CERTIFICATE OF CONFORMITY

№ РОСС FI.HA91.H00025

Validity from 15.05.2020 to 14.05.2023

№ 0014301

Certification body

Product Certification Body of the Limited Liability Company Certification Center “ENDURENCE”, Location (address of the legal entity) and address of the place of business: 115114, Russia, Moscow, 2nd Paveletsky proezd, house 5, building 1, floor 5, premise VII, room 11. Registration number of the accreditation certificate RA.RU.11HA91, Date of registration of the accreditation certificate 23.11.2018. Phone number: + 7-495-799-07-93, email address: info@ccendce.com.

Products

Pressure sensors of V-series, types VB, VG, VT, VL, VDt, VDtL, VDU, VV, VVFe
The products are manufactured in accordance with the technical documentation of the manufacturer Satron Instruments Inc.
Continuous serial production.

OK code
26.51.52

Complies with regulatory

GOST R MEK 61508-1-2012, GOST R MEK 61508-2-2012,
(GOST R IEC 61508-1-2012, GOST R IEC 61508-2-2012),
Safety integrity level SIL2

Tariff code
9026 20 200 0

Manufacturer Satron Instruments Inc.

Location (address of the legal entity) and address of the place of activity for the manufacture of products: Muuraintie 3, 33960 Pirkkala, Finland.

Certificate issued GOST-STANDARD Limited Liability Company. PSRN: 1187746783828. Location (address of the legal entity) and address of the place of business: 129281, Russia, Moscow, Izumrudnaya street, 11, room IV.
Phone: +79169510459; email address: 1@master-standart.ru

Basis Test report No. SDS0018.1.ST/20 dated 05.05.2020 Test Center for Industrial Products of the Federal State Unitary Enterprise "Russian Federal Nuclear Center - All-Russian Scientific Research Institute of Experimental Physics" (FSUE RFNC-VNIIEF) reg. No. SDS.SPTB.001.IL.03; certificate of conformity of the manufacturer’s quality management system with the requirements of ISO 9001: 2015 No. 67244-2009-AQ-FIN-FINAS; functional safety guides; functional safety assessment report No. 0027-SDS / FB dated 06.05.2020.

Additional Information

Certification Scheme: 5c.

Supervisor А.Ю. Вервейко

Expert Е.О. Зубрев

PRESSURE SENSORS SATRON SERIES V

A Guide to Functional Safety

Satron Instruments Inc. Muuraintie 3, 33960 Pirkkala FINLAND, Tel. +358 207 464 800

www.satron.com
sales@satron.com

Table of Contents

1. General information

This guide to functional safety was developed in accordance with GOST R IEC 61508-2-2012.
The purpose of the safety guide is to document information related to the SATRON series V pressure sensors used to ensure that the product is integrated into a safety-related system, or a subsystem, or an element in accordance with the requirements of GOST RC IEC 61508-2-2012.
The SATRON series V pressure sensors, versions VB, VG, VT, VL, VDt, VDtL, VDU, VVand VVFe are designed for continuous pressure measurement (excess, absolute and differential (pressure differential) and conversion of measured pressure into a unified analogue DC output (4-20) mA and digital frequency-modal signal (HART).

2. Scope of action

2.1. Design of the device

This safety guide works for the SATRON series V pressure sensors in the regular and explosive-proof design. Explosive-proof sensors are designated for example: **EEx ia II C T4**.
Sensors are produced in a variety of versions and designs, differing from each other according to the type and range of pressure measured, their construction and precision characteristics:

- version VB, designs 4, 5, 6 (hereinafter – VB4, VB5, VB6);
- version VG, designs 3, 4, 5, 6, 7, 8 (hereinafter – VG3, VG4, … VG8);
- version VT, designs 3, 4, 5, 6, 7, 8 (hereinafter – VT3, VT 4, …VT 8);
- version VL, designs 3, 4, 5, 6, 7 (hereinafter – VL3, VL4, …VL 7);
- version VDt, designs 2, 3, 4, 5, 6, 7 (hereinafter – VDt2, VDt3, … VDt7);
- version VDtL, designs 3, 4, 5, 6 (hereinafter – VDtL3, VDtL4, …VDtL6);
- version VDU, designs 3, 4, 5, 6 (hereinafter – VDU3, VDU4, …VDU6);
- version VV, designs 4, 5 (hereinafter – VV 4, VV 5);
- version VVFe, designs 4, 5, (hereinafter – VVFe4, VVFe5);

Sensors have the function of converting the range of measurements.

The degree of protection of the sensors provided by the shell from penetration by solid particles, dust and water corresponds to IP66
The construction of the sensors using welded joints restricts access to internal elements that affect metrological characteristics and does not require sealing.

SATRON series V pressure sensor designation scheme
using the example of **SATRON VG**

SATRON VG Flush Mount Pressure Transmitter

BPLV700
01.01.2014

Selection Chart

Adjustability	Span, min	Span, max	Measuring range
VG3	1.4 kPa (14 mbar)	35 kPa (350 mbar)	- 35...+35 kPa (-350...350 mbar)
VG4	4 kPa (40 mbar)	100 kPa (1000 mbar)	-100...+100 kPa (-1000...1000 mbar)
VG5	10 kPa (100 mbar)	500 kPa (5000 mbar)	-100...+500 kPa (-1000...5000 mbar)
VGA5	10 kPa (100 mbar)	500 kPa (5000 mbar)	0...+500 kPa (0...5000 mbar), abs.
VG6	0.03 MPa (0.3 bar)	3 MPa (30 bar)	-0.1...+3 MPa (-1...30 bar)
VGA6	0.03 MPa (0.3 bar)	3 MPa (30 bar)	0...+3 MPa (0...30 bar), abs.
VG7	0.15 MPa (1.5 bar)	15 MPa (150 bar)	0...+15 MPa (0...150 bar), abs.
VG8	1 MPa (10 bar)	25 MPa (250 bar)	-0,1...+25 MPa (-1...250 bar)

Output **S** 4-20mA DC/HART® -protocol

Process seal **4** metal/metal taper **5** O-ring FPM (Viton®) (1) **6** O-ring EPDM (1)

Wetted materials

Code	Material	Code	Material
2	AISI316L (EN 1.4435)	6	Titanium Gr2 (*) (**) (****)
3	Hast. C 276 (*) (**)	7	CoNi-alloy (*) (not ranges 3-4)
5	Tantalum (*) (**)	8	Duplex (EN 1.4462) (*) (**)

Diaphragm coating

Code	Material
9	gold/Rhodium
Y	diamond (specify only when coated)

Fill fluid **S** Silicon oil **G** Inert oil **A** Food and beverage special oil (Neobee M20)

Housing type

H Housing with PLUG-connector, DIN43650, no display, inlet PG9
T Housing with PLUG-connector and with manual adjust, DIN43650, no display, inlet PG9, (no ATEX)
M Housing with junction box/terminal strip, no display, inlet M20x1,5
N Housing with junction box/terminal strip, with display, inlet M20x1,5

Explosion proof **0** No explosion proof classification **1** Atex Intrinsic Safety, Ex II 1 GD T135°C (***)

Process temperature limits **N** -30 ... +125 °C **H** 0 ... +200 °C (*) (**)

Process coupling
0 No coupling
G Standard coupling
E Hygienic coupling

Material
2 AISI316L
3 Hast.C276
6 Titanium Gr2
8 Duplex

PASVE® mounting valve, specify separately in the order
Specify special couplings separately in the order

Special size of electrical inlet
N 1/2 NPT **G** Pg13.5 **P** Plug connector DIN 43650

Special features

Remote electronics (specify only if housing connected with cable to sensing element)
- connecting cable with protection hose
L Hose protected with PTFE/AISI316 braiding, straight
K Hose protected with PTFE/AISI316 braiding, angle of 90°

Length of connection cable between sensing element and housing
2 2 m cable **3** 3 m cable etc. (max. 10 m)

Mounting parts for remote electronics for Ø 51 mm tube
0 No mounting parts **1** Mounting parts

Documentation
Calibration certificate **AE** English

Installation and operating instructions **IE** English **IF** Finnish

Material certificates
0 No material certificate
MC1 Raw material certificate without appendices, in accordance with SFS-EN 10204-2.1 (DIN 50049-2.1) standard
MC2 Raw material certificate for wetted parts, in accordance with SFS-EN 10204-2.2 (DIN 50049-2.2) standard
MC3 Raw material certificate for wetted parts, in accordance with SFS-EN 10204-3.1 B (DIN 50049-3.1 B) standard

We reserve the right for technical modifications without prior notice.

HART is the registered trademark of HART Communication Foundation.
Pasve is the registered trademark of Satron Instruments Inc.
Hastelloy is the registered trademark of Haynes International.
Teflon is the registered trademark of E.I. du Pont de Nemours & Co.
Viton is the registered trademark of DuPont Down Elastomer.

(*) = only process seal code 4
(**) = not for range 3
(***) = Housing H and N : Ex II 2 GD T135°C ATEX transmitters with display are the model without membrane key.
(****) = Min. process temperature limits 0 °C
(1) = EHEDG - certified

2.2 . Range of application

The SATRON series V pressure transmitters are designed to convert pressure measurement into an electric output signal. Depending on the model, the sensors have the following output signal: analogue DC (4-20mA); digital (HART).

The product can be used in safety-related systems, according to GOST R IEC 61508, in low demand mode (low demand) or high demand mode (with a high frequency of requests):

Up to SIL2 in single-channel architecture.

3. Design development

3.1 . Safety function and safe state

The safety function is the correct display of the current pressure value in the work environment in units of the output signal.

Outgoing signals can take the following values depending on the design of the sensor:

Digital: HART

Analogue: 4-20 mA

Combined: 4-20 mA and HART

3.2 . The conditions required for correct operation

- The limits on the conditions of application specified in the instructions must be maintained. Sensors may not be in environments that will corrode the sensor materials.
- Specifications according to these instructions, especially the current load in the output chain, should be maintained within the specified limits.
- The instructions in Chapter 4.2. should be taken into account.
- All components of the measurement chain must meet the "Safety Integrity Level (SIL)" safety level.

4. Functional safety indicators

4.1. Indicators in accordance with GOST R IEC 61508

Table 3

Indicator	**Value**
Safety integrity level (Safety Integrity Level)	SIL2 in single-channel architecture
Resistance to hardware failures	HFT=0
Equipment type	Type B
Operating mode	With a low query frequency, with a high query frequency
SFF	40%
du	$2.73 \cdot 10^{-7}$
dd	$1.24 \cdot 10^{-7}$
λsd	0
λsu	0
PFD_{avg}	$0.019 \cdot 10^{-2}$ (TProof= 1 year) $0.96 \cdot 10^{-2}$ (TProof= 5 years)
PFH	$0.021 \cdot 10^{-6}$/hour

4.2. Additional information

The failure rates of the device are determined by FMEDA analysis in accordance with GOST R IEC 61508.

The calculations are based on the failure rates of the design elements on the SN 29500.

The following initial assumptions were made in the analysis of the types, effects and diagnostics of SATRON series V pressure sensor failures:

- The failure rate is a constant value, the mechanisms of natural wear are not taken into account. The distribution of failures is not considered.
- The wear and tear of the mechanical parts is not taken into account.
- Failures that occur during the setting of parameters are not considered.
- The SATRON series V pressure sensors belong to the type B component in accordance with GOST R IEC 61508-1-2012.
- A failure of the SATRON series V pressure sensor is considered to be the inability to perform its stated functions.
- The average repair time for the SATRON series V pressure sensors is 8 hours.
- The intensity of the failure of the external power source was not taken into account.
- These failure intensities shown correspond to the typical operating conditions in industrial plants described in the standard IEC 60654-1, Class C, at an average temperature over a long period of time of 40˚C. In the case of a higher average temperature of 60˚C, the failure intensity should be multiplied by a corrective factor of 2.5, which has been derived from statistics. This ratio should be used if there are frequent temperature changes.

The above values for PFD_{AVG} were calculated for the 1oo1 architecture as follows:

$$PFD_{avg} := \frac{\beta \cdot l_{du} \cdot Tproof}{2} + l_{dd} \cdot MTTR + \frac{(1-\beta) \cdot l_{du} \cdot LT}{2}$$

where: β - the effectiveness of the test at detecting dangerous failures (assumed 0.9)
λdu - the intensity of the undetected dangerous failures
Tproof - the time between carrying out diagnostic tests
λdd - the intensity of the dangerous failures detected
MTTR - average repair time (8 hours)
LT - average life of the product (10 years)

5. Commissioning

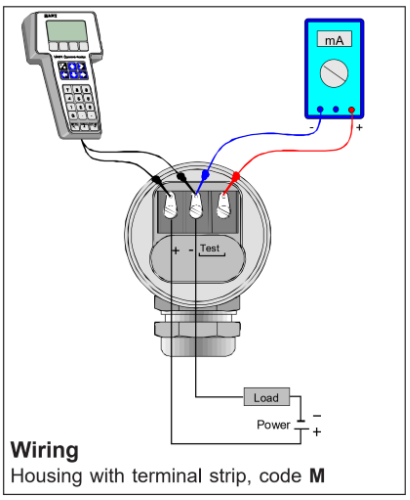
5.1. General

The instructions contained in the installation and configuration instructions (1300001AV, Edition 2, 2010-01-15) and the recommendations for the installation and connection of the SATRON V series pressure sensors must be followed.

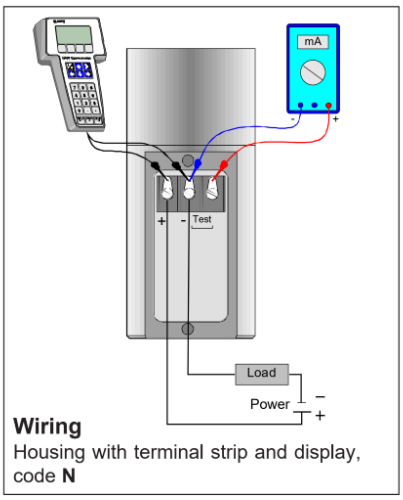
The pressure sensor connection diagrams are shown below:

Connection diagrams for external electrical circuits of SATRON series V sensors in versions

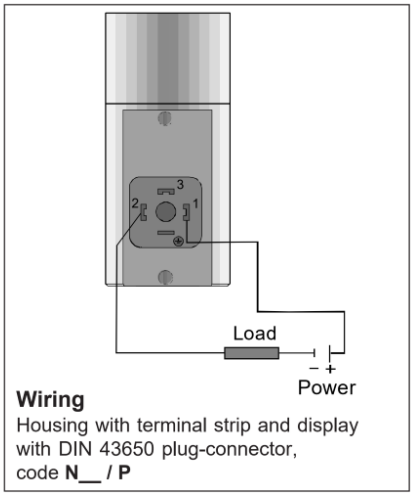
VG, VT, VV, VB, VL, VDt, VDtL, VVFe.



Wiring
Housing with terminal strip, code **M**

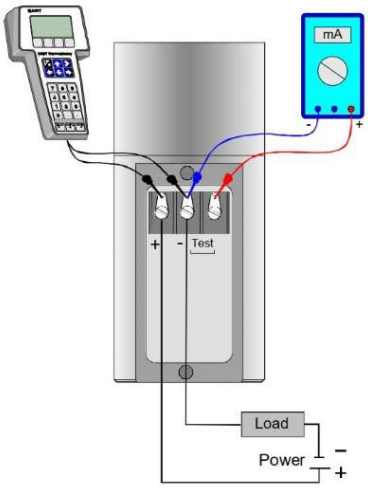


Wiring
Housing with terminal strip and display, code **N**

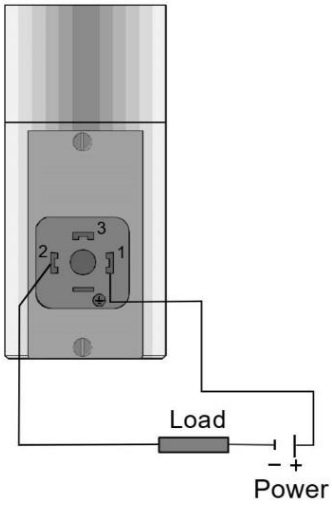


Wiring
Housing with terminal strip and display with DIN 43650 plug-connector, code **N__ / P**

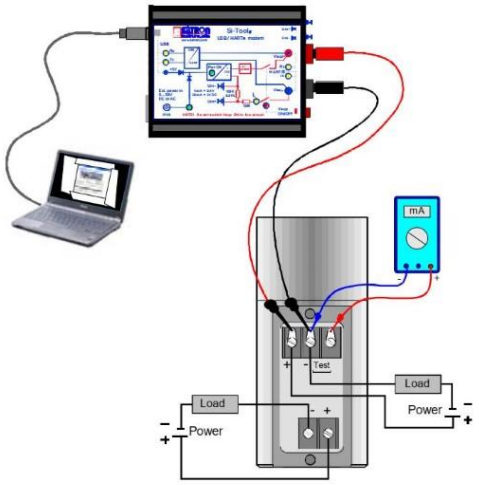
Connection diagrams for external electrical circuits for VDU model sensors



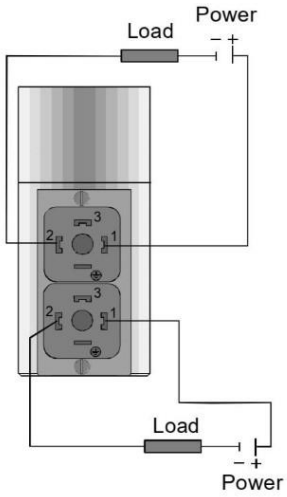
Wiring one current output



Wiring one current output, plug DIN43650 connector



Wiring double current output



Wiring double current output, plug DIN 43650 connector

6. Diagnosis & maintenance

7. Verification testing

To observe possible dangerous undetected errors, the safety function must be checked at appropriate intervals by means of a verification inspection. Choosing the type of inspection is the responsibility of the person operating the device. The time intervals between checks are selected based on the required average probability of dangerous errors as required by PFD_{AVG}
(see Ch. " 4. Functional safety indicators").
A verification record form that can be used to document this inspection is shown in Annex A.
If one of the turns out negative, the entire measuring system should be taken out of operation and the safe state of the process should be supported by other measures.
Attention!
During a functional test, the safety function should be considered unsafe. Keep in mind that the functional test has an impact on devices connected.
If necessary, other measures should be taken to maintain the safety function.
Once the functional test is complete, the state defined for safety operation must be restored.

Procedure No. 1: the device remains mounted and it is possible to vary the pressure on the system.
Procedure No. 2: the device has been dismantled and it is possible to vary the pressure with the appropriate test devices.

This requires

Applying a pressure that corresponds to 80 – 100% of the sensor setting limit. Reset the pressure to the initial level and compare the value of the sensor output signal with the value set during the initial setting.

Expected results:

The output signal corresponds to the pressure shown

Verification coverage

The remaining dangerous undetected errors are 2-5 FIT (β = 92 - 97%)

Annex A - Verification Protocol

Identification	
Company/testing body	
Device type/order code	
Device serial number	
Initial installation date	
Date of last check Safety function	

Base/volume of verification	
	Initial installation of the sensor
	Verification of the sensor parameters on the system
	Verification check with "pressure supply or sensor dismantling"

Result of inspection		
Expected measured value	Actual value	Result of inspection

Date:	Signature:

Appendix B – Definitions

Functional safety is part of a common safety system driven by the use of managed equipment and a control system, which depends on the proper functioning of electrical/electronic/programmed electronic safety-related systems and other risk-reduction tools.

Failure safety – the properties of the product, focused on the preservation of safety in the event of failure.

SFF - safety fail fraction **–** proportion of safe failures. The property of the safety element, determined by the ratio of the average frequencies of safe failures and dangerous detected failures to the total of the average frequencies of safe and dangerous failures.

λdu (du) – the intensity of the undetected dangerous failures.

λdd (**dd**) **-** the intensity of the dangerous failures detected.

HFT – hardware fault tolerance **–** hardware resilience.
HFT = X means that the X+1 is the minimum number of failures that can result in a loss of the safety function.

The average probability of a dangerous failure on demand (PFDavg) is the average unavailability of the E/E/PE safety system that is not prepared to provide safety, i.e. to perform this safety function when a request occurs.

Average frequency of dangerous failure per hour (PFH)
The average frequency of a dangerous E/E/PE safety-related system failure for a system providing this safety function over a given period of time.

β – the effectiveness of the test to detect dangerous failures.

Safety integrity is the likelihood that a safety-related system will perform the required safety functions satisfactorily under all specified conditions over a given period of time.

SIL – safety integrity level – the level of completeness of safety: a discrete level (taking one in four values) that determines the safety completeness requirements for a security function that is set in accordance with E/E/PES safety-related systems.