Operating instructions

xBALL Controller — Electronic expansion ball valve with integrated superheat controller

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Introduction and basic installation

Introduction

The xBALL Controller is an electronic valve with an integrated controller to control refrigerant superheat and optimise refrigerant circuit performance in compliance with the constraints imposed by low superheat (LSH), low suction temperature (LSU), high evaporation pressure (MOP) and low evaporation pressure (LOP) protections. It receives the signal from the refrigeration machine controller regarding the start, stop or modulation of control (digital on/off or Modbus) and positions the ball according to the setpoint. The xBALL Controller positions the ball independently, by using suction, temperature, and evaporation pressure readings from two probes in the refrigerant circuit. This removes the need for an external driver. The xBALL Controller is also available in a "fail-safe" version which uses a super-condenser and can perform an emergency shut-down in the event of a power failure, eliminating the need for the safety solenoid valve. The xBALL Controller provides, in all versions, a feedback signal indicating the position of the electronic valve in percent, from 0...100%. The opening movement of the ball is counter-clockwise, and the closing movement is clockwise.

Connection

The xBALL Controller is equipped with two circular connectors, respectively named **POWER** and **PROBE,** whose intended uses are as follows:

POWER (five wires)
Power supply (AC/DC 24 V– two wires) and control signals (three wires). The application of cable code Z-C24X4P010 is required; the association between wires and poles of which is as follows.

Number	Colour	Use
1	Black	AC power supply: G0 DC power supply: –
2	Brown	A/D mode: GND Bus mode: RS-485 GND
3	Red	AC power supply: G DC power supply: +
4	Orange	A/D mode: digital input Bus mode: RS-485 +
5	Yellow	A/D mode: analogue output Bus mode: RS-485 –

Actuator circular connector view

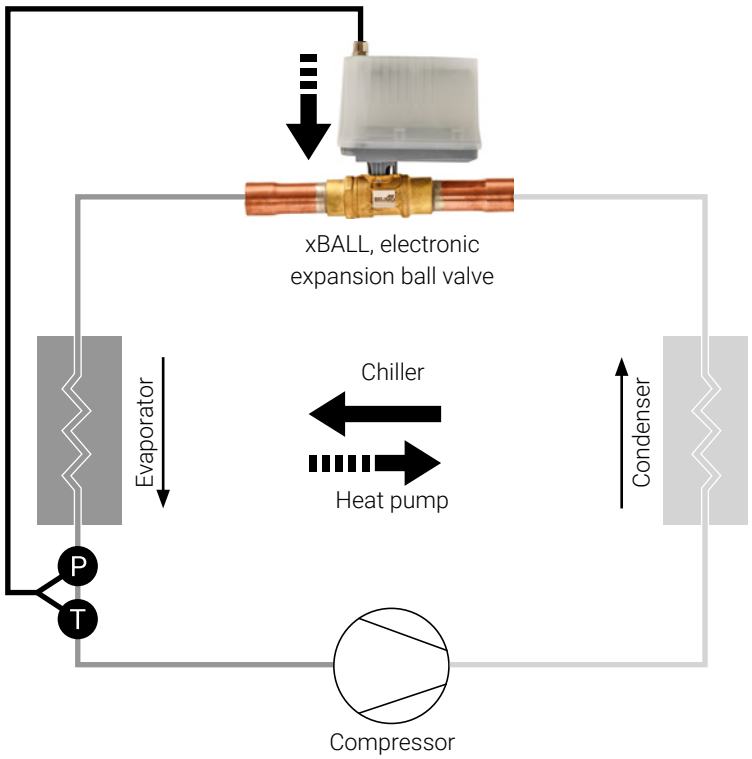
Cable circular connector view

PROBE
Measurement of suction temperature and evaporation pressure.

The application of cable Z-C24X4Y050 is required, which has both an NTC-type sensing element for temperature measurement and a Metri-Pack 150 3-way female "T" connector to be connected to the pressure sensor of choice (either electronic/4...20 mA or ratiometric/0...5 V).

Installation

In order to perform the measurement and control of refrigerant superheat, the placement within the refrigerant circuit of the xBALL Controller and the corresponding **PROBE** cable must be subject to the directions provided by the following diagram:



The letters “P” and “T” respectively indicate the correct placement of the pressure probe and temperature probe.

After the procedure is completed, make sure the actuator is properly engaged with the valve by applying light pressure as indicated by the vertical arrow in the figure.

Commissioning

Commissioning requirements

Commissioning the xBALL Controller requires an Android or Apple-compatible smartphone with a mobile data or Wi-Fi connection, on which the Syncra app is to be installed. This is available in both Android and iOS versions in the respective stores.

Download and install

Download on the App Store	GET IT ON Google Play	**Login to Belimo Gardian**

Syncra also plays the role of interfacing between the xBALL Controller and the Gardian cloud by interfacing with the electronic valve via radio signal and then transmitting the collected data to the Gardian cloud platform via the mobile data or Wi-Fi connection of the smartphone.

Once you start Syncra and complete entering credentials or creating a new account, you can access the main screen where all the xBALL electronic valves previously associated with the account and detected nearby are displayed. Selecting one of these automatically establishes a connection, thereby enabling the operating parameters to be viewed and modified. If the electronic valve is not detected, it is necessary to start the process of associating it with the account: to do this, select the “Add device” function on the bottom screen.
The association process involves selecting the location or installation where to register the electronic valve; if not already created, a new assignment can also be created. The xBALL device can then be linked to the user's account—making the user the owner—by scanning the QR code on the electronic valve label with the smartphone camera or by manually entering the registration key shown on the label. At this point, the electronic valve is detectable, and the respective operating parameters can be accessed.

Initial commissioning

If the process has not been completed previously, the first connection to the xBALL electronic valve prompts Syncra to present a guided configuration menu, allowing the user to place the valve into operating condition by setting just four parameters. These parameters are:

- **System of units**
  Defines the system of units to be used for the interpretation of pressure and temperature measurements. Allows a choice of two settings: International System (SI); Imperial British System (IMP).

- **Refrigerant**
  Defines the refrigerant and allows a choice of multiple types of CFCs, HFCs, and HFOs. R290 is included.

- **Control mode**
  Defines the nature of the control signal exerted by the refrigeration machine on the electronic valve and allows a choice of two settings: “A/D mode” or “bus mode”.

- **Pressure probe**
  Defines the model of the pressure probe used for evaporation pressure measurement. Allows a choice of multiple types differentiated by category (electronic/4...20 mA or ratiometric/0...5 V) and by measurement range. Available only on the Syncra app.

The “System of units” parameter allows you to choose between the “International System” (default) and “British Imperial System”. The “Refrigerant” specification allows you to choose one of several approved refrigerants compatible with the controller. The “control mode” allows you to indicate to the xBALL Controller the nature of the control signal from the refrigeration machine. In “A/D mode”, the start/stop control is sent via a digital signal, and the position feedback is provided via an analogue signal. In the “bus mode,” the electronic valve and refrigeration machine communicate using the RS-485 bus and Modbus protocol. The **Pressure probe** setting enables you to quickly select the type of pressure sensor by choosing from the supported models in the list.

When the “control mode” is set to “bus mode” the startup, shutdown and general definition by the machine's cooling capacity is controlled by the parameter “Machine cooling capacity”.

Control and protection

Control configuration

The electronic expansion valve is an essential component of a refrigeration system. Its purpose is to ensure that the refrigerant flow rate passing through the evaporator is sufficient to complete the evaporation process, preventing liquid from entering the compressor. Superheat control is the method used by the electronic valve to ensure that the refrigerant flow rate is correct. Superheat is the difference between the superheated gas temperature at the evaporator outlet and the evaporation saturation temperature. An ideal superheat value is between 3 and 15 K: values below 3 K may indicate the presence of liquid at the compressor inlet, while values above 15 K may indicate insufficient refrigerant flow rate. Accurate control of superheat is therefore necessary to ensure the safety and efficiency of the refrigeration system. For this purpose, the xBALL Controller realises superheat control based on PID (Proportional, Integral, Derivative) type backward-acting logic whose main configuration parameters are as follows:

- **Superheat setpoint**
  It defines the setpoint for superheat control. The controller will work to reach and maintain this value. It is expressed in tenths of K (SI) or tenths of °F (IMP).

- **Percent valve opening at start**
  It defines the valve opening position when the refrigeration machine is started. When the “Control start delay” expires, the control algorithm is triggered. It is expressed as a percentage.

- **Control start delay**
  It defines the delay from the startup of the refrigeration machine and the triggering of the control algorithm. It is expressed in seconds.

- **Standby opening percentage position**
  It defines the opening position of the valve during the stop state of the refrigeration machine. It is expressed as a percentage.

- **PID proportional gain**
  It defines the proportional coefficient of the PID controller (Proportional, Integral, Derivative) and acts by opening or closing the valve proportionally to the change in superheat. It is expressed in points of the electronic valve.

- **PID integral time**
  It defines the integral time of the PID controller (Proportional, Integral, Derivative) and acts in proportion to the distance of the superheat from the setpoint: the greater the distance, the stronger the action; the lower the parameter value, the firmer the effect. It is expressed in tenths of seconds.

- **PID derivative time**
  It defines the derivative time of the PID controller (Proportional, Integral, Derivative) and acts in opposition to variations by trying to anticipate the correction action. The greater the parameter value, the firmer the effect. It is expressed in tenths of seconds.

Protections configuration

Protections are additional adjustments that act in the event of anomalies that are potentially dangerous to the machine. They can inhibit control or add to it by differentiating the contribution of their action as the anomaly moves away from the trip threshold.

Low superheat (LSH)
Low superheat protection prevents low superheat values from posing a backflow hazard to the compressor. The action exerted is integral, where threshold and time determine the intensity of the corrective action. The greater the distance from the threshold, the more intense the action will be; the lower the value of the integral time, the more intense the action will be. The protection configuration parameters made available by the xBALL Controller are as follows:

- **Low superheat protection integral time**
  It defines the integral time of LSH protection. It is expressed in tenths of seconds.
- **Low superheat protection alarm delay**
  It defines the alarm trigger delay of LSH protection. It is expressed in seconds.
- **Low superheat protection threshold**
  It defines the tripping threshold of LSH protection. It is expressed in tenths of °C (SI) or tenths of °F (IMP).

Low suction temperature (LSU)
The low suction temperature protection does not exert any direct corrective action, but rather signals the user the possible occurrence of very low measured values that may be due to excessive opening of the electronic valve. The protection configuration parameters made available by the xBALL Controller are as follows:

- **Low suction temperature protection alarm delay**
  It defines the alarm trigger delay of LSU protection. It is expressed in seconds.
- **Low evaporation temperature protection alarm delay**
  It defines the alarm trigger delay of LOP protection. It is expressed in seconds.

Low evaporation temperature (LOP)
Low evaporation temperature protection prevents the compressor from stopping if the evaporation temperature is too low by triggering the intervention of the low-pressure switch. The action exerted is integral, where threshold and time determine the intensity of the corrective action. The greater the distance from the threshold, the more intense the action will be; the lower the value of the integral time, the more intense the action will be. The protection configuration parameters made available by the xBALL Controller are as follows:

- **Low evaporation temperature protection integral time**
  It defines the integral time of LOP protection. It is expressed in tenths of seconds.

- **Low evaporation temperature protection alarm delay**
  It defines the alarm trigger delay of LOP protection. It is expressed in seconds.

- **Low evaporation temperature protection threshold**
  It defines the tripping threshold of LOP protection. It is expressed in tenths of °C (SI) or tenths of °F (IMP).

High evaporation temperature (MOP)
High evaporation temperature protection allows the compressor to be preserved from operating under excessive load conditions, which can lead to risks of motor winding overheating and thermal protection tripping. The action exerted is integral, where threshold and time determine the intensity of the corrective action. The greater the distance from the threshold, the more intense the action will be; the lower the value of the integral time, the more intense the action will be. The protection configuration parameters made available by the xBALL Controller are as follows:

- **High evaporation temperature protection integral time**
  It defines the integral time of MOP protection. It is expressed in tenths of seconds.

- **High evaporation temperature protection alarm delay**
  It defines the alarm trigger delay of MOP protection. It is expressed in tenths of seconds.

- **High evaporation temperature protection thresholds. Both are expressed in tenths of °C (SI) or tenths of °F (IMP):**
  – Evaporation temperature threshold
    It defines the evaporation temperature threshold of MOP protection intervention.
  – Suction temperature threshold:
    It defines the suction temperature threshold above which the valve is permanently blocked.

Control monitoring

It is possible to observe the operating conditions of the xBALL Controller at any time by means of some monitoring variables:

- **Absolute valve position**
  Identifies the current valve position. It is expressed in points.
- **Percentage valve position**
  Identifies the current valve position. It is expressed as a percentage.
- **Feedback signal**
  Identifies the value taken by the feedback signal. It is expressed in hundredths of a volt.
- **Percentage feedback signal**
  Identifies the value taken by the feedback signal. It is expressed as a percentage.
- **Control state**
  Identifies the state assumed by the state machine. Each integer value identifies a state.
- **Evaporation pressure probe measurement**
  Identifies the measurement of the evaporation pressure probe. It is expressed in tenths of barg (SI) or tenths of psig (IMP).
- **Suction temperature probe measurement**
  Identifies the measurement of the suction temperature probe. It is expressed in tenths of °C (SI) or tenths of °F (IMP).
- **Evaporation temperature**
  Identifies the evaporation saturation temperature calculated from the evaporation pressure. It is expressed in tenths of °C (SI) or tenths of °F (IMP).
- **Superheat**
  Identifies the superheat expressed as the difference between the suction temperature and the evaporation saturation temperature. It is expressed in tenths of °C (SI) or tenths of °F (IMP).

Alarms and operation

Alarms and notifications

The following variables make it possible to identify critical issues and situations that are significant to the proper operation of the electronic valve. They are divided into two categories: alarms and notifications.

- **Hardware alarm**
  Identifies the occurrence of a major failure of the main electronic valve control board.
- **Gearbox alarm**
  Identifies the occurrence of a major failure of the component that controls the rotation of the electronic valve ball.
- **Bus communication alarm**
  Identifies the lack of communication via RS-485 bus and Modbus protocol between the electronic valve and the refrigeration machine. It is triggered when the “Bus communication failure recovery action delay” is exhausted.
- **Evaporation pressure probe alarm**
  Identifies the occurrence of a possible failure of the evaporation pressure probe that results in exceeding the alarm thresholds identified by “Maximum pressure probe alarm value” and “Minimum pressure probe alarm value”.
- **Suction temperature probe alarm**
  Identifies the occurrence of a possible failure of the suction temperature probe that results in exceeding the alarm thresholds identified by “Maximum temperature probe alarm value” and “Minimum temperature probe alarm value”.
- **Low superheat alarm**
  Identifies the occurrence of the low superheat alarm. It is triggered when the “Low superheat protection alarm delay” is exhausted.
- **Low suction temperature alarm**
  Identifies the occurrence of the low suction temperature alarm. It is triggered when the “Low suction temperature protection alarm delay” is exhausted.
- **Low evaporation temperature alarm**
  Identifies the occurrence of the low evaporation temperature alarm. It is triggered when the “Low evaporation temperature protection alarm delay” is exhausted.
- **High evaporation temperature alarm**
  Identifies the occurrence of the high evaporation temperature alarm. It is triggered when the “High evaporation temperature protection alarm delay” is exhausted.

- **Low superheat protection activation notification**
  Does not identify the occurrence of the low superheat alarm but represents notification of the triggering of the respective protection.

- **Low evaporation temperature protection activation notification**
  Does not identify the occurrence of the low evaporation temperature alarm but represents notification of the triggering of the respective protection.

- **High evaporation temperature protection activation notification**
  Does not identify the occurrence of the high evaporation temperature alarm but represents notification of the triggering of the respective protection.

- **Digital input activation notification**
  Does not identify the occurrence of a specific alarm but represents notification of the state assumed by the input.

Manual positioning

Manual positioning can be enabled at any time and operates in overlap with normal control. It can be operated via Syncra app or via RS-485 connection and Modbus protocol. The variables made available by the xBALL Controller are as follows:

- **Manual positioner enabling**
  It defines the activation or deactivation of the manual positioner.

- **Manual positioner position**
  It defines the position required in manual positioning. It is expressed in points and is a value 0...10'000.

Advanced configurations

General advanced configurations

General advanced configurations provide access to special and optional functions of the xBALL Controller. The parameters made available are:

- **Control enabling**
  It defines the activation or deactivation of the control. By default, this parameter is set to “disabled”; after the initial commissioning procedure is completed, the Syncra app automatically sets it to “enabled”.

- **Evaporation pressure probe alarm enabling**
  It defines the activation or deactivation of the evaporation pressure probe alarm. By default, this parameter is set to “active”.

- **Suction temperature probe alarm enabling**
  It defines the activation or deactivation of the suction temperature probe alarm. By default, this parameter is set to “active”.

- **Start adaptation procedure**
  It defines the activation of the “Adaptation” procedure, which allows the end stop positions of opening and closing of the electronic valve to be calibrated. At the factory, the xBALL Controller comes already calibrated.

- **Machine cooling capacity**
  Only in the case where the xBALL Controller is set to operate in “bus mode”, it allows the cooling capacity of the machine currently in use to be defined and allows the electronic valve to optimise its operating point. It is expressed as a percentage.

- **LED ring configuration (“halo”)**
  It defines the behaviour of the LED ring and allows you to choose from three different settings: always off; direction-of-motion indication; opening percentage indication.

- **Valve model optimisation**
  Specifically, it defines the valve model to activate specific optimisations. Allows a choice of four different settings: generic; EXC10; EXC20; EXC50.

- **Service (auto-resetting values)**
  It defines using specific codes for certain services or reserved functions. The value “2020” allows for a factory reset.

Advanced pressure probe configuration

The advanced configuration of the evaporation pressure probe makes it possible to increase the compatibility of the xBALL Controller with additional types of probes and to customise their characteristics in detail. The parameters made available are:

- **Pressure probe type**
  It defines the type of evaporation pressure probe and allows a choice of two settings: electronic (4...20 mA) or ratiometric (0...5 V).

- **Maximum pressure probe value**
  It defines the maximum value of evaporation pressure that can be measured by the probe. It is expressed in tenths of barg (SI) or tenths of psig (IMP).

- **Minimum pressure probe value**
  It defines the minimum value of evaporation pressure that can be measured by the probe. It is expressed in tenths of barg (SI) or tenths of psig (IMP).

- **Pressure probe calibration offset**
  It defines the calibration offset to be applied to the evaporation pressure probe measurement. It is expressed in tenths of barg (SI) or tenths of psig (IMP).

- **Maximum pressure probe alarm value**
  It defines the maximum value of the probe evaporation pressure beyond which the sensor can be considered to have failed. It is expressed in tenths of barg (SI) or tenths of psig (IMP).

- **Minimum pressure probe alarm value**
  It defines the minimum value of the probe evaporation pressure beyond which the sensor can be considered to have failed. It is expressed in tenths of a barg (SI) or tenths of a psig (IMP).

- **Pressure probe time constant of digital filter**
  It defines the time constant used for digital filtering of the evaporation pressure probe. The higher the value, the sharper the effect. By setting the value to 1, filtering is absent. It is expressed in seconds.

- **Pressure probe failure recovery action**
  It defines the action to be taken in the event of failure of the evaporation pressure probe and allows a choice of three settings: no action; valve in closed position; valve in start position (see parameter “Percent valve opening at start”).

- **Pressure probe failure recovery action delay**
  It defines both the trigger delay of the evaporation pressure probe alarm and the trigger delay of the corresponding recovery action. It is expressed in seconds.

Advanced temperature probe configuration

The advanced configuration of the suction temperature probe makes it possible to increase the compatibility of the xBALL Controller with additional types of probes and to customise their characteristics in detail. The parameters made available are:

- **Temperature probe calibration offset**
  It defines the calibration offset to be applied to the measurement of the suction temperature probe. It is expressed in tenths of °C (SI) or tenths of °F (IMP).

- **Maximum temperature probe alarm value**
  It defines the maximum value of the probe suction temperature beyond which the sensor can be considered to have failed. It is expressed in tenths of °C (SI) or tenths of °F (IMP).

- **Minimum temperature probe alarm value**
  It defines the minimum value of the probe suction temperature beyond which the sensor can be considered to have failed. It is expressed in tenths of °C (SI) or tenths of °F (IMP).

- **Temperature probe time constant of digital filter**
  It defines the time constant used for digital filtering of the suction temperature probe. The higher the value, the sharper the effect. By setting the value to 1, filtering is absent. It is expressed in seconds.

- **Temperature probe failure recovery action**
  It defines the action to be taken in the event of a failure of the suction temperature probe and allows a choice of three settings: no action; valve in closed position; valve in start position (see parameter “Percentage valve opening at start”).

- **Temperature probe failure recovery action delay**
  It defines both the trigger delay of the suction temperature probe alarm and the trigger delay of the corresponding recovery action. It is expressed in seconds.

RS-485 Modbus serial interface configuration

The RS-485 Modbus serial interface configuration allows any refrigeration machine to quickly connect to the xBALL Controller. The parameters made available are:

- **Network address**
  It defines the Modbus address to be associated with the electronic valve.
- **Speed**
  It defines the baud rate and can be chosen from the following settings: 1200 bps; 2400 bps; 4800 bps; 9600 bps; 19200 bps; 38400 bps.
- **Parity**
  It defines the parity bit and can be chosen from the following settings: none; even; odd.
- **Stop bits**
  It defines the number of stop bits and can be chosen from the following settings: 1; 2.
- **Bus communication failure recovery action**
  It defines the action to be taken in the event of a communication failure between the electronic valve and the refrigeration machine and allows a choice of two settings: no action; valve in closed position with deactivation of manual positioning.
- **Bus communication failure recovery action delay**
  Defines both the trigger delay of the bus communication alarm and the trigger delay of the related recovery action. It is expressed in seconds.

In accordance with the Modbus standard, the Register and Coil addresses correspond to the values listed in the table in the **Address** column. It corresponds to the value in the **ID** column decreased by 1.

Specifications

Actuator technical specifications

Power supply voltage	AC/DC 24 V (−10%/+15%)
Power supply frequency	50/60 Hz
Power consumption	1.5 W
Running time motor	20 sec. / 90° typical; 15 sec. / 90° during emergency closure (only for "Fail-Safe" option)
Sound power level	55 dB(A)
Power supply and control signals connection (POWER conn.)	5 poles cable cod. Z-C24X4P010
Probe connection (PROBE conn.)	6 poles cable cod. Z-C24X4Y050
Connection removal method	Cables may only be removed by qualified personnel (manufacturer or authorised service center)
Digital input	Operated by dry contact or transistor to GND
Analogue output	Voltage: 0.5...9.5 V DC
Temperature probe	NTC 10 kΩ @ 25°C; −40...120°C: – Maximum error: 1.0°C on −40...60°C range; 3.0°C on 60...120°C range
Probe pressure	Electronic configuration (4.0...20.0 mA): – Resolution: 0.1% F. S. – Maximum error: 2.0% F. S. Ratiometric configuration (0.0...5.0 VDC): – Resolution: 0.1% F. S. – Maximum error: 1.5% F. S.
Probe pressure power supply	Programmable output: 5.0 V DC or 12.0 VDC
RS-485 connection	Maximum length: 1000 m with shielded cable and point to point connection
Ambient temperature	−30...60°C (without irradiation)
Storage temperature	−40...80°C
Maximum ambient humidity	Max. 95% RH., non-condensing
Index of protection IEC/EN	IP 54
Protection class IEC/EN	III
Pollution degree	2
Rated impulse voltage supply	0.8 kV
Overvoltage category	Category III
Heat and fire strength	Category D
Operation type	Type 1
RoHS directives (2015/863/EU), RED (2014/53/EU), PED (2014/68/EU), LVD (2014/35/EU), EMC (2014/30/EU)	Compliant
Other wireless directives	Compliant to FCC and IC
Software class and structure	A
Flammable refrigerants	The product is not to be considered a source of ignition when used together with A2L and A3 classified refrigerants and is compliant against clauses 22.116 and 22.117 from IEC 60335-2-40. Compliance against cl. 22.117 is checked by measuring the appropriate surface temperatures during the tests of IEC 60335-2-40, clauses 11 and clauses 19. The maximum surface temperature of the devices and components does not exceed the temperature limit of 370°C.

Valve technical specifications

Compatible refrigerants	CFC, HFC, HFO
Fluid temperature	–20...70°C
Maximum pressure	Ps = 50 barg
Maximum differential pressure	Δp_{max} = 35 barg
Flow characteristic	Equal percentage (VDI/VDE 2178)
Leakage rate with closed valve	A: air bubble tight (EN 12266-1)
Connection	Brazing weld
Installation orientation	From vertical to horizontal
Maintenance	Not necessary
Maximum rated mechanical load	1.0 Nm
Angular rotation	90°

Further documentation

– Data sheet X80..M..3A4*
– Data sheet X80..M..AA4*
– Installation instructions – xBALL 4.0*

All inclusive

Belimo is the global market leader in the development, production, and sales of field devices for the energy-efficient control of heating, ventilation and air-conditioning systems. The focus of our core business is on damper actuators, control valves, sensors and meters.

Always focusing on customer value, we deliver more than only products. We offer you the complete product range for the regulation and control of HVAC systems from a single source. At the same time, we rely on tested Swiss quality with a five-year warranty. Our worldwide representatives in over 80 countries guarantee short delivery times and comprehensive support through the entire product life. Belimo does indeed include everything.

The “small” Belimo devices have a big impact on comfort, energy efficiency, safety, installation and maintenance.

In short: Small devices, big impact.

- 5-year warranty
- On site around the globe
- Complete product range
- Tested quality
- Short delivery times
- Comprehensive support

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