

Quartz™ Valve Position Indicator Rev. 1.3

Safety Manual

12/2021



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1. General information

The Quartz series valve position indicator is used to indicate the position of a valve assembly. This device is typically used as a safety component that provides a signal output of valve position. The end user can use this information in different ways depending on the SIF or sensory input that is being instrumented.

Quartz series valve position indicator can be used in a multitude of sensor input configurations and any sub classification depending on the model and SIF being implemented for the desired Safety Function and SIL level.

The valve position can be indicated using one of the defined outputs (mechanical switches, proximity sensors, or position transmitter). The Quartz unit provides input feedback of the valve to the safety system. End user must follow all guidance identified in the Installation, Maintenance and Operating Instructions (later referred as IMO) with this safety manual to verify the products proper installation and operation of the product product.

2. Structure of valve position indicator

2.1. System components and description of use

See the IMO for the detailed technical description of the device and the system architecture.

2.2. Permitted device types

The information in this manual pertaining to functional safety applies to all device variants mentioned in the device type coding below. It is up to the end-user to verify that the correct model is selected for the intended function and the SIF.

2.3. Supplementary device documentation

Related QX/QN Installation, Maintenance and Operating Instructions listing

IMO	Applicable models	Type	Description
105406	QX_J, QX_K, QX_L, QX_P, QN_J, QN_K, QN_L, QN_P	Limit switch	Maxx-Guard models SPST
105406	QX_S, QX_H, QX_G, QX_M, QN_S, QN_H, QN_G, QN_M	Limit switch	Maxx-Guard models SPDT
105406	QX_X, QN_X	Limit switch	SST models
105406	QX_A, QN_A	Limit switch	"A" Namur sensor models for intrinsically safe applications
105406	QX_N, QN_N	Limit switch	Namur sensor models for intrinsically safe applications
105406	QX33, QN33, QX35, QN35	Limit switch	SST dual module models
105406	QX44, QN44, QX45, QN45	Limit switch	Namur Sensor (EN 60947-5-6) Dual Module
105406	QX50, QN50	Position transmitter	4-20ma Position transmitter
105406	QXBO, QNBO	Potentiometer	10k Potentiometer
105406	QX70, QN70	Position transmitter	High performance 4-20mA position transmitter
105406	QXCO, QNCO	Potentiometer	High performance 10k potentiometer

Table 1

These are available from StoneL or for download from <http://www.stonel.com/en/products/quartz/installation-manuals>

3. Description of safety requirements

3.1. Safety function

Limit switch models: The function of the device is to provide contact inputs to the safety system that relates the position of the measured actuator / valve. Both sensors can be used in conjunction to verify valve position. In order to achieve the desired SIL safety level, redundant contacts/switches may be needed.

4-20 mA Position transmitter models: The function of this device is to provide position feedback inputs to the safety system that relates the position of the measured actuator / valve. If position transmitter produces feedback out of range (<3mA or >21mA) that is considered dangerous detected failure, the controller must perform the safety function.

10k Potentiometer models: The function of this device is to provide position feedback inputs to the safety system that relates the position of the measured actuator / valve. If the potentiometer unit transmitter produces feedback out of range (>11K Ω) that is considered dangerous detected failure, the controlled must perform the safety function.

3.2. Restrictions for use in safety-related applications

Please ensure that the valve monitor is used correctly for the application in question and that the ambient conditions are taken into account. The instructions for installation conditions, as detailed in the IMO, shall be observed. The specifications in the IMO shall not be exceeded.

3.3. Functional safety indicators

The table below shows the specific values for functional safety.

Model Series	Type	λ	λ_s	λ_d	λ_{dd}	λ_{du}
QX_J, QN_J	A	9.93E-09	8.27E-09	1.66E-09	0	1.66E-09
QX_K, QN_K	A	1.97E-08	1.23E-08	7.38E-09	0	7.38E-09
QX_L, QN_L	A	1.97E-08	1.23E-08	7.38E-09	0	7.38E-09
QX_P, QN_P	A	9.93E-09	8.27E-09	1.66E-09	0	1.66E-09
QX_G, QN_G	A	9.93E-09	8.27E-09	1.66E-09	0	1.66E-09
QX_H, QN_H	A	9.93E-09	8.27E-09	1.66E-09	0	1.66E-09
QX_M, QN_M	A	9.93E-09	8.27E-09	1.66E-09	0	1.66E-09
QX_S, QN_S	A	1.97E-08	1.23E-08	7.38E-09	0	7.38E-09
QX_X, QN_X	A	1.60E-07	9.34E-08	6.62E-08	0	6.62E-08
QX_A, QN_A	A	2.97E-08	1.91E-08	1.07E-08	0	1.07E-08
QX_N, QN_N	A	2.90E-08	2.21E-08	6.91E-09	0	6.91E-09
QX33, QN33	A	2.73E-07	1.64E-07	1.10E-07	0	1.10E-07
QX35, QN35	A	2.24E-07	1.40E-07	8.40E-08	0	8.40E-08
QX44, QN44	A	2.02E-07	1.35E-07	6.78E-08	0	6.78E-08
QX45, QN45	A	3.55E-07	2.43E-07	1.11E-07	0	1.11E-07
QX50, QN50	A	1.36E-07	2.84E-08	1.07E-07	7.03E-08	3.69E-08
QXBO, QNBO	A	3.80E-08	3.50E-09	3.45E-08	3.04E-08	4.10E-09
QX70, QN70	A	1.31E-07	2.84E-08	1.03E-07	6.65E-08	3.64E-08
QXCO, QNCO	A	3.37E-08	3.07E-09	3.06E-08	2.70E-08	3.67E-09

Table 2

- λ = Total Failure Rate ($\lambda = \lambda_s + \lambda_d$)
- λ_s = Safe Failure Rate
- λ_d = Dangerous Failure Rate
- λ_{dd} = Dangerous Detected Failure Rate
- λ_{du} = Dangerous Undetected Failure Rate

Limit switch models: The failure rates assume that idle current principle has been applied. The switch must be chosen such that an open switch must result in an action which performs the safety function. In normal operation (no safety demand) the switch is closed and a current, sourced by the controller, flows through the switch (idle current). If the current flow is interrupted, due to switch or line break etc., the safety function will be performed.

The achievable SFF of the Quartz unit depends on the configuration and number of the switches and the evaluation of the signals from the Quartz in the connected safety controller.

Position transmitter and potentiometer models: The failure rates assume the following:

- < 20% deviation from actual position is considered a safe failure
- > 20% deviation from actual position is considered a dangerous failure.
- If position transmitter produces feedback out of range(<3mA or >21mA) that is considered dangerous detected failure, the controlled must perform the safety function.
- If the potentiometer unit produces feedback out of range (>11KΩ) that is considered dangerous detected failure, the controlled must perform the safety function.

4. Installation

4.4.1. Hardware fault tolerance

The hardware fault tolerance of the standalone installation is $HFT=0$. If hardware fault tolerance of ≥ 1 is required, then a redundant configuration of the limit switch installation shall be used. Since position transmitter and potentiometer units are not available in redundant configuration they are limited to $HFT=0$, therefore can only be used up to SIL2.

4.4.2. Installation and commissioning

The installation and commissioning/calibration of the device must be done by qualified technician, according to the IMO. It is important that the mechanical connection to the valve/actuator is installed correctly and securely by a qualified technician. Every parameter related to the device type in question and mentioned in the IMO needs to be checked and compared against the device settings. If any deviations exist the safety of the installation cannot be guaranteed.

4.4.3. Orientation

Orientation of the device is described in the IMO.

4.5. Operation

See IMO for the operation of the device.

Limit switch models: The sensors are triggered by a rotating cam at a fixed distance from the sensors, this ensures that the switch points are repeatable and consistent over the full temperature range, even in high vibration environments.

Position transmitter and potentiometer models: These have a potentiometer that is driven by the rotating shaft. It is fixed to the shaft to give positive engagement to ensure that the position feedback is repeatable and consistent over the full temperature range, even in high vibration environments

4.6. Maintenance



See the IMO for maintenance instructions.

During maintenance work on the device, alternative safety function methods shall be taken to ensure process safety. This device should be considered in all SIF proof tests.

5. Repair

Any repair to the device shall be carried out under guidance by the manufacturer. Device failures must be reported to the manufacturer. The user shall provide a detailed report to the manufacturer describing the failure and any possible effects.

6. QX/QN Certificate

Certificate			
			
No.: 968/FSP 1064.04/20			
Product tested	Quartz™ Valve Position Indicator/Sensor	Certificate holder	Neles USA Inc. dba StoneL 26271 US Highway 59 Fergus Falls, MN 56537 USA
Type designation	QX- and QN- Models (Details see Appendix of Certificate)		
Codes and standards	IEC 61508 Parts 1-7:2010 (in extracts)		
Intended application	<p>The Quartz™ Valve Position Indicator/Sensor can be used in a safety instrumented system (SIS) as sensor(s) to indicate the position of a valve assembly.</p> <p>Some variants listed on the next pages can be used in applications up to SIL 3 acc. to IEC 61508 and IEC 61511-1. The configuration and number of switches (HFT = 0 or 1) depend on the target safety level (SIL) and the evaluation of the signals in the safety controller.</p> <p>Other variants listed on the next pages are not available in a redundant configuration. Due to this fact the hardware fault tolerance is 0 (HFT=0) and considering the achieved SFF of < 90 %, the devices fulfil the requirements for the hardware integrity of SIL 2 of IEC 61511-1, table 6 and IEC 61508-2, table 2.</p>		
Specific requirements	The instructions of the associated Installation, Maintenance and Operating Instructions and Safety Manual shall be considered.		
Valid until	2025-07-03		
<p>The issue of this certificate is based upon an examination, whose results are documented in Report No. 968/FSP 1064.04/20 dated 2020-07-03. This certificate is valid only for products which are identical with the product tested.</p>			
<p>TÜV Rheinland Industrie Service GmbH Bereich Automation Funktionale Sicherheit Am Grauen Stein, 51105 Köln</p>			
Köln, 2020-07-03	 Certification Body Safety & Security for Automation & Grid		Dr.-Ing. Thorsten Gantevoort

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7. QX/QN Certificate page 2

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Safety function: Sensing of the position of valves or actuators. The configuration and number of switches (HFT = 0 or 1) depend on the target safety level (SIL) up to SIL 3 and the evaluation of the signals in the safety controller.

Opening and closing position of the switches may be configured such that an open contact results to an action into the safe direction of the SIF.

Model Series	Type	λ / 1/h	λ_s / 1/h	λ_d / 1/h	SFF
QX2J, QX4J, QX5J, QX7J QN2J, QN4J, QN5J, QN7J	A	9.93E-09	8.27E-09	1.66E-09	83,3%
QX2L, QX4L, QX5L, QX7L QN2L, QN4L, QN5L, QN7L	A	1.97E-08	1.23E-08	7.38E-09	62,4%
QX2P, QX4P, QX5P, QX7P QN2P, QN4P, QN5P, QN7P	A	9.93E-09	8.27E-09	1.66E-09	83,3%
QX2G, QX4G, QX5G, QX7G QN2G, QN4G, QN5G, QN7G	A	9.93E-09	8.27E-09	1.66E-09	83,3%
QX2H, QX4H, QX5H, QX7H, QX8H QN2H, QN4H, QN5H, QN7H, QN8H,	A	9.93E-09	8.27E-09	1.66E-09	83,3%
QX2M, QX4M, QX5M, QX7M, QN2M, QN4M, QN5M, QN7M	A	9.93E-09	8.27E-09	1.66E-09	83,3%
QX2S, QX4S, QX5S, QX7S QN2S, QN4S, QN5S, QN7S	A	1.97E-08	1.23E-08	7.38E-09	62,4%
QX4X, QX6X, QN4X, QN6X	A	1.80E-07	9.34E-08	6.62E-08	58,4%
QX2A, QX4A, QX5A, QX7A, QN2A, QN4A, QN5A, QN7A	A	2.97E-08	1.91E-08	1.07E-08	64,4%
QX2N, QX4N, QX5N, QX6N, QX7N QN2N, QN4N, QN5N, QN6N, QN7N	A	2.90E-08	2.21E-08	6.91E-09	76,2%
QX33, QN33	A	2.73E-07	1.64E-07	1.10E-07	60,1%
QX44, QN44	A	2.02E-07	1.35E-07	6.78E-08	66,8%

λ Total Failure Rate ($\lambda = \lambda_s + \lambda_d$)

λ_s Safe Failure Rate

λ_d Dangerous Failure Rate

Safe Failure Fraction SFF = λ_s / λ

8. QX/QN Certificate page 3

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Safety function: Sensing of the position of valves or actuators and translating it into a 4-20mA value. Certified up to SIL 2, see note below.

Diagnostic measures: For the calculation of the safety related reliability data it is assumed that the safety controller has to perform the following diagnostic measures:
In case the current <3mA or >21mA the safety controller has to perform a safety related action.

Model Series	λ 1/h	λ_S / 1/h	λ_d / 1/h	λ_{dd} / 1/h	λ_{du} / 1/h	SFF
QN50, QX50	1,36E-07	2,84E-08	1,07E-07	7,03E-08	3,69E-08	72,8 %
QN70, QX70	1,31E-07	2,84E-08	1,03E-07	6,65E-08	3,64E-08	72,3 %

λ total failure rate
 λ_d Current deviates more than 20% from the "real" value (valve Position)
 λ_S Current deviates less than 20% from the "real" value (valve Position)
 λ_{dd} Current is <3mA or >21mA
 λ_{du} Current deviates more than 20% from the "real" value (valve Position), but is still within 3 to 21mA

Safe Failure Fraction SFF = $(\lambda - \lambda_{du}) / \lambda$

Note: The models listed in the table above are not available in a redundant configuration. Due to this fact the hardware fault tolerance is 0 (HFT=0) and considering the achieved SFF, which is smaller than 90%, the devices fulfil the requirements for the hardware integrity up to SIL 2 of IEC 61511-1, table 6 and IEC61508-2, table 2.

9. QX/QN Certificate page 4

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Safety function: Sensing of the position of valves or actuators and translating it into a 0-10kOhm resistance value. Certified up to SIL 2, see note below.

Diagnostic measures: For the calculation of the safety related reliability data it is assumed that the safety controller has to perform the following diagnostic measures:
In case the resistance is > 11kOhm the safety controller has to perform a safety related action.

Model Series	λ / 1/h	λ_s / 1/h	λ_d / 1/h	λ_{dd} / 1/h	λ_{du} / 1/h	SFF
QNBO, QXBO	3,80E-08	3,50E-09	3,45E-08	3,04E-08	4,10E-09	89,2%
QNCO, QXCO	3,37E-08	3,07E-09	3,06E-08	2,70E-08	3,67E-09	89,1%

λ total failure rate

λ_d Resistance deviates more than 20% from the "real" value (valve Position)

λ_s Resistance deviates less than 20% from the "real" value (valve Position)

λ_{dd} Resistance is >11kOhm

λ_{du} Resistance deviates more than 20% from the "real" value (valve Position), but is still below 11kOhm

Safe Failure Fraction SFF = $(\lambda - \lambda_{du}) / \lambda$

Note: The models listed in the table above are not available in a redundant configuration. Due to this fact the hardware fault tolerance is 0 (HFT=0) and considering the achieved SFF, which is smaller than 90%, the devices fulfil the requirements for the hardware integrity up to SIL 2 of IEC 61511-1, table 6 and IEC61508-2, table 2.

Safety function: Sensing of the position of valves or actuators. Certified up to SIL 2.

Model Series	λ / 1/h	λ_s / 1/h	λ_d / 1/h	λ_{dd} / 1/h	λ_{du} / 1/h	SFF
QN35, QX35	2,24E-07	1,40E-07	8,40E-08	0	8,40E-08	62,5%
QN45, QX45	3,55E-07	2,43E-07	1,11E-07	0	1,11E-07	68,6%