



element

Tenant Company

SS300, T300, T300e, SS500, T500, T500e, T600, T600e, SS350, T350, S16L, S16H, T17, M17, T20, M20, M30

FCC 2.1091:2021

FCC 2.1093:2021

802.11 b/g/n

Cellular

Report: TENN0148.3, issue date June 10, 2021



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CERTIFICATE OF EVALUATION



Last Date of Evaluation: Wednesday, June 9, 2021
Tennant Company
EUT: ATWILC3000-MR110CA

RF Exposure Evaluation

Models included in this evaluation:

SS300, T300, T300e, SS500, T500, T500e, T600, T600e, SS350, T350, S16L, S16H, T17, M17, T20, M20, M30

Standards

Specification	Method
FCC 2.1093:2021	FCC 447498 D01 General RF Exposure Guidance v06
FCC 2.1091:2021	FCC 447498 D01 General RF Exposure Guidance v06

Results

Method Clause	Description	Applied	Results	Comments
4.3.1	SAR Test Exclusion	Yes	Pass	This covers the 802.11 b/g/n radio, which is used at a distance less than 20 cm from the limbs/extremities of the user.
7.1	Maximum Permissible Exposure	Yes	Pass	This covers the cellular radio, which is used at a distance greater than 20 cm from the user.

Deviations From Evaluation Standards

None

Approved By:

Donald Facteau, Process Architect

Product compliance is the responsibility of the client; therefore, the tests and equipment modes of operation represented in this report were agreed upon by the client, prior to testing. The results of this test pertain only to the sample(s) tested. The specific description is noted in each of the individual sections of the test report supporting this certificate of test. This report reflects only those tests from the referenced standards shown in the certificate of test. It does not include inspection or verification of labels, identification, marking or user information. As indicated in the Statement of Work sent with the quotation, Element's standard process is to always use the latest published version of the test methods even when earlier versions are cited in the test specification. Issuance of a purchase order was de facto acceptance of this approach. Otherwise, the client would have advised Element in writing of the specific version of the test methods they wanted applied to the subject testing

PRODUCT DESCRIPTION



Client and Equipment Under Evaluation Information

Company Name:	Tennant Company
Address:	701 N Lilac Drive
City, State, Zip:	Golden Valley, MN 55422
Evaluation Requested By:	Curtis Bender
EUT:	SS300, T300, T300e, SS500, T500, T500e, T600, T600e, SS350, T350, S16L, S16H, T17, M17, T20, M20, M30
802.11 Radio Module:	ATWILC3000-MR110CA
Date of Evaluation:	Wednesday, June 9, 2021

Information Provided by the Party Requesting the Evaluation

Functional Description of the Equipment:

Each model listed is a cleaning machine that has the IRIS telemetry option. The IRIS telemetry option is a circuit board that contains both an 802.11 b/g/n WiFi radio (FCC ID: 2AYRZWILC3000) and cellular radio (FCC ID: XMR201707BG96). The IRIS telemetry board is mounted to the user interface board of the machine and gets its power from that board. The 802.11 b/g/n WiFi radio has an integrated chip antenna and the cellular radio has an external antenna.

Objective:

To demonstrate compliance with FCC RF exposure requirements for 2.1093 portable devices and 2.1091 mobile devices.

RF Exposure Condition



The following RF Exposure conditions were used for the assessment documented in this report:

Intended Use	802.11 b/g/n: Portable Cellular: Mobile
Location on Body (if applicable)	Limb
How is the Device Used	<p>The 802.11 b/g/n antenna is used at a distance of less than 20cm from limbs/extremities of the user.</p> <p>The cellular antenna is used at a distance of greater than 20cm from the limbs/extremities of the user.</p> <p>The separation between the 802.11 b/g/n and cellular antennas is greater than 20cm on all of the models listed.</p>
Radios Contained in the Same Host Device	802.11 b/g/n Cellular
Simultaneous Transmitting Radios	802.11 b/g/n Cellular
Body Worn Accessories	None
Environment	General Population/Uncontrolled Exposure

SAR TEST EXCLUSION



OVERVIEW

Human exposure to RF emissions from portable devices (47 CFR §2.1093) used with the radiating antenna closer than 20 cm to the user requires Specific Absorption Rate (SAR) to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation.

COMPLIANCE WITH FCC 2.1093

47 CFR §1.1307

“(b)(1) Requirements. (i) With respect to the limits on human exposure to RF provided in §1.1310 of this chapter, applicants to the Commission for the grant or modification of construction permits, licenses or renewals thereof, temporary authorities, equipment authorizations, or any other authorizations for radiofrequency sources must either:

(A) Determine that they qualify for an exemption pursuant to §1.1307(b)(3);

(B) Prepare an evaluation of the human exposure to RF radiation pursuant to §1.1310 and include in the application a statement confirming compliance with the limits in §1.1310; or

(C) Prepare an Environmental Assessment if those RF sources would cause human exposure to levels of RF radiation in excess of the limits in §1.1310.

The EUT will be used with a separation distance of less than 20 centimeters between the radiating antenna and the body of the user or nearby persons and must therefore be considered a portable transmitter per 47 CFR 2.1093(b).

47 CFR §2.1093

“(b) For purposes of this section, the definitions in §1.1307(b)(2) of this chapter shall apply. A portable device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that the RF source's radiating structure(s) is/are within 20 centimeters of the body of the user.”

COMPLIANCE WITH FCC KDB 447498 D01 General RF Exposure Guidance v06

“KDB 447498 D01 General RF Exposure Guidance v06” provides the procedures, requirements, and authorization policies for mobile and portable devices.

Standalone radio SAR test exclusion is covered under section 4.3.1. Unless specifically required by the published RF exposure KDB procedures, standalone 1-g head or body and 10-g extremity SAR evaluation for general population exposure conditions, by measurement or numerical simulation, is not required when the corresponding SAR Test Exclusion Thresholds are met as shown in the Limits section below.

Simultaneous transmission SAR test exclusion is covered under section 4.3.2. SAR test exclusion is determined for each operating configuration and exposure condition according to the reported standalone SAR of each applicable simultaneously transmitting antenna. When the sum of 1-g or 10-g SAR of all simultaneously transmitting antennas in an operating mode and exposure condition combination is within the SAR limit, SAR test exclusion applies to that simultaneous transmission configuration.

SAR TEST EXCLUSION



LIMITS

Limits for General Population /Uncontrolled Exposure: 47 CFR 1.1310 (c)

The SAR limits for general population/uncontrolled exposure are 0.08 W/kg, as averaged over the whole body, and a peak spatial-average SAR of 1.6 W/kg, averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the parts of the human body treated as extremities, such as hands, wrists, feet, ankles, and pinnae, where the peak spatial-average SAR limit is 4 W/kg, averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube). Exposure may be averaged over a time period not to exceed 30 minutes to determine compliance with general population/uncontrolled SAR limits.

For 100 kHz to 6 GHz and test separation distances \leq 50 mm, the SAR test exclusion thresholds are 1-g for head and body SAR and 10-g SAR for extremity SAR.

ASSESSMENT (KDB 447498 D01 GENERAL RF EXPOSURE GUIDANCE V06)

For 100 MHz to 6 GHz and test separation distances \leq 50 mm, the 1-g and 10-g SAR test exclusion thresholds are determined by the following:

$$\left[\frac{(\text{max. power of channel, including tune-up tolerance, mW})}{(\text{min. test separation distance, mm})} \right] \cdot \left[\sqrt{f(\text{GHz})} \right] = \begin{array}{l} 3.0 \text{ for 1-g SAR} \\ 7.5 \text{ for 10-g extremity SAR} \end{array}$$

Where:

- $f(\text{GHz})$ is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison
- 3.0 and 7.5 are referred to as the numeric thresholds

The test exclusions are applicable only when the minimum test separation distance is \leq 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is $<$ 5 mm, a distance of 5 mm according to 4.1f) is applied to determine SAR test exclusion.

The SAR Test Exclusion Threshold is summarized in the following table(s):

Radio	Transmit Frequency (MHz)	Rated Output Power	Units	Duty Cycle	Minimum Separation Distance (mm)	Exclusion Threshold	Limit	Compliant
802.11 b/g/n	2412	12	dBm	100.0%	5	4.9	7.5	Yes

The information in the table above was obtained from:

Customer supplied information, Element test report # TENN0148 and Microchip ATWILC3000-MR110xA Datasheet.

MAXIMUM PERMISSIBLE EXPOSURE (MPE)



OVERVIEW

Human exposure to RF emissions from mobile devices (47 CFR §2.1091) may be evaluated based on the MPE limits adopted by the FCC for electric and magnetic field strength and/or power density, as appropriate, since exposures are assumed to occur at distances of 20 cm or more from persons. ANSI C95.1:2005 + Amd 1:2010 specifies a minimum separation distance of 20 cm for performing reliable field measurements to determine adherence to MPE limits. If the minimum separation distance between a transmitter and nearby persons is more than 20 cm under normal operating conditions, compliance with MPE limits may be determined at such distance from the transmitter. When applicable, operation instructions and prominent warning labels may be used to alert the exposed persons to maintain a specified distance from the transmitter or to limit their exposure durations and usage conditions to ensure compliance. If the use of warning labels on a transmitter is not effective or desirable, the alternative of performing SAR evaluation with the device at its closest range to persons under normal operating conditions may be used. The field strength and power density limits adopted by the FCC are based on whole-body averaged exposure and the assumption of RF field levels relate most accurately to estimating whole-body averaged SAR. This means some local values of exposures exceeding the stated field strength and power density limits may not necessarily imply non-compliance if the spatial average of spatially averaged RF fields over the exposed portions of a person's body does not exceed the limits.

COMPLIANCE WITH FCC 2.1091

47 CFR §1.1307

“(b)(1) Requirements. (i) With respect to the limits on human exposure to RF provided in §1.1310 of this chapter, applicants to the Commission for the grant or modification of construction permits, licenses or renewals thereof, temporary authorities, equipment authorizations, or any other authorizations for radiofrequency sources must either:

(A) Determine that they qualify for an exemption pursuant to §1.1307(b)(3);

(B) Prepare an evaluation of the human exposure to RF radiation pursuant to §1.1310 and include in the application a statement confirming compliance with the limits in §1.1310; or

(C) Prepare an Environmental Assessment if those RF sources would cause human exposure to levels of RF radiation in excess of the limits in §1.1310.

47 CFR §2.1091

“A mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the RF source's radiating structure(s) and the body of the user or nearby persons. In this context, the term “fixed location” means that the device is physically secured at one location and is not able to be easily moved to another location while transmitting. Transmitting devices designed to be used by consumers or workers that can be easily re-located, such as wireless devices associated with a personal desktop computer, are considered to be mobile devices if they meet the 20-centimeter separation requirement.”

The device will only be used with a separation distance between the antenna and the body of the user or nearby persons as shown in the table below and can therefore be considered a mobile transmitter per 47 CFR 2.1091(b).

COMPLIANCE WITH FCC KDB 447498 D01 General RF Exposure Guidance v06

“KDB 447498 D01 General RF Exposure Guidance v06” provides the procedures, requirements, and authorization policies for mobile and portable devices.

MAXIMUM PERMISSIBLE EXPOSURE (MPE)



Devices operating in standalone mobile device exposure conditions may contain a single transmitter or multiple transmitters that do not transmit simultaneously are covered in section 7.1.

Devices containing multiple transmitters capable of simultaneous transmissions are covered in section 7.2.

LIMITS

Limits for General Population /Uncontrolled Exposure: 47 CFR 1.1310

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Averaging Time (minutes)
0.3 - 1.34	614	1.63	*(100)	30
1.34 - 30	824/f	2.19/f	*(180/f ²)	30
30 - 300	27.5	0.073	0.2	30
300 - 1500			f/1500	30
1500 - 100000			1	30

f = frequency in MHz

* = Plane-wave equivalent power density

ASSESSMENT

The exposure level for the radio is evaluated at a 20 cm distance from the radio's transmitting antenna using the general equation:

$$S = \frac{P * G}{4 * \pi * R^2}$$

Where: S = power density (mW/cm²)

P = power input to the antenna (mW)

G = numeric power gain relative to an isotropic radiator

R = distance to the center of the radiation of the antenna (20 cm = limit for MPE estimates)

P*G = EIRP

Solving for S, the maximum power density 20 cm from the transmitting antenna is determined. This level is then compared to the applicable limit for the transmit frequency. If limits were not met at the 20 cm boundary the evaluation distance is increased until the limit is met as shown in the table below.

For co-located radios, the ratio of the calculated level to the limit is determined. The ratios for each co-located radio are summed. If the sum is less than or equal to one, then the device is excluded from testing and is deemed compliant.

MAXIMUM PERMISSIBLE EXPOSURE (MPE)



The standalone MPE and summed MPE ratios are summarized in the following table(s):

Radio	Transmit Frequency (MHz)	Rated Output Power (dBm)	Tune-up Tolerance (dB)	Duty Cycle	Antenna Assembly Gain (dBi)	Minimum Separation Distance (cm)	Power Density (mW/cm ²)	Limit (mW/cm ²)	Compliant
Cellular: PCS1900	1910	23	2	100.0%	0	20	0.1	1.0	Yes
Cellular: LTE B5	849	23	2	100.0%	0	20	0.1	0.6	Yes
Cellular: LTE B3	1755	23	2	100.0%	4	20	0.2	1.0	Yes
Cellular: LTE B26	849	23	2	100.0%	0	20	0.1	0.6	Yes
Cellular: LTE B2	1910	23	2	100.0%	4	20	0.2	1.0	Yes
Cellular: LTE B13	787	23	2	100.0%	0	20	0.1	0.5	Yes
Cellular: LTE B12	716	23	2	100.0%	0	20	0.1	0.5	Yes
Cellular: GSM850	849	23	2	100.0%	0	20	0.1	0.6	Yes

The information in the table above was obtained from:

Customer supplied information, and NimbeLink Skywire Global 4G LTE Cat M1 Datasheet.

The following separation distance information was provided by Paul Letsche, Senior Test Engineer at Tennant Company.

Model	Distances		
	Wifi antenna to operator	Minimum cell antenna to operator	Minimum Wi-fi antenna to cellular antenna
SS300	2.508cm	33.2cm	37.6cm
T300	2.508cm	33.2cm	37.6cm
T300e	2.508cm	33.2cm	37.6cm
SS500	2.508cm	25.3cm	32.8cm
T500	2.508cm	25.3cm	32.8cm
T500e	2.508cm	25.3cm	32.8cm
T600	2.508cm	25.1cm	35.2cm
T600e	2.508cm	25.1cm	35.2cm
SS350	2.4cm	26cm	23.6cm
T350	2.4cm	26cm	23.6cm
S16L	2.373cm	20.1cm	23.2cm
S16H	2.373cm	20.1cm	23.2cm
T17	2.58cm	39.6cm	104.5cm
M17	2.58cm	39.6cm	104.5cm
T20	2.58cm	20.1cm	44.1cm
M20	2.58cm	20.1cm	44.1cm
M30	2.58cm	20.1cm	44.1cm

End of Test Report