Neles ValvGuard™
VG9000H
Rev 2.0
Safety Manual
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1. General information

1.1 Purpose of the document

This safety manual provides necessary information to design, install, verify and maintain safety instrumented function (SIF) using the Metso’s Neles ValvGuard Intelligent Safety Solenoid and/or the integrated position transmitter.

The document must be used as part of the safety lifecycle. Information provided in this manual is necessary for meeting the IEC 61508 or IEC 61511 functional safety standards.

1.2 Description of the device

Neles ValvGuard VG9000H is loop (mA) powered SIL 3 certified intelligent safety solenoid and thus a safety related product. VG9000H can be used with or without Local Control Panel (LCP). LCP has different product options; externally powered (24 VDC) version (LCP9H_) or the loop powered (mA) version (LCP9H_L). LCP9H_L is powered via the input signal of VG9000H. Optional integrated position transmitter (T01) is loop powered SIL 2 certified device and provides 4-20 mA output signal related to valve position.

Extra attention is required to make sure they are used in a way they are intended to be used and in a safe manner.

NOTE:
HART communication can be used for informational purposes, but is not safety certified for diagnostic annunciation.

2. Structure of safety valve controller

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 in the IMO.

2.3 Supplementary device documentation

This manual is not intended to be used as a stand-alone document. It must be used together with the document 7VG9H70EN; Installation, Maintenance and Operating Instructions for Neles ValvGuard VG9000H (later referred as IMO).

It is available from your local Metso office or for download from www.metso.com/VG9000

3. Description of safety requirements

3.1 Safety function

3.1.1 Intelligent safety solenoid

Intelligent safety solenoid part of the Neles ValvGuard consists of the spool valve (SV), the prestage unit (PR) and the safety electronics. They are the components, which take part of the safety action. Prestage unit is coil operated flapper valve, which is open when de-energized. De-energized is the safe state of the device prestage unit coil. Prestage unit is controlling the spool valve, which is operated by spring force to fail safe position and by pneumatic force to the normal position. See figure 1 for the principle of operation. Prestage will be de-energized when input signal (loop current) to the device (VG9000H) is below 6.0 mA (nominal 4.0 mA). If using VG9000H_L3 product option, then the prestage will be de-energized when input signal is below 10.0 mA (nominal 8.0 mA). That will cause the spool valve to release the air from C2 port via spool valve exhaust and drive the emergency shutdown valve to close or open position depending on the application type.

Safety function is to release the air from C2 port via the spool valve exhaust. Reaction time of safety function is <200 milliseconds. The closing (or opening) time of the valve depends on the size of the spool valve, size and type of the pneumatic actuator and the valve, the supply pressure etc.

Micro controller and firmware are not part or cannot prevent the safety action. Measurements from the pressure sensors (Px) and position sensor (α) are used for controlling the Partial Stroke and other tests and used for the device diagnostics only.
**Figure 1.** Principle of operation. Spool valve and prestage are shown in de-energized position.

Figures 2 and 3 show the thresholds of VG9000H and VG9000H_L3 product option respectively. Thresholds for the de-energized states are the main safety related information, but the figures show also all other loop current thresholds of the intelligent safety solenoids.

**Figure 2.** Loop current thresholds of the intelligent safety solenoid input signal (VG9000H product option)
20.0 mA (nominal value)
8.0 mA (nominal value)
16.0 mA
10.0 mA
7.7 mA
22.0 mA
0 mA

Normal state (prestage energized)
Hysteresis state
Safe state (prestage de-energized)

Diagnostics available
Diagnostics NOT available

Figure 3. Loop current thresholds of the intelligent safety solenoid input signal (VG9000H_L3 product option)

3.1.2 Position transmitter

In the position transmitter part of the Neles ValvGuard the feedback sensor, located in the extension housing, measures the valve position and the transmitter electronics convert the position into a 4-20 mA signal. This signal is used by the safety control system. Safety function of the position transmitter is sensing the position of the valve or actuator and translating it into a 4-20 mA value. If the position transmitter produces feedback out of range (<3 mA or >21 mA), that is considered dangerous detected failure, and the safety system must perform the safety action.

3.2 Restrictions for use in safety-related applications

Please ensure that both, the intelligent safety solenoid and the position transmitter, are used correctly for the application in question and that the ambient conditions and air supply quality 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 tables below show the specific indicators for functional safety.

3.3.1 Data for intelligent safety solenoid
Table 1. Functional safety indicators of intelligent safety solenoid

<table>
<thead>
<tr>
<th>Operation with diagnostics tests enabled (pneumatics test and/or PST) for ValvGuard mechanical part</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability of Dangerous Failure on Demand</td>
</tr>
<tr>
<td>Assumed Valve Proof Test Interval</td>
</tr>
<tr>
<td>Confidence Interval</td>
</tr>
<tr>
<td>Safe Failure Fraction</td>
</tr>
<tr>
<td>Hardware Fault Tolerance</td>
</tr>
<tr>
<td>Diagnostic Coverage</td>
</tr>
<tr>
<td>Type of Sub System IEC 61508-2, 7.4.4.1.2/3</td>
</tr>
<tr>
<td>Mode of Operation IEC 61508-4, 3.5.16</td>
</tr>
</tbody>
</table>

### Derived Values

| Assumed Demands per Year | $f_{np}$ | 1/a | 1.14E-04/h |
| Total Failure Rate | $\lambda_0 + \lambda_D$ | 1/h | 1.06 E-06/h | 1058 FIT |
| Lambda Dangerous Detected | $\lambda_D$ | 1/h | 5.28 E-08/h | 53 FIT |
| Lambda Dangerous Undetected | $\lambda_{DU}$ | 1/h | 2.98 E-09/h | 3 FIT |
| Lambda Safe Detected | $\lambda_{SD}$ | 1/h | 8.42 E-08/h | 84 FIT |
| Lambda Safe Undetected | $\lambda_{SU}$ | 1/h | 9.18 E-07/h | 918 FIT |
| MTBF total | | h | 9.45 E+08 h | 1.08 E+03 a |
| MTBF (Dangerous Failures) | MTBF$_D$ | h | 1.79 E+07 h | 2.05 E+03 a |
| Average Probability of Failure on Demand | PFD$_{avg}$ | | 6.53 E-05 |

<table>
<thead>
<tr>
<th>Operation with diagnostics disabled for ValvGuard mechanical part</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability of Dangerous Failure on Demand</td>
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<tr>
<td>Test Interval</td>
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</tr>
</tbody>
</table>

### Derived Values

| Assumed Demands per Year | $f_{np}$ | 1/a | 1.14E-04/h |
| Total Failure Rate | $\lambda_0 + \lambda_D$ | 1/h | 9.79 E-07/h | 979 FIT |
| Lambda Dangerous Detected | $\lambda_D$ | 1/h | 5.20 E-08/h | 52 FIT |
| Lambda Dangerous Undetected | $\lambda_{DU}$ | 1/h | 3.82 E-09/h | 4 FIT |
| Lambda Safe Detected | $\lambda_{SD}$ | 1/h | 6.40 E-08/h | 64 FIT |
| Lambda Safe Undetected | $\lambda_{SU}$ | 1/h | 8.59 E-07/h | 859 FIT |
| MTBF total | | h | 1.02 E+06 h | 116 a |
| MTBF (Dangerous Failures) | MTBF$_D$ | h | 1.79 E+07 h | 2.05 E+03 a |
| Average Probability of Failure on Demand | PFD$_{avg}$ | | 8.37 E-05 |

All channel inside the device fulfil the requirements on the SFF individually.
Therefore, it is assumed that the equivalent SFF for a “calculated 1oo1” device is SFF > 90 %.
3.3.2 Data for position transmitter

Table 2. Functional safety indicators of position transmitter part of Neles ValvGuard

<table>
<thead>
<tr>
<th>Safety function: Sensing of the position of valves or actuators and translating it into a 4-20mA value.</th>
<th>Diagnostic measures: In case the current is &lt;3 mA or &gt;21 mA the sensor has an internal failure and the process has to be controlled in a way to lower the risk.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda$</td>
<td>$\lambda_d$</td>
</tr>
<tr>
<td>1,36E-07</td>
<td>2,84E-08</td>
</tr>
</tbody>
</table>

$\lambda$ total failure rate

$\lambda_d$ Current deviates more than 5 % from the “real” value (valve Position)

$\lambda_s$ Current deviates less than 5 % from the “real” value (valve Position)

$\lambda_{dd}$ Current is <3mA or >21mA

$\lambda_{du}$ Current deviates more than 5 % from the “real” value (valve Position), but is still within 3 to 21mA

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

Note: Position transmitter is not available in a redundant configuration. Due to the SFF is smaller than 90 % and the limitation of HFT=0, they can only be used up to SIL 2.

The failure rates assume the following:
- < 5 % deviation from actual position is considered a safe failure
- > 5 % deviation from actual position is considered a dangerous failure
- If position transmitter produces feedback out of range (<3 mA or >21 mA) that is considered dangerous detected failure, the controlled must perform the safety function

3.3.3 Useful lifetime

A useful lifetime of approximately 12 years is expected for Neles ValvGuard.

3.4 Behavior of device

3.4.1 During power-up

It may take up to 9 seconds for device diagnostics to power up and the intelligent safety solenoid to be fully operational in the diagnostics point of view. This is valid when the loop current is switched on and goes to 3.7 mA (7.7 mA for VG9000H_L3 product option) or above. This does not effect to the safety function of the device.

3.4.2 During operation

Once the loop current goes to 16.0 mA or above the prestage will be energized and the supply air will be fed to the pneumatic actuator by spool valve. That will eventually cause the valve to go to its normal operating position, which is open or close depending on the application type. Valve will remain in its normal operating position if the loop current is above 16.0 mA (nominal 20.0 mA). See all the loop current thresholds in section 3.1.

3.4.3 During emergency trip

See section 3.1.

3.4.4 In the event of alarms and warnings

Device alarms or warnings do not cause the intelligent safety solenoid to go to fail safe. See the ‘behavior of device during operation’ above.
4. Installation

4.1 Hardware fault tolerance
The required hardware fault tolerance of the installation is zero (HFT = 0). If hardware fault tolerance of one (HFT = 1) is required, then a dual redundant configuration of the valve installation shall be used.

The overall safety integrity depends mainly on the actuator and the valve (ESD or ESV). Therefore a hardware fault tolerance (HFT) of 1 in SIL 3 applications is strongly recommended.

4.2 Installation and commissioning
The installation of the device needs to be done according to the IMO. 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.

The VG9000H shall be configured before commissioning. The parameters configured to the VG9000H shall be read back and verified before commissioning using the HART Device Description (DD) or Metso's Valve Manager (DTM) for VG9000H.

4.3 Orientation
Orientation of the device is described in the IMO.

4.4 Diagnostics coverage
To obtain the best possible diagnostic coverage, the automatic test intervals and the various alarm limits in the VG9000 intelligent safety solenoid shall be set, see Section 4 in the IMO.

The pneumatic test shall be enabled in case a safety integrity level of 3 (SIL 3) is required by the overall application.

The diagnostic coverage factor for an ESD-valve (fail to close valve) can be assumed to be around 75 % (valve + actuator), depending on the valve and actuator types. The diagnostic coverage factor for an ESV-valve (fail to open valve) can be assumed to be around 90 % (valve + actuator), depending on the valve and actuator types. For more accurate estimates contact Metso.

4.5 Parameters write protection
The parameters programmed in the VG9000H shall be write protected. If the organizational procedures are established, this can be done using the user access levels in the configuration software. See section 4.8.5 in the IMO.

4.6 Operation
See the IMO for the operation of the device.

4.7 Maintenance
See the IMO for maintenance instructions.

During maintenance work on the device, alternative safety function methods shall be taken to ensure process safety.
5. **Testing**

5.1 **Internal tests of intelligent safety solenoid**

Internal tests can be separated to two different parts, internal safety diagnostics and pneumatics test. They are described below.

5.1.1 **Internal safety diagnostics**

Device performs internal testing for its safety related electronics with the predefined interval of 10 minutes. User does not need to perform any electronics related tests manually. Problems in the internal safety related electronics test will be shown by diagnostics.

5.1.2 **Pneumatics test**

Device can perform internal pneumatics test for its pneumatics function. The test can be manual or automatic. Minimum automatic test interval is 10 minutes. The operation of the prestage and spool valve will be checked during the test. For procedure and details see the IMO. This test does not affect the operation of the safety shutdown valve.

5.2 **Position transmitter**

If the device is equipped with the position transmitter, it can be tested by measuring the output signal. It shall be 4 mA when the valve is closed and 20 mA when the valve is open.

5.3 **Partial stroke test (PST)**

Device can perform valve partial stroke test, where the safety shutdown valve will be stroked certain amount from its normal operating position. Typically this stroke size is about 10-20% depending on the process. The stroke size shall be defined by the user and should be defined so that the upset for the process is kept as minimum. The partial stroke test can be manual or automatic. Minimum automatic test interval is 10 minutes. For procedure and details see the IMO.

5.4 **Valve proof-test**

Safety shutdown valve proof-test is related to the required SIL level of the application. PFD calculations should define this safety shutdown valve proof test interval.

The valve proof test can be performed by using VG9000H’s Emergency Trip Test (ETT) and it is available via HART. ETT can only check the valve closing/opening time, but not the the tightness. See the valve safety manual for further info regarding the proof testing.

The whole safety loop shall be tested via the safety system / logic solver.

6. **Repair and maintenance**

Any repair and maintenance to the device shall be carried out only by the manufacturer or the person certified 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.
7. **SIL certificate**

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**Certificate**

No.: 968/FSP 1343.00/16

**Product tested** Intelligent Safety Solenoid including a position transmitter

**Certificate holder** Metso Flow Control, Oy Vanha Porvoontie 229 01380 Helsinki-Vantaa Finland

**Type designation** VG9000H/T01

**Codes and standards** IEC 61508 Parts 1-7:2010

**Intended application** Safety-related Emergency Shut-down of a valve by releasing pressured air from the actuator in low demand mode applications up to SIL 3 (VG9000H). Sensing of a position of a valve and translating the position into a 4-20mA signal in low demand mode applications up to SIL 2 (T01 option).

**Specific requirements** The overall safety integrity depends mainly on the connected actuator and the final valve (ESD or ESV) to the safety solenoid. Therefore a hardware fault tolerance (HFT) of 1 in SIL 3 applications is strongly recommended. The instructions of the associated safety and installation manual shall be considered.

Summary of test results see pages 2 and 3 of this certificate.

Valid until 2021-12-20

The issue of this certificate is based upon an examination, whose results are documented in Report No. 968/FSP 1343.00/16 dated 2016-12-20. This certificate is valid only for products which are identical with the product tested. It becomes invalid at any change of the codes and standards forming the basis of testing for the intended application.

Köln, 2016-12-20

Certification Body Safety & Security for Automation & Grid

Dipl.-Ing. Stephan Häb

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