEST ECH2O ON ECH2O	Off Horn Running 0 Horn Open 1 Horn Overload 0
MCU Temp:         21.7           MOSFET Temp:         23.6           VEHICLE STATE         0 X 20	C Dashboard Check	Brake Running 0 Brake Open 0 Brake Overload 0
ERROR VALUE	BEEPER SW ONE KEY SQUEGEE VALVE SW PRESSURE ECH SW SW SW SW SW SW	Accel SRO         0           Scrub Act Direction         0           Squ Act Direction         0

CAN Information: Indicates CAN system is operational.

Controller General Information: Indicates the controller firmware version, the Firmware Rev (firmware revision), STM32 App Checksum, and Stu Checksum are listed. Confirm these three numbers to ensure the latest version of the firmware is installed on the machine. Contact the Tennant Customer Service Department for the latest controller firmware version, Firmware Rev, and Stu Checksum.

#### **OUTPUT INFORMATION/CURRENT AND VOLTS**

Tennant T16 Diagnostic Tool V1.6		- 🗆 🗙
CAN Information	Controller General Information (Configuration Group: KCGC0237-0028) Firmware Rev 2 30 25 STM32 App Checksum 0xF85D Stu Checksum 0x191A	Output Information Tract Running 0 Tract Open 0
Further and Volts       TRACT DIRECTION       TRACT CURRENT       0       A       TRACTION VOLTAGE       0	Seat SW Dirty Water Clean Water Service Propel Motor Scrub Motor Accel Pedal Temp SW Temp SW	Tract Short 0 Brush Running 0 Brush Open 0 Brush Short 0 Vacuum Running 0 Vacuum Open 0
BRUSH CURRENT     0     A       BRUSH VOLTAGE     -0.4     V       VACUUM CURRENT     0     A       VACUUM VOLTAGE     0.2     V	Output Check (Diagnostic Test)         BRUSH & ACT         Itest         ON         DIAGNOSTIC         OFF         Diagnostic commands         are enabled when         traction is not running         Please click button         "DIAGNOSTIC OFF"	Vacuum Short 0 Squ Act Running 0 Squ Act Open 1 Squ Act Short 0 Scrub Act Running 0 Scrub Act Running 0
SQU ACT CURRENT     0     A       SCRUB ACT CURRENT     0     A       ACCEL VOLTAGE     0     V	HORN TEST	Scrub Act Open Scrub Act Short 0 HM Running 0 HM Open 1 HM Overload 0
BATTERY VOLTAGE35.1VHEATSINK V(Tra):35VHEATSINK V(Oth):34.8V	PUMP TEST     -     No     No     No       BRAKE TEST     ONE KEY TEST     ECH20 On     ECH20 Off	Pump Open 0 Pump Overload 0 Horn Running 0 Horn Open 1
MCU Temp: 21.7 C MOSFET Temp: 23.6 C VEHICLE STATE 0 X 20 EPPOR VALUE	BEEPER SW ONE KEY SOLIEGEE VALVE SW PRESSURE ECH20	Brake Running 0 Brake Open 0 Brake Overload 0 Accel SRO 0
	SW SW SW SW SW	Sau Act Direction

Current and Volts: This column indicates the current and volt ranges for the listed machine operating systems. In the below example the TRACT CURRENT A (Amps) and TRACT VOLTAGE V (Voltage) measure are displayed. See MACHINE SYSTEM RANGES for normal voltage and amp ranges.



NOTE: The letters FWD in the TRACT DIRECT cell indicate the machine is in the forward direction for the testing being conducted.

ERROR VALUE: Error codes are located at the bottom for the Currents and Volts column. See FAULTS AND WARNINGS for error code and further troubleshooting information.



In the above example the error code of 0X31 shows there is a brush adjustment time out error.
Output Information: This column indicates whether a system is running, open, or short. A numeral 1 appears in the corresponding cell if the cell is active. A numeral 0 appears in the cell if the cell is inactive. In the below example the numeral 1 is in the Tract Running cell, indicating the Tract Running cell is active and there are no faults.

	_ 0	X		
	Output Informatio			
um 0x1470	Tract Running	1		
	Tract Open	0		
	Tract Short	0		
	Brush Running	0		
	Brush Open	0		
	Brush Short	0		
anal Radal	Vacuum Running	0		

If the numeral 1 was in either the Tract Open or Tract Short cell, this would indicated there was either an Open or Short fault condition with that system and additional troubleshooting is required.

	-0	×
	Output Informa	tion
um 0x1470	Tract Running	11.
	Tract Open	0
	Tract Short	0
	Brush Running	D
	Brush Open	0
	Brush Short	0
and Dadal	Vacuum Running	0

### MACHINE SYSTEM RANGES

Refer to the below table to confirm voltage/amp when using the AMR SERVICE CONNECTION diagnostics software application for machine troubleshooting.

System	Component	Minimum Value	Nominal Value	Maximum Value	Measure
Propel	Traction Current	-120		110	Amps
	Traction Voltage (Forward)	0		93	% of VBat
	Traction Voltage (Reverse)	0		60	% of VBat
	Traction Voltage (Low Battery)	0		30	% of VBat
	Propel Pedal Voltage (Released)	0.2	0.3	0.5	Volts
	Propel Pedal Voltage (Fully Pressed)	3.8	4.2	4.6	Volts
	Brake Pedal Voltage (Released)	0.2	0.3	0.5	Volts
	Brake Pedal Voltage (Pressed)	3.8	4.2	4.6	Volts
	Parking Brake Voltage (Applied)	0			Volts
	Parking Brake Voltage (Released)		36		Volts
	Propel Disabled Voltage		28		Volts
Scrub	Combined Scrub Motor Current (High Down Pressure)	27	30	33	Amps
	Combined Scrub Motor Current (Medium Down Pressure)	22	25	28	Amps
	Combined Scrub Motor Current (Low Down Pressure)	14	17	20	Amps
	Scrub Motor Voltage	0		36	Volts
	Scrub Actuator Current (Lowering)	0		7	Amps
	Scrub Actuator Current (Raising)	0		5	Amps
	Scrub Actuator Voltage (Lowering)	0	25	25	Volts
	Scrub Actuator Voltage (Raising)	0	25	25	Volts
	Scrub Actuator Voltage (Adjusting for Down Pressure)	3		25	Volts
	Scrubbing Disabled Voltage (Propel Only)		32.7		Volts
	ec-H2O Enable (Active)	0			Volts
	ec-H2O Enable (Inactive)		12		Volts
Water	Vacuum Current	0		42	Amps
Pickup	Vacuum Voltage	0		36	Volts
	Squeegee Actuator Current (Lowering)	0		7	Amps
	Squeegee Actuator Current (Raising)	0		7	Amps
	Squeegee Actuator Voltage (Lowering)	0		9	Volts
	Squeegee Actuator Voltage (Raising)	0		9	Volts
	Horn Voltage (Active)		36		Volts
	Vehicle State		0x20		
	Error Value (See FAULTS AND ERRORS for all error codes)		0x00		No Errors

#### INPUT CHECK/OUTPUT CHECK (DIAGNOSTIC TEST)



Input Check: When these indicators are green the machine is ready for operation. If any indicator is red, the machine is not ready for operation and corrective action must be taken to correct the problem before the machine can be operated. If any of the Input Check indicators is showing a "false red" (indicating an error or action is occurring that is not occurring) further troubleshooting will be necessary to find what is causing the indicator to turn red.

Seat SW: The seat switch indicator is green when the seat switch recognizes there is an operator sitting in the operator seat. The indicator is red to indicate there is no operator in the operator seat.

Dirty Water: The Dirty Water (recovery tank) indicator is green to indicate the recovery tank is not full. The indicator is red when the recovery tank is full. Clean Water SW. The Clean Water SW (solution tank) indicator is green when there is solution for cleaning in the solution tank. The indicator is red when the solution tank is empty.

Service Pedal: The Service Pedal indicator is green when the service brake is not depressed. The indicator is red when the brake pedal is pressed.

Propel Motor Temp Switch: The Service Pedal indicator is green when the service brake is not depressed. The indicator is red when the brake pedal is pressed.

Scrub Motor Temp Switch: The Service Pedal indicator is green when the service brake is not depressed. The indicator is red when the brake pedal is pressed.

Accel Pedal: The three Accel Pedal (propel pedal) indicators illuminate to indicate low, medium, and high travel speed. The first indicator is blue when the machine is travelling at low speed. The next indicator is yellow when the machine is travelling at medium speed (the blue light low speed indicator is also illuminated). The last button is red when the machine is travelling at high speed (the previous two lower speed lights are also illuminated).



Output Check (Diagnostic Test): Press the

DIAGNOSTIC ON button to activate the Output Check (Diagnostic Test) function Enter Diagnostics Mode will appear in the diagnostics status box.



Text appears in the diagnostic status box indicating the diagnostics on/off status and the result(s) of the diagnostic test(s).

BRUSH & ACT	DIAGNOSTIC	DIAGNOSTIC OFF	are enabled traction is no	when ot running
VACUUM & ACT TEST	Enter Disgnostic Squeegee Motor is	Node Open	Please click "DIAGNOST you can use buttons.	button C ON", the the test
HORN TEST			Diagnostic C	off Mode
PUMP TEST 5 +			RVS Alarm On	RVS Alarn Off
BRAKE TEST	ONE KEY	TEST	ECH2O On	ECH2O O

NOTE: Allow the diagnostic results of the previously chosen test to appear in diagnostic status box before initiating another test.

Press the BRUSH & ACT TEST button to test the scrub brush and scrub head actuator function. Use the + button or - button to change the down pressure settings if necessary to test machine at the low, medium, or high settings.

Press the VACUUM & ACT TEST button to test the squeegee actuator and vacuum functions.

Press the HORN TEST button to test the horn and audible alarm.

Press the PUMP TEST button to test the solution control system. Use the + button or - button to change the pump activation time (1-5 seconds) if necessary to test pump at different activation times.

Press the BRAKE TEST button to test the service brakes.

NOTE: There is no indicator that the test is completed if no fault is noted in the diagnostic status box. Check the Output Information column to confirm the tests are completed. If all cells in the Output Information column are 0 (zero), then no tests are active. Press the ONE KEY TEST button to test all previously mentioned systems. All systems will briefly activate separately in sequential order after the button is pressed.

TEST _	ON	OFF	traction is no	when of running
VACUUM & ACT TEST	Enter Diagnostic	Rede 🛁	Please click "DIAGNOST you can use buttons.	button IC ON", the the test
HORN TEST			Diagnostic C	off Mode
PUMP TEST 5 +		~	RVS Alarm On	RVS Alarn Off
BRAKE TEST	ONE KE	TEST		ECH20 O
ashboard Check			-	

Press the RVS Alarm On button to test the reverse alarm. The reverse alarm will continue to sound until the RVS Alarm Off button is pressed.



Press the ECH2O On button to test the ec-H2O system. The ec-H2O system will continue to function until the ECH2O Off button is pressed.

BRUSH & ACT 1 ±	DIAGNOSTIC	DIAGNOSTIC	are enabled when traction is not running
VACUUM & ACT TEST	Enter Disgnootic	Rode	Please click button "DIAGNOSTIC ON", ther you can use the test buttons.
HORN TEST			Diagnostic Off Mode use below buttons RVS Alarm On Off
BRAKE TEST	ONE KEY	TEST	ECH2O On ECH2O Of
ashboard Check			4242

Press the DIAGNOSTICS OFF button when through testing machine diagnostics. Exit Diagnostics Mode will appear in the diagnostics status box.

TEST	ON	OFF	n is no	t running
VACUUM & ACT TEST	Enter Diagnostic Rod Exit Diagnostic Mode	1	Please click "DIAGNOSTI you can use buttons.	C ON", their the test
HORN TEST			Diagnostic C	ff Mode
PUMP TEST 5 +			RVS Alarm On	RVS Alam Off
BRAKE TEST	ONE KEY TES	т	ECH2O On	ECH2O Of
ashboard Check				

#### DASHBOARD CHECK

🔄 Tennant T16 Diagnostic Tool V	1.6							- 0	×
CAN Information		Cont Firm	roller General Informa ware Rev 2 30 25	ation (Configuration C STM32 App Checksur	Group: KCGC( n 0xF85D	0237-0028) Stu Checksum	0x191A	- Output Informati Tract Running Tract Open	
Current and Volts	FWD 0	A Seat S	tt Check	ater Service Propel Mo Pedal Temp St	tor Scrub M	otor Ac	cel Pedal	Tract Short Brush Running Brush Open Brush Short Vacuum Running	0
BRUSH CURRENT BRUSH VOLTAGE VACUUM CURRENT	0	A Out V BRI	put Check (Diag USH & ACT 1 ± TEST -	DIAGNOSTIC	DIAGNOSTIC	Diagnostic c are enabled traction is no	ommands when of running	Vacuum Short Squ Act Running Squ Act Open Squ Act Short	0
VACUUM VOLTAGE SQU ACT CURRENT SCRUB ACT CURRENT	-0.2 0		HORN TEST			Please click "DIAGNOSTI you can use buttons.	button IC ON", then e the test	Scrub Act Running Scrub Act Open Scrub Act Short HM Running HM Open	0
ACCEL VOLTAGE BATTERY VOLTAGE	0	V			~	RVS Alarm	RVS Alarm Off	HM Overload Pump Running Pump Open Pump Overload	0
HEATSINK V(Tra): HEATSINK V(Oth): MCU Temp:	35 34.8 21.7	V V —	BRAKE TEST	ONE KEY T	EST	ECH2O On	ECH2O Off	Horn Running Horn Open Horn Overload	0
MOSFET Temp: VEHICLE STATE	23.6 0 X 20	C			141.VE 014		50100	Brake Running Brake Open Brake Overload Accel SRO	0 0 0 0
ERROR VALUE	0 X 0	BEEF	SW	SQUEGEE	VALVE SW	SW	SW	Scrub Act Direction Squ Act Direction	0

Dashboard Check: Each of these indicators will change colors, depending on the input from the button being pushed to activate a particular system and at what level the chosen system is functioning at in the case of systems that have different operating levels. If one of the indicators does not turn green in the case of single function button or blue, yellow, red in the case of multifunction buttons, further troubleshooting is needed to determine why the button is not functioning.

BEEPER SW: When the beeper/alarm is activated the indicator will be green.

ONE KEY SW: When the 1-Step button is activated the indicator will be green.

SQUEEGEE SW: When the squeegee is activated the indicator will be green.

VALVE SW: When the solution flow is activated the indicator will be blue when the flow is set to the lowest level, yellow when the solution flow is set to the medium level, and red when the solution flow is at the high level.

PRESSURE SW: The pressure is always illuminated blue, yellow, or red. The pressure cannot be turned off like the other machine functions. Blue indicates the lowest pressure setting, yellow indicates the medium pressure setting, and red indicates the high pressure setting.

ECH2O SW: This indicator turns green after the machine is moving and all other scrubbing functions are active.

### FAULT CODES

When the machine or battery charger detects a fault, the service indicator will flash. A fault code is provided to determine problem. Refer to the Faults and Warnings table for fault codes, conditions, reasons, and corrective action for the various fault codes.

Error Code	Fault Condition	Reason	Correction
0x12	EEPROM Error	<ol> <li>Controller parameter setting out of range.</li> <li>Controller Problem (EEPROM fault).</li> </ol>	
0x17	E-Stop Active	1. E-Stop button is engaged.	1. Disengage E-Stop button
0x1A	Battery Low (All Functions Off)	<ol> <li>Battery voltage is less than 18V.</li> <li>Parameter"Battery Voltage" set to 1 but actual battery is 24V.</li> <li>Controller hardware fault.</li> </ol>	<ol> <li>Charge batteries.</li> <li>Power cycle machine.</li> <li>Contact Tennant Customer Service Department.</li> </ol>
0x21	Battery Low (Traction Only)	<ol> <li>Battery voltage is less than set parameter value (Class 0 Volt for FLA batteries or Class 1 Volt for TPPL batteries).</li> <li>Controller hardware fault.</li> </ol>	<ol> <li>Charge batteries.</li> <li>Power cycle machine.</li> <li>Contact Tennant Customer Service Department.</li> </ol>
0x23	MCU Over Temperature	1. Controller is over temperature.	<ol> <li>Power cycle machine.</li> <li>Contact Tennant Customer Service Department.</li> </ol>
0x26	Precharge Failure (Traction)	<ol> <li>Wiring problem.</li> <li>Controller hardware fault.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Contact Tennant Customer Service Department.</li> </ol>
0x29	Traction Left Null Error	<ol> <li>Controller firmware fault.</li> <li>Controller hardware fault.</li> </ol>	1. Contact Tennant Customer Service Department.
0x2D	Brush Null Error	<ol> <li>Controller firmware fault.</li> <li>Controller hardware fault.</li> </ol>	1. Contact Tennant Customer Service Department.
0x2E	Vacuum Null Error	<ol> <li>Controller firmware fault.</li> <li>Controller hardware fault.</li> </ol>	1. Contact Tennant Customer Service Department.
0x2F	Squeegee Null Error	<ol> <li>Controller firmware fault.</li> <li>Controller hardware fault.</li> </ol>	1. Contact Tennant Customer Service Department.
0x31	Brush Adjustment Time Out	1. Brush pressure adjustment parameters setting not reasonable.	<ol> <li>Adjust brush pressure.</li> <li>Power cycle machine.</li> </ol>
0x32	Solenoid Welded (Traction)	1. Controller hardware fault.	1. Contact Tennant Customer Service Department.
0x33	Solenoid Did Not Close (Traction)	1. Controller hardware fault.	1. Contact Tennant Customer Service Department.
0x37	Throttle Fault	1. Hall accelerator output more than 5V.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot propel pedal/brake pedal sensor.</li> </ol>
0X3A	Brake Fault	<ol> <li>Brake output over current.</li> <li>Controller hardware fault.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Troubleshoot brake circuit.</li> </ol>
0X3B	Alarm Fault	<ol> <li>Alarm output over current.</li> <li>Controller hardware fault.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Troubleshoot horn circuit.</li> </ol>
0X3C	Aux1 Fault	<ol> <li>Aux1 output over current.</li> <li>Controller hardware fault.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Troubleshoot hour meter circuit.</li> </ol>
0X3D	Aux2 Fault	<ol> <li>Aux2 output over current.</li> <li>Controller hardware fault.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Troubleshoot conventional solution valve circuit.</li> </ol>
0x3F	Brush Deck Null Error	<ol> <li>Controller firmware fault.</li> <li>Controller hardware fault.</li> </ol>	1. Contact Tennant Customer Service Department.

Error Code	Fault Condition	Reason	Correction
0x42	Traction Motor Stalled	<ol> <li>Traction motor stalled.</li> <li>Parameter "Traction I Limit" set too low.</li> </ol>	1. Power cycle machine.
0x44	Traction Reverse Short Circuit Protection	1. Traction motor short circuit.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot propel circuit.</li> </ol>
0x4C	Traction Forward Short Circuit Protection	1. Traction motor short circuit.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot propel circuit.</li> </ol>
0x4D	Brush Over Current Protection	1. Brush motor peak current more than 150A.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot scrub motor circuit.</li> </ol>
0x4E	Brush Short Circuit Protection	1. Brush motor short circuit.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot scrub motor circuit.</li> </ol>
0x59	Traction Left Drain Fault	1. Controller hardware fault.	1. Contact Tennant Customer Service Department.
0x5B	Traction Right Drain Fault	1. Controller hardware fault.	1. Contact Tennant Customer Service Department.
0x5C	Traction Reverse Over Current Protection	1. Traction motor peak current greater than 190A.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot propel circuit.</li> </ol>
0x5D	Traction Forward Over Current Protection	1. Traction motor peak current greater than 190A.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot propel circuit.</li> </ol>
0x61	Brush Drain Fault	1. Controller hardware fault	1. Contact Tennant Customer Service Department.
0x62	Supply Out Of Range	1. Controller hardware fault	1. Contact Tennant Customer Service Department.
0X64	Brush Deck Over Current Protection	1. Brush deck motor peak current greater than 9A.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot scrub head lift/lower circuit.</li> </ol>
0x65	Vacuum Short Circuit Protection	1. Vacuum motor short circuit.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot vacuum circuit.</li> </ol>
0X66	Brush Deck Short Circuit Protection	1. Brush deck motor short circuit.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot scrub head lift/lower circuit.</li> </ol>
0X67	Squeegee Over Current Protection	1. Squeegee motor peak current greater than 9A.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot squeegee lift/lower circuit.</li> </ol>
0x68	Vacuum Over Current Protection	1. Vacuum motor peak current greater than 60A.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot vacuum circuit.</li> </ol>
0X69	Squeegee Short Circuit Protection	1. Squeegee motor short circuit.	<ol> <li>Power cycle machine.</li> <li>Troubleshoot squeegee lift/lower circuit.</li> </ol>
0X6A	Valve Fault	<ol> <li>Valve output over current.</li> <li>Controller hardware fault.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Troubleshoot conventional solution valve circuit.</li> </ol>
0x6C	Traction Right Null Error	<ol> <li>Controller firmware fault.</li> <li>Controller hardware fault.</li> </ol>	1. Contact Tennant Customer Service Department.
0x71	Trial Timeout	1. Controller set to trial mode and hours exceeded.	<ol> <li>Power cycle machine.</li> <li>Contact Tennant Customer Service Department.</li> </ol>
0x72	Solenoid Welded (Others)	1. Controller hardware fault.	1. Contact Tennant Customer Service Department.
0x73	Solenoid Did Not Close (Others)	1. Controller hardware fault.	1. Contact Tennant Customer Service Department.

Error Code	Fault Condition	Reason	Correction
0x74	Squeegee Motor Stalled	<ol> <li>Squeegee motor stalled.</li> <li>Parameter "Squeegee Current Limit" set too low.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Troubleshoot squeegee lift/lower circuit.</li> </ol>
0x75	Brush Deck Motor Stalled	<ol> <li>Brush deck motor stalled.</li> <li>Parameter "Bru-D Current Limit" set too low.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Troubleshoot scrub head lift/lower circuit.</li> </ol>
0x76	Precharge Failure (Others)	<ol> <li>Wiring problem.</li> <li>Controller hardware fault.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Contact Tennant Customer Service Department.</li> </ol>
0x77	Brush Motor Stalled	<ol> <li>Brush motor stalled.</li> <li>Parameter "Brush Current Limit" set too low.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Troubleshoot scrub motor circuit.</li> </ol>
0x78	Vacuum Motor Stalled	<ol> <li>Vacuum motor stalled.</li> <li>Parameter "Vacuum Current Limit" set too low.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Troubleshoot vacuum circuit.</li> </ol>
0x79	Traction Temp Switch	1. Traction motor over temperature.	<ol> <li>Power cycle machine.</li> <li>Contact Tennant Customer Service Department.</li> </ol>
0x7B	Brush Temp Switch	1. Brush motor over temperature.	<ol> <li>Power cycle machine.</li> <li>Contact Tennant Customer Service Department.</li> </ol>
0x7E	Tract_Left_Low_FET_ Short	1. Controller hardware fault.	1. Contact Tennant Customer Service Department.
0X83	MOSFET Over Temperature	<ol> <li>Output current too big.</li> <li>Controller heat dissipation not good (installation baseplate, etc).</li> <li>Controller hardware fault.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Contact Tennant Customer Service Department.</li> </ol>
0x8E	Tract_Left_High_FET_ Short	1. Controller hardware fault.	1. Contact Tennant Customer Service Department.
0xA2	High Battery Protection	<ol> <li>Battery voltage greater than 45V.</li> <li>Parameter "Battery Voltage" set to 0 but battery 36V.</li> <li>Controller Hardware fault.</li> </ol>	<ol> <li>Power cycle machine.</li> <li>Contact Tennant Customer Service Department.</li> </ol>
0x9A	Tract_Right_Low_FET_ Short	1. Controller hardware fault.	1. Contact Tennant Customer Service Department.
0x9B	Tract_Right_High_FET_ Short	1. Controller hardware fault.	1. Contact Tennant Customer Service Department.
0x9C	Brush_Negative_Short_ To_Gnd	1. Brush negative J42 short to ground.	1. Contact Tennant Customer Service Department.
0x9D	Vac_Negative_Short_To_ Gnd	1. Vacuum negative J42 short to ground.	1. Contact Tennant Customer Service Department.
0x9E	Bru_Deck_Act_SW1_ Error	1. Incorrect configuration file installed.	1. Contact Tennant Customer Service Department.
0x9E	Bru_Deck_Act_SW2_ Error	1. Incorrect configuration file installed.	1. Contact Tennant Customer Service Department.

#### ec-H2O NANOCLEAN ICON FAULTS



Machine Indicator	Module Status	Fault Code	Fault Condition	Cause	Correction
Solid Red	Off	0x0711	ec-H2O Pump Open Fault	1. ec-H2O pump wiring, connector or control board issue.	Control board is not detecting pump current. Check connections for voltage and verify pump is operating.
	Off	0x0713	ec-H2O Pump Over Current Fault	1. Current draw higher than expected.	Check pump operating current.
	Off	0x0716	ec-H2O Pump Short Fault	<ol> <li>Shorted load condition</li> <li>Higher current draw than hardware design limit.</li> </ol>	Refer to ec-H2O NanoClean Troubleshooting Guide.
	Off	0x0717	ec-H2O Pump FET Short	<ol> <li>Current detected on pump drive circuit when not actively operating.</li> </ol>	Refer to ec-H2O NanoClean Troubleshooting Guide.
	Off	0x0727	ec-H2O Cell FET Faults	<ol> <li>Control board problem.</li> <li>Power/battery issue on startup.</li> </ol>	Replace control board. FET detection includes motor, actuator, detergent pump, vacuum and battery watering pump.
	Off	0x0741	ec-H2O WCM Pump Open Warning	1. Wiring, connector or control board issue on ec-H2O pump.	Verify the water conditioning module micro pump is connected to machine harness and pump is functional.
	Off	0x0746	ec-H2O WCM Pump Short Warning	<ol> <li>Shorted load condition</li> <li>Some higher current draw than hardware design limit.</li> </ol>	Check harness. Verify water conditioning module micro pump is functional.
Flashing Red	Off	0x0702	ec-H2O Pressure Switch Active	1. The system pressure switch is detecting a trip or unconnected.	<ol> <li>System pressure too high.</li> <li>Check connections. Connectors possibly wired to incorrect switches.</li> </ol>
	Fast blink	0x0708	ec-H2O System Over Regulation Warning	1. Cell has operated over target current condition for last 50 treated gallons.	Check water in solution tank for presence of detergents.
	Slow blink	0x0721	ec-H2O Cell Open Fault	1. ec-H2O cell wiring, connector or control board issue.	Check connector/wire connections.
	Slow blink	0x072A	ec-H2O Cell Electrode Fault	1. Cell current is operating below allowed operating condition.	Refer to ec-H2O NanoClean Troubleshooting Guide.
	Fast blink	0x0726	ec-H2O Cell Short Warning	1. Shorted load condition 2. Higher current draw than hardware design limit.	Refer to ec-H2O NanoClean Troubleshooting Guide

Machine Indicator	Module Status	Fault Code	Fault Condition	Cause	Correction
Green/ Blue	Fast blink	0x0728	ec-H2O Cell Over Regulation	1. Cell current exceeds set point for expected operation. Fault is indicated via a flashing blue light on ec-H2O module.	Refer to ec-H2O NanoClean Troubleshooting Guide.
	Fast blink	0x072B	ec-H2O Cell Over Current Warning	1. Cell current is exceeding set point during the first 60 seconds when machine is powered on. Will most likely lead to a cell short fault if conditions persists.	Refer to ec-H2O NanoClean Troubleshooting Guide.
	Slow blink	0x0729	ec-H2O Cell Under Regulation	1. Cell Current under set point for expected operation. Fault is indicated via a flashing blue light on ec-H2O module.	Refer to ec-H2O NanoClean Troubleshooting Guide.
Red- Green/ Red-Blue	-	0x0707	ec-H2O Water Conditioning Cartridge Expired Warning	1. ec-H2O water cartridge has expired due to either gallons of usage or 2 years of use.	1. Replace ec-H2O water conditioning cartridge.

# OFF-BOARD BATTERY CHARGING ON (STANDARD)



#### BATTERIES FAIL TO CHARGE/REDUCED RUN TIME (OFF-BOARD CHARGER)

Step	Action	Value(s)	Yes	No
1	• Key OFF	1	Connect the	Proceed to STEP 2
	Are batteries disconnected?		batteries	
2	Key OFF		Proceed to STEP 3	Check AC supply
	Check AC power supply			circuit protection
	<ul> <li>Is the rated AC supply voltage present?</li> </ul>			
3	Key OFF		Repair or replace	Proceed to STEP 4
	<ul> <li>Inspect battery and charger cables for damage/ corrosion/contamination/terminal problems</li> </ul>		battery/battery charger cables	
4	Key OFF		Proceed to STEP 5	Add distilled water
	Disconnect batteries			as necessary until
	Check water level in all battery cells			covered
	<ul> <li>Are the lead plates submerged?</li> </ul>			
5	Key OFF		Replace battery	Replace battery
	<ul> <li>Use a hydrometer or refractometer to test specific gravity of each cell (Lead-Acid)</li> </ul>		charger	charger or batteries
	<ul> <li>Are all battery cells within 0.050 (50 points) specific gravity of each other?</li> </ul>			

Terms:

AC = Alternating Current

Specific Gravity = Relative density of a substance compared to water (1.000 specific gravity)

# OFF-BOARD BATTERY CHARGING ON (LITHIUM-SAMSUNG)



#### BATTERIES FAIL TO CHARGE/REDUCED RUN TIME (OFF-BOARD CHARGER)

Step	Action	Value(s)	Yes	No
1	Key OFF		Connect the	Proceed to STEP 2
	Are batteries disconnected?		batteries	
2	Key OFF		Proceed to STEP 3	Check AC supply
	Check AC power supply			circuit protection
	<ul> <li>Is the rated AC supply voltage present?</li> </ul>			
3	Key OFF		Repair or replace	Replace battery
	<ul> <li>Inspect battery and charger cables for damage/ corrosion/contamination/terminal problems</li> </ul>		battery/battery charger cables	charger or batteries

Terms:

AC = Alternating Current

#### **POWER UP ON (STANDARD)**



## MACHINE FAILED TO POWER UP

Step	Action	Value(s)	Yes	No
1	• Key ON		Proceed to STEP 2	Recharge batteries
	<ul> <li>AMR Bypass Switch in "I" (ON) position</li> </ul>			and test power-up
	<ul> <li>Use a voltmeter to test the total battery voltage</li> </ul>			
	<ul> <li>Is total battery voltage greater than 24 VDC?</li> </ul>			
2	Key OFF		Reset and test	Proceed to STEP 3
	<ul> <li>AMR Bypass Switch in "I" (ON) position</li> </ul>		power-up circuit	
	<ul> <li>Firmly press circuit breaker #1 to reset</li> </ul>			
	<ul> <li>Is circuit breaker #1 tripped?</li> </ul>			
3	Key ON		Repeat STEP 1 Iden	Identify voltage drop location and repair or
	<ul> <li>AMR Bypass Switch in "I" (ON) position</li> </ul>			
	<ul> <li>Test voltage applied to power-up subsystem as shown on electrical schematic</li> </ul>			components
	<ul> <li>Are electrical circuits operating as shown on electrical schematic?</li> </ul>			
4	• Key ON		Replace Brain	Identify voltage drop
	<ul> <li>Move the AMR Bypass Switch to "O" (OFF) position</li> </ul>		Control Module or	location and repair or
	<ul> <li>Test voltage applied to power-up subsystem as shown on electrical schematic</li> </ul>		Module lower harness	components
	<ul> <li>Are electrical circuit operating as shown on electrical schematic?</li> </ul>			

Terms:

VDC = DC Voltage

#### POWER UP ON (LITHIUM-SAMSUNG)



## MACHINE FAILED TO POWER UP

Step	Action	Value(s)	Yes	No
1	• Key ON		Proceed to STEP 2	Recharge batteries
	<ul> <li>AMR Bypass Switch in "I" (ON) position</li> </ul>			and test power-up
	<ul> <li>Use a voltmeter to test the total battery voltage</li> </ul>			chour operation
	<ul> <li>Is total battery voltage greater than 24 VDC?</li> </ul>			
2	Key OFF		Reset and test	Proceed to STEP 3
	<ul> <li>AMR Bypass Switch in "I" (ON) position</li> </ul>		power-up circuit	
	<ul> <li>Firmly press circuit breaker #1 to reset</li> </ul>			
	<ul> <li>Is circuit breaker #1 tripped?</li> </ul>			
3	• Key ON		Repeat STEP 1	Identify voltage drop location and repair or
	<ul> <li>AMR Bypass Switch in "I" (ON) position</li> </ul>			
	<ul> <li>Test voltage applied to power-up subsystem as shown on electrical schematic</li> </ul>			components
	<ul> <li>Are electrical circuits operating as shown on electrical schematic?</li> </ul>			
4	• Key ON		Replace Brain	Identify voltage drop
	<ul> <li>Move the AMR Bypass Switch to "O" (OFF) position</li> </ul>		Control Module or lo Brain Control re Module lower co harness	location and repair or replace necessary components
	<ul> <li>Test voltage applied to power-up subsystem as shown on electrical schematic</li> </ul>			
	<ul> <li>Are electrical circuit operating as shown on electrical schematic?</li> </ul>			

Terms:

VDC = DC Voltage

#### PROPEL SYSTEM



### PROPEL SYSTEM OPERATIONAL MATRIX

Enabled	Disabled
<ul> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>	<ul> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>
Operator in seat	Operator not in seat
Propel pedal pressed	<ul> <li>Propel pedal not pressed</li> </ul>
<ul> <li>E-Stops not engaged</li> </ul>	<ul> <li>E-Stops engaged</li> </ul>
<ul> <li>Charger interlock not engaged</li> </ul>	Charger interlock engaged
<ul> <li>No faults on propel motor output</li> </ul>	<ul> <li>Faults on propel motor output</li> </ul>

\* SOC = State of Charge

\*\* SOC percentages shown when service device is connected to service terminal may not be accurate. Service device must be connected to the lithium battery control board USB cable for accurate SOC percentage. See ACCESS LITHIUM BATTERY SERVICE SCREEN in LITHIUM BATTERIES section.

#### MACHINE FAILED TO PROPEL

Step	Action	Value(s)	Yes	No
1	<ul> <li>Key OFF</li> <li>Are all interlocks in the proper state to enable manual propel?         <ul> <li>* Front E-stop not engaged</li> <li>* Rear E-stop not engaged</li> <li>* Operator in seat</li> </ul> </li> </ul>		Proceed to STEP 2	Ensure all interlocks are in the proper state to enable manual propel
2	<ul> <li>Key OFF</li> <li>Firmly press circuit breaker #1 to reset</li> <li>Is circuit breaker #1 tripped?</li> </ul>		Reset and test power-up circuit operation	Proceed to STEP 3
3	<ul><li>Key OFF</li><li>Is the in-line fuse blown?</li></ul>		Replace fuse	Proceed to STEP 4
4	<ul> <li>Key ON</li> <li>Use a voltmeter to test the total battery voltage</li> <li>Is total battery voltage greater than 31.5 VDC for FLA batteries and 30.5 VDC for lithium batteries?</li> </ul>		Proceed to STEP 5	Recharge batteries and test power-up circuit operation
5	<ul> <li>Key OFF</li> <li>Place machine on blocks so drive wheel is lifted from floor</li> <li>Key ON</li> <li>Enable propel</li> <li>Test voltage applied to propel subsystem as shown on electrical schematic</li> <li>Are electrical circuits operating as shown on electrical schematic?</li> </ul>		Use AMR Service Connection to read error code from controller	Identify voltage drop location and repair or replace necessary components

Terms:

VDC = DC Voltage

#### SCRUB MOTORS ON



### SCRUB MOTOR OPERATIONAL MATRIX

Enabled	Disabled
<ul> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>	<ul> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>
<ul> <li>1-Step enabled</li> </ul>	1-Step disabled
Scrub deck lowered	Scrub deck raised/raising
Machine is propelling	Machine not propelling
Solution tank not empty	Solution tank empty
Recovery tank not full	Recovery tank full
<ul> <li>E-Stops not engaged</li> </ul>	<ul> <li>E-Stops engaged</li> </ul>
<ul> <li>Charger interlock not engaged</li> </ul>	Charger interlock engaged
<ul> <li>No faults on scrub motor output</li> </ul>	<ul> <li>Faults on scrub motor output</li> </ul>

\* SOC = State of Charge

\*\* SOC percentages shown when service device is connected to service terminal may not be accurate. Service device must be connected to the lithium battery control board USB cable for accurate SOC percentage. See ACCESS LITHIUM BATTERY SERVICE SCREEN in LITHIUM BATTERIES section.

#### SCRUB MOTOR FAILED TO TURN ON

Step	Action	Value(s)	Yes	No
1	<ul><li>Key ON</li><li>Enable scrub motor</li><li>Is there a fault on the membrane panel?</li></ul>		Use AMR Service Connection to read error code from controller	Proceed to STEP 2
2	<ul><li>Key OFF</li><li>Is the in-line fuse blown?</li></ul>		Replace fuse	Proceed to STEP 3
3	<ul> <li>Key ON</li> <li>Enable scrub motor</li> <li>Test voltage applied to scrub motor subsystem as shown on electrical schematic</li> <li>Are electrical circuits operating as shown on electrical schematic?</li> </ul>		Repeat STEP 1	Identify voltage drop location and repair or replace necessary components

#### SCRUB HEAD LIFT



### SCRUB HEAD ACTUATOR OPERATIONAL MATRIX

Enabled	Disabled
<ul> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>	<ul> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>
<ul> <li>1-Step enabled/disabled</li> </ul>	<ul> <li>1-Step not enabled</li> </ul>
Lifts until current limits is reached on power-up and end	Lifting current limit is reached
of scrub	<ul> <li>Machine is scrubbing at desired down pressure target</li> </ul>
<ul> <li>Lowers for fixed time duration at beginning of scrub</li> </ul>	<ul> <li>E-Stops engaged</li> </ul>
<ul> <li>Adjusts during scrubbing to maintain down pressure</li> </ul>	Charger interlock engaged
<ul> <li>Solution tank not empty</li> </ul>	<ul> <li>Faults on scrub deck actuator output</li> </ul>
Recovery tank not full	
<ul> <li>E-Stops not engaged</li> </ul>	
Charger interlock not engaged	
<ul> <li>No faults on scrub deck actuator output</li> </ul>	

\* SOC = State of Charge

\*\* SOC percentages shown when service device is connected to service terminal may not be accurate. Service device must be connected to the lithium battery control board USB cable for accurate SOC percentage. See ACCESS LITHIUM BATTERY SERVICE SCREEN in LITHIUM BATTERIES section.

#### SCRUB HEAD FAILED TO LIFT/LOWER

Step	Action	Value(s)	Yes	No
1	<ul><li>Key ON</li><li>Enable lift actuator</li><li>Is there a fault on the membrane panel?</li></ul>		Use AMR Service Connection to read error code from controller	Proceed to STEP 2
2	<ul> <li>Key OFF</li> <li>Inspect actuator and lift mechanism</li> <li>Is there anything causing the actuator or lift linkage to bind?</li> </ul>		Remove anything causing the actuator/ lift linkage to bind	Proceed to STEP 3
3	<ul><li>Key OFF</li><li>Is the in-line fuse blown?</li></ul>		Replace fuse	Proceed to STEP 4
4	<ul> <li>Key ON</li> <li>Enable scrub motor</li> <li>Test voltage applied to actuator subsystem as shown on electrical schematic</li> <li>Are electrical circuits operating as shown on electrical schematic?</li> </ul>		Repeat STEP 1	Identify voltage drop location and repair or replace necessary components

#### **REAR SQUEEGEE LIFT**



## REAR SQUEEGEE ACTUATOR OPERATIONAL MATRIX

Enabled	Disabled		
<ul> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>	<ul> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>		
<ul> <li>1-Step or water-pickup enabled</li> </ul>	<ul> <li>1-Step or water-pickup not enabled</li> </ul>		
<ul> <li>Directional switch set to forward</li> </ul>	Will not lower if directional switch set to reverse		
Lifts when directional switch is set to reverse	Internal limit switches are hit		
• Lifts until internal limit switch is hit on power-up and at	Recovery tank full		
end of 1-Step/water pickup	<ul> <li>E-Stops engaged</li> </ul>		
<ul> <li>Lowers until internal limit switch is hit at beginning of 1-Step/water pickup</li> </ul>	Charger interlock engaged		
Recovery tank not full	<ul> <li>Faults on squeegee actuator output</li> </ul>		
<ul> <li>E-Stops not engaged</li> </ul>			
Charger interlock not engaged			
<ul> <li>No faults on squeegee actuator output</li> </ul>			

\* SOC = State of Charge

\*\* SOC percentages shown when service device is connected to service terminal may not be accurate. Service device must be connected to the lithium battery control board USB cable for accurate SOC percentage. See ACCESS LITHIUM BATTERY SERVICE SCREEN in LITHIUM BATTERIES section.

### REAR SQUEEGEE FAILED TO LIFT/LOWER

Step	Action	Value(s)	Yes	No
1	<ul><li>Key ON</li><li>Enable lift actuator</li><li>Is there a fault on the membrane panel?</li></ul>		Use AMR Service Connection to read error code from controller	Proceed to STEP 2
2	<ul> <li>Key OFF</li> <li>Inspect actuator and lift mechanism</li> <li>Is there anything causing the actuator or lift linkage to bind?</li> </ul>		Remove anything causing the actuator/ lift linkage to bind	Proceed to STEP 3
3	<ul><li>Key OFF</li><li>Is the in-line fuse blown?</li></ul>		Replace fuse	Proceed to STEP 4
4	<ul> <li>Key ON</li> <li>Enable lift actuator</li> <li>Test voltage applied to actuator subsystem as shown on electrical schematic</li> <li>Are electrical circuits operating as shown on electrical schematic?</li> </ul>		Repeat STEP 1	Identify voltage drop location and repair or replace necessary components

#### VACUUM FAN ON



### VACUUM FAN OPERATIONAL MATRIX

Enabled	Disabled		
<ul> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>	<ul> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>		
<ul> <li>1-Step or water-pickup enabled</li> </ul>	<ul> <li>1-Step or water-pickup not enabled</li> </ul>		
Direction switch set to forward	<ul> <li>Direction switch set to reverse</li> </ul>		
Vacuum fan continues to operate for a period of time	Vacuum off timer expired		
after disabling	Recovery tank full		
Recovery tank not full	E-Stops engaged		
<ul> <li>E-Stops not engaged</li> </ul>	Charger interlock engaged		
<ul> <li>Charger interlock not engaged</li> </ul>	Faults on vacuum fan output		
<ul> <li>No faults on vacuum fan output</li> </ul>			

\* SOC = State of Charge

\*\* SOC percentages shown when service device is connected to service terminal may not be accurate. Service device must be connected to the lithium battery control board USB cable for accurate SOC percentage. See ACCESS LITHIUM BATTERY SERVICE SCREEN in LITHIUM BATTERIES section.

#### VACUUM FAN FAILED TO TURN ON

Step	Action	Value(s)	Yes	No
1	<ul><li>Key ON</li><li>Enable vacuum fan</li><li>Is there a fault on the membrane panel?</li></ul>		Use AMR Service Connection to read error code from controller	Proceed to STEP 2
2	<ul><li>Key OFF</li><li>Is the in-line fuse blown?</li></ul>		Replace fuse	Proceed to STEP 3
3	<ul> <li>Key ON</li> <li>Enable vacuum fan</li> <li>Test voltage applied to scrub motor subsystem as shown on electrical schematic</li> <li>Are electrical circuits operating as shown on electrical schematic?</li> </ul>		Repeat STEP 1	Identify voltage drop location and repair or replace necessary components

#### SOLUTION CONTROL ON (CONVENTIONAL)



# SOLUTION CONTROL (CONVENTIONAL) OPERATIONAL MATRIX

Enabled	Disabled		
<ul> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>	<ul> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>		
<ul> <li>1-Step enabled</li> </ul>	<ul> <li>1-Step not enabled</li> </ul>		
<ul> <li>ec-H2O not enabled</li> </ul>	ec-H2O is enabled		
Machine is scrubbing	Machine not scrubbing		
Solution tank not empty	Solution tank empty		
Recovery tank not full	Recovery tank full		
<ul> <li>E-Stops not engaged</li> </ul>	<ul> <li>E-Stops engaged</li> </ul>		
<ul> <li>Charger interlock not engaged</li> </ul>	Charger interlock engaged		
<ul> <li>No faults on water valve output</li> </ul>	<ul> <li>Faults on water valve output</li> </ul>		

\* SOC = State of Charge

\*\* SOC percentages shown when service device is connected to service terminal may not be accurate. Service device must be connected to the lithium battery control board USB cable for accurate SOC percentage. See ACCESS LITHIUM BATTERY SERVICE SCREEN in LITHIUM BATTERIES section.

## SOLUTION CONTROL (CONVENTIONAL) FAILED TO TURN ON

Step	Action	Value(s)	Yes	No
1	<ul> <li>Key ON</li> <li>Enable solution control (conventional)</li> <li>Is there a fault on the membrane panel?</li> </ul>		Use AMR Service Connection to read error code from controller	Proceed to STEP 2
2	<ul><li>Key OFF</li><li>Is the in-line fuse blown?</li></ul>		Replace fuse	Proceed to STEP 3
3	<ul> <li>Key ON</li> <li>Enable solution control (conventional)</li> <li>Test voltage applied to solution control (conventional) subsystem as shown on electrical schematic</li> <li>Are electrical circuits operating as shown on electrical schematic?</li> </ul>		Repeat STEP 1	Identify voltage drop location and repair or replace necessary components

#### SOLUTION CONTROL ON ec-H2O NANO-CLEAN



## SOLUTION CONTROL ec-H2O NANO-CLEAN OPERATIONAL MATRIX

Enabled	Disabled		
<ul> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>	<ul> <li>Battery voltage &lt; 32.7 for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>		
1-Step enabled	<ul> <li>1-Step not enabled</li> </ul>		
ec-H2O enabled	ec-H2O disabled		
Machine is scrubbing	Machine not scrubbing		
Solution tank not empty	Solution tank empty		
Recovery tank not full	Recovery tank full		
<ul> <li>E-Stops not engaged</li> </ul>	<ul> <li>E-Stops engaged</li> </ul>		
<ul> <li>Charger interlock not engaged</li> </ul>	Charger interlock engaged		
<ul> <li>No faults on ec-H2O enable output</li> </ul>	<ul> <li>Faults on ec-H2O enable output</li> </ul>		

\* SOC = State of Charge

\*\* SOC percentages shown when service device is connected to service terminal may not be accurate. Service device must be connected to the lithium battery control board USB cable for accurate SOC percentage. See ACCESS LITHIUM BATTERY SERVICE SCREEN in LITHIUM BATTERIES section.

# SOLUTION CONTROL FAILED TO TURN ON ec-H2O NANO-CLEAN

Step	Action	Value(s)	Yes	No
1	<ul> <li>Key ON</li> <li>Enable solution control ec-H2O</li> <li>Is there a fault on the membrane panel?</li> </ul>		Use AMR Service Connection to read error code from controller	Proceed to STEP 2
2	<ul> <li>Key OFF</li> <li>Firmly press circuit breaker #8 to reset</li> <li>Is circuit breaker #8 tripped?</li> </ul>		Reset and test power-up circuit operation	Proceed to STEP 3
3	<ul><li>Key OFF</li><li>Is the in-line ec-H2O fuse blown?</li></ul>		Replace fuse	Proceed to STEP 4
4	<ul> <li>Key ON</li> <li>Enable solution control ec-H2O</li> <li>Test voltage applied to solution control ec-H2O subsystem as shown on electrical schematic</li> <li>Are electrical circuits operating as shown on electrical schematic?</li> </ul>		Repeat STEP 1	Identify voltage drop location and repair or replace necessary components

#### **TURN SIGNALS**



Turn on voltage for the coil is  $\sim$ 24V, but the hold voltage is  $\sim$ 4. The contactor coil requires 24V to charge to close and power up the machine, and the voltage has to drop to below 4V for the coils to open.

## TURN SIGNAL(S) FAIL(S)

Step	Action	Value(s)	Yes	No
1	<ul><li>Key ON</li><li>Operate machine in Robotic Mode</li></ul>			Proceed to STEP 2
	<ul> <li>Does/do turn signal(s) flash when machine is navigating corners?</li> </ul>			
2	<ul> <li>Key ON</li> <li>Test voltage applied to turn signal subsystem.</li> <li>Are electrical circuits operating?</li> </ul>		Repeat STEP 1	Identify voltage drop location and repair or replace necessary components

#### **START/PAUSE SWITCH**



Turn on voltage for the coil is  $\sim$ 24V, but the hold voltage is  $\sim$ 4. The contactor coil requires 24V to charge to close and power up the machine, and the voltage has to drop to below 4V for the coils to open.
### START/PAUSE SWITCH FAILS TO OPERATE

Step	Action	Value(s)	Yes	No
1	Key ON		Check continuity	Identify voltage drop
	Remove front shroud			location and repair
	<ul> <li>Locate BCM (4-pin connector) that contains both the start/pause LED and the start/pause switch signal.</li> </ul>			components
	<ul> <li>Disconnect one spade terminal at switch-side to remove the led from the circuit.</li> </ul>			

#### STEERING SUBSYSTEM



Turn on voltage for the coil is  $\sim$ 24V, but the hold voltage is  $\sim$ 4. The contactor coil requires 24V to charge to close and power up the machine, and the voltage has to drop to below 4V for the coils to open.

### STEERING SYSTEM OPERATIONAL MATRIX

Enabled	Disabled
<ul> <li>Battery voltage &gt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>	<ul> <li>Battery voltage &lt; 32.7V for FLA batteries, or 32.6V for lithium batteries (Samsung), or 5% SOC* for lithium batteries (Inventus)**</li> </ul>
<ul> <li>E-Stops not engaged</li> </ul>	<ul> <li>E-Stops engaged</li> </ul>
<ul> <li>Charger interlock not engaged</li> </ul>	Charger interlock engaged
<ul> <li>No faults on steering output</li> </ul>	<ul> <li>Faults on steering output</li> </ul>

#### \* SOC = State of Charge

\*\* SOC percentages shown when service device is connected to service terminal may not be accurate. Service device must be connected to the lithium battery control board USB cable for accurate SOC percentage. See ACCESS LITHIUM BATTERY SERVICE SCREEN in LITHIUM BATTERIES section.

#### STEERING MOTOR FAILED TO OPERATE

Step	Action	Value(s)	Yes	No
1	<ul> <li>Key OFF</li> <li>Are all interlocks in the proper state to enable the steering system?         <ul> <li>Front E-Stop button not engaged</li> <li>Rear E-Stop button not engaged</li> <li>Charger not connected</li> </ul> </li> </ul>		Proceed to STEP 2	Ensure all interlocks are in proper state to enable steering motor
2	<ul> <li>Key OFF</li> <li>Is circuit breaker #4 tripped?</li> <li>Firmly press circuit breaker #4 to reset</li> </ul>		Reset and test power-up circuit operation	Proceed to STEP 3
3	<ul> <li>Key ON</li> <li>Test voltage applied to steering subsystem as shown on electrical schematic</li> <li>Are electrical circuit operating as shown on electrical schematic?</li> </ul>			Identify voltage drop location and repair or replace necessary components

#### **HEADLIGHTS ON**



#### HEADLIGHT OPERATIONAL MATRIX

Enabled	Disabled	
<ul> <li>Battery voltage &gt; 31.5V for FLA batteries, or 30.5V for lithium batteries (Samsung), or 2% SOC* for lithium batteries (Inventus)**</li> </ul>	<ul> <li>Battery voltage &lt; 31.5V for FLA batteries, or 30.5V for lithium batteries (Samsung), or 2% SOC for lithium batteries (Inventus)**</li> </ul>	
Light switch ON	Light switch OFF	
<ul> <li>E-Stops not engaged</li> </ul>	<ul> <li>E-Stops engaged</li> </ul>	
<ul> <li>Charger interlock not engaged</li> </ul>	<ul> <li>Charger interlock engaged</li> </ul>	

#### \* SOC = State of Charge

\*\* SOC percentages shown when service device is connected to service terminal may not be accurate. Service device must be connected to the lithium battery control board USB cable for accurate SOC percentage. See ACCESS LITHIUM BATTERY SERVICE SCREEN in LITHIUM BATTERIES section.

#### **HEADLIGHT FAIL**

Step	Action	Value(s)	Yes	No
1	• Key ON			Proceed to STEP 2
	Enable headlights.			
	Do headlights function?			
2	<ul> <li>Key OFF</li> <li>Firmly press circuit breaker CB7 to reset.</li> <li>Is circuit breaker CB7 tripped?</li> </ul>		Reset and test headlight operation	Proceed to STEP 3
3	<ul> <li>Key ON</li> <li>Light switch ON</li> <li>Test voltage applied to headlight subsystem.</li> <li>Are electrical circuits operating?</li> </ul>		Repeat STEP 1	Identify voltage drop location and repair or replace necessary components

# CAN (CONTROLLER AREA NETWORK) OPEN NETWORK ISSUES/TROUBLESHOOTING



### CAN OPEN NETWORK ISSUES

The following items include procedures to investigate a fault related to a CAN open network.

### CONNECTOR FULLY SEATED

Each node on the network has a connector for the CAN communication wires. A loose connection could cause a fault code error. Check each board individual to ensure the connectors are fully seated. There may also be other connectors within the harness that should be checked. If the connector is not fully seated, fully seat the connector and power cycle the machine to see if the fault clears.



#### PIN FULLY SEATED

A pin within the harness side of the connector may not be fully seated or may come loose over time causing a fault. If the pin is not fully seated, push it back in and power cycle the machine to see if the fault clears.



### NETWORK RESISTANCE

The network resistance must be correct for the network to operate correctly. Depending on which node the measurement is taken at and the method of measurement, the resistance may be one of two values:  $121\Omega$  or  $61\Omega$ . Any value other than these two means something is wrong with the network.

#### Method 1



- 1. Turn off the machine.
- 2. Locate a CAN node location on the machine.
- 3. Disconnect the connector containing the CAN wires.
- 4. Measure the resistance between the green and yellow wires.
- 5. Depending which nodes are still connected, resistance should be  $61\Omega$  or  $121\Omega$ .

#### Method 2



- 1. Turn off the machine.
- 2. Locate a CAN node location on the machine.
- 3. Carefully push probes into the back of the connector containing the CAN wires.
- 4. Since the network remains connected in this node, resistance should measure approximately  $61\Omega$ .

#### **COMPONENT TESTING**

TEST THE RECOVERY TANK AND SOLUTION TANK LEVEL SENSORS

FOR SAFETY: Before leaving or servicing machine, stop on level surface.

- 1. Turn key switch ON.
- 2. Use an ohmmeter to test the resistance of the level sensor as shown below. The tank level switch should test as "O.L." or open.



3. Use an ohmmeter to test the resistance of the level sensor as shown below. The tank level switch should test at  $0-1\Omega$  or closed.



4. The recovery tank full sensor condition is also viewable through the AMR SERVICE CONNECTION.

#### TEST THE PARKING BRAKE, ELECTROMAGNETIC

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, remove key, and set parking brake.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 1. Turn key switch OFF.
- 2. Turn steering wheel so the encoder and brake assembly installed on the drive wheel assembly can be easily accessed.
- Remove the hardware securing the encoder to the brake assembly. <u>Do Not</u> lose hardware securing the controller to the brake assembly. Hardware will be needed to reinstall the encoder.



4. Remove brake assembly mounting screws. Leave brake assembly on the splined shaft.



5. The brake applies when the key switch is turned off. Attempt to manually rotate the brake assembly by hand on the splined shaft as shown below. The brake assembly SHOULD NOT rotate freely on the splined shaft when the wheel is in a fixed position.



6. Remove the brake assembly from the splined shaft.



7. Remove three flat head screws to disassemble the brake assembly.



8. Use a vernier caliper to measure the thickness of the brake rotor. Replace the rotor if it is less than 0.17 in (4.3 mm) thick.



9. Reassemble the brake assembly and slide it back onto the splined shaft.

#### **TEST THE PROPEL MOTOR**

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, remove key, and set parking brake.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 1. Turn key switch OFF.
- 2. Remove the terminal cover from the drive wheel assembly.
- 3. Disconnect V and W cables from A- and A+ terminals (respectively).



4. Use an ohmmeter to test the resistance of all three motor windings as shown below. The resistance of each winding should be within 5% of each other. An open or shorted winding indicates a faulty motor.



 Test the resistance between all three motor terminals and the motor case as shown below. The ohmmeter should read "O.L." or open. A shorted winding indicates a faulty motor.



 The motor encoder and temperature sender are non-serviceable components of the drive motor. The motor encoder senses rotor position, speed, and direction. The encoder is integrated into an internal roller bearing assembly.

The temperature sender senses the propel motor temperature. Test the resistance of the temperature sender using an ohmmeter and then compare the values to the chart below. Replace the motor assembly if the resistance values are out of the specified range.



Temperature		Resistance (Ω)			
(°C)	(°F)	MIN.	TYP.	Max.	
-30	-22	362	381	368	
0	32	464	486	507	
25	77	565	588	611	
30	86	587	610	633	
50	122	679	704	728	
70	158	781	806	831	
80	176	835	860	885	
100	212	950	975	1000	
110	230	1007	1036	1064	

#### TEST THE PROPEL MOTOR CABLES

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, remove key, and set parking brake.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 1. Turn key switch OFF.
- 2. Remove the terminal cover from the drive wheel assembly.
- 3. Disconnect V and W cables from A- and A+ terminals (respectively).



4. Disconnect the V and W cables from the Kinetic controller.



- 5. Reconnect the battery cable to the machine.
- Use an ohmmeter to test each cable for a short to battery + as shown below. Each cable should test as "O.L." or open to battery +. Replace shorted cable(s).



 Use an ohmmeter to test each cable for a short to battery - as shown below. Each cable should test as "O.L." or open to battery -. Replace shorted cable(s).



 Use an ohmmeter to test each cable for a short to chassis as shown below. Each cable should test as "O.L." or open to chassis. Replace shorted cable(s).



9. Use an ohmmeter to test each cable for end-to-end continuity. Each cable should test between  $0-1\Omega$  resistance. Replace open cable(s).



 "Tug test" each cable (motor end) to determine if a cable is broken inside the insulation. Do not exceed 10 lbs (45 N) of force as cable damage may occur. Replace broken cables.



# TEST THE THROTTLE/BRAKE SENSOR

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, remove key, and set parking brake.

FOR SAFETY: When servicing machine, avoid moving parts. Do not wear loose jackets, shirts, or sleeves when working on machine.

- 1. Turn key switch OFF.
- Jack the front end of the machine approximately 12.7 mm (0.50 in) from the floor (high enough so the front drive wheel moves freely).

FOR SAFETY: When servicing machine, block machine tires before jacking machine up. Use a hoist or jack that will support the weight of the machine. Jack machine up at designated locations only.

3. The throttle hall effect sensor is a component of the pedal subassembly.



Pin	Notes	Color
А	Power (Battery +)	Red
В	Forward Output (0-5 VDC)	Yellow
С	Brake (0-5 VDC)	Blue
D	Ground (Battery -)	Black
E	Gate A	N/A
F	Gate B	N/A

- 4. Turn key switch ON.
- 5. Use a voltmeter to back probe the power supply to the throttle/brake sensor terminals A and D as shown below. The voltmeter should display battery voltage.



- 6. Turn key switch ON.
- Use a voltmeter to back probe the throttle sensor output terminals B and D as shown below. The voltmeter should display 0-5 volts proportional to 0-100% propel pedal movement.



 See "Propel Diagnostic Mode" in the TROUBLE SHOOTING section. The voltage in step 3 should match the LCD displayed voltage in Propel Diagnostic Mode.

- 9. Turn key switch ON.
- 10. Use a voltmeter to back probe the brake sensor terminals C and D as shown below. The voltmeter should display 5 volts when the brake pedal is activated.



11. See OUTPUT INFORMATION/CURRENT AND VOLTS section. The change in voltage should correspond to a brake pedal "On" or "Off" in AMR SERVICE CONNECTION screen.

#### TEST THE SCRUB HEAD ACTUATOR

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, remove key, and set parking brake.

FOR SAFETY: When servicing machine, avoid moving parts. Do not wear loose jackets, shirts, or sleeves when working on machine.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 1. Turn key switch OFF.
- 2. Disconnect the scrub head actuator from the wire harness.



Pin Assignment		
2	Black	
1	Red	

 Use fuse-protected jumper leads to apply battery voltage to the actuator as shown below. Connect battery + to terminal 1 and battery - to terminal 2. The actuator should retract completely. Replace the actuator if it fails to retract.



 Reverse polarity and use fuse-protected jumper leads to apply battery voltage to the actuator as shown below. Connect battery - to terminal 1 and battery + to terminal 2. The actuator should extend completely. Replace the actuator if it fails to extend.



#### TEST THE REAR SQUEEGEE ACTUATOR

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, remove key, and set parking brake.

FOR SAFETY: When servicing machine, avoid moving parts. Do not wear loose jackets, shirts, or sleeves when working on machine.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 1. Turn key switch OFF.
- 2. Disconnect the rear squeegee actuator from the wire harness.



Pin Assignment		
2	Black	
1	Black	

 Use fuse-protected jumper leads to apply battery voltage to the lift actuator as shown below. Connect battery + to terminal 1 and battery - to terminal 2. The actuator should retract completely. Replace the actuator if it fails to retract.



 Reverse polarity and use fuse-protected jumper leads to apply battery voltage to the lift actuator as shown below. Connect battery - to terminal 1 and battery + to terminal 2. The actuator should extend completely. Replace the actuator if it fails to extend.



#### TEST THE VACUUM FAN

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, remove key, and set parking brake.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 1. Turn key switch OFF.
- 2. Disconnect the wire harness from the vacuum fan.
- 3. Remove the vacuum fan from the vacuum fan housing. See *REMOVE/REINSTALL/REPLACE THE VACUUM FAN* for instructions how to remove the vacuum fan.
- 4. Remove the carbon brushes from the vacuum fan. See *REMOVE/INSPECT/REPLACE THE VACUUM FAN CARBON BRUSHES* for information how to access the vacuum fan carbon brushes.
- 5. Inspect carbon brushes. Replace carbon brushes if they are shorter than 10mm (0.375 in).



6. Use fuse-protected jumper leads to apply battery voltage to the vacuum fan as shown below. The fan should turn On. Replace the vacuum fan if it fails to turn On.



- 7. Reconnect the main wire harness to the vacuum fan.
- 8. Reconnect the battery cable to the machine.
- 9. See OUTPUT INFORMATION/CURRENT AND VOLTS section. Activate the vacuum fan in AMR SERVICE CONNECTION screen. The amperage displayed should be approximately 15 Amps.

#### TEST THE MAIN SCRUB BRUSH MOTOR(S)

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, remove key, and set parking brake.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 1. Turn key switch OFF.
- 2. Disconnect the main brush motor from the wire harness.



Pin Assignment		
2	Black	
1	Red	

- Remove the main scrub brush motor(s) from the scrub head. See REMOVE/REINSTALL/REPLACE THE MAIN SCRUB BRUSH MOTOR(S) for instructions how to remove the main scrub brush motors.
- 4. Remove the carbon brushes from the main scrub brush motor(s). See *REMOVE/INSPECT/ REPLACE THE MAIN SCRUB BRUSH MOTOR CARBON BRUSHES* for information how to access the main scrub brush motor carbon brushes.

5. Inspect carbon brushes. Replace carbon brushes if they are shorter than 0.39 in (10mm).



6. Use fuse-protected jumper leads to apply battery voltage to the main brush motor(s) as shown below. The brush motor should turn On. Replace the brush motor if it fails to turn On.



# TEST THE SOLUTION PUMP AND ec-H2O NANO-CLEAN PUMP

# FOR SAFETY: Before leaving or servicing machine, stop on level surface.

- 1. Turn key switch OFF.
- 2. Disconnect pump outlet hose.
- 3. Fill the solution tank.
- Connect a temporary outlet hose to the pump. The hose must be long enough to reach a 5 gallon (19 liter) container.



5. Enter the AMR SERVICE CONNECTION screen and manually turn ec-H2O system on at the main screen. See DIAGNOSTIC TOOLS.



 Use a stop watch to time how long it takes to fill a 5 gallon (19 liter) container. The open flow specification for the ec-H2O pump/solution pump is 3.3 GPM (12.5 LPM). The pump should fill the container in approximately 1.5 - 2.0 minutes. Replace the pump if it takes longer than 2 minutes to fill and the pump has an adequate water supply.

NOTE: Open flow is different than system flow and should not be used for scrubbing mode water consumption calculations.



7. Manually turn off the ec-H2O system at the AMR SERVICE CONNECTION screen.

# TEST THE ec-H2O NANO-CLEAN PRESSURE SWITCH

FOR SAFETY: Before leaving or servicing machine, stop on level surface.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 1. Turn key switch OFF.
- 2. Disconnect the ec-H2O pressure switch from the main wire harness.
- 3. Remove the ec-H2O pressure switch from the machine.



 Use an ohmmeter to test the resistance of the switch between the common and normally closed terminals. There should be 0-1Ω resistance. Replace the switch if the N.C. contacts are open.



 Use an ohmmeter to test the resistance of the switch between the common and normally open terminals. The switch should test as "O.L." or open. Replace the switch if the N.O. contacts are shorted.



 Use a bicycle pump with pressure gauge to apply pressure to the switch as shown below. The normally open contacts should close at 20 +/- 2 psi (1.4 Bar), increasing pressure. Replace the switch if it does not open correctly.



#### COVERS/SHROUDS/SUPPORT BRACKET/ OPERATOR SEAT/MAIN FRAME

#### MAIN FRAME GROUP



# REMOVE/REINSTALL THE FRONT PERIMETER GUARD



# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Completely lower the scrub head.
- 2. Turn the key switch OFF.
- 3. Remove all hardware (hex screws, springs, flat washers, and pins) securing the support bracket to the mounting bracket installed on the stabilizer located on the front left side of the machine.



4. Remove all hardware (hex screws, springs, flat washers, and pins) securing the support bracket to the mounting bracket installed on the stabilizer located on the front right side of the machine.



5. Pull the support bracket assembly from under the machine.



- 6. If replacing the support bracket assembly, remove both caster wheels and the bumper wheel from the support bracket assembly.
- 7. Install the caster wheels and the bumper wheel removed from the removed support bracket assembly onto the new support bracket assembly.
- 8. Reinstall the removed support bracket assembly/ new support bracket assembly onto the machine in the reverse order of disassembly.

#### FRONT COVERS GROUP



#### **REMOVE/REINSTALL THE FRONT SHROUD**

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

1. Remove all hardware securing the front cover to the machine.







- 2. Remove the front shroud from the machine.
- 3. Reinstall the front shroud onto the machine in reverse order of disassembly.

#### **REMOVE/REINSTALL THE LOWER SHROUD**

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

1. Remove all hardware securing the lower shroud to the machine.







2. Disconnect the battery cable from the machine.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 3. Carefully lower the lower shroud, disconnect the harness connections from both headlights, and completely remove the lower shroud from the machine.
- 4. Reinstall the lower shroud onto the machine in reverse order of disassembly.

# REMOVE/REINSTALL THE COLUMN ACCESS PANEL COVER

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

1. Remove all hardware securing the column access panel cover to the machine.



- 2. Remove the column access panel cover from the machine.
- 3. Reinstall the column access panel cover onto the machine in reverse order of disassembly.

#### REMOVE/REINSTALL THE SEAT/SEAT PLATE/ SEAT SHROUD



FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

1. Lift the operator seat open, engage the seat support bar.



2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

3. Disconnect the wire harness from the seat switch.



4. Lift the seat/seat plate from the machine.

5. Remove the hardware securing the seat shroud cover to the machine.



- 6. Lift the seat shroud cover from the machine.
- 7. Reinstall the seat/seat shroud cover onto the machine in reverse order of disassembly and reconnect the wire harness to the seat switch.
- 8. Reconnect the battery cable to the machine.

#### CONTROLS/SENSORS/CAMERAS

#### INSTRUMENT PANEL GROUP



# REMOVE/REINSTALL/REPLACE THE LCD TOUCH MONITOR

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

 Remove the front cover from the steering column. See REMOVE/REINSTALL THE FRONT SHROUD.



NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

4. Remove the front bezel from the machine.



5. Disconnect the LCD touch monitor cable from the Brain Control Module.



6. Remove the hardware securing the LCD touch monitor to the steering shroud.



 Carefully lift the LCD touch monitor from the steering shroud. Do not break any wire or cable connections when lifting the LCD touch monitor from the steering shroud.



- If replacing the LCD touch monitor or if the LCD touch monitor must be completely removed to service or replace other components, set it aside where it cannot be damaged or the monitor surface broken, cracked, or scratched.
- 9. Place the LCD touch monitor onto the steering shroud and connect the LCD touch monitor cable to the Brain Control Module.

NOTE: Be sure the red stripe on the shoulder of the Brain Control Module terminal is completely covered when tightening the LCD touch monitor connector onto the controller. The connector must be completely tightened/seated.





- 10. Reinstall hardware to secure the LCD touch monitor onto the steering shroud.
- 11. Contact Tennant Customer Service Department for instructions for returning components for inspection and tracking.

NOTE: Do Not discard AMR components replaced in this procedure. All AMR components must be returned for inspection and tracking purposes.

# REMOVE/REINSTALL/REPLACE THE MEMBRANE PANEL

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

3. Remove the hardware securing the control panel to the machine.



4. Carefully lift the control panel from the steering shroud. Do not break any wire or cable connections when lifting the control panel from the steering shroud.



- 5. If replacing the control panel or if removing the control panel to access/remove/replace other components disconnect all wire and cable connections from the control panel.
- If replacing the control panel, remove the key switch, directional switch, and emergency shutoff button from the control panel. See REMOVE/ REINSTALL/REPLACE THE KEY SWITCH, DIRECTIONAL SWITCH, ec-H20 LIGHT, AND E-STOP (EMERGENCY STOP) BUTTON.
- 7. If replacing the control panel, install the key switch, directional switch, and emergency shutoff button removed from the control panel in the previous step onto the new control panel.
- 8. Connect wire and cable connections to the new control panel/previously removed control panel.
- 9. Reinstall the control panel onto the steering shroud.

#### REMOVE/REINSTALL/REPLACE KEY SWITCH, DIRECTIONAL SWITCH, ec-H2O LIGHT, AND E-STOP (EMERGENCY STOP) BUTTON

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

#### FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

- 3. Remove the control panel from the steering shroud. See REMOVE/REINSTALL/REPLACE THE MEMBRANE PANEL for additional information.
- Disconnect the main wire harness connection(s) from the membrane panel control(s) being replaced.

5. Remove the control(s) being replaced from the membrane panel.



- 6. Install the new control(s) into the membrane panel.
- 7. Connect the main wire harness connections to the new control(s).
- 8. Reinstall the membrane panel onto the shroud.
#### REMOVE/REINSTALL/REPLACE THE FRONT MARKER LIGHTS

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

- 3. Remove the hardware securing the control panel and/or touchscreen to the steering shroud and carefully lift the control panel and/or touchscreen from the shroud. See REMOVE/REINSTALL/ REPLACE THE LCD TOUCH MONITOR and/ or REMOVE/REINSTALL/REPLACE THE MEMBRANE PANEL.
- 4. Disconnect the main wire harness from the marker light(s).



- 5. Remove the marker light(s) from the shroud.
- 6. Install the new marker light(s)/removed marker light(s) into the shroud.
- 7. Connect the main wire harness to the marker light(s).
- 8. Reinstall the membrane panel and/or LCD touch monitor onto the shroud.

#### **REMOVE/REINSTALL/REPLACE THE ANTENNA**

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

- 3. Remove the hardware securing the control panel to the steering shroud and carefully lift the control panel touchscreen from the shroud. See REMOVE/ REINSTALL/REPLACE THE MEMBRANE PANEL ASSEMBLY.
- Remove the hardware securing the touchscreen to the steering shroud and carefully lift the touchscreen from the shroud. See REMOVE/ REINSTALL/REPLACE THE LCD TOUCH MONITOR.
- 5. Disconnect the antenna cable from the telemetry controller.



6. Remove the antenna/antenna bracket from inside the steering shroud.



- 7. Remove the antenna from the antenna bracket.
- 8. Clean all remaining adhesive from the removed antenna from the antenna bracket.
- 9. Install the new antenna bracket onto the antenna bracket.
- 10. Install antenna/antenna bracket into the steering shroud.
- 11. Connect the antenna cable to the telemetry controller.
- 12. Reinstall components removed to access the antenna in reverse order of disassembly.
- 13. Contact Tennant Customer Service Department for instructions for returning components for inspection and tracking.

## REMOVE/REINSTALL/REPLACE THE TELEMETRY CONTROLLER

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

- 3. Remove the hardware securing the control panel to the steering shroud and carefully lift the control panel touchscreen from the shroud. See REMOVE/ REINSTALL/REPLACE THE TOUCH PANEL.
- 4. Disconnect the antenna cable from the telemetry controller.



5. Disconnect the wire harness from the telemetry controller.



- 6. Remove the telemetry controller from the touch panel assembly.
- 7. Install the new telemetry controller/removed telemetry controller onto the touch panel assembly.
- 8. Connect the wire harness to the telemetry controller.
- 9. Connect the antenna cable to the telemetry controller.
- 10. Reinstall components removed to access the telemetry controller in reverse order of disassembly.
- 11. Contact Tennant Customer Service Department for instructions for returning components for inspection and tracking.

## REMOVE/REINSTALL/REPLACE THE MEMBRANE CONTROLLER

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

## FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

- 3. Remove the hardware securing the control panel to the steering shroud and carefully lift the control panel touchscreen from the shroud. See REMOVE/ REINSTALL/REPLACE THE TOUCH PANEL.
- 4. Remove the telemetry controller from the circuit board cover/control panel. See REMOVE/ REINSTALL/REPLACE THE TELEMETRY CONTROLLER.



- 5. Disconnect the wire harness from the membrane controller assembly.
- 6. Remove the circuit board cover/membrane controller from the control panel.
- 7. Remove the membrane controller from the circuit board cover.
- Install the shunt onto the new membrane controller. Note position of the shunt in terminal J7 on the membrane controller terminal.



Shunt



- 9. Install the new membrane controller onto the circuit board cover.
- 10. Install the circuit board cover/membrane controller onto the control panel.
- 11. Connect the wire harness to the membrane controller.
- 12. Reinstall components removed to access the membrane controller in reverse order of disassembly.

### REMOVE/REINSTALL/REPLACE THE SIDE 2D CAMERAS

Clean the side 2D cameras after completing maintenance/service. Debris, streaks, or smudges could deliver false environmental information to the machine. Use a microfiber cloth to clean the cameras. Do not apply water to the cameras or the microfiber cloth.

NOTE: Do not scratch or damage the side 2D camera lens. Robotic machine performance could be adversely affected if the camera lens is scratched or damaged.

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

- 3. Remove the touchscreen and/or the control panel (depending on which camera(s) are being replaced) from the machine. See REMOVE/ REINSTALL/REPLACE THE CONTROL PANEL and/or REMOVE/REINSTALL/REPLACE THE TOUCHSCREEN for additional information.
- 4. Remove the side cover from the steering shroud.



5. Disconnect the main wire harness from the camera.



6. Remove the 2D camera from the steering shroud.



- 7. Install the new 2D camera into the steering shroud.
- 8. Connect the main wire harness to the new 2D camera.
- 9. Reinstall components removed to access the 2D camera in reverse order of disassembly.
- 10. Repeat procedure if replacing the 2D camera located on the other side of the steering shroud.
- 11. Contact Tennant Customer Service Department for instructions for returning components for inspection and tracking.

## REMOVE/REINSTALL/REPLACE THE SIDE 3D CAMERAS

NOTE: Clean the side 3D cameras after completing all maintenance/service. Debris, streaks, or smudges could deliver false environmental information to the machine. Use a microfiber cloth to clean the cameras. Do not apply water to the cameras or the microfiber cloth.

NOTE: Do not scratch or damage the side 3D camera lens. Robotic machine performance could be adversely affected if the camera lens is scratched or damaged.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- Remove the LCD touch monitor from the steering shroud to allow access to harness connection inside the steering shroud. See REMOVE/ REINSTALL/REPLACE THE LCD TOUCH MONITOR.
- 4. Remove the side cover from the steering shroud.



5. Remove the hardware securing the side 3D camera to the steering shroud.



6. Disconnect the wire harness from the side 3D camera.





7. Remove the side 3D camera assembly from the machine.

- 8. If replacing the side 3D camera, remove the side 3D camera from the camera mounting plate.
- 9. If replacing the side 3D camera, install the new side 3D camera onto the camera mounting plate.
- 10. Install the new side 3D camera/reinstall removed side 3D camera onto the steering shroud in reverse order of disassembly.
- 11. Calibrate the side 3D camera. See the Side 3D Camera Adjustment/Calibration document for instructions how to calibrate/adjust the side 3D cameras.
- 12. Repeat procedure if replacing the side 3D camera located on the other side of the steering shroud.

#### FRONT CAMERAS AND RANGE SENSORS



#### REMOVE/REINSTALL/REPLACE THE FRONT UPPER RANGE SENSOR (LIDAR)

NOTE: Clean the front upper LIDAR after completing maintenance/service. Debris, streaks, or smudges could deliver false environmental information to the machine. Use a microfiber cloth to clean the LIDAR. Do not apply water to the LIDAR or the microfiber cloth.

NOTE: Do not scratch or damage the front upper LIDAR . Robotic machine performance could be adversely affected if the LIDAR is scratched or damaged.



- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

 Remove the front cover from the steering column. See REMOVE/REINSTALL THE FRONT SHROUD.



4. Remove the center bezel from the machine.



- 5. Remove the hardware securing the sensor hood bracket to the camera bracket.
- 6. Disconnect the wire harness from the upper LIDAR.
- 7. Remove the sensor hood bracket/upper LIDAR from the machine.
- 8. Remove the upper LIDAR from the sensor hood bracket.
- Install the new upper LIDAR/reinstall the removed upper LIDAR onto the machine in reverse order of disassembly.
- 10. Reconnect the battery cable to the machine.
- 11. Calibrate the upper LIDAR. See the Front Upper Range Sensor (LIDAR) Adjustment/Calibration document for instructions how to calibrate/adjust the upper LIDAR.
- 12. Reinstall the center bezel and front shroud onto the machine in reverse order of disassembly.

#### REMOVE/REINSTALL/REPLACE THE FRONT LOWER RANGE SENSOR (LIDAR)

NOTE: Clean the front lower LIDAR after completing maintenance/service. Debris, streaks, or smudges could deliver false environmental information to the machine. Use a microfiber cloth to clean the LIDAR. Do not apply water to the LIDAR or the microfiber cloth.

NOTE: Do not scratch or damage the front lower LIDAR . Robotic machine performance could be adversely affected if the LIDAR is scratched or damaged.



- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

3. Remove the lower shroud from the machine. See REMOVE/REINSTALL THE LOWER SHROUD.



- 4. Disconnect the wire harness from the lower LIDAR.
- 5. Remove the lower LIDAR from the lower sensor bracket.
- 6. Install the new lower LIDAR/reinstall the removed lower LIDAR onto the machine in reverse order of disassembly.
- 7. Reconnect the battery cable to the machine.
- 8. Calibrate the lower LIDAR. See the Front Lower Range Sensor (LIDAR) Adjustment/Calibration document for instructions how to calibrate/adjust the lower LIDAR.
- 9. Reinstall the lower shroud onto the machine in reverse order of disassembly.

## REMOVE/REINSTALL/REPLACE THE FRONT 3D CAMERA

NOTE: Clean the front 3D camera after completing maintenance/service. Debris, streaks, or smudges could deliver false environmental information to the machine. Use a microfiber cloth to clean the camera. Do not apply water to the camera or the microfiber cloth.

NOTE: Do not scratch or damage the front 3D camera lens when removing/installing the camera. Robotic machine performance could be adversely affected if the camera lens is scratched or damaged during disassembly/assembly.



- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

 Remove the front cover from the steering column. See REMOVE/REINSTALL THE FRONT SHROUD.



4. Remove the center bezel from the machine.



5. Remove the hardware securing the front 3D camera to the camera bracket.





- 6. Carefully pull the front 3D camera from the camera bracket, disconnect the harness from the camera, and completely remove the camera from the bracket.
- 7. Install the new front 3D camera/reinstall the removed front 3D camera into the camera bracket in reverse order of disassembly.
- 8. Reconnect the battery cable to the machine.
- 9. Calibrate the front 3D camera. See the Front 3D Camera Adjustment/Calibration document for instructions how to calibrate/adjust the front 3D camera.
- 10. Reinstall the center bezel and front shroud onto the machine in reverse order of disassembly.

## REMOVE/REINSTALL/REPLACE THE FRONT 2D CAMERA

Clean the front 2D camera after completing maintenance/service. Debris, streaks, or smudges could deliver false environmental information to the machine. Use a microfiber cloth to clean the camera. Do not apply water to the camera or the microfiber cloth.

NOTE: Do not scratch or damage the 2D camera lens. Robotic machine performance could be adversely affected if the camera lens is scratched or damaged.

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

 Remove the front cover from the steering column. See REMOVE/REINSTALL THE FRONT SHROUD.



4. Remove the center bezel from the machine.



5. Remove the front 2D camera from the camera bracket.



- 6. Disconnect the wire harness from the front 2D camera.
- 7. Install the new front 2D camera/removed front 2D camera onto the camera bracket.
- 8. Connect the wire harness to the front 2D camera.
- 9. Reinstall center bezel and front shroud onto the machine in reverse order of disassembly.
- 10. Contact Tennant Customer Service Department for instructions for returning components for inspection and tracking.

### REMOVE/REINSTALL/REPLACE THE BRAIN CONTROLLER

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

## FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

 Remove the front cover from the steering column. See REMOVE/REINSTALL THE FRONT SHROUD.



4. Remove the front bezel from the machine.



5. Disconnect all wire harness connections from the Brain controller.



- 6. Remove the Brain controller from the steering column.
- 7. Install the new Brain controller/removed Brain controller onto the steering column.
- 8. Connect the wire harness connections to the Brain controller.

NOTE: Be sure the red stripes on the shoulders of all Brain Control Module terminals are completely covered when tightening the harness connectors onto the control module. All connectors must be completely tightened/seated.





- 9. Reinstall center bezel and front shroud onto the machine in reverse order of disassembly.
- 10. Contact Tennant Customer Service Department for instructions for returning components for inspection and tracking.

## REMOVE/REINSTALL/REPLACE THE KINETEK CONTROLLER



FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Raise the seat and lock the seat into the fully raised position.
- 3. Disconnect the battery cable from the batteries.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 4. Remove the seat/seat plate from the machine. See REMOVE/REINSTALL THE SEAT/SEAT PLATE/ SEAT SHROUD.
- 5. Remove the seat shroud from the machine.
- 6. Disconnect all wire harness connections from the Kinetek controller.



- 7. Move the battery located closest to where the Kinetek controller is installed on the charger mounting bracket enough to access the hardware securing the controller to the bracket.
- 8. Remove the Kinetek controller from the charger mounting bracket.
- 9. Install the new Kinetek controller/removed Kinetek controller onto the charger mounting bracket.

10. Connect wire harness connections to the Kinetek controller.





- 11. Reassemble the seat shroud and seat/seat plate back onto the machine in reverse order of removal.
- 12. Reconnect the battery cable to the batteries.
- Start and test the machine to ensure the machine functions correctly. All machine functions should be fully operational when the corresponding buttons/ switches are activated.
- 14. Contact Tennant Customer Service Department for instructions for returning components for inspection and tracking.

#### RECOVERY TANK COVER CONTROLS/ COMPONENTS



#### REMOVE/REINSTALL/REPLACE THE START/ PAUSE BUTTON

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

3. Remove the hardware securing the light button module cover to the recovery tank cover.



4. Carefully pull the light button module cover from the recovery tank cover. Do Not break or damage wire/cable connections when pulling the light button module cover from the recovery tank cover.



5. Loosen the retainer screw securing the start/pause button assembly to the start/pause plate.



6. Press the retainer lever and remove the start/pause button assembly from the start/pause button plate.



- 7. Disconnect the harness connections from the blue start/pause button assembly.
- 8. Loosen the new retainer screw on the start/pause button body and remove the start/pause button assembly from the light button module cover.



- Install the new start/pause button assembly onto the light button module cover and tighten the retainer screw to secure the start/pause button assembly into place.
- 10. Connect the harness connections to the start/ pause button assembly.
- 11. Install the start/pause button assembly onto the recovery tank cover.
- 12. Install the start/pause button assembly onto the recovery tank cover.

#### REMOVE/REINSTALL/REPLACE THE REAR E-STOP (EMERGENCY STOP) BUTTON

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

3. Remove the hardware securing the light button module cover to the recovery tank cover.



4. Carefully pull the light button module cover from the recovery tank cover. Do Not break or damage wire/cable connections when pulling the light button module cover from the recovery tank cover.



5. Push the lever to disconnect the E-Stop button connector from the E-Stop button.



6. Remove the E-Stop button retainer ring and remove the E-Stop button from the light button module cover.



7. If replacing E-Stop button connector, disconnect the harness connections from the E-Stop button connector and connect the harness connections to the new E-Stop button connector.



- 8. Install the new E-Stop button/removed E-Stop button onto the light button module cover.
- 9. Push the lever to connect the E-Stop button connector to the E-Stop button.
- 10. Reinstall the light button module cover onto the recovery tank cover.

#### REMOVE/REINSTALL/REPLACE THE REAR MARK-ER LIGHTS

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

3. Remove the hardware securing the light button module cover to the recovery tank cover.



4. Carefully pull the light button module cover from the recovery tank cover. Do Not break or damage wire/cable connections when pulling the light button module cover from the recovery tank cover.



5. Disconnect the wire harness from the LED light assembly.



- 6. Remove the hardware securing the LED light assembly to the light button module cover and carefully pull the LED light assembly from the light button module cover.
- 7. Disconnect the main wire harness from the marker light(s).
- 8. Pull the marker light(s) from the recovery tank cover.

NOTE: Replace the clear plastic membrane labels covering the rear marker lights if the labels are missing or damaged.



- 9. Install the new marker light(s)/removed marker light(s) into the recovery tank cover.
- 10. Connect the main wire harness to the marker light(s).
- 11. Install the recovery tank cover onto the fan mounting plate.

## REMOVE/REINSTALL/REPLACE THE STROBE LIGHT

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

3. Remove the hardware securing the light button module cover to the recovery tank cover.



4. Carefully pull the light button module cover from the recovery tank cover. Do Not break or damage wire/cable connections when pulling the light button module cover from the recovery tank cover.



5. Disconnect the wire harness from the strobe light.

6. Remove the hardware securing the light module base to the recovery tank cover.



7. Remove the strobe light from the light module base.



- 8. Connect the wire harness to the new strobe light/ removed strobe light.
- 9. Install the strobe light onto the light module base.
- 10. Reinstall the light module base onto the recovery tank cover.
- 11. Reinstall the light button module cover onto the recovery tank cover.

## REMOVE/REINSTALL/REPLACE THE BACKUP ALARM

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

## FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

3. Remove the hardware securing the light button module cover to the recovery tank cover.



4. Carefully pull the light button module cover from the recovery tank cover. Do Not break or damage wire/cable connections when pulling the light button module cover from the recovery tank cover.



5. Disconnect the wire harness from the backup alarm.



- 6. Cut the cable tie securing the backup alarm to the light module base and remove the backup alarm.
- 7. Use a new cable tie to install the new backup alarm onto the light module base.
- 8. Connect the wire harness to the backup alarm.
- 9. Reinstall the light button module cover onto the recovery tank cover.

#### STEERING GROUP



#### REMOVE/REINSTALL/REPLACE THE STEERING MOTOR/STEERING GEAR BOX/STEERING POSITION SENSOR

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electronic components. Attach the other end of the static ground strap to the machine chassis.

 Remove the front cover from the steering column. See REMOVE/REINSTALL THE FRONT SHROUD.



4. Remove the column access panel cover from the steering column. See REMOVE/REINSTALL THE COLUMN ACCESS PANEL COVER.



5. Loosen both set screws securing the steering shaft into the u-joint.



6. Slide the steering wheel/steering shaft up, through the steering motor enough to remove the steering motor from the machine.

NOTE: <u>Do Not</u> lose either of the keys in the steering shaft when sliding the steering wheel/steering shaft from the lower steering shaft and steering motor.

7. If replacing/removing the steering motor amplifier: Disconnect the wire harness and steering motor able from the steering motor amplifier.





- 8. If replacing/removing the steering motor amplifier: Remove the steering motor amplifier from the machine.
- **9.** If replacing/removing the steering motor: Disconnect the steering motor cable from the motor control amplifier and wire harness.



**10. If replacing/removing the steering motor:** Remove the hardware securing the steering motor to the steering motor plate.





**11. If replacing/removing the steering motor:** Remove the steering motor from the machine.



- 12. Reinstall the steering motor amplifier and/or steering motor onto the machine.
- 13. Apply a small amount of adhesive onto the key that will be installed into the notch in the steering shaft that is to be inserted into the lower steering shaft.
- 14. Install the key into the notch in the steering shaft that is to be inserted into the lower steering shaft.



- 15. Install the key into the notch steering shaft that is to be inserted into the notch in the steering motor.
- Slide the steering wheel/steering shaft down through the steering motor and into the lower steering shaft.

NOTE: The steering shaft must be properly aligned before set screws and hardware are tightened. Damage to lower steering shaft may result if steering shaft is not properly aligned. 17. Position the lower steering shaft onto the steering shaft so there is no gap between the lower steering shaft and the steering motor and a small gap between the upper and lower sections of the lower steering shaft.



- Tighten the upper set screws in the lower steering shaft to secure the steering shaft into the lower steering shaft.
- 19. Turn the steering wheel in the complete range of motion in both directions to allow the steering gear box and steering position sensor to self-align.
- 20. Tighten the hardware securing the steering motor plates to the steering column.
- 21. Reassemble the front cover and column access panel cover back onto the machine in reverse order of disassembly.
- 22. Contact Tennant Customer Service Department for instructions for returning components for inspection and tracking.

### REMOVE/REINSTALL/REPLACE THE STEERING AMPLIFIER MODULE

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

## FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electronic components. Attach the other end of the static ground strap to the machine chassis.

 Remove the front cover from the steering column. See REMOVE/REINSTALL THE FRONT SHROUD.



4. Disconnect the harness connector and steering motor from the steering amplifier module.



- 5. Remove the steering amplifier module from the steering column.
- 6. Reinstall the removed steering amplifier module/ install the new steering amplifier module onto the machine.
- 7. Connect the harness connections to the steering amplifier module.
- 8. Reassemble all items removed to access the steering amplifier module onto the machine in the reverse order of disassembly.
- 9. Contact Tennant Customer Service Department for instructions for returning components for inspection and tracking.

#### ELECTRICAL



## REMOVE/REINSTALL/REPLACE THE MAIN CONTACTOR

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

NOTE: To avoid damaging electronic components, a static ground strap must be worn at all times while handling electrical components. Attach the other end of the static ground strap to the machine chassis.

- Remove the operator seat/seat plate from the machine. See REMOVE/REINSTALL THE SEAT/ SEAT PLATE.
- 4. Remove the seat shroud from the machine.
- 5. Confirm the machine battery cable is disconnected from the batteries.

ATTENTION: Potential electrical hazard if the battery cable is left connected to the batteries. <u>The machine battery cable must be disconnected</u> from the batteries before accessing/performing maintenance on the 200-Amp 36 VDC contactor.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

 Remove hardware securing wire harness connections/busbars from the top terminals of the 200-Amp 36 VDC.



7. Remove the hardware securing the 200-Amp 36 VDC contactor to the seat mounting support.



 If necessary, loosen the hardware securing busbar (unswitched B+) and busbar (switched) to the seat mounting support as necessary to remove the 200-Amp 36 VDC contactor from the machine.





- 9. Disconnect both wire harness connections from the bottom of the 200-Amp 36 VDC contactor.
- 10. Carefully remove the 200-Amp 36 VDC contactor from the machine.
- 11. Connect the wire harness to the terminals located on the bottom of the new 200-Amp 36 VDC contactor/removed 200-Amp 36 VDC contactor.
- 12. Install the 200-Amp 36 VDC contactor onto the seat mounting support.
- 13. Install the bus bars, and all cable connections removed when the bus bars were removed, onto the 200-Amp 36 VDC contactor and panel insulator standoffs.
- 14. Connect the wire harness connections to the terminals located on the top of the 200-Amp 36 VDC contactor.
- 15. Reconnect the battery cable to the batteries.
- 16. Reinstall the seat shroud and seat/seat plate onto the machine.

#### DRIVE WHEEL GROUP


# REMOVE/REINSTALL/REPLACE THE DRIVE WHEEL ASSEMBLY



# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Completely drain the solution tank and the recovery tank.
- 2. Turn the key switch OFF.
- 3. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

 Remove the front perimeter guard from the machine. See REMOVE/REINSTALL THE FRONT PERIMETER GUARD.

- 5. Chock both rear tires.
- Jack up the front end of the machine enough to access the drive wheel assembly/remove the drive wheel assembly from under the machine. Place jack stands under the machine and lower the machine onto the jack stands.

FOR SAFETY: When servicing machine, block machine tires before jacking machine up. Use a hoist or jack that will support the weight of the machine. Jack machine up at designated locations only. Support machine with jack stands.

7. Remove the terminal cover from the drive wheel assembly.

- 8. Disconnect all main harness connectors from the drive wheel. Note locations of nuts and washers securing the main wire harness connectors to the drive wheel. Nuts and washers must be arranged the same when connecting the main wire harness to the new drive wheel.
- Loosen the M12 socket screws (Qty. 4) securing the drive wheel assembly to the output housing. Do not remove the socket screws. Turn drive wheel assembly to the right and left as necessary to access/remove hardware.
- 10. Jack the machine up off the jack stands, remove the jack stands from under the machine, and lower the machine to the floor.
- 11. Raise the jack until it is touching the frame on one side of the machine, but not enough to raise the machine from the floor, and position a jack stand under that side of the machine.
- 12. Repeat the previous step to slightly raise the other side of the machine.
- 13. Remove the M12 socket screws (Qty. 4) from the drive wheel assembly/machine.
- 14. Jack the machine back up off the floor until the drive wheel can be easily removed from under the machine, position the jack stands under the machine, and lower the machine onto the jack stands.

NOTE: Use care when removing the drive wheel assembly from the machine. The drive wheel weighs approximately 140 lbs (64 kg). If necessary, seek help to remove the drive wheel assembly from the machine.

- 15. Carefully remove the drive wheel assembly from under the machine.
- 16. If replacing the drive wheel assembly, remove the terminal cover from the new drive wheel.
- 17. If replacing the drive wheel assembly, remove hardware necessary to connect main wire harness connectors to the drive wheel assembly.
- Place the drive wheel assembly onto the jack, position the jack underneath the machine, and raise the drive wheel up to the output housing.
- 19. Use the M12 socket screws (Qty. 4) to secure the drive wheel (1) to the output housing.

- 20. Remove the jack from under the machine.
- 21. Torque the M12 socket screws (Qty. 4) to 125 Nm (92 ft. lbs).
- 22. Connect all wire harness connectors to the drive wheel assembly and encoder. Position/route cables exactly as shown so the terminal cover can be installed.



23. Neatly arrange and secure all cables and wire harness so they do not get caught in other components, or are pulled or bind, when the steering wheel is turned.



- 24. Install the terminal cover onto the drive wheel assembly.
- 25. Slightly raise machine from jack stands, remove the jack stands from under the machine, and lower the machine to the floor
- 26. Reinstall the front perimeter guard onto the machine.
- 27. Reconnect the battery cable to the machine.

# REMOVE/REINSTALL/REPLACE THE DRIVE MOTOR CARBON BRUSHES



NOTE: Carbon brushes should be replaced as sets.

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Completely drain the solution tank and the recovery tank.
- 2. Turn the key switch OFF.
- 3. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- Remove the front perimeter guard from the machine. See REMOVE/REINSTALL THE FRONT PERIMETER GUARD.
- 5. Turn steering wheel so the drive wheel motor can be easily accessed from the front of the machine.
- 6. Chock both rear tires.
- Jack up the front end of the machine until the bottom of the front drive wheel is between 4.5 in. (114 mm) and 5.00 in. (127 mm) from the floor. Place jack stands under the machine and lower the machine onto the jack stands.

NOTE: The machine must be jacked up high enough to prevent oil from draining from the drive wheel assembly when the motor is removed from the drive wheel motor housing.

FOR SAFETY: When servicing machine, block machine tires before jacking machine up. Use a hoist or jack that will support the weight of the machine. Jack machine up at designated locations only. Support machine with jack stands.

8. Disconnect the harness from the brake assembly.



9. Remove the drive motor cover from the drive wheel assembly.



10. Remove the terminal cover from the drive wheel assembly.



11. Remove the p-clamps securing the propel harness to the drive wheel assembly,





13. Remove the hardware (Qty. 4) securing the motor to the drive wheel motor housing.



14. Carefully lift the motor from the drive motor housing and position the motor to allow easy access to the carbon brushes.





15. Remove the hardware securing the carbon brush cable to the motor.



16. Remove the spring securing the carbon brush inside the motor from the top of the carbon brush and remove the carbon brush from the motor.





- 17. Inspect carbon brushes. Replace carbon brushes if they are stuck or are less than 10 mm (0.375 in) in length.
- 18. Use contact cleaner to carefully clean dust/ debris from inside the drive motor assembly.
- 19. Install the new carbon brushes/reinstall the removed carbon brushes into the motor in reverse order of disassembly.
- 20. Inspect the drive wheel motor shaft seal for damage. Replace the drive wheel shaft seal if damaged.



- 21. Reinstall the motor into the drive wheel motor housing.
- 22. Reinstall the support rod onto the drive wheel assembly.
- 23. Neatly arrange and secure all cables and wire harness so they do not get caught in other components, or are pulled or bind, when the steering wheel is turned.
- 24. Reconnect the harness to the brake assembly.
- 25. Reinstall the p-clamps to secure the propel harness to the drive wheel assembly.
- 26. Reinstall the terminal cover onto the drive wheel assembly.
- 27. Reinstall the drive motor cover onto the drive wheel assembly.
- 28. Reinstall the front perimeter guard onto the machine.
- 29. Jack the machine up off the jack stands, remove the jack stands from under the machine, and lower the machine to the floor.
- 30. Reconnect the battery cable to the machine.

#### REMOVE/REINSTALL/REPLACE THE BRAKE ASSEMBLY AND ENCODER



# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 3. If jacking up the machine to access the encoder/ brake assembly: Place chocks behind both rear wheels.
- 4. If jacking up the machine to access the encoder/ brake assembly: Jack up the front end of the machine enough to access the parking brake and encoder. Place jack stands under the machine and lower the machine onto the jack stands. If jacking up machine, be sure to chock both rear tires prior to jacking up machine.

FOR SAFETY: When servicing machine, block machine tires before jacking machine up. Use a hoist or jack that will support the weight of the machine. Jack machine up at designated locations only. Support machine with jack stands.

- 5. Remove the front perimeter guard from the machine. See REMOVE/REINSTALL THE FRONT PERIMETER GUARD.
- 6. Turn steering wheel so the encoder/brake assembly can be easily accessed from the front of the machine.
- Remove the hardware securing the encoder to the brake assembly. <u>Do Not</u> lose hardware securing the controller to the brake assembly. These parts will be needed to reinstall the encoder.



8. If replacing the encoder only: Disconnect the encoder cable from the wire harness.

If not replacing the encoder, the encoder cable can remain connected to the main harness.

9. If replacing the encoder only: Connect the new encoder cable to the wire harness and install the new encoder onto the brake assembly.

If replacing the brake assembly: Proceed to the following step.

- 10. Remove the drive motor cover from the drive wheel assembly.
- 11. Remove the terminal cover from the drive wheel assembly.



12. Disconnect the brake assembly wires from the drive wheel motor B1 and B2 terminals.



- 13. Remove the brake assembly from the drive wheel assembly.
- 14. Install the new brake assembly/reinstall the removed brake assembly onto the drive wheel assembly.
- 15. Reconnect the brake assembly to the drive wheel motor B1 and B2 terminals.
- 16. Reinstall the drive motor terminal cover onto the drive wheel assembly.
- 17. Install the encoder onto the new brake assembly/ removed brake assembly.
- 18. Reconnect the harness to the encoder.
- 19. Reinstall the drive motor cover onto the drive wheel assembly.
- 20. Reinstall the front perimeter guard onto the machine.
- 21. If machine was jacked up to access the encoder/ brake assembly: Jack the machine up off the jack stands, remove the jack stands from under the machine, and lower the machine to the floor.

#### INSPECT THE BRAKE ASSEMBLY AIR GAP



FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 3. If jacking up the machine to access the brake assembly: Place chocks behind both rear wheels.
- 4. If jacking up the machine to access the brake assembly: Jack up the front end of the machine enough to access the parking brake and encoder. Place jack stands under the machine and lower the machine onto the jack stands. If jacking up machine, be sure to chock both rear tires prior to jacking up machine.

FOR SAFETY: When servicing machine, block machine tires before jacking machine up. Use a hoist or jack that will support the weight of the machine. Jack machine up at designated locations only. Support machine with jack stands.

- 5. Remove the front perimeter guard from the machine. See REMOVE/REINSTALL THE FRONT PERIMETER GUARD.
- 6. Turn steering wheel so the brake assembly can be easily accessed.
- 7. Remove the plastic motor cover from the drive wheel assembly.



 Use a 0.35 mm thickness gauge to check the air gap. The brake air gap is 0.2 ±0.05 mm nominal. If it is possible to fit the 0.35 mm thickness gauge into the air gap the brake assembly must be replaced. See REMOVE/REINSTALL/REPLACE THE PARKING BRAKE AND ENCODER.



- 9. Reinstall the drive motor cover onto the drive wheel assembly.
- 10. Reinstall the front perimeter guard onto the machine.
- 11. If machine was jacked up to access the brake assembly: Jack the machine up off the jack stands, remove the jack stands from under the machine, and lower the machine to the floor.

#### **REMOVE THE DRIVE WHEEL**

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, remove key, and set parking brake.

- 1. Turn the key switch ON.
- 2. If scrub head is not raised, completely raise the scrub head.
- 3. Turn the steering wheel as far to the left as possible.
- 4. Turn the key switch OFF.
- 5. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connections and charger cord before working on machine.

- 6. Remove the front perimeter guard from the machine. See REMOVE/REINSTALL THE FRONT PERIMETER GUARD.
- 7. Place a chock behind both rear wheels.
- 8. Loosen the socket screws (Qty. 4) on the drive wheel.



9. Jack up the front end of the machine enough to access the drive wheel assembly. Place jack stands under the machine and lower the machine onto the jack stands. See MACHINE JACKING in the MAINTENANCE section of this manual. FOR SAFETY: When servicing machine, block machine tires before jacking machine up. Use a hoist or jack that will support the weight of the machine. Jack machine up at designated locations only. Support machine with jack stands.

- 10. Remove the main scrub brush from the machine.
- 11. Turn the steering wheel as far to the right as possible to allow easier access to the other side of the drive wheel assembly.
- 12. Use M10-1.5 x 70 (Class 12.9) hex screws (Qty. 2) to press the wheel from the drive wheel assembly. Tighten the screws evenly until the wheel comes freely from the drive wheel assembly.





#### **INSTALL THE DRIVE WHEEL**

#### FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, remove key, and set parking brake.

1. Place the wheel onto the drive wheel assembly and use two dowels to align the holes in the wheel with the holes in the drive wheel assembly.





- 2. Apply red thread sealant onto the threads of two of the hex screws needed to secure the wheel onto the drive wheel assembly.
- 3. Loosely hand tighten the two hex screws from the previous step into the wheel and the drive wheel assembly until the wheel is loosely secured into place.
- 4. Remove the alignment dowels from the drive wheel assembly.

- 5. Apply red thread sealant onto the threads of the two remaining hex screws needed to secure the wheel onto the drive wheel assembly.
- 6. Loosely hand tighten the two hex screws from the previous step into the wheel and the drive wheel assembly.



7. Tighten the previously installed hex screws (Qty. 4) to 75 Nm (55.3 ft. lbs.). Use a star pattern to evenly tighten the hex screws.

NOTE: It maybe not be possible to achieve final torque with machine jacked up from the floor. It may be necessary to lower machine to the floor to tighten the hex screws to correct torque.

- 8. Jack the machine up off the jack stands, remove the jack stands from under the machine, and lower the machine to the floor.
- 9. If necessary, tighten the hex screws (Qty. 4) to the correct torque.
- 10. Reinstall the perimeter guard onto the machine. See REMOVE/REINSTALL THE FRONT PERIMETER GUARD.

#### SOLUTION SYSTEMS

#### **RECOVERY TANK GROUP**



#### REMOVE/REINSTALL/REPLACE THE VACUUM FAN



FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Completely drain the recovery tank.
- 2. Turn the key switch OFF.
- 3. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

4. Disconnect the vacuum hose from the rear squeegee.

5. Remove the hardware securing the vacuum fan housing/fan housing mounting bracket to the recovery tank.



6. Carefully pull the vacuum fan housing from the machine.



7. Disconnect the main wire harness from the vacuum fan.



- 8. Remove the vacuum fan assembly from the machine.
- 9. Remove the acoustic insulation from the vacuum fan.
- 10. If removing/inspecting/replacing the vacuum fan carbon brushes, proceed to REMOVE/INSPECT/ REPLACE THE VACUUM FAN CARBON BRUSHES.

11. Loosen the clamp securing the vacuum fan to the vacuum fan housing.



12. Remove the vacuum fan from the vacuum fan housing.



13. Inspect the vacuum fan mounting seal for damage. Replace the seal if it is damaged.



- 14. Inspect the vacuum fan muffler for damage. Replace the vacuum fan muffler if it is damaged.
- 15. Install the new vacuum fan/reinstall the removed vacuum fan onto the vacuum fan housing.
- 16. Position the vacuum fan assembly into the vacuum fan compartment at the rear of the recovery tank.
- 17. Connect the main wire harness to the vacuum fan.
- 18. Reinstall the vacuum fan housing/fan housing mounting bracket onto the machine. Use a pry bar to exert approximately 90 N (20 lbs) of force against the vacuum fan housing onto the recovery tank to provide a tight seal and tighten the hardware to secure the vacuum fan housing/fan housing mounting bracket to the recovery tank.





19. Reconnect the battery cable to the machine.

# REMOVE/INSPECT/REPLACE THE VACUUM FAN CARBON BRUSHES

NOTE: Carbon brushes should be replaced as sets.

- 1. Remove the vacuum fan(s) from the machine. See *REMOVE/REINSTALL/REPLACE THE VACUUM FAN(S).*
- 2. Remove the cover from the vacuum fan.



3. Remove/loosen the carbon brush retainer mounting hardware securing the carbon brush into the vacuum motor.



4. Remove the carbon brush from the vacuum fan motor.



5. Inspect carbon brushes. Replace carbon brushes if they are stuck or are less than 10 mm (0.375 in) in length.



6. Use a stone to clean the commutator.



7. Use compressed air to clean dust from inside the vacuum fan motor.

 Insert and hold the removed/new carbon brush completely into the vacuum fan and tighten/reinstall the hardware into the retainer to hold the carbon brush into place in the vacuum fan.





- 9. Repeat procedure to remove or replace remaining vacuum fan carbon brushes.
- 10. Reinstall the vacuum fan(s) onto the recovery tank. See REMOVE/REINSTALL/REPLACE THE VACUUM FAN(S).

# REMOVE/REINSTALL/REPLACE THE ec-H2O NANO-CLEAN PUMP/SOLUTION PUMP



- 1. Completely drain the solution tank and the recovery tank.
- 2. Turn the key switch OFF.
- 3. Pull the pin from the right perimeter guard to allow perimeter guard to be lifted.



4. Unlatch and open the side squeegee support door.



5. Remove the debris trough from the scrub head.



- 6. Turn the key switch ON.
- 7. Completely lower the scrub head.
- 8. Turn the key switch OFF.

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

9. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 10. Place a chock in front of the front tire and in front of the rear left tire.
- 11. Jack up the right side back end of the machine to allow easier access to the ec-H2O solution pump and/or the solution pump, position jack stands under the back end of the machine, and lower the machine onto the jack stands.

#### FOR SAFETY: When servicing machine, jack machine up at designated locations only. Support machine with jack stands. Use jack or hoist that will support the weight of the machine.

- 12. Remove the hardware securing the ec-H2O pump to the ec-H2O pump bracket and/or the hose clamp securing the solution pump to the pump bracket and remove the pump from the bracket.
- 13. Disconnect both solution hoses from the ec-H2O pump and/or the solution pump.
- 14. Disconnect the main wire harness from the ec-H2O pump and/or solution pump.
- 15. Connect the solution hoses and main wire harness to the new/removed ec-H2O pump and/or solution pump.
- 16. Reinstall the ec-H2O pump onto the ec-H2O pump bracket and or the solution pump onto the pump bracket.
- 17. Remove the jack stands from under the machine and lower the machine to the floor.
- 18. Reinstall the debris trough onto the scrub head.
- 19. Close the squeegee support door.
- 20. Secure the right perimeter guard closed.

### SOLUTION TANK GROUP



# REMOVE/REINSTALL/REPLACE THE ec-H2O NANO-CLEAN PRESSURE SWITCH



FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Completely drain the solution tank and the recovery tank.
- 2. Turn the key switch OFF.
- 3. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

4. Lift the operator seat open and secure the seat into the open position.



5. Open the ec-H2O compartment cover to access the ec-H2O module.



NOTE: If necessary, remove the ec-H2O compartment cover from the machine to allow easier access to the pressure switch.

- 6. Disconnect the main wire harness from the pressure switch.
- 7. Remove the pressure switch from the brass straight fitting.
- 8. Install the new/removed pressure switch onto the brass straight fitting.
- 9. Connect the main wire harness to the pressure switch.
- 10. Reinstall all items removed from the machine to access the pressure switch.

# REMOVE/REINSTALL/REPLACE THE ec-H2O NANO-CLEAN MODULE

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Completely drain the solution tank and the recovery tank.
- 2. Turn the key switch OFF.
- 3. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

4. Lift the operator seat open and secure the seat into the open position.



5. Open the ec-H2O compartment cover to access the ec-H2O module.



NOTE: If necessary, remove the ec-H2O compartment cover from the machine to allow easier access to the ec-H2O module.

- 6. Remove the hardware securing the ec-H2O module to the ec-H2O module bracket.
- 7. Disconnect all main wire harness connections from the ec-H2O module.
- 8. Disconnect all solution hoses from the ec-H2O module.
- 9. Carefully remove the ec-H2O module from the machine.
- 10. Reinstall removed ec-H2O module/install new ec-H2O module in the reverse order of disassembly.
- 11. Install all items removed from the machine to access the ec-H2O module.

# VIEW/ADJUST THE ec-H2O NANO-CLEAN FLOW SETTING

# FOR SAFETY: Before leaving or servicing machine, stop on level surface.

To view the current ec-H2O flow setting:

- 1. Turn the key switch ON.
- 2. Press and hold the solution flow button until the solution flow lights momentarily turn off (approximately 2 seconds) and release the button after the LEFT solution flow indicator light is illuminated (approximately 4 seconds).

NOTE: If the solution flow button is held too long, the module may enter the firmware mode. To exit the firmware mode, press the solution flow button and repeat previous step.



 Observe the ec-H2O flow setting indicators. The solution flow indicators will blink the current machine flow setting for 10 seconds. One LED= low flow setting, two LEDs=medium flow setting, and three LEDs= high flow setting. After 10 seconds, the module reverts back to normal operation.



4. Repeat the previous two steps to again view the current ec-H2O flow setting.

To change the ec-H2O flow setting:

- 1. Turn the key switch ON.
- 2. Press and hold the solution flow button until the solution flow lights momentarily turn off (approximately 2 seconds) and release the button after the LEFT solution flow indicator light is illuminated (approximately 4 seconds).

NOTE: If the solution flow button is held too long, the module may enter the firmware mode. To exit the firmware mode, press the solution flow button and repeat previous step.



3. While the indicator lights are blinking (within 10 seconds), press the solution flow button to advance to the next the flow setting. Continue to press the solution flow button to advance through the flow settings to the desired setting.



4. After selecting the desired flow setting, wait 5 seconds for the module to save the flow setting. The module automatically reverts back to normal operation after the new flow setting is saved.

NOTE: It is recommended that medium or high flow settings be used for uncoated or unpolished floors (more porous). This applies to both conventional and ec-H2O scrubbing modes.

#### SERVICE THE ec-H2O MODULE



FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key to the OFF position.
- 2. Disconnect the battery cable from the machine.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 3. Remove the ec-H2O module from the machine. See REMOVE/INSTALL THE ec-H2O NANO-CLEAN MODULE.
- 4. Remove the ec-H2O upper module housing from the ec-H2O module.
- 5. Further disassemble the ec-H2O module as necessary to access and replace parts.
- 6. Reassemble the ec-H2O module in the reverse order of disassembly.
- 7. Reinstall the ec-H2O module onto the machine. See REMOVE/INSTALL THE ec-H2O NANO-CLEAN MODULE.

#### CONNECT HOSES TO PTC (PUSH-TO-CONNECT) FITTINGS



1. Cut the tube square. The outer diameter of the tubing must be free of score marks, burrs, or sharp edges.



2. Insert tube into the fitting. The fitting will grip the hose before it seals.



3. Push into the tube stop. The stainless steel teeth inside the collet firmly hold the tube in position and the o-ring provides a permanent leak-proof seal.



4. Pull on the fitting to ensure the hose connection is secure.



5. Test the fitting/hose connections for leaks prior to leaving the site.

#### DISCONNECT HOSES FROM PTC (PUSH-TO-CONNECT) FITTINGS

1. Push the hose into the fitting and push the collet squarely in against face of fitting to release the hose from the fitting. Continue to hold the collet held in against the fitting and pull the hose from the fitting.



NOTE: Be sure there is no pressure in the system and the system is emptied of all solution before disconnecting hose(s) from the fitting.

#### SCRUBBING SYSTEMS



#### REMOVE/REINSTALL/REPLACE THE SCRUB HEAD

- 1. Completely empty the solution tank and recovery tank.
- 2. Turn the key switch OFF.
- 3. Remove the brushes from the scrub head.
- 4. Remove the debris tray from the scrub head.
- 5. Turn ON the machine, completely lower the scrub head to the floor, turn OFF the machine, and remove the key.

# FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- Pull the pin from the right perimeter guard or the left perimeter guard to allow perimeter guard to be lifted, depending on from which side of the machine the scrub head is being removed. See MAIN FRAME GROUP for right/left perimeter guard location.
- 7. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

8. Remove the clevis pin/cotter pin securing the scrub actuator to the scrub head.



NOTE: There is spring tension on the lift mechanism. If necessary, use a pry bar to remove the clevis pin.

 Remove the clevis pins/cotter pins securing the scrub head lift arms to the frame of the machine and the scrub head.



10. Remove the clevis pins/cotter pin securing the scrub head lift mechanism to the scrub head.







- 11. Disconnect the solution supply hoses from the scrub head.
- 12. Disconnect all main wire harness connections from the scrub brush motors.
- 13. Remove the scrub head from under the machine.



14. Reinstall the scrub head onto the machine in reverse order of disassembly.

# REMOVE/REINSTALL/REPLACE THE SCRUB HEAD ACTUATOR

- 1. Completely empty the solution tank and recovery tank.
- 2. Turn the key switch OFF.

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 3. Remove the brushes from the scrub head.
- 4. Disconnect the main wire harness from the scrub head actuator.
- 5. Insert spacer blocks to support both sides of the scrub head.



6. Remove the clevis pin/cotter pin securing the scrub actuator to the scrub head.



NOTE: There is spring tension on the lift mechanism. If necessary, use a pry bar to remove the clevis pin.

7. Remove the clevis pin/cotter pin securing the scrub actuator to the frame of the machine.



8. Remove the actuator from the machine.



9. Reinstall the scrub head actuator onto the machine in reverse order of disassembly.

NOTE: This actuator does not require adjustment before installation. Turn the actuator tube manually by hand to align the mounting holes and install clevis and cotter pins.

# REMOVE/REINSTALL/REPLACE THE MAIN SCRUB DRIVE MOTOR(S)



- 1. Turn the key switch OFF.
- 2. Remove both scrub brushes from the main scrub head. See REMOVING THE MAIN SCRUB BRUSHES in MAINTENANCE.
- 3. Turn the key switch ON, completely lower the scrub head, and turn the key switch OFF.

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, rand remove key.

4. Disconnect the battery cable from the machine.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 5. Place a chock behind both rear wheels.
- 6. If necessary, jack up the front end of the machine enough for additional access to remove the main scrub motor(s).

FOR SAFETY: When servicing machine, block machine tires before jacking machine up. Use a hoist or jack that will support the weight of the machine. Jack machine up at designated locations only. Block machine up with jack stands.

7. Remove the belt cover from the scrub head.



 Remove the belt from the scrub head. See REMOVE/REPLACE THE SCRUB MOTOR DRIVE BELT.



9. Remove the M6 hex screws (Qty. 4) securing the brush drive motor to the scrub head.



10. Disconnect the main wire harness from the brush drive motor and remove the motor from the scrub head.



- 11. Repeat procedure if removing/replacing the other scrub brush motor.
- 12. If replacing the main brush drive motor carbon brushes, proceed to REPLACE THE MAIN BRUSH DRIVE MOTOR CARBON BRUSHES. If not replacing the carbon brushes, proceed to the following step.
- 13. Reinstall the main brush drive motor/install the new main brush drive motor onto the scrub head in reverse order of disassembly.
- 14. Reinstall the main scrub brush drive belt(s) onto the machine. See REMOVE/REPLACE THE SCRUB MOTOR DRIVE BELT.

# REMOVE/REPLACE THE SCRUB MOTOR DRIVE BELT

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

1. Unlatch and open the side squeegee support door.



2. Remove the scrubbing drive belt cover from the scrub head.



3. Remove the existing scrub motor drive belt from the machine.


4. Remove the hardware securing the larger sheave to the machine and use hardware to install the belt installation tool onto the larger sheave.





5. Position the new brush drive belt onto the smaller sheave installed on the electric motor and belt installation tool.



6. Turn the sheave clockwise and coax the belt over the belt installation tool and onto both sheaves.



 Rotate the belt on the sheaves and use fingers to work the belt the rest of the way onto the sheaves. Be sure the belt is completely seated into the grooves in both sheaves.

NOTE: Take care to not pinch fingers in the belt and the sheaves while rotating the belt onto the sheaves.



8. Reassemble all items removed to install the new belt in reverse order of disassembly.

## REPLACE THE SCRUB BRUSH DRIVE MOTOR CARBON BRUSHES

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Remove the scrub brush motor(s) from the scrub head. See REMOVE/REINSTALL/REPLACE THE MAIN SCRUB DRIVE MOTOR(S).
- 2. Squeeze/lift the retainer to loosen the band covering the carbon brushes and remove the band from the scrub brush motor.





3. Remove the hardware securing the carbon brush cable to the scrub brush motor.



4. Lift the clip securing the carbon brush inside the scrub brush motor and pull the carbon brush from the retainer.





5. Use compressed air to clean dust from inside the motor.



6. Inspect the removed carbon brush.



- 7. Install a new carbon brush/reinstall the removed carbon brush into the scrub brush motor in reverse order of disassembly.
- 8. Repeat procedure to remove or replace the remaining scrub brush motor carbon brushes.
- 9. Reinstall the retaining band/retainer onto the scrub brush drive motor.
- 10. Reinstall the scrub brush motor onto the scrub head. See REMOVE/REINSTALL/REPLACE THE MAIN SCRUB DRIVE MOTOR(S).

#### SCRUB HEAD FRAME GROUP



#### REAR SQUEEGEE LIFT GROUP



## REMOVE/REINSTALL/REPLACE THE REAR SQUEEGEE ACTUATOR

1. Completely empty the solution tank and the recovery tank.

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 2. Turn the key switch OFF.
- 3. Disconnect the battery cable from the machine.

# FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

- 4. Machines equipped with squeegee guard: Place the squeegee guard into the raised position.
- 5. Disconnect the vacuum hose from the rear squeegee assembly and remove the rear squeegee assembly from the machine.
- 6. Remove the hardware securing the vacuum fan assembly to the recovery tank.



7. Carefully pull the vacuum fan housing from the machine and disconnect the main wire harness from the vacuum fan.



8. Remove the hardware securing the rear squeegee adjustment mechanism to the squeegee coupling,



 Remove the hardware securing the actuator mounting bracket to the frame of the machine. Allow the actuator to lower from the installed position.



10. Remove cotter pin and use a pry bar to release coil spring tension. Remove clevis pin.



11. Remove the cotter pin/clevis pin securing the actuator barrel to the squeegee lift arm.



12. Disconnect the main wire harness from the squeegee actuator and remove the actuator from the machine.



- 13. Remove the actuator mounting bracket from the removed rear squeegee actuator and install the actuator mounting bracket onto the new rear squeegee actuator.
- 14. Connect the main wire harness to the new rear squeegee actuator.
- 15. Install the new actuator onto the frame of the machine.
- Reinstall all rear squeegee components removed to remove the actuator in reverse order of disassembly.
- 17. Install the rear squeegee onto the machine.

#### REAR SQUEEGEE



#### **RIGHT SIDE SQUEEGEE GROUP**



#### LEFT SQUEEGEE GROUP



## LITHIUM BATTERIES

#### TROUBLESHOOTING

#### PRELIMINARY LITHIUM BATTERY SYSTEM CHECKS

Check these items first before checking battery error codes and further advanced lithium battery trouble shooting procedures.

1. Ensure the lithium battery charge door is closed and the latch is securely holding the lithium battery charge door closed.



If the lithium battery charge door is open/not fully secured closed, close the lithium battery charge door and use the latch to secure the door closed.



 Ensure the lithium battery charge door switch is properly adjusted and roller does not toggle switch when the lithium battery charge door is closed. Also ensure the roller and roller lever are not damaged.



3. Ensure the wire connection to the lithium battery charge door switch are firmly connected to the switch.



If wire connections to the lithium battery charge door are disconnected/broken from the switch reconnect the wire connections/repair wire connections to the switch as necessary.

4. Proceed to CHECK LITHIUM BATTERY STATUS VIA INDICATOR LIGHTS to further troubleshoot the lithium batteries/lithium battery system.

#### **INSPECT LITHIUM BATTERY CABLES**

The battery red (+) cables, black (-) cables, and lithium battery CAN communication cables must be undamaged and correctly torqued to the lithium batteries.

1. Inspect all red (+) cables and black (-) cables for damage.



2. Repair/replace damaged red (+) cables and black cables (-). Ensure cables are all correctly torqued to the batteries.

Torque red (+) connections to 22 Nm (16 ft. lbs.)

Torque black (-) connections to 17 Nm (12.5 ft. lbs.)

 Proceed to TROUBLESHOOT UI POWER ELECTRIC HARNESS (J7-8/J7-10) if issue persists. 4. Inspect the lithium battery CAN communication cables for obvious damage.



5. Repair/replace damaged lithium battery CAN communication cables. Ensure cables are all correctly torqued to the batteries.

Torque lithium battery CAN communication cable connections to 0.6 Nm (0.44 ft. lbs.).

6. Proceed to INSPECT/TROUBLESHOOT LITHIUM BATTERY PACK if issue persists.

#### CHECK LITHIUM BATTERY STATUS/FAULT CODES

Check the lithium battery status and for battery error codes if there are issues with machine short run times/ battery pack not retaining charge.

1. Lift the operator seat open and engage the seat support bar.



 Press power button for 1 second on each battery to see the battery status. Observe the indicator lights on each battery.



If the indictor lights do not illuminate, the batteries may not be turned on. Press the battery power button on one battery for 5 seconds to turn on all batteries (may take up to approximately 30 seconds for all batteries to come on). Press the power button for 1 second on each battery again and observe the indicator lights to ensure each battery is on.

All indicator lights should be flashing green to display the battery charge level if the batteries are in normal operating status (no faults). Charge batteries as necessary if all indicators are not flashing green or there is a fault code requiring the batteries be charged.

If the indicator lights are flashing red, there is an issue generating a fault code. Refer to the lithium battery fault codes table for the Fault ID, Battery Indicator Light Pattern, Fault Description, and Correction for the fault.

If fault still persists after initial battery maintenance procedures, proceed to ACCESS LITHIUM BATTERY SERVICE SCREEN to further troubleshoot the lithium battery system.

NOTE: Some battery faults will not only appear as faults on the battery indicator lights, but could also appear as a fault on the UI (User Interface), and also prevent the machine from being operated (flashing operator controls and indicators).

Fault ID	Battery Indicator Light Pattern	Fault Description	Correction
F0		Over Temperature (Cells)	<ol> <li>Allow temperature to lower into accept- able operating range.</li> <li>If fault persists, contact T.A.C. for further assistance.</li> </ol>
F1		Over Temperature (BMS)	<ol> <li>Allow temperature to lower into accept- able operating range.</li> <li>If fault persists, contact T.A.C. for further assistance.</li> </ol>
F2		Under Temperature (Charge)	<ol> <li>Allow temperature to raise into acceptable operating range.</li> <li>If fault persists, contact T.A.C. for further assistance.</li> </ol>
F3		Over Current (Recoverable)	<ul> <li>If charging:</li> <li>1. Power cycle charger.</li> <li>2. Replace charger if fault persists.</li> <li>If discharging:</li> <li>1. Disconnect battery cable from batteries.</li> <li>2. Reconnect battery cable to batteries.</li> <li>3. Battery should resume operation after discharge has been stopped.</li> <li>4. If fault persists, contact T.A.C. for further assistance.</li> </ul>
F4		Over Current (Permanent Fault)	1. Replace battery. See REMOVE/ REINSTALL/REPLACE LITHIUM BATTERIES.
F5		Short Circuit	<ol> <li>Inspect all battery system electrical connections.</li> <li>Repair electrical connections as necessary.</li> <li>If fault persists, contact T.A.C. for further assistance.</li> </ol>
F6		Cell Under Voltage-During Discharge Only	<ol> <li>Recharge battery.</li> <li>If fault persists, contact T.A.C. for further assistance.</li> </ol>
F7		Cell Over Voltage-During Charge Only (Primary)	<ol> <li>Discharge battery down to 20% SOC (State of Charge) and recharge battery.</li> <li>If fault persists, contact T.A.C. for further assistance.</li> </ol>
F8		Cell Over Voltage-During Charge Only (Secondary)	1. Replace battery.
F9		Safety Under Voltage	<ol> <li>Recharge battery.</li> <li>If fault persists, contact T.A.C. for further assistance.</li> </ol>

Fault ID	Battery Indicator Light Pattern	Fault Description	Correction
F10		Cell Pre-Charge Fault	<ol> <li>Power cycle charger.</li> <li>If fault persists, replace charger.</li> </ol>
F11		Charge Fault	<ol> <li>Power cycle charger.</li> <li>If fault persists, replace charger.</li> </ol>
F12		Under Temperature (Discharge)	<ol> <li>Allow temperature to raise into acceptable operating range.</li> <li>If fault persists, contact T.A.C. for further assistance.</li> </ol>
F13		Miscellaneous Fault	<ol> <li>Power cycle battery.</li> <li>If fault persists, replace battery.</li> </ol>
F14		Pre-Discharge Fault	<ol> <li>Disconnect cables from battery.</li> <li>Observe indicator lights for a fault.</li> <li>If no fault, reconnect cables to battery.</li> <li>If fault persists, replace battery. See REMOVE/REINSTALL/REPLACE LITHIUM BATTERIES.</li> </ol>
F15		Permanent Fault	1. Replace battery. See REMOVE/ REINSTALL/REPLACE LITHIUM BATTERIES.

#### ACCESS LITHIUM BATTERY SERVICE SCREEN

1. Disconnect the main wire harness from the seat switch and remove the operator seat from the machine.



2. Connect a USB cable to the service device.

**ATTENTION:** <u>Never</u> allow the metallic tip on the loose end of the service USB cable to touch a lithium battery positive (+) terminal when connecting the USB cable to the service device/lithium battery control board USB cable. USB cables, service device, and/or lithium battery control board could be damaged if loose metallic end of the service USB cable touches a lithium battery positive (+) terminal.

3. Connect the other end of the USB cable connected to the service device in the previous step to the lithium battery control board USB cable.



4. Turn the key switch ON.

5. Double click the Service Diagnostics desktop shortcut or find the software in All Programs to launch the software.



NOTE: Confirm key switch is ON and check USB cable connection to the machine if the screen below appears on the screen.





6. The Service Diagnostics tool now connects to the lithium ion battery network.



7. The lithium battery service screen opens.



8. Observe the lithium battery operational status in the lithium battery status column. See LITHIUM BATTERY SYSTEM RANGES for lithium battery operational values/ranges.

## Battery

Voltage	36.34
Voltage CAN	36.02
Туре	Inventus
CAN SOC Level	47%
Number of Batteries	4.00
Battery Temperature	20.00
CAN SOH Level	100%
Current	-2.30
Number of Faulted Batteries	0.00
Number of Active Batteries	4.00
Operator Mode	5.00

Proceed to LITHIUM BATTERY SYSTEM VALUES/ RANGES for battery status battery/battery system operating range information.

#### LITHIUM BATTERY SYSTEM VALUES/RANGES

Refer to the table to confirm lithium battery operating values observed on the AMR SERVICE CONNECTION are within the minimum/maximum operating ranges.

System	Operating Parameter	Minimum Value	Nominal Value	Maximum Value	Measure
Lithium	Voltage	28		41.5	Volts
Battery	Voltage CAN*	28		41.5	Volts
	Туре		Inventus		NA
	CAN SOC Level	0		100	Percent (%)
	Number of Batteries	0	4	4	Quantity
	Battery Temperature	-20°C (-4°F)		55°C (131°F)	Temperature
	CAN SOH Level	80		100	Percent (%)
	Current	-150		90	Amps
	Number of Faulted Batteries	0	0	4	Quantity
	Number of Active Batteries	0	4	4	Quantity
	Operator Mode	5	5	5	Charge/Discharge

\*CAN (Controller Area Network) communication bus between the BMS (Battery Management System) and battery board.

**Voltage**: Minimum/maximum voltage range necessary for normal machine operation as measured by the lithium circuit battery board. Battery terminals will shut down when below the minimum value and will need to be recovered. Proceed to following troubleshooting sections to further investigate/correct issue:

See LITHIUM BATTERY HARD RESET to turn on batteries if they are in shutdown mode due to low voltage (being allowed to discharge beyond minimum voltage value).

See TROUBLESHOOT UI POWER ELECTRIC HARNESS (J7-8/J7-10) to further troubleshoot issue.

Voltage CAN (Control Area Network): Minimum/ maximum voltage range necessary for normal operation, as reported over the CAN by the BMS. Charge battery pack if voltage is below the minimum value. Proceed to following troubleshooting sections if issue persists:

See INSPECT/TROUBLESHOOT LITHIUM BATTERY PACK to troubleshoot issue.

See TROUBLESHOOT UI TO BMS ELECTRICAL HARNESS (J3-1/J3-2 AND J10-5/J10-6) to further troubleshoot issue if issue persists.

See TROUBLESHOOT DIGITAL POT 5V ENABLE ELECTRIC HARNESS (J4-1/J4-4) to further troubleshoot if issue persists. Type: Battery Manufacturer - Inventus.

**CAN SOC Level** (State of Charge): Percent of remaining available battery pack capacity. At 100% the battery pack is fully charged. A lower SOC value signifies less remaining available battery pack capacity. Proceed to following troubleshooting sections to further investigate/correct issue:

See TROUBLESHOOT UI TO BMS ELECTRICAL HARNESS (J3-1/J3-2 AND J10-5/J10-6) to further troubleshoot issue.

See TROUBLESHOOT DIGITAL POT 5V ENABLE ELECTRIC HARNESS (J4-1/J4-4) to further troubleshoot if issue persists.

**Number of Batteries**: Number of batteries must be four (4.00). If number is less than four, inspect all CAN communication cables and connections. Proceed to following troubleshooting sections to further troubleshoot issue:

See INSPECT/TROUBLESHOOT LITHIUM BATTERY PACK to troubleshoot issue.

See TROUBLESHOOT UI TO BMS ELECTRICAL HARNESS (J3-1/J3-2 AND J10-5/J10-6) to further troubleshoot if issue persists.

See TROUBLESHOOT DIGITAL POT 5V ENABLE ELECTRIC HARNESS (J4-1/J4-4) to further troubleshoot if issue persists. **Battery Temperature**: Current battery pack temperature. Stop operating machine and allow the battery pack temperature to raise/lower within the acceptable temperature range. Observe the batteries for over/under temperature fault codes. Proceed to following troubleshooting sections to further troubleshoot issue:

See lithium battery fault code table in CHECK LITHIUM BATTERY STATUS/FAULT CODES for lithium battery fault code information.

See TROUBLESHOOT UI TO BMS ELECTRICAL HARNESS (J3-1/J3-2 AND J10-5/J10-6) to further troubleshoot issue.

**CAN SOH Level** (State of Health): Condition of battery pack when compared to a new battery pack. This value should always be above the minimum. Battery pack performance deteriorates as number drops below minimum value, and battery pack will eventually need to be replaced. Proceed to following troubleshooting sections to further investigate/correct issue:

See TROUBLESHOOT UI TO BMS ELECTRICAL HARNESS (J3-1/J3-2 AND J10-5/J10-6) to troubleshoot issue.

See TROUBLESHOOT DIGITAL POT 5V ENABLE ELECTRIC HARNESS (J4-1/J4-4) to further troubleshoot if issue persists.

**Current:** Minimum/maximum battery amperage values. Performance and operational expectancy is adversely affected if battery pack is outside the acceptable range. Proceed to following troubleshooting section to further troubleshoot issue:

See TROUBLESHOOT UI TO BMS ELECTRICAL HARNESS (J3-1/J3-2 AND J10-5/J10-6) to troubleshoot issue.

**Number of Faulted Batteries**: If there is any number other than zero (0.00) in Number of Faulted Batteries observe the battery indicator lights on each battery to find which battery/batteries are displaying a fault condition. Proceed to following troubleshooting sections to further troubleshoot issue:

See lithium battery fault code table in CHECK LITHIUM BATTERY STATUS/FAULT CODES for lithium battery fault code information.

See INSPECT/TROUBLESHOOT LITHIUM BATTERY PACK if issue persists after battery faults are cleared.

See TROUBLESHOOT UI TO BMS ELECTRICAL HARNESS (J3-1/J3-2 AND J10-5/J10-6) if issue persists. Proceed to following troubleshooting sections to further troubleshoot issue:

**Number of Active Batteries**: Number of batteries available to power the machine. This value should be four (4.00). The number of active batteries decreases as the number of faulted batteries increases. Proceed to following troubleshooting sections to further troubleshoot issue:

See INSPECT/TROUBLESHOOT LITHIUM BATTERY PACK to troubleshoot issue.

See TROUBLESHOOT UI TO BMS ELECTRICAL HARNESS (J3-1/J3-2 AND J10-5/J10-6) to further troubleshoot if issue persists.

See TROUBLESHOOT DIGITAL POT 5V ENABLE ELECTRIC HARNESS (J4-1/J4-4) to further troubleshoot if issue persists.

**Operator Mode**: Usually machine will not function unless the Operator Mode is 5 (discharging). If the machine does power up and any number other than 5 appears in Operator Mode on the service device, contact T.A.C. for further troubleshooting guidance.

NOTE: In some circumstances, if the battery pack is operating outside acceptable minimum/maximum range(s), not only will these issues appear on the lithium battery operational status screen, but could also appear as a fault on the UI (User Interface), and prevent the machine from being operated (flashing operator controls and indicators).

## TROUBLESHOOT SERVICE DIAGNOSTIC CONNECTION

Proceed with this procedure if Service Diagnostics does not advance beyond the "Connect USB to machine..." screen.



 Check the USB connection from service device to the lithium battery control board USB cable. Ensure the USB cable is completely connected to the service device and lithium battery control board USB cable.



- 2. Attempt again to connect to the machine/access the lithium ion service screen. If issue persists, use another USB cable to connect the service device to the lithium battery control board USB cable.
- 3. If there is still no connection to the machine/access the lithium battery service screen, proceed to the following step.
- 4. Disconnect the USB cable/service device from the lithium circuit board USB cable.
- 5. Remove the board mounting bracket from the board mounting plate.
- 6. Ensure the lithium battery control board USB cable is completely connected to the lithium battery circuit board.



- 7. Reconnect the USB cable/service device to the lithium circuit board USB cable.
- 8. Attempt again to connect to the machine/ access the lithium ion service screen. If there is still no connection to the machine/access the lithium battery service screen, proceed to TROUBLESHOOT LITHIUM BATTERY CONTROL BOARD.

## TROUBLESHOOT LITHIUM BATTERY CONTROL BOARD

 Observe the indicator lights (Green LED D25 indicating there is power to the lithium battery circuit board and Yellow LED D26 indicating there is CAN (Controller Area Network) communication to the lithium battery circuit board) on the lithium battery circuit board. Both LEDs should be flashing.



If neither LED (D25 and D26) is flashing troubleshoot the power to the lithium battery circuit board. Replace the UI power electric harness if it is damaged. See TROUBLESHOOT UI POWER ELECTRIC HARNESS (J7-8 / J7-10).

If neither LED (D25 and D26) is flashing, and the UI power electric harness is fully functional/ undamaged, inspect the lithium battery circuit board for obvious damage. Replace the lithium battery circuit board if it is damaged. See REPLACE LITHIUM BATTERY CIRCUIT BOARD.

If only the green LED D25 is flashing (indicating there is power to the lithium battery circuit board), but the yellow LED D26 (indicating there is CAN communication to the lithium battery circuit board) is not flashing, troubleshoot the lithium battery CAN (Controller Area Network) communication. See TROUBLESHOOT UI TO BMS ELECTRICAL HARNESS (J3-1/J3-2 AND J10-5/J10-6) and TROUBLESHOOT DIGITAL POT 5V ENABLE ELECTRIC HARNESS (J4-1/J4-4).

2. Contact T.A.C. for further troubleshooting guidance if issue persists.

## INSPECT/TROUBLESHOOT LITHIUM BATTERY PACK

The lithium battery CAN communication cables and lithium battery communication terminals must be undamaged and functional for the lithium batteries to communicate via the CAN system. The lithium battery CAN communication cables must also be completely tightened onto the lithium battery communication terminals.

- 1. Inspect the lithium battery CAN communication cables for obvious damage. Replace damaged cables.
- 2. Disconnect the UI to BMS electrical harness from the battery pack.



3. Disconnect the termination resistor from the battery pack.



4. Check continuity between the corresponding pins at the lithium battery communication terminals (continuity is being measured across entire battery pack from the UI to BMS electrical harness communication terminal to the termination resistor communication terminal).

If continuity across battery pack is good, proceed to TROUBLESHOOT UI TO BMS ELECTRICAL HARNESS (J3-1/J3-2 AND J10-5/J10-6) and TROUBLESHOOT DIGITAL POT 5V ENABLE ELECTRIC HARNESS (J4-1/J4-4).

If there is no continuity across battery pack, proceed to the following step.

- 5. Disconnect all lithium battery CAN communication cables from the lithium batteries.
- Inspect all lithium battery communication terminals for damage. Replace a lithium battery if the battery communication terminals are damaged. See REMOVE/REINSTALL/REPLACE LITHIUM BATTERIES.
- Check continuity between the corresponding communication terminal pins on each lithium battery. Replace the lithium battery if there is continuity between the corresponding communication terminal pins. See REMOVE/ REINSTALL/REPLACE LITHIUM BATTERIES.





NOTE: Note locations of terminal notches when checking continuity between lithium battery terminal pins. The terminals are not oriented the same.

 Inspect the resistor plug for obvious damage. Inspect resistor plug pins for damage. Replace the resistor plug if damaged.



 Check resistance between resistor plug pins 1 and 2 and pins 6 and 7. Resistance between pins 1 and 2 and pins 6 and 7 should be 120Ω. Replace the resistor plug if no resistance/excessive resistance.



10. Remove the resistor plug connector from the resistor plug.



11. Inspect the resistor connections at the terminals inside the resistor plug. Both resistors should be undamaged and both ends of the resistors firmly secured inside the plug terminals.





- 12. Check resistance between the resistor at terminals 1 and 2 and the resistor at terminals 6 and 7. Resistance between terminals 1 and 2 and terminals 6 and 7 should be  $120\Omega$ . Replace the resistor plug if no resistance/excessive resistance at either resistor.
- 13. If plug resistor is good, reassembly the resistor plug connector onto the resistor plug.

 Inspect the lithium battery CAN communication cable connector/connector pins for damage. Replace the lithium battery communication cable if connector/connector pins are damaged or any other part of cable is damaged.



 Check the resistance between the corresponding pins in the lithium battery CAN communication cable connectors on each end of each cable. Resistance between the corresponding pins should be 120Ω. Replace the cable if no resistance/ excessive resistance.



2- BMS CONNECTION		
WIRE NO.	POS.	
CAN+A/SQUARE	1	
CAN-A/SQUARE	2	
92/SQUARE	3	
13AD/SQUARE	4	
OPEN	5	
CAN2+/SQUARE	6	
CAN2-/SQUARE	7	
OPEN	8	

 Reinstall the lithium battery CAN communication cables/install new lithium battery CAN communication cables onto the battery pack. Torque lithium battery CAN communication cable connections to 0.6 Nm (0.44 ft. lbs.). 17. Recheck continuity between the corresponding pins at the lithium battery communication terminals (continuity is being measured across entire battery pack from the UI to BMS electrical harness communication terminal to the termination resistor communication terminal).

If continuity between the corresponding pins at the lithium battery communication terminals is good, reconnect the termination resistor and UI to BMS electrical harness to the battery pack. Torque the resistor plug and UI to BMS electrical harness connections to 0.6 Nm (0.44 ft. lbs.).

Contact T.A.C. for further troubleshooting guidance if there are still continuity issues at the battery pack.

- Recheck the lithium battery operational status in the lithium battery status column on the service device. See LITHIUM BATTERY SYSTEM RANGES for lithium battery operational values/ ranges.
- Proceed to TROUBLESHOOT UI TO BMS ELECTRICAL HARNESS (J3-1/J3-2 AND J10-5/ J10-6) and TROUBLESHOOT DIGITAL POT 5V ENABLE ELECTRIC HARNESS (J4-1/J4-4) for further troubleshooting if issue persists.

## TROUBLESHOOT UI POWER ELECTRIC HARNESS (J7-8/J7-10)

Proceed with this procedure if there is no CAN communication/power at the lithium battery control board.

NOTE: See TROUBLESHOOT LITHIUM BATTERY CONTROL BOARD if the indicator light (Green LED D25 indicating there is power to the lithium battery circuit board) is not flashing.

 Inspect the UI power electric harness connected to lithium battery circuit board terminal J7. Disconnect the UI power electric harness connector from the lithium battery circuit board. Check for battery voltage at the connector. Verify connector and connector pins are fully seated and are not damaged. Repair pins/replace connector/cable as necessary.



J7-8 (13AC/BLK)	Result
lf open	Board reports to system battery pack has a problem*
If short to B-	B- is the connection
If short to chassis	Short to chassis may cause non-obvious issues
If short To B+	Damage to wiring on power on. Possible damage to board*
*Notes	High probability of irreparable board damage

J7-10 (87/PUR)	Result
lf open	No power to board
If short To B-	Damage to wiring on power on. Possible damage to board*
If short to chassis	Short to chassis may cause non-obvious issues
If short to B+	B+ is the connection
*Notes	High probability of irreparable board damage

- 2. Reconnect the UI power electric harness to lithium battery circuit board terminal J7. Continue testing/ troubleshooting if still no power at the lithium battery circuit board.
- 3. Remove the seat shroud cover from the machine.
- 4. Inspect the UI power electric harness connections at the B+ switch terminal and B- standoff. Secure/ repair connections. Test/inspect the 2-Amp fuse on the UI power electric harness lead to the B+ switch terminal. Replace 2-Amp fuse if fuse is blown.



If neither LED (D25 and D26) is flashing, or if just the Yellow LED D26 is flashing, replace the lithium battery circuit board. See REPLACE LITHIUM BATTERY CIRCUIT BOARD.

5. If the cable/connections are good and issue persists (neither LED (D25 and D26) is flashing is flashing) contact T.A.C. for further troubleshooting guidance.



## TROUBLESHOOT LEG ELECTRIC HARNESS (J5-1/ J5-2)

The lithium battery circuit board will be unable to communicate with the Kinetek controller if there is an issue with these connections. The machine will still propel, but all automated/scrubbing systems will be inoperable, there may be a battery fault code displayed on the UI (User Interface), and all operator controls/ indicators will be flashing.

 Inspect the leg electric harness connection to lithium battery control board terminal J5. Disconnect the leg electric harness from the lithium battery control board and verify connector and connector pins are fully seated and are not damaged. Repair pins/replace connector/harness as necessary.



J5-1 (13AB/BLK)	Result
lf open	Board reports to system battery pack has a problem
If short to B-	B- is connection
If short to chassis	Board reports to system battery pack has a problem
If short to B+	Board reports to system battery pack has a problem*
*Notes	High probability of irreparable board damage

J5-2 (91/PNK)	Result
lf open	Board reports to system battery pack has a problem**
If short to B-	Board reports to system battery pack has a problem**
If short to chassis	Board reports to system battery pack has a problem**
If short to B+	Board reports to system battery pack has a problem*
*Notes	High probability of irreparable board damage. If J5-2 is B+ shorted Kinetek will send message to UI that battery pack is good, but service device might show battery pack as bad.
**Notes	Kinetek will send message to UI that battery pack is bad, but service device might show battery pack as good.

- Reconnect the leg electric harness to lithium battery control board terminal J5. Continue testing/troubleshooting if there is still no CAN communication at the lithium battery control board.
- 3. Disconnect the main wire harness P3 20-pin connector from the Kinetek controller.
- Inspect the leg electric harness connections to the main wire harness P3 20-pin connector terminals 15 and 19. Verify the connections are secure and pins are not damaged. Repair pins/replace connector/cable as necessary.



- If the cable/connections are good and issue persists, replace the lithium battery control board. See REPLACE LITHIUM BATTERY CONTROL BOARD.
- 6. Contact T.A.C. for further troubleshooting guidance if issue persists.



#### TROUBLESHOOT UI TO BMS ELECTRICAL HARNESS (J3-1/J3-2 AND J10-5/J10-6)

If the Yellow LED indicating there is CAN (Controller Area Network) communication to the lithium battery control board is not flashing, there are CAN communication issues/faults. Troubleshoot the UI to BMS electrical harness connections to the board.

 Inspect the UI to BMS electrical harness connection to lithium battery control board terminals J3 and J10. Disconnect the UI to BMS electrical harness connectors from the lithium battery control board and verify connectors and connector pins are fully seated and are not damaged. Repair pins/replace connector/harness as necessary.



J3-1 (CAN+/YEL)	Result
lf open	Board reports to system battery pack has a problem
If short to B-	Board reports to system battery pack has a problem
If short to chassis	Board reports to system battery pack has a problem
If short to B+	Board reports to system battery pack has a problem*
*Notes	High probability of irreparable board damage

J3-2 (CAN-/GRN)	Result
lf open	Board reports to system battery pack has a problem
If short to B-	Board reports to system battery pack has a problem
If short to chassis	Board reports to system battery pack has a problem
If short to B+	Board reports to system battery pack has a problem*
*Notes	High probability of irreparable board damage

J10-5 (13AD/BLK)	Result
lf open	Board reports to system battery pack has a problem
If short to B-	B- is the connection
If short to chassis	Short to chassis may cause non-obvious issues
If short to B+	Damage to wiring on power on. Possible damage to board*
*Notes	High probability of irreparable board damage

J10-6 (92/BRN)	Result
lf open	Board reports to system battery pack has a problem
If short to B-	Battery will not go into sleep mode
If short to chassis	Short to chassis may cause non-obvious issues
If short to B+	Damage to wiring when waking up battery. Possible damage to board*
*Notes	High probability of irreparable board damage

- Reconnect the UI to BMS electrical harness to lithium battery control board terminals J3 and J10. Continue testing/troubleshooting if there is still no CAN communication at the lithium battery control board.
- Disconnect the UI to BMS electrical harness from the lithium battery. Verify the connector pins are fully seated and are not damaged. Repair pins/ replace connector/harness as necessary.







2- BMS CONNEC	TION
WIRE NO.	POS.
CAN+A/SQUARE	1
CAN-A/SQUARE	2
92/SQUARE	З
13AD/SQUARE	4
OPEN	5
CAN2+/SQUARE	6
CAN2-/SQUARE	7
OPFN	8

4. Remove the resister from the UI to BMS electrical harness.

 Check the resistance from connector disconnected from battery back pin CAN2+/SQUARE and pin CAN2-/SQUARE with the UI to BMS electrical harness resistor connector CAN+C/CIRCLE pin 1 and CAN-C/CIRCLE pin 2. Should be 120Ω. Replace the UI to BMS electrical harness if no resistance/excessive resistance.



6. Inspect the resistor for damaged pins. Replace the resistor if pins are damaged/broken.



- 7. Check the resistance at the resistor pins. Should be  $120\Omega$ . Replace the resistor if no resistance/ excessive resistance.
- 8. Reconnect the UI to BMS electrical harness to the lithium battery. Torque the UI to BMS electrical harness connection to 0.6 Nm (0.44 ft. lbs.).
- 9. Contact T.A.C. for further troubleshooting guidance if issue persists.







### TROUBLESHOOT DIGITAL POT 5V ENABLE ELECTRIC HARNESS (J4-1/J4-4)

If the digital pot 5V enable electric harness connected to terminal J4 on the lithium battery control board is damaged there will be SOC (State of Charge)/voltage issues with the batteries. The machine will still propel, but all automated/scrubbing systems will be inoperable, there may be a battery fault code displayed on the UI (User Interface), and all operator controls/indicators will be flashing.

 Inspect the digital pot 5V enable electric harness connection to lithium battery control board terminal J4. Disconnect the digital pot 5V enable electric harness from the lithium battery control board and verify connector and connector pins are fully seated and are not damaged. Repair pins/replace harness as necessary.



J4-1 (30/RED)	Result
lf open	Board reports to system battery pack has a problem
If short to B-	Board reports to system battery pack has a problem
If short to chassis	Board reports to system battery pack has a problem
If short to B+	Board reports to system battery pack has a problem*
*Notes	High probability of irreparable board damage

J4-4 (30/RED)	Result
If open	Board reports to system battery pack has a problem
If short to B-	Board reports to system battery pack has a problem
If short to chassis	Board reports to system battery pack has a problem
If short to B+	Board reports to system battery pack has a problem*
*Notes	High probability of irreparable board damage

- Reconnect the digital pot 5V enable electric harness to lithium battery control board terminal J4. Continue testing/troubleshooting if there is still no CAN communication at the lithium battery control board.
- 3. Contact T.A.C. for further troubleshooting guidance if issue persists.


#### LITHIUM BATTERY HARD RESET

Perform a "hard reset" if all four lithium batteries go into a low power shutdown mode (0% charge level). This procedure will be necessary if the machine is operated for too long after the low voltage warning is displayed, or the machine is left on for too long while unattended.

- 1. Turn the key switch OFF.
- 2. Lift the operator seat open and engage the seat support bar.



3. Disconnect the battery cable from the machine.



4. Connect the battery charger to the battery cable disconnected from the machine in the previous step.

5. Press the power button on one of the lithium batteries for 5 seconds.



All connected batteries will activate "wake up" from the low power shutdown mode.

- 6. The charger will begin charging the batteries. Wait for batteries to complete charging.
- 7. Disconnect the battery charger from the battery cable and reconnect battery cable to the machine after the batteries are completely charged. The machine is now ready for operation.

# REMOVE/REINSTALL/REPLACE LITHIUM BATTERIES

FOR SAFETY: Before leaving or servicing machine, stop on level surface, turn off machine, and remove key.

- 1. Turn the key switch OFF.
- 2. Lift the operator seat open and engage the seat support bar.



3. Disconnect the battery cable from the machine.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

4. Disconnect the wire harness from the seat switch.



5. Lift the seat/seat plate from the machine.

6. Remove the hardware securing the seat shroud cover to the machine.



- 7. Lift the seat shroud cover from the machine.
- 8. Turn off the lithium batteries. Hold the power button on one lithium battery for 20 seconds to turn off all four batteries.



- 9. Quickly press the power button again and observe the charge indicator lights near the button. None of the charge indicator lights should be illuminated.
- 10. Quickly press the power button on the remaining three batteries and observe the charge indicator lights near the button. None of the charge indicator lights should be illuminated on these batteries either.

NOTE: All four (4) lithium batteries must be turned off prior to removing the batteries from the machine.





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- 12. Disconnect the UI to BMS electrical harness and all communication cables from the lithium battery communication terminals.
- 13. If replacing lithium battery with the resistor plug installed, remove the resistor plug from the battery.

Torque lithium battery CAN communication cable, resistor plug, and UI to BMS electrical harness connections to 0.6 Nm (0.44 ft. lbs.)



- 14. Remove the lithium batteries from the battery compartment.
- 15. Remove the battery/batteries to be replaced.
- 16. Install the new battery/batteries into the battery compartment.
- 17. Reinstall the battery cables and lithium battery CAN communication cables onto the batteries.

Torque all red (+) connections to 22 Nm (16 ft. lbs.).

Torque all black (-) connections to 17 Nm (12.5 ft. lbs.).

Torque lithium battery CAN communication cable, resistor plug, and UI to BMS electrical harness connections to 0.6 Nm (0.44 ft. lbs.).

- 18. Reinstall the removed support bracket assembly onto the machine in reverse order of disassembly.
- 19. Reinstall the seat shroud onto the machine.
- 20. Reinstall the operator seat onto the machine and reconnect the main wire harness to the seat switch.

#### **REPLACE LITHIUM BATTERY CIRCUIT BOARD**



- 1. Turn the key switch OFF.
- 2. Lift the operator seat open and engage the seat support bar.



3. Disconnect the battery cable from the machine.

FOR SAFETY: When servicing machine, disconnect battery connection and charger cord before working on machine.

4. Disconnect the wire harness from the seat switch.



- 5. Lift the seat/seat plate from the machine.
- 6. Remove the hardware securing the seat shroud cover to the machine.



- 7. Lift the seat shroud cover from the machine.
- Turn off the lithium batteries. Hold the power button on one lithium battery for 20 seconds to turn off all four batteries.



- 9. Quickly press the power button again and observe the charge indicator lights near the button. None of the charge indicator lights should be illuminated.
- 10. Quickly press the power button on the remaining three batteries and observe the charge indicator lights near the button. None of the charge indicator lights should be illuminated on these batteries.

NOTE: All four (4) lithium batteries must be turned off prior to removing any of the batteries from the machine.

- 11. Remove the lithium batteries from the machine. See REMOVE/REINSTALL/REPLACE LITHIUM BATTERIES.
- 12. Remove the board mounting bracket from the board mounting plate.



- 13. Disconnect all harness/wire connections from the control board.
- 14. Remove the control board from the board mounting plate.
- 15. Install the new control board onto the board mounting plate.
- 16. Connect all cable/wire connections to the new control board.
- 17. Reinstall the board bracket onto the board mounting plate.
- 18. Reinstall the lithium batteries into the battery compartment and reconnect all cables to the batteries.
- 19. Reconnect the battery cable to the machine.
- 20. Connect a USB cable to the service device.

**ATTENTION:** <u>Never</u> allow the metallic tip on the loose end of the service USB cable to touch a lithium battery positive (+) terminal when connecting the USB cable to the service device/USB cable connected to the lithium battery control board. USB cables, service device, and/ or lithium battery control board could be damaged if loose metallic end of the service USB cable touches a lithium battery positive (+) terminal.

21. Connect the other end of the USB cable connected to the service device in the previous step to the USB cable installed on the lithium battery control board.



22. Turn the key switch ON.

SYSTEM REQUIREMENTS: Windows® 7 Operating System, Microsoft .NET 4.5 or later, USB to Mini-USB cable.

- 23. Double click the Service Diagnostics desktop shortcut or find the software in All Programs to launch the software.
- 24. Allow the Service Diagnostics tool to connect to the lithium battery control board network.



25. The Service Diagnostics tool automatically detects a new board was installed. A Service Diagnostic window with text "A new board has been installed in this machine and must be properly configured. This wizard will guide you through the process." appears on the screen.

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CONNECTED: THO TENNANT COMPANY	hatStill Soluti Couldenier Estang CAN Companyation Lass	
-	A new board has been installed in this machine and must be properly configured. This will guide you through the process.	wizard
9		
	Tang Houter   Le 1900-1044	

26. Enter the serial number, select the model from the pull down menu, and click the arrow button to proceed with reconfiguring the machine for the new lithium battery control board.

Y	
Serial Number Ex: 7300-1234	
~	

27. The firmware update screen appears and will begin programming the machine. The process status indicator and firmware update status box appear on the left side of the screen.



28. Allow the firmware update to proceed. A process status indicator with a percent (%) status of the update also appears next to the selected firmware update. Firmware update process typically takes 2 or 3 minutes.

Terman Engineering 2042		
CONNECTED T350 Quader1455	C 0/120, Soult Controller Rued CAN Commancion Lian	
6-100	MODULE: User Interface Hardware Rev: 1.00 Firmware Rev: 1.2.0.221 FCT (Update: 1.6.0.37)	21%
~	MODULE : Sorub Controller Hardware Rev: 0.00 Firmware Rev: 0.00.0.0	7/
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<ul> <li>Upbline Master Filmmann</li> <li>The</li> <li>Write Director (Master Filmmann)</li> </ul>		
Annual Court Frances		

29. A check appears where the process status indicator with the percent status was previously located when the firmware update is complete.

E Lemant Engineering 2042	
COMPACTED: T250 TENNANT COMPANY	Could not that nucleae (only variant his motion liver (2097)111
-09	MODULE: User Interface Hardware Rev: 1:00 Firmware Rev: 1:6:0.37
1	7/
Opin Frankase Package	Ĺ
Styclate Master Permany     Signat Machine     Second Contemporate	
Reset Machine     Locker-Conel Terminal	
Annual Manual	

30. A text box with "Press OK, then Key cycle machine." appears. Select the OK button and then key cycle the machine to complete the firmware update.



NOTE: Firmware update status box on left side of the screen will be at "Reset Machine" when text box to key cycle machine appears. All previous listed items are checked/completed.



31. A screen with "Machine Setup Complete" appears when the firmware update is complete.



32. Use the Service Diagnostics tool to access the lithium battery screen.



33. Observe the lithium battery information pane on the left side of the screen. The "Number of Batteries" and "Number of Active Batteries" should be four (4.00), and the number of "Number of Faulted Batteries" should be zero (0.00).



See LITHIUM BATTERY SYSTEM VALUES/ RANGES for battery status battery/battery system operating range information.