Controls Subsystem Requirements Specification (SRS)

Monaco (T350/SS350)

Revision Number 4
August 2017
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Revision History

Revision	Description of Change	Source of Change	Date	Author
0	Initial release			
1	Major update Several edits made to clean up document and fill in gaps Cleaned up “modes” section and added detail defining “Manual Mode” Removed “Acoustic Noise” requirements Re-arranged and cleaned up the entire “Controls Subsystems” section 3.5	Multiple	April 2017	W. Zanto
2	Updated Operator Environment with missing buttons and indicators Cleaned up formatting for Cleaning, Propel Control, Debris Management, Solution Delivery, Battery/Charging, ABW2.0 subsystems. Update Controls Software Features section	Clean-up testability	June 2017	TL
3	Added detergent metering requirements Added ECH2O can continue operation when cartridge expires. Cleaned up cleaning subsystem section; actuator requirements, brush eject requirements. Added updated switch diagram. Updated section 7.7.1 for low-batt cutoff	Multiple	6/28/2017	TL & WZ
4	Further cleanups Corrected conventional flow-rates Removed reference to cost targets Elaborated on one-touch button and vacuum button functionality	Multiple	8/9/17	WZ
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1 Introduction

1.1 Purpose

The Monaco machine is a stand-on floor scrubber. The machine is intended to compliment Tennant's current offering of commercial walk-behind floor scrubbers. The machine offers 20" single-disk and 24" dual-disk heads and is for use in commercial and industrial applications. There will be two models offered: The Tennant Model T350, and the Nobles Model SS350.

Standard electrical features include:

- Debris Management
- Hour Meter
- Circuit Protection
- Key Switch
- Emergency Stop Switch
- On-Board Charging System
- Low-battery cutoff
- Brush Change
- CAN communication between hardware modules
- USB connection for system programming and diagnostics
- Electric drive with adjustable speed control and reverse function
- Electrically Controlled two position scrubbing pressure selection

Optional Features include:

- Off-Board Charging System
- EC-H_2O (Gen. II "NanoClean")
- Sound reduction (Quite mode Vacuum)
- Detergent Dispensing ("Severe Environment" mode)
- LCD touchscreen
- IRIS Telemetry
- Automatic Battery Watering System

All Requirements will be identified by "Shall" Statements.

Design Goals will be identified by "Should" Statements.

1.2 Intended Audience and Reading Suggestions

This Subsystem Requirements Specification (SRS) is intended to define the features and functions for the Monaco micro rider, based on the requirements outlined in the Monaco micro rider Product Requirements Specification (PRS). It is targeted for electrical and software designers and will be the defining document for the creations of the Hardware Design Specification (HDS) and Software Design Specification (SDS). This document is also targeted for other stakeholders, such as the Product Manager, Engineers, Software Developers, Mechanical Designers, Marketing and Test.

1.3 Project Scope

This document is designed specifically to describe the functional requirements as they relate to and are influenced by the hardware and software designs. All requirements contained within this document are for the Monaco micro rider electrical controls design. Any references to other subsystems outside of

Monaco micro rider are only in support of this design. This document does not describe functional requirements for other elements of the machine.

1.4 Support Documentation

The defining requirements for this document are contained within the Monaco Scrubber Performance Requirements Specification (PRS) and this requirement document shall comply with it.

Monaco Scrubber Performance Requirements Specification (PRS)
Machine Directive 2006/42/EC (European Commission)
CE Volga Wet Technical File

1.4.1 Other sub-system Documentation

There are sub-systems that will be mentioned in this document that have their own requirements documentation.

2 Context

2.1 Monaco Scrubber Context Diagram

The following context diagram highlights the major components of the Monaco Controls architecture.

Figure 2-1 Monaco Scrubber Diagram

Adobe Acrobat
Document

3 Certifications

Reference PRS Section 3.2.2 for a complete list of regulatory/safety/agency compliance requirements.

3.1 Machine Directive Requirements

The Monaco Control System shall be compliant to the European Commission Machine Directive 2006/42/EC defined in the following table:

Machinery Directive Clause	Title	Related Tennant Safety Standard
1.1.2	Principles of Safety Integration	
1.1.4	Lighting	
1.2.1	Safety and reliability of control systems	
1.2.2	Control devices	
1.2.3	Starting	
1.2.4.1	Normal stop	
1.2.4.2	Operational stop	
1.2.4.3	Emergency stop	
1.2.5	Selection of control or operating modes	
1.2.6	Failure of power supply	
1.3.6	Risk related to variations in operating conditions	
1.3.7	Prevention of risks related to moving parts	
1.3.9	Risks of uncontrolled movemetns	
1.4.2.2	Interlocking movable guards	
1.5.1	Electricity supply	83095 Electrical
1.5.2	Static electricity	
1.5.3	Energy supply other than electricity	
1.5.4	Errors of fitting	
1.5.10	Radiation	83095 Electrical
1.5.11	External radiation	
1.7.1	Information and warnings on the machinery	73638 Warning Labels
1.7.1.1	Information and information devices	
1.7.1.2	Warning devices	73984 Warning Devices
1.7.2	Warning of residual risks	73638 Warning Labels
1.7.3	Marking of machinery	73638 Warning Labels
3.3.2	Starting/moving	
3.3.3	Travelling function	83091 Brakes 83099 Machine Creep
3.3.4	Movement of pedestrian cotnrolled machinery	
3.3.5	Control circuit failure	
3.6.1	Signs, signals and warnings	
3.6.2	Marking	

3.2 CE Technical File

Compliance to machine Directive requirements shall be identified in the Monaco CE Technical File.

3.3 Safety

The controls system shall be designed to prevent hazardous situations.

Reference: IEC 60335-1, EN 894-X, EN 62061, ISO 13849-1

3.3.1 Touch Temperature

The maximum surface temperature of any electrical component, heat-sink, cover, etc. likely to be touched shall be less than 122 degrees F (50 degrees C). (Highest ambient operating temperature for the machine shall be 110 degrees F (43.3 degrees C))

This temperature is less than the no burn threshold identified in CENELEC GUIDE 29 Temperatures of hot surfaces likely to be touched, Guidance document for Technical Committees and manufacturers (Edition 1, 2007-04) Appendix A.

3.3.2 Control Devices

Monaco control devices shall be clearly visible, identifiable, easily operated, and intuitive.

Reference: IEC 60335-1, IEC 60335-2-72, EN 894-1, EN 894-2, EN 894-3, EN 981, IEC 61310-1, IEC 61310-2, IEC 61310-3

4 System Voltage

Primary machine power shall be provided by a rechargeable battery powered 24VDC electrical system.

The Scrubber control system shall be able to operate at system voltages as high as 34VDC.

4.1 Batteries

The types of batteries used shall be limited to the types outlined in PRS section 3.3 “Power System”

4.2 Runtime

Machine runtimes will vary depending on battery size/type and machine configuration

The requirements for machine runtime are specified in PRS Section 3.2.4.

4.3 Battery Cables

The battery connection to the machine shall have a 'quick-disconnect' connector for safety during emergency and service.

The 'quick-disconnect' connector shall allow battery disconnection without pulling on the cables.

The positive '+' battery cable to the machine shall have a fuse to protect the cable and the batteries.

5 Control Subsystem States

The Monaco Scrubber electrical controls subsystems shall have three states of operation:

1. OFF
2. ON
    a. Pad Change Mode
    b. Transport Mode
    c. Squeegee Mode
    d. Scrub Mode
    e. Manual Mode
    f. Supervisor Mode
3. CHARGE

5.1 OFF State

In the OFF state, the Scrubber control system shall consume less than 2W of battery power.

In the OFF state, no control subsystems shall be operable (such as cleaning, debris management, or propel control subsystems).

5.2 ON State

The operator interface shall provide a key switch to control power to the machine.

The key switch shall have open contacts in the OFF position, and closed contacts in the ON position.

The key switch shall transition the Scrubber from the Off State to the On State.

The On State shall be indicated by illumination of the BDI in the operator environment.

In the ON state, control subsystems shall be operable.

The Scrubber controls shall provide battery charge level in the ON and CHARGE States (on-board chargers only).

5.2.1 Manual Mode

The machine shall be capable of operating in a "Manual Mode", where independent user control of certain machine functions is possible.

The Propel Control subsystem shall be inoperable while in Manual Mode.

For Monaco machines with a membrane keypad, Manual Mode shall be entered by pressing and holding the One-Touch button while using the key switch to enter the ON state.

For Monaco machines with a ProPanel touchscreen user interface, Manual Mode shall be entered by logging in as a Service Technician. Logging in as a Service Technician shall require a passcode.

In Manual Mode (for membrane keypads):

- Pressing the One-Touch button shall toggle the scrub motor on and off
  - Scrub motor shall default to off
  - One-Touch button LED shall be on when motor is on
  - One-Touch button LED shall be off when motor is off
- Pressing the GO and OPS switches simultaneously shall move the scrub head actuator
  - Pressing the Down Force select button shall toggle actuator direction
  - Default direction shall be down/actuator extend
  - High Down Force LED shall indicate down/actuator extend
  - Low Down Force LED shall indicate up/actuator retract
- Pressing the Flow Rate adjustment button shall cycle solution flow through its four settings (off, low, medium, and high flow rate)
  - Default flow rate shall be OFF, with no Flow Adjustment LEDs illuminated
  - Cycling through flow rates shall illuminate the Flow Adjustment LEDs accordingly (off, low, medium, high, repeat)
- Pressing the Vacuum button shall toggle the vacuum motor on and off
  - Vacuum motor shall default to off
  - Vacuum button LED shall be on when vacuum motor is on
  - Vacuum button LED shall be off when vacuum motor is off
  - Pressing the Fan Quiet button shall toggle Fan Quiet mode

5.3 CHARGE State

The Scrubber shall provide for an on-board battery charging system.

Activation of the battery charging system shall put the machine into the CHARGE state.

In the CHARGE state, no control subsystems shall be operable (such as cleaning, debris management, or propel control subsystems).

6 Environments

Monaco Scrubber is designed to clean a variety of flat floor surfaces primarily in indoor environments.

6.1 Temperature

The machine controls shall operate in temperatures between 36°F (2.2°C) and 110°F (43.3°C).

The machine controls shall function after storage temperatures between -20°F (-29°C) and 150°F (65.6°C).

6.2 Humidity

The machine controls shall operate in non-condensing humidity from 5% to 95% within the operational temperature range.

The machine controls shall function after storage in non-condensing humidity from 5% to 95% within the storage temperature range.

6.3 Temperature Cycling

After exposure to the storage temperature and humidity conditions identified in PRS sections 3.2.1.2 and 3.2.1.3, the machine controls shall be functional within 1 hour after return to operational temperature and humidity conditions.

6.4 Ingress Protection Rating

The placement of machine controls components shall prevent ingress of water and cleaning detergents during machine operation.

The machine controls Charger shall be rated at greater than or equal to IP20

The machine shall meet IPX3 rating.

6.5 Service Life

The service life of the machine controls shall be 3 years or 2000 hours minimum. Service life does not include routine maintenance items and motor brush replacements.

6.6 Vibration

The machine controls circuit card assemblies shall be VITA 47 V3 levels for vibration.

Levels are MIL-STD-810F test method $0.1G^2/Hz$ at any frequency from 100 Hz to 1 KHz.

3dB/OCT at frequencies between 5 Hz to 100 Hz.

-6dB/OCT at frequencies between 1 KHz to 2 KHz.

6.7 ESD/Electrical Fast Transient

The Scrubber controls shall be functional after exposure to Electrostatic discharge (ESD) per Tennant Testing Standard – Electrical Static Discharge Testing, (Reference Standard: ES0010).

The Scrubber controls shall be functional after exposure to Electrical Fast Transient Burst (EFTB) per Tennant Standard – Electrical Fast Transient Burst Testing, (Reference Standard: ES0011).

6.8 EMI/EMC

The machine controls subsystem shall be immune to radiation from other equipment per IEC 60335-1 and Directive 2004/108/EC section 1.5.1.

7 Controls Subsystems

All hardware modules (PCB Assemblies) on the machine shall be able to be connected to a CAN bus.

7.1 Operator Environment

Definition: The Operator Environment is defined as the area where operator inputs, machine status, and indications are located.

The Operator controls and indicators shall be clearly visible from the operator position.

The Operator controls and indicators shall be simple to use, i.e. switches, buttons, knobs, LEDs, etc.

7.1.1 Operator Console

7.1.1.1 User Interface

The operator console shall provide a main User Interface panel.

The panel shall be the main area of focus for the users, where the main indicators and inputs are located.

The User Interface shall display:

- Fault indication
- Battery status
- ABW status (if equipped)
- Fan Quiet mode status (if equipped)
- “Severe Environment” detergent metering system status (if equipped)
- EC-H2O status (if equipped)
- Down force setting (low or high)
- Flow rate setting (off, low, medium, or high)
- “One-Touch” mode (on or off)
- Vacuum only mode (on or off)
- Machine presets (on or off)
- Brush Change

The user interface shall provide buttons for

- Down force adjustment
- “One-Touch” operation
- Flow rate adjustment
- 2 Machine Presets
- Vacuum only mode
- Fan Quiet mode
- “Severe Environment” detergent metering mode

- EC-H_2O
- Brush eject

The various features and functions of the User Interface panel shall be discussed in the following sections.

The operator console shall house a User Interface hardware module (“UI” board). The UI board shall provide the connections and signals for the buttons and LEDs on the operator interface.

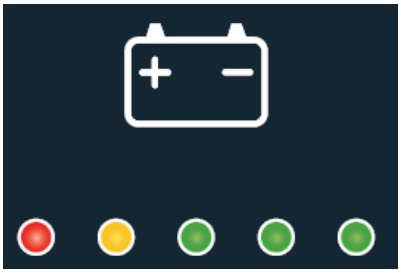
The UI board shall have a CAN bus connection.

7.1.1.2 Optional LCD Interface

The Controls Subsystem shall provide for the utilization of an optional LCD Display Touchscreen controller (as specified in the Controls Subsystem Requirements Specification (SRS) for the “Pascal” Touchscreen Module). The Touchscreen module shall be a drop in replacement for the Controls Subsystem User Interface hardware module. The Touchscreen Module shall have a CAN bus connection.

7.1.1.3 Battery Discharge Indicator

The User Interface panel shall provide a Battery Discharge Indicator (BDI) which accurately indicates state of charge remaining on the batteries based on battery voltage level while under load (i.e. Cleaning Subsystem operational).



BDI Indicator

The BDI shall be visible to the operator while operating the machine.

The BDI shall consist of 5 levels with the following specifications:

Level	Display Color	Battery Level
1	Red	> 20%
2	Yellow	> 30 %
3	Green	> 40 %
4	Green	> 50 %
5	Green	> 60 %

Low-voltage cutoff state shall be indicated by flashing the level 1 RED indicator. See “Power Management Systems” section of this document for details on low-voltage cutoff.

The BDI status shall be driven according to the type of battery installed in the machine (based on charger configuration).

The BDI shall also be used as the machine ON/OFF indicator.

7.1.1.4 One-Touch Button

One-Touch Button

Operator Interface button with illuminated icon and “system active” LED

The One-Touch button shall allow the user to enter into or exit from scrub mode.

The One-Touch button shall have an LED in the corner that illuminates when the system is in scrub mode.

7.1.1.5 Vacuum Button

Vacuum Button

Operator Interface button with illuminated icon and “system active” LED

The Vacuum button shall allow the user to enable or disable the vacuum.

The Vacuum button shall have an LED in the corner that illuminates when the system is operating the vacuum.

When entering scrub mode by pressing the One-Touch button, the Vacuum Button LED shall also illuminate, indicating that the Vacuum is active.

When in scrub mode the user shall be able to turn off the vacuum by pressing the vacuum button.

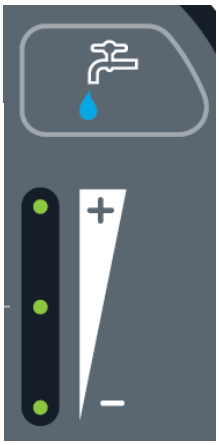
7.1.1.6 Solution Flow Rate

There shall be a single push-button on the operator interface that will allow the user to cycle through the 4 set points.

There shall be 3 LED indicators on the operator console to indicate the current solution flow rate as follows: OFF = NO LEDs lit, LOW = 1 LED, MED = 2 LEDs, HIGH = 3 LEDs

Operator Interface

Solution flow rate adjustment button and LEDs



The operator shall be able to select the solution flow rate in Transport Mode, Vac-Only Mode or Scrub Mode.

The conventional solution flow rate shall be able to be turned off while scrubbing (for double-scrubbing purposes).

At machine startup, the flow rate shall default to the last flow setting.

7.1.1.7 Detergent Metering

There shall be a single push-button on the operator interface that will allow the user to control operation of the detergent metering subsystem.

The button shall have an illuminated system icon when the option is installed on the scrubber.

The button shall indicate when the detergent metering system is active.

The operator shall be able to enable Detergent Metering in Transport Mode, Vac-Only Mode or Scrub Mode.

Detergent Metering system

Operator Interface button with illuminated icon and “system active” LED

Pushing the detergent button for less than 1 second shall run the detergent system in Timed Mode.

The active status shall blink at 1 Hz in Timed Mode.

The active status in Timed Mode shall blink at 2Hz when 5 seconds of less of dosing is remaining.

Pushing the button for at least 3 seconds shall run the detergent system in Constant-On mode.

The active status indicator shall remain on in Constant-On Mode.

The detergent tank empty status shall be indicated by blinking the button icon for 15 seconds when the tank runs out of detergent while operating.

The detergent tank empty status shall be indicated by blinking the button icon for 15 seconds when the operator presses the button.

Pressing the button while system is active shall turn off the system.

After key cycle, detergent status shall not be maintained.

7.1.1.8 Down Pressure

There shall be a single push-button on the operator interface that will allow the user to cycle through the 2 down pressure set points.

There shall be 2 LEDs indicators on the operator console to indicate the current down pressure as follows: high position (max down pressure) = 2 LEDs, low position (low down pressure) = 1 LED.

Operator Interface

Down Pressure adjustment button and LEDs

The operator shall be able to select the down pressure in Transport Mode, Vac-Only Mode or Scrub Mode.

The down pressure LED indicators shall blink when the machine has automatically reduced the users down force set point.

At machine startup, the downforce setting shall default to the last setting used.

Low downforce shall be the factory default setting.

7.1.1.9 Quiet Mode Button

There shall be a single push-button on the operator interface that will allow the user to activate and deactivate the vacuum Quiet Mode operation.

The operator shall be able to enable Quiet Mode in Transport Mode, Vac-Only Mode or Scrub Mode.

When Fan Quiet mode is active, the “system active” LED shall be illuminated green.

Fan Quiet mode

Operator Interface button with illuminated icon and “system active” LED

Machines with the Fan Quiet mode option shall illuminate the button icon upon machine power up.

7.1.1.10 ec-H_2O Button

The User Interface panel shall provide a button for toggling the ec-H_2O system ON/OFF.

Machines with ec-H_2O installed shall default to having the ec-H_2O system ON upon power up.

The ec-H_2O button shall have an LED in the corner that illuminates when the ec-H_2O system is ON.

The "ec-H_2O" icon on the user interface panel shall be lit blue when the ec-H_2O system is installed and no system faults are detected.

The "ec-H_2O" icon on the user interface panel shall be able to turn red for displaying ec-H_2O faults when the ec-H_2O system is installed.

The status indicator shall operate as follows:

- **Solid Blue (Text):** Indicates that we have ec H2O option on the machine
- **Solid Green (LED)**: indicates that the ec-H_2O system is enabled and no system faults are being reported
- **Solid Red (Text)**: indicates to the user that an electrical fault has been detected
- **Flashing Red (Text)**: indicates to the user of a water condition or plumbing failure
- **Alternating Blue/Red (Text)**: indicates the need to replace the cartridge in the water conditioning module

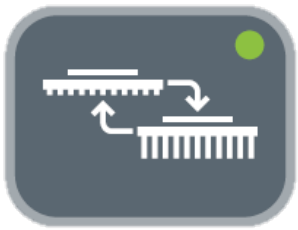
The solution flow rate button shall be used to set ec-H_2O flow rates when ec-H_2O is active.

The ec-H_2O module flow rate indicator shall match the machine flow rate setting.

At machine startup, the flow rate shall default to the last flow setting used.

7.1.1.11 Brush Eject Button

The User Interface panel shall provide a button for operating the brush eject function.



The brush eject function shall be optional.

The brush eject button shall have an LED that illuminates while the eject process is active. See Section 7.3.3.2 for Eject Process.

7.1.1.12 Preset Buttons

The scrubber shall offer configurable preset buttons for the operator to quickly select a set of scrubbing features.

The operator shall be able to enable Presets in Transport Mode, Vac-Only Mode or Scrub Mode.

When a preset is activated, the active state shall be indicated.

7.1.1.13 Battery Watering Indicator

The operator console shall provide an indicator for battery watering system status.

The battery watering icon shall be lit per the requirements of the automated battery watering system. See “ABW2.0 SRS” for more details on system operation.

7.1.1.14 Fault Indicator

The operator console shall provide an indicator for scrubber faults and warnings.

Service icon on User Interface

The Service Indicator icon shall illuminate when a fault is detected.

7.1.1.15 Emergency Stop Switch

The operator console shall provide an Emergency Stop switch.

The Emergency Stop switch shall be located within easy reach of the operator.

The Emergency Stop switch shall be initiated by a single human action using a manually actuated control device.

To resume machine operation from an emergency stop condition, the user shall be required to unlatch the emergency stop switch AND cycle the key switch to the OFF position, then back to the ON position.

7.1.1.16 Horn Button

The operator console shall provide a horn button.

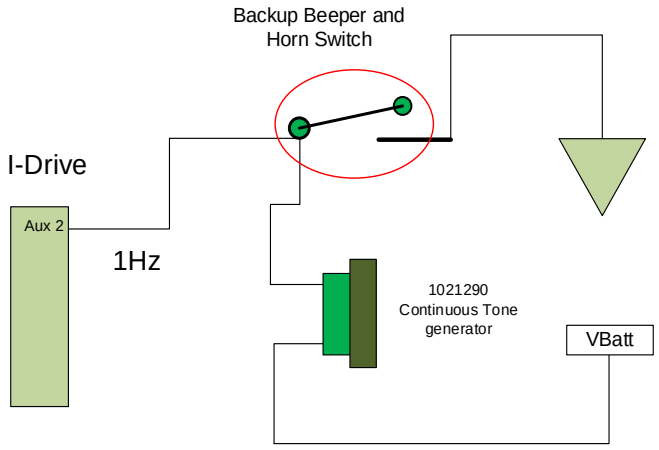
The horn button shall be normally open, with momentary-close action.

Pressing the horn switch at any time when the machine is powered on shall result in the sounding of the horn.

The horn shall have a continuous tone while the switch is held closed.

As a configurable option, the horn shall also be able to be used as a backup beeper. The “Aux2” output on the propel controller shall be used to facilitate the backup beeper functionality. The diagram below outlines the connections for this circuit.

When configured as a backup beeper, the horn shall have a pulsed tone anytime the machine is driving in reverse. Pressing the horn switch while driving in reverse shall override the backup beeper function and revert to a continuous tone.



7.1.1.17 Hour Meter

The operator console shall provide an hour meter.

The hour meter shall display total machine hours as defined by scrub activation in the On State.

The total machine hour display shall be readable without battery power.

The total machine hour display shall not be able to be reset.

7.1.1.18 Key Switch

The operator console shall provide a machine on/off key switch as identified in Paragraph 3.3.2.

7.1.1.19 Forward/Reverse Direction Selector Switch

The operator console shall provide a rocker switch that allows the user to select the desired propel direction in forward or reverse.

The Forward/Reverse Direction Selector Switch shall have the following functionality:

- DPDT
- Momentary ON – NONE – Momentary ON

The Forward/Reverse Direction Selector Switch shall have illuminated indication of the selected direction. The indicators shall be two arrows arranged to indicate forward or reverse direction. The backlighting for the indicators shall be independently controlled.

The logic for operating the switch and switch indicators is outlined in the "Propel Control Logic" section below.

7.1.1.20 Drive Speed Adjustment knob

The operator console shall provide a knob for selecting the speed of the machine.

Twisting the knob clockwise shall increase the machine speed. Twisting the knob counter-clockwise shall decrease the machine speed.

The maximum forward speed of the machine shall be 3.50 MPH +/- 0.4 MPH

The minimum forward speed of the machine shall 7 FPM +/- 2 FPM

The maximum reverse speed of the machine shall be 1.6 MPH +/- 0.3 MPH (144 FPM +/- 24 FPM)

The minimum reverse speed of the machine shall be 0 FPM

As an option, the maximum forward speed of the machine shall be 2.8 MPH +/- 0.4 MPH

Details on setting propel control subsystem speed limitations is covered below in the "Propel Control Subsystem" in section 7.2.

7.1.2 Operator Platform

7.1.2.1 Go Switch

The operator platform shall provide a Go switch.

The Go Switch shall be normally open, with momentary-close action.

The logic for operating the switch is outlined in the "Propel Control Logic" section below.

7.1.2.2 Operator Presence Switch

The operator platform shall provide an Operator Presence Switch.

The Operator Presence Switch shall be normally open, with momentary-close action.

The logic for operating the switch is outlined in the "Propel Control Logic" section below.

7.1.3 Other Operator Interfaces

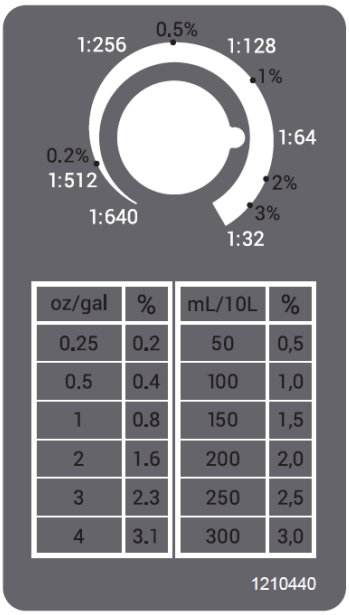
7.1.3.1 Detergent Flow Knob

A potentiometer knob shall provide operator detergent flow rate adjustment.

The knob shall contain an indicator that points to the selected mix ratio of detergent to solution.

Detergent Metering system

Adjustment potentiometer and label showing mix ratios



oz/gal	%	mL/10L	%
0.25	0.2	50	0,5
0.5	0.4	100	1,0
1	0.8	150	1,5
2	1.6	200	2,0
3	2.3	250	2,5
4	3.1	300	3,0

7.2 Propel Control Subsystem

The machine controls architecture shall provide for a means of propelling the machine.

The machine Propel Control subsystem shall be comprised of a propel motor and a motor controller. Requirements for these components are outlined below.

The machine Propel Control subsystem shall be capable of continuously transporting the machine with the worst-case weight and feature configuration.

The machine Propel Control subsystem shall be capable of transporting up a 35 ft., 5 degree ramp at GVW and a 9ft., 11 degree ramp with empty tanks and heavy operator as specified by PRS Section 3.2.13.

7.2.1 Propel Motor

The propel motor shall be rated at 24 VDC.

The propel motor shall be equipped with a 24 VDC electronic parking brake with manual release lever. The parking brake shall be active/holding when power is OFF, and release when power is applied.

The propel motor shall be equipped with a thermal switch for over-temperature protection. The switch shall be normally closed, and open when motor is determined to be too hot per manufacturer specifications.

The propel motor and transaxle assembly shall be sized appropriately to meet the transport requirements as outlined in the PRS.

7.2.2 Propel Motor Controller

The Propel Motor Controller shall be a commercially available, off-the-shelf, device that is capable of being configured to meet the requirements of the Propel Control Subsystem as outlined in the sections below.

The Propel Motor Controller shall be rated to operate at 24 VDC nominal, and capable of delivering up to 90A to the propel motor when conditions demand.

The Propel Motor Controller shall have configurable I/O to meet the following requirements:

- An output to control the propel motor parking brake
- An input to monitor the state of the propel motor thermal switch
- An output to activate the backup beeper

The Propel Motor Controller shall have an RS232 serial port.

The Propel Motor Controller shall be able to transmit diagnostic information, including propel motor current, when queried over the RS232 port.

7.2.3 Propel Control Logic

In order for the machine to transport, a specific sequence of steps shall be followed by the user to ensure safe operation. The logic shall be setup such that unexpected machine movement is never experienced by the user.

The steps that shall be followed to propel the machine are as follows:

1. Key ON machine
2. User shall step onto operator platform (thus closing Operator Presence Switch)
3. Upon sensing presence of user, the Direction Selector Switch arrows shall flash at 1 Hz, prompting the user to select a direction.
4. Once user has selected direction, pressing the Go Switch shall propel the machine in the desired direction.
5. Machine speed can be adjusted at any time by adjusting the Drive Speed Adjustment Knob.

If a user attempts to transport the machine by closing the Go switch while the Operator Presence Switch is closed, but hasn't selected a direction yet, the Direction Selector Switch arrows shall flash at a rate of 5 Hz and prevent scrubber motion.

Once a direction has been selected, the user shall be able to start and stop transport by closing and opening the Go switch. As long as the Operator Presence Switch stays closed, the user shall not be forced to select a direction again.

While propelling, a user shall be allowed to change direction without releasing the GO switch.

The machine shall never be allowed to transport if any of the following switches are detected to be OPEN:

- Operator Presence Switch
- Go Switch
- E-Stop Switch
- Propel Motor Thermal Switch

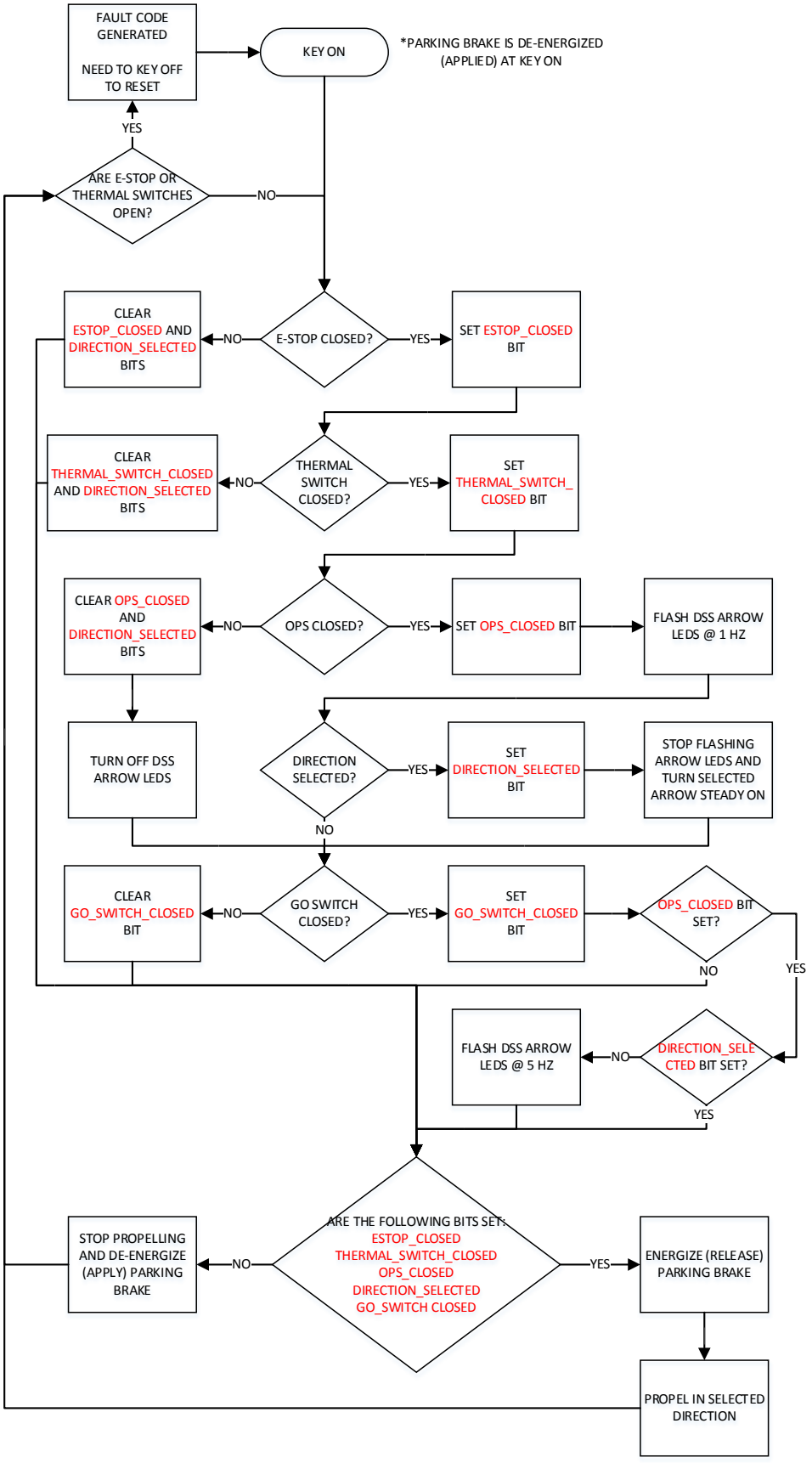
Opening of the E-Stop Switch at any time while the machine is keyed on shall result in a shutdown of the Propel Control Subsystem and display appropriate fault code.

An E-Stop fault shall require a key cycle to clear the fault code.

Opening of the Propel Motor Thermal Switch at any time while the machine is keyed on shall result in a shutdown of the Propel Control Subsystem and display appropriate fault code.

A Propel Motor Thermal Switch fault shall require a key cycle to clear the fault code.

The flow chart below details the logic for the Propel Control Subsystem:


FAULT CODE GENERATED
NEED TO KEY OFF TO RESET
KEY ON
*PARKING BRAKE IS DE-ENERGIZED (APPLIED) AT KEY ON
YES
ARE E-STOP OR THERMAL SWITCHES OPEN?
NO
CLEAR ESTOP_CLOSED AND DIRECTION_SELECTED BITS
NO
E-STOP CLOSED?
YES
SET ESTOP_CLOSED BIT
CLEAR THERMAL_SWITCH_CLOSED AND DIRECTION_SELECTED BITS
NO
THERMAL SWITCH CLOSED?
YES
SET THERMAL_SWITCH_CLOSED BIT
CLEAR OPS_CLOSED AND DIRECTION_SELECTED BITS
NO
OPS CLOSED?
YES
SET OPS_CLOSED BIT
FLASH DSS ARROW LEDS @ 1 HZ
TURN OFF DSS ARROW LEDS
DIRECTION SELECTED?
YES
SET DIRECTION_SELECTED BIT
STOP FLASHING ARROW LEDS AND TURN SELECTED ARROW STEADY ON
NO
CLEAR GO_SWITCH_CLOSED BIT
NO
GO SWITCH CLOSED?
YES
SET GO_SWITCH_CLOSED BIT
OPS_CLOSED BIT SET?
NO
YES
FLASH DSS ARROW LEDS @ 5 HZ
NO
DIRECTION_SELECTED BIT SET?
YES
ARE THE FOLLOWING BITS SET:
ESTOP_CLOSED
THERMAL_SWITCH_CLOSED
OPS_CLOSED
DIRECTION_SELECTED
GO_SWITCH CLOSED
STOP PROPELLING AND DE-ENERGIZE (APPLY) PARKING BRAKE
NO
YES
ENERGIZE (RELEASE) PARKING BRAKE
PROPEL IN SELECTED DIRECTION

7.2.4 Controller Configuration

The Propel Motor Controller shall be capable of being configured to meet the requirements of the Propel Control Subsystem.

There shall be two configurations for the propel controller available: one standard and one for available backup alarm. Table 1 displays the standard settings.

Table 1. Standard Configuration

Parameter	Setting
Forward Acceleration - Fast	6.0 secs
Forward Acceleration - Slow	5.0 secs
Reverse Acceleration - Fast	3.0 secs
Reverse Acceleration - Slow	3.0 secs
Forward Deceleration - Fast	0.6 secs
Forward Deceleration - Slow	0.6 secs
Reverse Deceleration - Fast	1.5 secs
Reverse Deceleration - Slow	1.5 secs
Maximum Forward Speed - Fast	100%
Minimum Forward Speed - Fast	2%
Maximum Forward Speed - Slow	100%
Minimum Forward Speed - Slow	2%
Maximum Reverse Speed - Fast	30%
Minimum Reverse Speed - Fast	2%
Maximum Reverse Speed - Slow	30%
Minimum Reverse Speed - Slow	2%
Start Rate Coefficient	5%
End Rate Coefficient	5%
Maximum Current Limit	60 Amps
Minimum Current Limit	25 Amps
Current Foldback Time	255 secs
Current Foldback Level	100%
Current Foldback Threshold	60 Amps
Drive Boost Current	90 Amps
Drive Boost Time	10 secs
Motor Cooling Time	900 secs
Current Limit Threshold Temperature	80 deg. C
Motor Compensation	10 mOhms
Solenoid Brake Timeout	100 ms
Full Speed Output Voltage	24 V
Traction Soft Stop	Enable
Push too fast Speed Limit	78
ISO Tests / ISO Test Resistor	On
Throttle Polarity / Throttle Invert	Normal
Throttle Gain	360%
Throttle Deadband	26%
Throttle Type	Single-ended
Throttle handling at power-up	Inhibit
TruCharge Cable Resistance	25 mOhms
TruCharge Calibration Factor	100
Low Battery Alarm	Off
Auxiliary 1 Output Mode	Solenoid Brake
Auxiliary 1 Output Off Delay	0 secs

Parameter (Cont.)	Setting
Auxiliary 2 Output Mode	Off
Auxiliary 2 Output Off Delay	0 secs
Auxiliary 3 Output Mode	Reverse Traction
Auxiliary 3 Output Off Delay	0 secs
Aux 3 Input Type	None
Aux 3 Output Voltage	24V
Diagnostic Flash Sequence	TruCharge
Diagnostic Alarm	Off
Status Output Type	TruCharge
Auto Power Down Time / Sleep Timer	0 mins
Belly button switch state	Normally Closed
Belly button speed	1%
Belly button timer	0 secs
Battery Lockout Voltage	20.0 Volts
Battery Lockout Time	15 secs
Battery Lockout Voltage 2	20.0 Volts
Battery Lockout Type	Traction
Battery Lockout Input Select	None
Pulse Alarm	No
Reverse Alarm	No
Check Throttle References	No
Inhibit 1 Latching	Yes
Inhibit 1 Mode	Open Circuit
Inhibit 1 Target	Forward Drive,Reverse Drive
Inhibit 1 debounce time	0.50 secs
Inhibit 1 Speed	0%
Inhibit 2 Latching	No
Inhibit 2 Mode	Pull Low
Inhibit 2 Target	Forward Drive,Reverse Drive
Inhibit 2 debounce time	0
Inhibit 2 Speed (TNC Revision Parameter)	0%
Direction Switches	No
Tiller Arm Switch	No
Solenoid Brake Check / Brake Fault Detect	Yes
Anti-Rollback Level	12
Slope Factor	265
Anti-Rollback velocity	0
Pull Away Delay	30
Speed Limit Potentiometer enabled	On
Brake Alarm	Off

Table 2 below shows the optional controller configuration settings for the available backup alarm machine:

Table 2. Available Backup Alarm Configuration

Parameter	Setting
Forward Acceleration - Fast	6.0 secs
Forward Acceleration - Slow	5.0 secs
Reverse Acceleration - Fast	3.0 secs
Reverse Acceleration - Slow	3.0 secs
Forward Deceleration - Fast	0.6 secs
Forward Deceleration - Slow	0.6 secs
Reverse Deceleration - Fast	1.5 secs
Reverse Deceleration - Slow	1.5 secs
Maximum Forward Speed - Fast	100%
Minimum Forward Speed - Fast	2%
Maximum Forward Speed - Slow	100%
Minimum Forward Speed - Slow	2%
Maximum Reverse Speed - Fast	30%
Minimum Reverse Speed - Fast	2%
Maximum Reverse Speed - Slow	30%
Minimum Reverse Speed - Slow	2%
Start Rate Coefficient	5%
End Rate Coefficient	5%
Maximum Current Limit	60 Amps
Minimum Current Limit	25 Amps
Current Foldback Time	255 secs
Current Foldback Level	100%
Current Foldback Threshold	60 Amps
Drive Boost Current	90 Amps
Drive Boost Time	10 secs
Motor Cooling Time	900 secs
Current Limit Threshold Temperature	80 deg. C
Motor Compensation	10 mOhms
Solenoid Brake Timeout	100 ms
Full Speed Output Voltage	24 V
Traction Soft Stop	Enable
Push too fast Speed Limit	78
ISO Tests / ISO Test Resistor	On
Throttle Polarity / Throttle Invert	Normal
Throttle Gain	360%
Throttle Deadband	26%
Throttle Type	Single-ended
Throttle handling at power-up	Inhibit
TruCharge Cable Resistance	25 mOhms
TruCharge Calibration Factor	100
Low Battery Alarm	Off
Auxiliary 1 Output Mode	Solenoid Brake
Auxiliary 1 Output Off Delay	0 secs

Parameter (Cont.)	Setting
Auxiliary 2 Output Mode	Diagnostic/Reverse Alarm
Auxiliary 2 Output Off Delay	0 secs
Auxiliary 3 Output Mode	Reverse Traction
Auxiliary 3 Output Off Delay	0 secs
Aux 3 Input Type	None
Aux 3 Output Voltage	24V
Diagnostic Flash Sequence	TruCharge
Diagnostic Alarm	Off
Status Output Type	TruCharge
Auto Power Down Time / Sleep Timer	0 mins
Belly button switch state	Normally Closed
Belly button speed	1%
Belly button timer	0 secs
Battery Lockout Voltage	20.0 Volts
Battery Lockout Time	15 secs
Battery Lockout Voltage 2	20.0 Volts
Battery Lockout Type	Traction
Battery Lockout Input Select	None
Pulse Alarm	Yes
Reverse Alarm	Yes
Check Throttle References	No
Inhibit 1 Latching	Yes
Inhibit 1 Mode	Open Circuit
Inhibit 1 Target	Forward Drive,Reverse Drive
Inhibit 1 debounce time	0.50 secs
Inhibit 1 Speed	0%
Inhibit 2 Latching	No
Inhibit 2 Mode	Pull Low
Inhibit 2 Target	Forward Drive,Reverse Drive
Inhibit 2 debounce time	0
Inhibit 2 Speed (TNC Revision Parameter)	0%
direction switches	No
Tiller Arm Switch	No
Solenoid Brake Check / Brake Fault Detect	Yes
Anti-Rollback Level	12
Slope Factor	265
Anti-Rollback velocity	0
Pull Away Delay	30
Speed Limit Potentiometer enabled	On
Brake Alarm	Off

7.2.5 Automatic Parking break

The Automatic Parking Break shall be a safety standard on the Monaco scrubber machine.

The propel motor shall have Automatic Parking Break that disengages when the Go Switch is active.

The Automatic Parking Break shall always be engaged when power is not available or when the Go Switch is not active.

7.3 Cleaning Subsystem

The machine controls architecture shall provide for a means of operating a Cleaning Subsystem.

The Cleaning subsystem controls architecture shall be comprised of a scrub motor, scrub motor control circuit, actuator, and actuator control circuit. The assembly that includes these components is commonly referred to as a "scrub head". Requirements for these components are outlined below.

7.3.1 Scrub Motor

The scrub motors used for all scrub head variations shall be permanent magnet DC motors rated at 24 VDC, and 1 HP or less.

7.3.1.1 Scrub Motor Controller

The scrub motor shall be driven by a PWM-controlled output, with over-current protection, current measurement, and fault detection capabilities.

The scrub motor controller shall be able to provide status and current sense data via CAN message to enable scrub motor diagnostics, such as open load, shorted load, and shorted driver.

The controller shall turn off the brush motor driver when an over-current or a short-circuit condition are detected.

7.3.1.2 Scrub Motor Control Logic

The brushed motor speed shall be a fixed voltage over the battery operating range.

The scrub motor shall generate a fault condition if the motor current exceeds 60A continuous for 5 seconds.

7.3.2 Actuator

The scrub head actuator should be rated at 24 VDC.

The actuator shall contain internal limit switches.

The actuator shall contain two internal switches for position detection.

7.3.2.1 Actuator Controller

The actuator shall be driven by a bi-directional PWM-controlled output, with over-current protection, current measurement, and fault detection capabilities.

The controller shall contain input detection of two internal actuator ON/OFF switches.

The actuator controller shall be able to provide status and current sense data via CAN message to enable actuator diagnostics, such as open load, shorted load, and shorted driver.

The controller shall be able to sink/source a nominal current of 2 amps with a maximum of 20 amps.

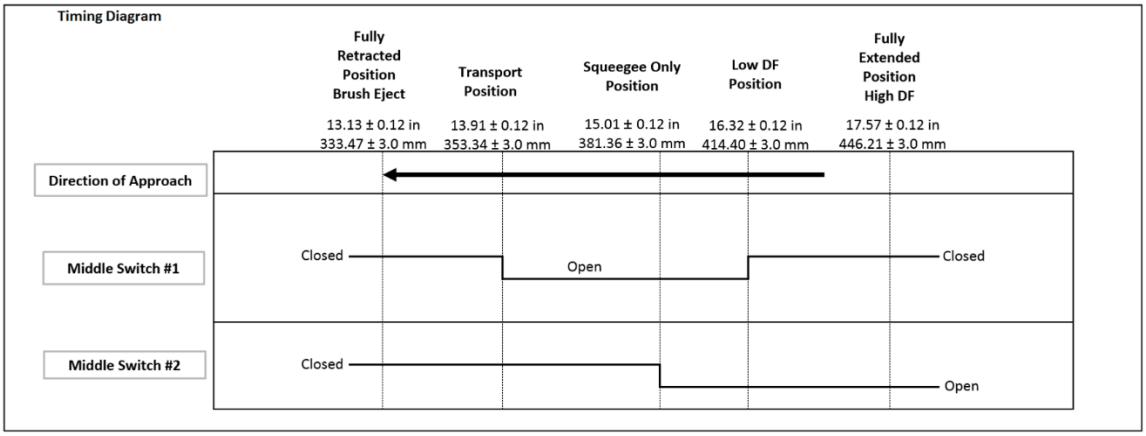
7.3.2.2 Actuator Control Logic

The actuator controls shall lift and lower the head attached scrub motor.

The actuator shall provide positional feedback to the controller via internal switches. There are 5 discrete positions defined as:

1. Pad Eject Position
2. Transport Position
3. Ready/Vac-Only Position
4. Low Down Force Position
5. High Down Force Position

The internal switch states shall behave according to the following logic:



To accommodate for switch hysteresis, the logic shall always stop on change of switch state while moving towards the fully retracted position, as noted in the diagram above.

7.3.3 Cleaning Subsystem Control Logic

The scrub motor shall operate and is considered active *only* when all the following conditions are met:

- The scrubber is propelling forward.
- The cleaning subsystem is enabled.
- The scrub head position is at low or high down pressure positions.
- There are no machine level faults (there may be warnings).

7.3.3.1 Down Pressure Logic

A down pressure change shall apply immediately when actively scrubbing.

The head shall move to the Ready/Vac-Only Position when scrubbing is enabled and operator present switch is engaged.

The head shall return to the Transport position when propelling in reverse.

Down pressure targets shall be obtained through 2 fixed control positions.

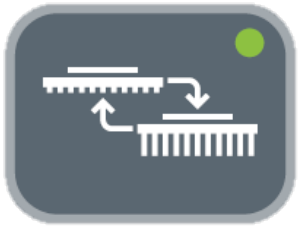
The controller shall automatically reduce the high down pressure to low if either of the following conditions occur:

- Scrub motor current exceeds 40A for 30 seconds, or

- Scrub motor current exceeds 50A for 5 seconds.

If scrubbing is stopped when the scrubber automatically modified the down pressure, the machine shall return to the user set down pressure when scrubbing is resumed.

7.3.3.2 Pad Eject Logic



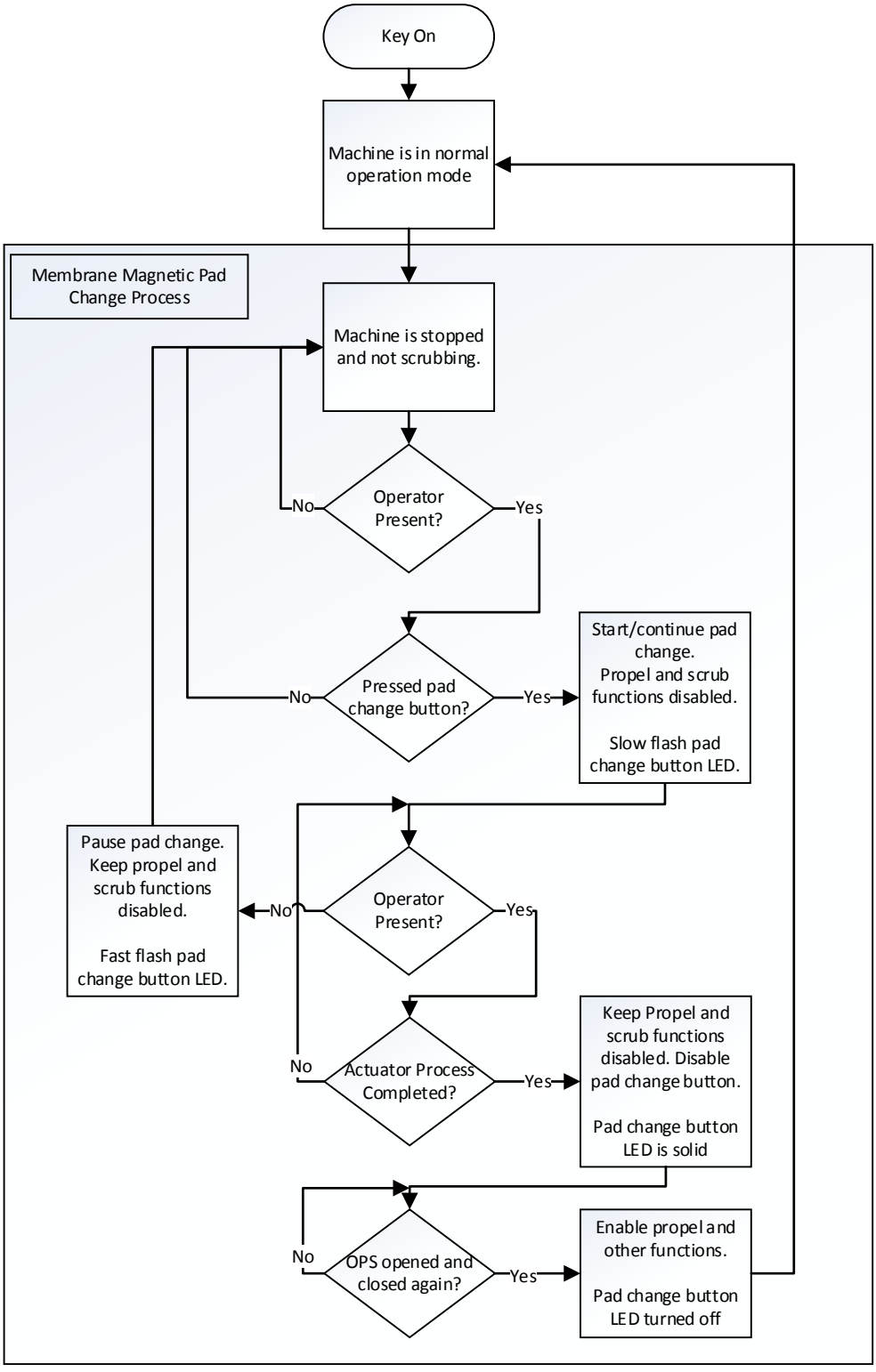
7.3.3.2.1 Magnetic Pad Eject Logic

For machines configured with a magnetic hub type, the magnetic pad eject process shall begin when the following conditions are met:

- The key switch shall be on
- The machine shall be at a complete stop
- The operator presence switch shall be closed
- The machine shall be in Transport Mode
- The machine is configured for magnetic heads
- The user presses Eject button for 1 second

The brush eject function shall operate as follows:

1. The actuator shall retract to the brush eject position (or stop if the actuator current exceeds 5A)
    - OPS needs to stay closed in order for the actuator to fully retract, for safety reasons
    - Actuator drive signal during retract shall be set to 50% to reduce force on mechanical linkages
    - If OPS opens while actuator is retracting, actuator shall stop and wait for OPS to close and user pressing Eject button again before continuing
    - Eject button LED shall flash at 1Hz while actuator is retracting
    - Eject button LED shall flash at 4Hz if OPS opens while actuator is retracting
2. The scrub motor shall run for 0.5 seconds to help eject the brush
3. The actuator shall extend to the transport position
    - Actuator drive signal during extend shall be set to max duty cycle in order to get to the transport position as fast as possible.
    - If OPS opens while actuator is extending, actuator shall stop and wait for OPS to close and user pressing Eject button again before continuing
    - Eject button LED shall flash at 1Hz while actuator is extending
    - Eject button LED shall flash at 4Hz if OPS opens while actuator is extending
4. Normal operation shall be disabled until OPS is opened and closed again to show user has replaced the head that was ejected.
    - Eject button LED shall light solid once actuator has finished lowering after brush head has been ejected
    - Eject button LED shall turn off once OPS is opened and closed
    - Eject button shall be disabled until OPS is opened and closed


Key On
Machine is in normal operation mode
Membrane Magnetic Pad Change Process
Machine is stopped and not scrubbing.
Operator Present?
No
Yes
Pressed pad change button?
No
Yes
Start/continue pad change.
Propel and scrub functions disabled.
Slow flash pad change button LED.
Pause pad change.
Keep propel and scrub functions disabled.
Fast flash pad change button LED.
Operator Present?
No
Yes
Actuator Process Completed?
No
Yes
Keep Propel and scrub functions disabled. Disable pad change button.
Pad change button LED is solid
OPS opened and closed again?
No
Yes
Enable propel and other functions.
Pad change button LED turned off

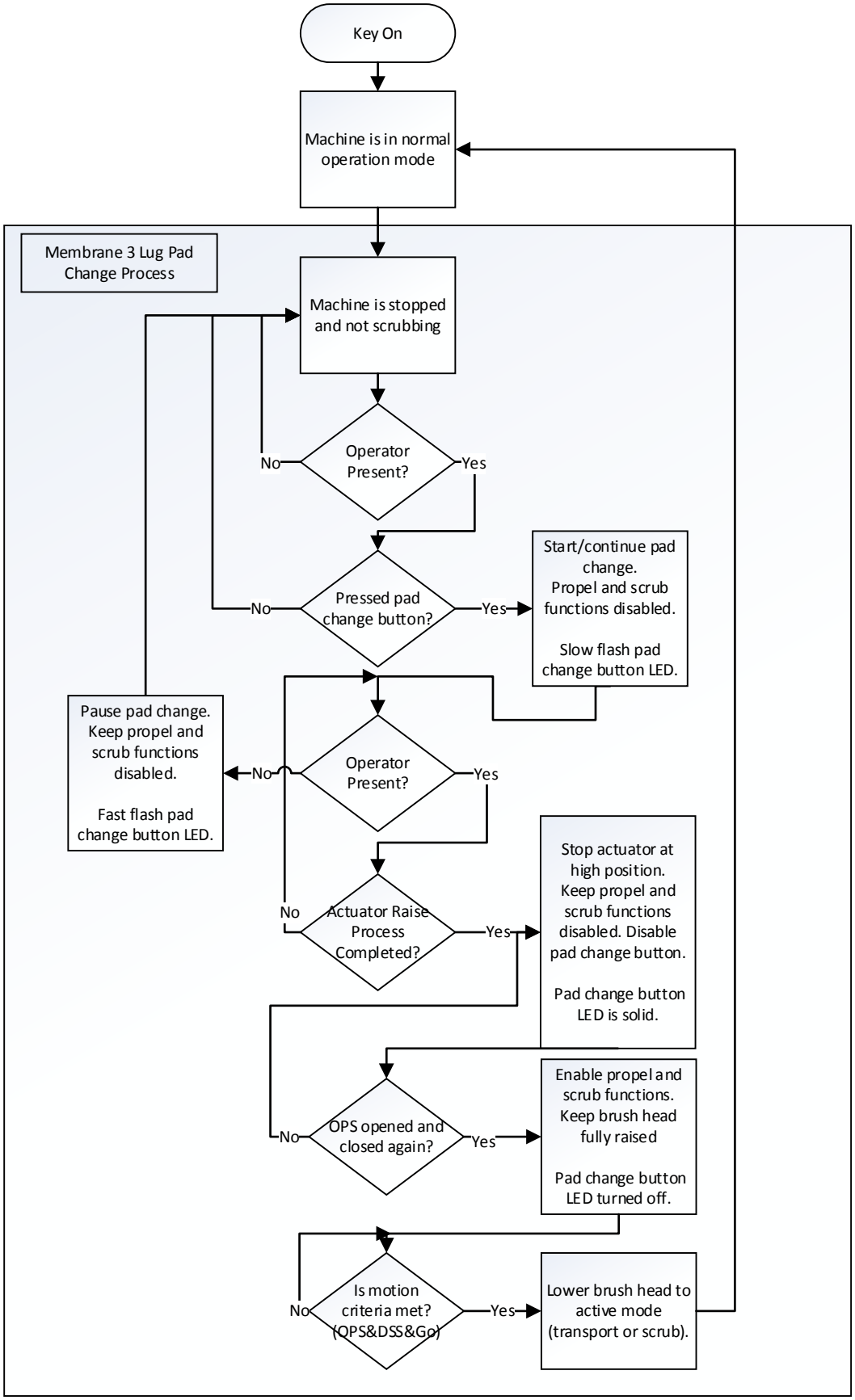
7.3.3.2.2 3-Lug Pad Change Logic

For machines configured with a 3-lug type, the pad eject process shall begin when the following conditions are met:

- The key switch shall be on
- The machine shall be at a complete stop
- The operator presence switch shall be closed
- The machine shall be in Transport Mode
- The machine is configured for 3-lug heads
- The user presses Eject button for 1 second

The brush eject function shall operate as follows:

1. The actuator shall retract to the brush eject position (or stop if the actuator current exceeds 5A)
    - OPS needs to stay closed in order for the actuator to fully retract, for safety reasons
    - Actuator drive signal during retract shall be set to 50% to reduce force on mechanical linkages
    - If OPS opens while actuator is retracting, actuator shall stop and wait for OPS to close and user pressing Eject button again before continuing
    - Eject button LED shall flash at 1Hz while actuator is retracting
    - Eject button LED shall flash at 4Hz if OPS opens while actuator is retracting
2. Control system shall look for the OPS to open and then close again (to indicate that user has stepped off, removed pad driver, installed new pad, and installed pad driver).
    - Eject button LED shall be lighted solid while system is waiting for OPS to open and close
    - Eject button LED shall turn off after OPS closes
    - Eject button shall be disabled until OPS is opened and closed
    - User shall be able to select a new mode of operation as soon as OPS closes
3. The actuator shall remain in brush eject position until the user selects a new mode (drive or scrub) and begins to move the machine.
    - Actuator shall extend to transport or scrub based on mode that was selected before movement started


Key On
Machine is in normal operation mode
Membrane 3 Lug Pad Change Process
Machine is stopped and not scrubbing
Operator Present?
No
Yes
Pressed pad change button?
No
Yes
Start/continue pad change.
Propel and scrub functions disabled.
Slow flash pad change button LED.
Pause pad change.
Keep propel and scrub functions disabled.
Fast flash pad change button LED.
Operator Present?
No
Yes
Actuator Raise Process Completed?
No
Yes
Stop actuator at high position.
Keep propel and scrub functions disabled. Disable pad change button.
Pad change button LED is solid.
OPS opened and closed again?
No
Yes
Enable propel and scrub functions.
Keep brush head fully raised
Pad change button LED turned off.
Is motion criteria met? (OPS&DSS&Go)
No
Yes
Lower brush head to active mode (transport or scrub).

7.4 Debris Management Subsystem

The Debris management subsystem shall enable when the cleaning subsystem is enabled.

The operator shall be able to disable the debris management subsystem.

7.4.1 Vacuum Motor

Vacuum motor shall be a standard feature on all machines.

7.4.2 Vacuum Motor Controller

The motor shall be driven by a PWM-controlled output, with over-current protection, current measurement, and fault detection capabilities.

The motor controller shall be able to provide status and current sense data via CAN message to enable scrub motor diagnostics, such as open load, shorted load, and shorted driver.

The controller shall turn off the vacuum motor driver when an over-current or a short-circuit condition are detected.

7.4.3 Debris Management Control Logic

The vacuum shall activate when commanded by the operator through the activation of cleaning subsystem or the debris management subsystem.

The vacuum system shall be operational according to the following table:

Propel Direction	Propel Motion	Head Position	Cleaning Subsystem	Debris Subsystem	Vacuum State
-	-	Pad Change	-	-	**Off**
-	-	Transport	-	-	**Off**
Forward	Moving	Ready/Vac-Only (Vac-Only Mode)	Off	On	**On**
Forward	-	Ready/Vac-Only	Off	Off	**Off**
Forward	Moving	Low Down Force	On	On	**On**
Forward	Moving	Low Down Force (Double Scrub)	On	Off	**Off**
Forward	-	Low Down Force	Off	Off	**Off**
Forward	Moving	High Down Force	On	On	**On**
Forward	Moving	High Down Force (Double Scrub)	On	Off	**On**
Forward	-	High Down Force	Off	Off	**Off**
Reverse	-	-	-	-	**Off**

A delayed vacuum shutoff sequence shall be initiated every time the system transitions the debris subsystem from the ON state to the OFF state. The delayed vacuum shutoff sequence is covered in SRS 7.4.3.2.

7.4.3.1 Vacuum Motor Voltage / Fan Quiet Mode

The machine shall allow the operator to select a reduced operating voltage called “Quiet Mode” for the vacuum motor to meet sound level requirements as defined in PRS 3.2.16.2.

- Standard fan voltage: 19V
- Reduced fan voltage: 15V

“Quiet mode” shall operate at the reduced voltage when active and vacuum operating conditions are met as defined in Section 7.4.3.

7.4.3.2 Delayed Vacuum Shutoff

Any time the vacuum is running and commanded to turn off, the control system shall delay shutting off the vacuum fan based on the following criteria:

Standard fan voltage:

- When running the vacuum at standard voltage, the main control board shall delay shutting off the vacuum fan for 15 seconds (+/- 1 second) when commanded to disable the debris management system.
- The actuator shall position itself in Ready/Vac Only position until the 15 second delay has passed. Then it will travel to the transport position.
- When running the vacuum at standard voltage, the main control board shall increase the vacuum fan voltage during the delay period to 24V or 95% duty cycle, whichever is lower.

Reduced fan voltage:

- When running the vacuum at the reduced “Quite Mode” voltage, the main control board shall delay shutting off the vacuum for 15 seconds (+/- 1 second) when commanded to disable the debris management system.
- The actuator shall position itself in Ready/Vac Only position until the 15 second delay has passed. Then it will travel to the transport position.
- When running the vacuum at the reduced “Quiet Mode” voltage, the main control board shall keep the vacuum voltage the same during the delay period (the fan shall remain quiet during the delay period).

7.4.3.3 Delayed Reverse Enable

When in scrub mode, the machine shall delay from moving forward to reverse until the scrub head has been raised to the scrub ready position.

The machine shall allow reverse movement to begin as soon as the scrub head reaches scrub ready position, and then continue raising the scrub head to transport position.

7.5 Solution Delivery Subsystem

The solution delivery system shall only be operational when the cleaning subsystem is active.

Disabling the solutions delivery subsystem shall be permitted by the operator.

7.5.1 Conventional Solution

7.5.1.1 Solution Valve

The machines shall have a valve to control the conventional solution flow rate from the solution tank.

The machines shall be capable of delivering solution to the floor at adjustable flow rates.

7.5.1.2 Solution Valve Controller

The valve controller shall be sufficient to drive the following valve specifications:

- Solenoid valve with nominal coil voltage of 24 VDC at 10 W
- Coil resistance: 56Ω +/- 10% @ 25°C
- Continuous duty

The controller shall be driven by a micro-controlled output, with over-current protection, current measurement, and fault detection capabilities.

The controller shall be able to provide status and current sense data via CAN message to enable diagnostics, such as open load and overcurrent conditions.

The controller shall turn off the driver when an over-current or a short-circuit condition are detected.

7.5.1.3 Solution Valve Control Logic

The solution valve shall be provided a pulsed signal to achieve target flow rate.

The target flow rate shall be selected by the operator from a table of predefined values:

Selection	Name	Rate
0	Off	0.00 GPM
1	Low	0.15 GPM
2	Medium	0.35 GPM
3	High	0.50 GPM

The solution valves shall only be able to open when the Cleaning Subsystem is active and the machine is NOT in ec-H_2O mode.

7.5.2 ec-H_2O System

The control system shall be able to accommodate an optional ec-H_2O cleaning system module.

7.5.2.1 ec-H_2O Controller

The scrubber shall communicate to the ec-H_2O module via CAN Open.

The controller shall detect a tripped circuit breaker in the ec-H_2O system.

7.5.2.2 ec-H_2O Control Logic

The target flow rate shall be selected by the operator from a table of predefined values:

Selection	Name	Rate
0	Off	0.00 GPM

1	Low	0.12 GPM
2	Medium	0.25 GPM
3	High	0.35 GPM

The ec-H_2O control system shall only activate when the cleaning subsystem is enabled.

The ec-H_2O control system shall not operate with conventional solution delivery.

The scrubber shall detect and report faults from the ec-H_2O module as defined in the NanoClean specification.

The ec-H_2O control system shall operate after the WCM cartridge expired warning.

7.6 Detergent Metering System

The Detergent Metering system shall be optional when ec-H_2O systems installed.

The main components of the Detergent Metering System shall be a pump, an adjustment potentiometer, and a detergent tank with a level switch.

7.6.1 Detergent Components

The Detergent Metering Pump shall operate in a voltage range between 5 VDC – 24 VDC, with a maximum current of 2 Amps.

The pump shall deliver detergent in a range of 0.09 oz./min to 2.2 oz./min. Detergent flow rate shall be proportional to supply voltage.

The on-board detergent tank shall have a tank level switch in order to detect when the tank is empty.

7.6.1.1 Detergent Pump Controller

The motor shall be driven by a micro-controlled PWM output, with over-current protection, current measurement, and fault detection capabilities.

The motor controller shall be able to provide status and current sense data via CAN message to enable scrub motor diagnostics, such as open load, shorted load, and shorted driver.

The controller shall turn off the motor driver when an over-current or a short-circuit condition are detected.

7.6.1.2 Detergent Potentiometer Controller

The controller shall provide a voltage signal representative of the potentiometer position.

7.6.1.3 Detergent Tank Float Controller

The switch contacts shall open to indicate an empty tank.

The controller shall be able to detect the state of the detergent tank level switch.

7.6.2 Detergent Metering Control Logic

The detergent metering system shall only operate if the cleaning subsystem is active and solution flow set point is not off.

The detergent metering system shall use the ec-H_2O pump for the conventional solution delivery.

Activating detergent metering system shall disable ec-H_2O system, if enabled.

The detergent metering system shall turn off in the event of an ec-H_2O pump fault/warning condition and revert to conventional solution delivery.

When the detergent metering subsystem is enabled, the scrubber shall automatically adjust the solution flow rate and actuated down pressure to their maximum levels.

When the detergent metering is deactivated, the scrubber shall revert to the operator set solution flow, down pressure and solution type.

The scrubber shall allow down pressure and solution flow rate to be adjusted while detergent metering system is active.

If the solution flow rate is set to OFF, the scrubber shall turn off the detergent metering system.

The detergent dosing shall automatically adjust to the solution flow rate.

The detergent-to-water mix ratio shall be determined by the setting of a potentiometer.

When the measured potentiometer resistance is at its minimum level (fully rotated counter-clockwise), the main control board shall control the pump speed such that a ratio of 1:640 is targeted.

When the measured potentiometer resistance is at its maximum level (fully rotated clockwise), the main control board shall control the pump speed such that a ratio of 1:32 is targeted.

If the controls subsystem determines that the target detergent pump voltage during reduced solution flow is less than the minimum pump voltage, then the controls subsystem shall change over to a pulsed pump mode.

The pulsed pump mode shall start and stop the pump such that the average volume of detergent being pumped will meet the selected mix ratio.

7.6.2.1 Timed Mode

The detergent system shall run for 30 seconds in timed mode.

The detergent dosing timer and system shall pause if scrubbing is stopped.

The detergent dosing timer and system shall continue when scrubbing is resumed.

Adjusting the solution flow or down pressure while detergent is active shall not modify the dosing time remaining.

7.6.2.2 Constant-On Mode

The detergent metering system shall remain active during scrubbing when in Constant-On Mode.

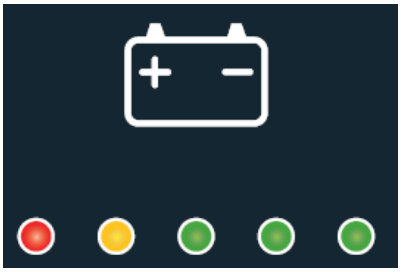
The detergent system shall pause if scrubbing is stopped.

The detergent system shall continue when scrubbing is resumed.

7.7 Power Management systems

7.7.1 Battery Monitoring

The User Interface panel shall provide a Battery Discharge Indicator (BDI) which accurately indicates state of charge remaining on the batteries based on battery voltage level while under load (i.e. Cleaning Subsystem operational).



BDI Indicator

Level	Display Color	Battery Level
1	Red	> 20%
2	Yellow	> 30 %
3	Green	> 40 %
4	Green	> 50 %
5	Green	> 60 %

When the battery reaches an 80% discharged state, the control electronics shall shut down certain machine functions as follows:

- If actively scrubbing and 80% discharge state is reached, the cleaning subsystem shall be disabled and the machine shall proceed to transport mode:
    - The red BDI LED shall flash at a rate of 2 Hz
    - Scrub functionality shall be disabled
    - Head shall lift to vac only position
    - Vac fan shut-off shall be delayed for 15 seconds (+/- 1 second)
    - After vac fan delay, head shall lift to transport position
- The One-Touch button shall be disabled in a low-voltage cutoff state.

The debris management subsystem and the electric drive subsystem shall remain operational in a low-voltage cutoff state.

Vac only mode shall remain operational until an 85% discharge state is reached. The only functionality available to the user beyond an 85% state of discharge shall be the electric drive subsystem.

7.7.2 Charger System

The Scrubbers shall be available with a standard on-board charging system, with the option of an off-board charger.

The charging system shall be a commercially developed product qualified to Tennant Test Standard for battery chargers ES0036.

The battery charger shall provide charging profiles for all batteries identified in Section 4.1.

The charging system shall have the ability to be reconfigured for specific battery types.

7.7.3 On-board charger

The on-board charger shall have a CAN bus connection.

The on-board battery charger status shall be indicated on the operator interface BDI. Charger status shall be communicated to the User Interface hardware module via CAN messages.

The battery charger shall have an input power cord with a minimum length of 15 foot/5 meters.

The on-board Charger shall be rated at greater than or equal to IP20.

7.7.4 Off-board charger

The off-board battery charger shall have a visible indication of the charger status. The BDI on the operator interface shall remain inactive when used with an off-board charger.

The Scrubber controls optional off-board charger connector shall prevent reverse charger connections, and allow disconnection without pulling on the cables.

The off-board Charger shall be rated at greater than or equal to IP33.

7.7.5 Charger Interlock Switch

The scrubber control system shall provide a method which prevents machine operation during battery charging.

For on-board chargers, the interlock switch shall be internal to the charger.

For off-board chargers, the interlock switch shall be a discrete switch mounted in such a way that it changes state when an external charger is plugged into the machine.

7.8 Automatic Battery Watering 2.0 (ABW2.0)

For detailed sequence of ABW2.0 operations and other specifics, see the Automated Battery Watering Specification.

The control system shall be able to accommodate an optional ABW2.0 system module.

7.8.1 ABW2.0 Controller

The scrubber shall communicate to the ABW2.0 module via CAN Open.

7.9 Fault Detection and Service Indication

The machines shall be able to detect and report system faults.

Each fault shall contain a unique identifier available through the USB communication port for reference.

7.9.1 Emergency Stop Controller

The Emergency Stop switch shall be normally closed, and have latched open contacts upon activation.

Activation of the Emergency Stop switch shall disable functionality of the following subsystems:

- Propel Control subsystem
- Cleaning subsystem
- Debris Management subsystem

7.10 Circuit Breaker Panel

The Scrubber controls shall provide circuit protection for the Scrubber components and wiring of the system.

The circuit breakers shall provide positive indication when tripped.

The following subsystem components shall have breakers:

- Keyswitch (4A)
- Propel Controller (70A)
- EC-H_2O Pump, ABW and EC-H2O control module (10A).

The scrubber controls shall sense the opening of the 10A EC-H_2O/ABW breaker

8 Controls Software Features

8.1 Presets

Presets shall apply multiple machine settings with a single button press.

8.1.1 Preset Apply

Presets shall be selectable at any time during machine operation.

Changing between presets shall cause no interruption of machine function.

Changing presets shall apply immediately while cleaning subsystem is active.

The following machine functions shall be able to be configured, saved and recalled for the presets:

- Solution Flow Rate
- Down Pressure
- Detergent metering (if equipped, constant-on mode only)
- Fan quiet mode (if equipped)
- ec-H_2O (if equipped; supervisors only)
- Maximum Scrub Speed (supervisors only)

8.1.2 Preset Save

Configuration of the preset buttons shall vary depending on the mode of operation, as follows:

A preset shall be saved according to the following process:

1. Adjust machine parameters as desired (solution flow rate, down pressure, ec-H_2O mode on/off OR constant-on detergent dispense mode, and fan quiet mode on/off)
2. Press and hold desired preset button for >3 seconds
3. Preset button LED shall flash 3 times and then remain ON to indicate that the preset configuration has been saved.

Machine Supervisors shall have the ability to set and lock the preset configurations (see Section 8.2 for details on Supervisor Lockout)

8.2 Supervisor Lockout

There shall be Supervisor Lockout capability.

Supervisors shall require a special process to access the Supervisor Mode.

Supervisor mode shall offer the ability to lockout the following machine functions:

- Preset Saving
- Solution Flow Rate change
- Down Pressure change
- Quiet Mode
- Constant-On Detergent Metering
- Ec-H_2O On/Off
- Maximum allowed scrubber speed

Supervisor shall be allowed to configure and save presets.

8.2.1 Supervisor Modes – Membrane

The machine shall have 3 modes of operation controlled via Supervisor Lockout.

8.2.1.1 Mode 1 – Unlocked Mode

Shall be factory default

Operator shall have full control of all available machine parameters

Operator shall be free to configure and save presets as they see fit

Maximum scrub speed shall NOT be configurable for presets in Unlocked Mode

Operator shall be able to reduce speed with speed knob

8.2.1.2 Mode 2 – Locked Presets

Machine presets have been set and locked by a supervisor

Operator shall be able to freely select between presets, but shall not be able to modify them.

Operator shall be able to adjust flow rate, down pressure, detergent dispense mode, fan quiet mode, and ec-H_2O mode while operating under a preset, effectively cancelling the preset mode (preset button LED would turn off).

Scrubber shall restrict maximum scrub speed if reduced.

Operator shall be able to reduce speed with speed knob.

After Supervisor configuration of presets and machine mode, starting up the machine in Mode 2 shall not have any of the presets active.

8.2.1.3 Mode 3 – Preset Use Only

Machine presets shall be set and locked in this mode

Operator shall be free to select between presets.

Operator shall not be able to adjust any machine parameters.

Operator shall not be able to modify presets.

Operator must release the go switch in order to switch between presets.

Scrubber shall restrict maximum scrub speed if reduced.

Operator shall be able to reduce speed with speed knob.

After Supervisor configuration of presets and machine mode, starting up the machine in Mode 3 shall have Preset 1 active. Subsequent power ups will always use the last used preset.

8.2.2 Entering Supervisor Mode – Membrane

In order to configure presets as a Supervisor, the user shall be required to first start the machine in Supervisor Configuration Mode, as follows:

1. Machine must be powered OFF
2. Press and HOLD the Down Pressure Adjust button
3. While holding button, power on machine
4. Right-most green BDI LED will illuminate. Let go of Down Pressure Adjust button – machine is now in Supervisor Configuration Mode.

Machine shall be inoperable while in Supervisor Configuration Mode (however, machine shall still be able to propel)

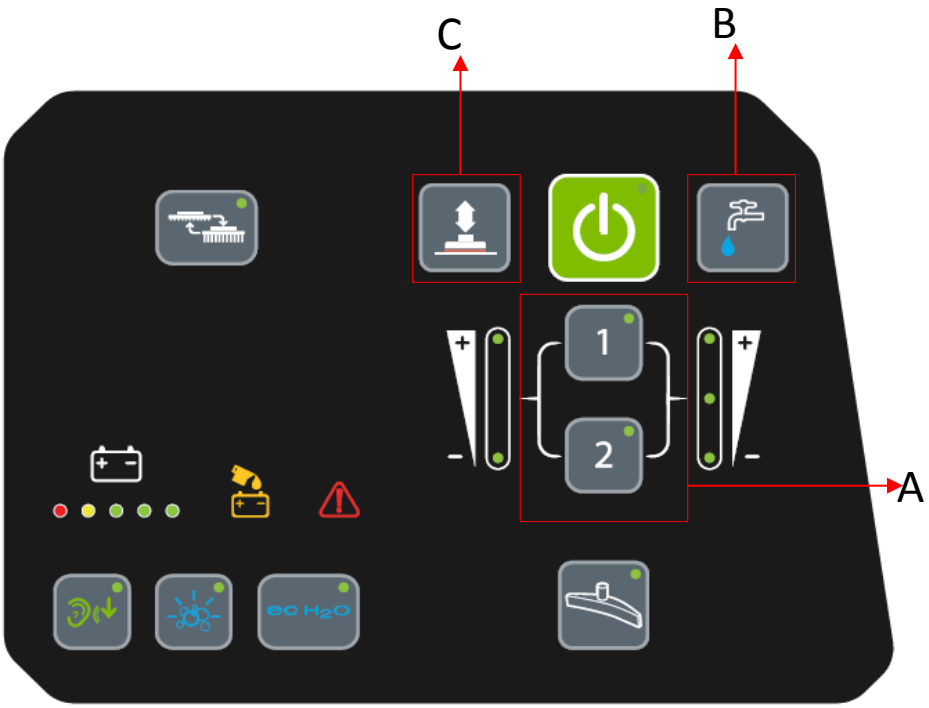
Once in Supervisor Configuration Mode, the supervisor shall first select the mode of operation that the machine will operate in: Mode 1, Mode 2, or Mode 3.

8.2.3 Setting Mode of Operation – Membrane

After entering Supervisor mode, the operator shall set the mode of operation. The choices are: Mode 1, Mode 2, or Mode 3.

The supervisor mode shall be set according to the following steps:

1. Press the preset button (“A” below) to select the desired mode of operation. Preset 1 corresponds to Mode 1, preset 2 corresponds to Mode 2, and Preset 3 (buttons 1 and 2 simultaneously) corresponds with Mode 3.
2. If button LED is blinking, press and hold the selection for 3 seconds to apply. The LED will remain on.
3. Key cycle if task is complete or see Section 8.2.4 for preset configuration.



8.2.4 Configuring Supervisor Presets – Membrane

After setting the Supervisor Mode operation, the supervisor shall perform the following steps to configure presets:

1. Press Solution Flow button ("B" above) to move to next 'page' of supervisor configuration.
2. Select configuration settings for a preset:
   a. **Solution Flow Rate** – Press the Solution Flow Rate button to cycle through off, low, medium, and high flow rates. LED's shall illuminate accordingly to indicate setting.
   b. **Down Pressure** – Press the Down Pressure button to cycle through low, and high down pressure. LED's shall illuminate accordingly to indicate setting.
   c. **Detergent Dispense** (if equipped) – Press and HOLD the Detergent Dispense button until the LED in upper-right corner of button illuminates (constant-on mode only).
   d. **Fan Quiet mode on/off** (if equipped) – Press the Fan Quiet button to turn feature ON/OFF. LED on Fan Quiet button shall illuminate when feature is ON.
   e. **ec-H_2O on/off** (if equipped) – Depress the button on the membrane panel to turn feature ON/OFF. "ec-H_2O" icon on operator interface shall illuminate when feature is on. **NOTE**: Constant-on Detergent Dispense mode and ec-H2O mode are mutually exclusive – they can't be on at the same time.
   f. **Maximum Scrub Speed** – Press the Detergent Dispense button to cycle through the 5 choices for maximum scrub speed (only when lockout mode 2 or 3 are active). The BDI LEDs shall indicate selection:

LED's	Max Speed
1	100%
2	90%
3	80%
4	70%
5	60%

3. Press and hold preset button for >3 seconds to save new configuration.
4. Repeat process steps 2 and 3 for remaining presets.

8.2.5 Supervisor Mode – Touchscreen

Presets and Supervisor Mode configuration shall also be available on the touchscreen option. Details for these functions can be found in the "Pascal" touchscreen module SRS.

8.3 USB Capability ("Galileo")

The scrubbers shall have a USB cable located near the on-board charger location (behind access door).

The USB cable shall provide the ability to connect to the machine with a second standard, off-the-shelf, cable.

8.3.1 Machine Configuration

The machine shall be capable of configuration of various machine parameters over USB including but not limited to:

- Installed VC options
- Propel parameters and limits
- Charger Profiles
- Head type

The machine shall be able to read and write parameters from other control modules on the CANbus network.

The machine shall report its configuration over USB.

8.3.2 Machine Testing and Diagnostics

The machine shall support system control over USB using the Control protocol.

The machine shall support system diagnostic reporting over USB using the Dashboard protocol.

The machine shall have all hardware necessary to be capable of supporting automatic end-of-line system testing over USB.

8.3.3 Firmware Update

The machine shall support updating the firmware on hardware modules connected to the CAN bus over USB.

All Tennant control modules shall support a hardware and firmware revision reporting and tracking.

The machine shall report firmware and hardware revisions over USB for those modules supporting the feature.

8.4 Telemetry (“IRIS”)

Telemetry shall be an option

The Telemetry feature shall enable wireless communications, and provide key performance data from the machine.

The Telemetry option shall be drop in replacement of the main scrub board with the telemetry integrated main scrub board

More information on the telemetry option can be found in the “AMII” Project PRS and SRS documents.

Update!!! – This list is not correct.

Appendix A: Fault Codes

Service Indicator

BDI Indicator

BDI Blink Pattern	Code(s)	Fault Condition	Action
	0xFFFF	Unknown Fault	
	0x0201	Actuator Open Warning	Wiring, connector or control board issue on the actuator.
	0x0101	Scrub Motor Open Warning	Needs repair. Check connections. Board gets power from key switch and battery. If connections check out, replace control board.
	0x0501	Vacuum Motor Open Warning	Needs repair. Check connections. Board gets power from key switch and battery.
	0x0601	Detergent Pump Open Warning	Needs repair. Check connections.
	0x0910	Propel Breaker Tripped Fault	Disconnect battery and reset the circuit breaker. If issue persists, contact service.
	0x0901	Propel Motor Open Fault	Motor on the propel I-Drive is not connected.
	0xF102	Charger Overheat	Charger environment is not cool enough and cannot complete charge. Move machine to well-ventilated area.
	0x0301	Valve Open Warning	Check connections.

	0x0711	EC H_2O Pump Open Warning	Control board is not detecting pump current. Check connections for voltage and verify pump is operating or not.
	0xFF00	Software Load Failure	Contact service.
	0xF101	Charger No Load Warning	Battery pack may not be plugged into the charger.
	0xF104	Charger Timer Phase I Fault	Batteries not able to be charged correctly.
	0xF103 0xFF20 0x0704	Charger CAN Fault CAN Communication Fault EC-H_2O CAN Fault	Power cycle machine. If fault persists, contact service. Charger not communicating.
	0x0713 0x0714 0x0715	EC-H_2O Pump HW Over Current EC-H_2O Pump SW Over Current 1 EC-H_2O Pump SW Over Current 2	Current draw higher than expected. Contact service.
	0x0707	EC H_2O Pump FET Fault	Contact service to replace control board.
	0x0900 0x0903	Propel I-Drive Fault Propel I-Drive Comm. Lost	Power cycle machine. If fault persists, contact service.
	0x0906	Propel Motor Short Fault	Contact service.
	0x0103 0x0104 0x0105	Scrub Motor HW Over Currents Scrub Motor SW Over Current 1 Scrub Motor SW Over Current 2	Current draw higher than expected. Contact service.
	0x0703 0x0712	EC-H_2O Breaker Tripped EC-H_2O Pump Breaker Tripped	Reset Breaker. If trips again, contact service.
	0x0902	High Throttle Fault	Release bail or bail obstruction before turning on the machine.

	0x0107 0x0207 0x0507 0x0607 0x0617	Scrub Motor FET Fault Actuator Motor FET Fault Vacuum Motor FET Fault Detergent Pump FET Fault H_2O Pump FET Fault	Contact service to replace control board. FET detection includes motor, actuator, detergent pump, vacuum and battery watering pump.
	0x0503 0x0504 0x0505	Vacuum HW Over Current Fault Vacuum SW Over Current 1 Fault Vacuum SW Over Current 2Fault	Contact service.
	0x0506	Vacuum Shorted Load	Contact service.
	0x0603 0x0604 0x0605	Deterg. Pump HW Over Current Deterg. Pump SW Over Current 1 Deterg. Pump SW Over Current 2	Contact service.
	0x0606	Detergent Pump Shorted Load	Contact service.
		Reserved	
	0xF100	Charger Fault	An error condition has occurred with the charger unit. Contact service.
	0x0106	Scrub Motor Short Fault	Contact service.
	0x0102	Scrub Control Board Voltage/Power Loss	Check wiring and/or inline fuse for bad connection.
	0xFFF0	E-Stop Active	Release E-Stop button and power cycle machine to clear.

Icon	Code	Condition	Action
	0x0010	Parking Brake	This flashing indicator alerts the manual parking brake is engaged on the wheel and should be released before machine operation.

	0x0721	Detergent Tank Empty	This blinking icon indicates the detergent tank level is too low to operate correctly. Refill the detergent to clear the indicator.
	*	EC H_2O Issue	This icon is used for a variety of fault codes. See the table below for list of fault conditions.

EC H_2O Nanoclean Icon Faults

Icon	Code	Condition	Action
	0x0703 0x0704 0x0711 0x0712 0x0713 0x0716 0x0717 0x0727 0x0741 0x0746	EC-H_2O Electrical Faults	See the Gen II EC-H_2O Fault List.
	0x0702 0x0708 0x0721 0x0723 0x0726	EC-H_2O Water and Plumbing Faults	See the Gen II EC-H_2O Fault List.

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<Fault ID="0B15" Value="Battery Watering Pump Software Overcurrent 2 Fault" />
<Fault ID="0B16" Value="Battery Watering Pump Shorted Load Fault" />
<Fault ID="0B17" Value="Battery Watering Pump FET Short Fault" />
<Fault ID="2000" Value="LCD General Fault" />
<Fault ID="F100" Value="Charger Fault" />
<Fault ID="F101" Value="Charger Open Load Warning" />
<Fault ID="F102" Value="Charger Overheat Fault" />
<Fault ID="F103" Value="Charger CAN Lost Fault" />
<Fault ID="F104" Value="Charger Phase I Timeout" />
<Fault ID="FF00" Value="Software Load Fault" />
<Fault ID="FF10" Value="Scrub Controller Board Power Loss" />
<Fault ID="FF20" Value="Scrub Controller Board CAN Communication Lost" />
<Fault ID="FFF0" Value="E-Stop Pushed" />
<Fault ID="FFFF" Value="Unknown Fault" />
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