

1 Document history

Version	ECN	Date	Status	Author	Reviewed by	Description of changes
0.1		12 May 2020	Draft	R. Schmurr		Initial Draft
0.2		18 Aug 2020	Draft	B. Xu		
0.3		10 Oct 2023	Draft	M. Gross		General updates for project 11023
0.4		13 Oct 2023	Draft	M. Gross		Added recommended PWMIN driving circuit information.
0.5		17 Oct 2023	Draft	M. Gross		Updated text for Regulatory compliance.
0.6		03 Nov 2023	Draft	D. Zuzuly		Updated Electrical and I/O specs, added EMC tests
0.7		7 Nov 2023	Draft	M. Gross		Updates to Electrical specs and Firmware config options.
0.8		8 Jan 2024	Draft	M. Gross		Updated description of Safety Angle. Added D _{VAL} parameter to Table 3.
0.9		18 Mar 2024	Draft	M. Gross		Updated start-up and fault re-start times. Updates to Sec. 9.
0.10		7 Oct 2024	Draft	M. Gross		Updates to software performance specifications to match software rev. V00.03.03.
0.11		17 Feb 2025	Draft	M. Gross		Changed Model Matrix for 24V 90° actuator to "TBD" since this design is unreleased.
A	00000	27 Mar 2025	Released	M. Gross	M.Pietraszak, E.Gonzalez, A.Madduri, K.Svejcar, L.Knapp	Updates from formal review.

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3 Overview

3.1 Product description

The Robertshaw Ranco electric motor driven water valve actuator is part of Robertshaw’s automotive coolant valve products. The actuator rotates the valve stem based an electronic PWM control signal from the vehicle as well as providing an independent PWM feedback signal to report the actuator position.

The modular design of the actuator and valve enables the actuator to be coupled to various versions of the coolant valve.

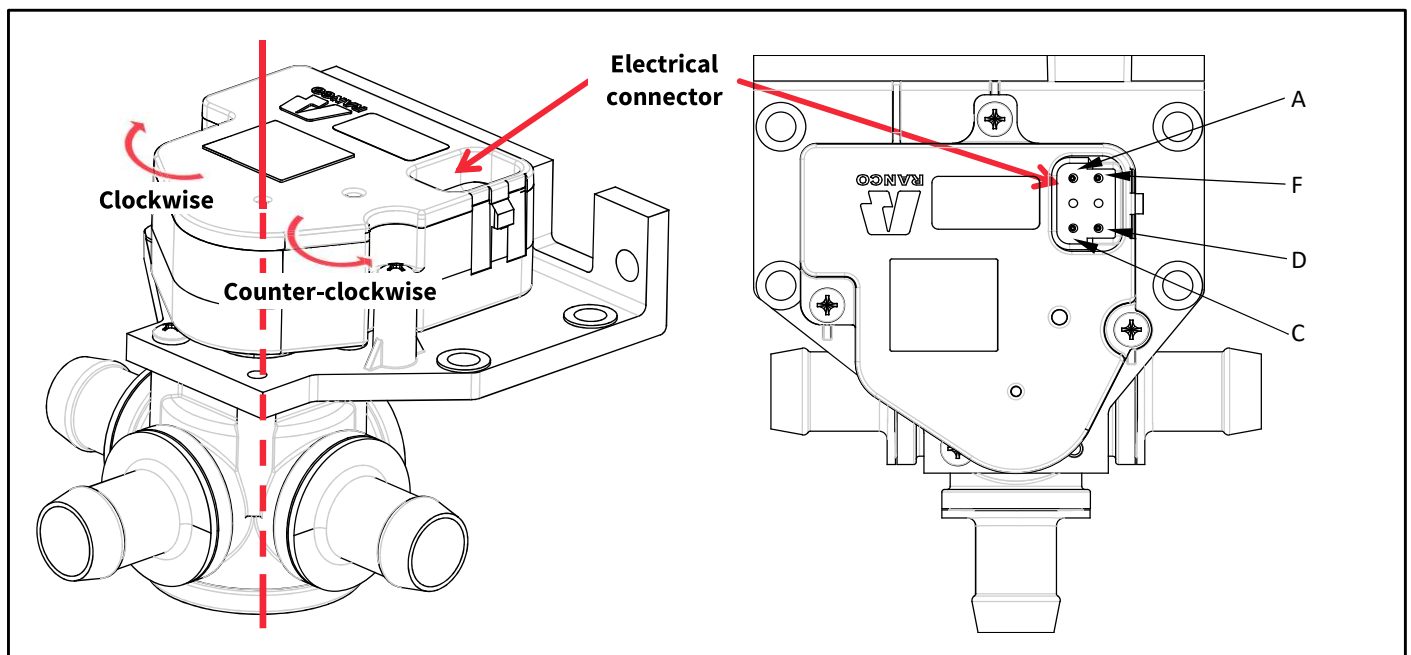


Figure 1: Actuator rotational orientation and connector position

3.2 Document scope

This product specification describes the electronic interface parameters and functional operation of the PWM valve actuator used on Robertshaw’s automotive valve product line. This specification may be shared with OEMs to aid in their understanding of the actuator’s interface as they integrate the valve with their vehicle control system.

3.3 Model matrix

The following actuator models are covered within this product specification.

Note that some parameters may be reconfigured at the factory to meet the requirements of a specific valve product. See Section 9 for details on firmware configuration options.

Actuator part number	Description	Voltage, Nominal	Operational range
TBD	ACTUATOR PWM 24V; 90 DEG	24VDC	90°
127-00310-001	ACTUATOR PWM 12V; 90 DEG	12VDC	90°
TBD	ACTUATOR PWM 24V; 180 DEG	24VDC	180°
TBD	ACTUATOR PWM 12V; 180 DEG	12VDC	180°

Table 1: PWM actuator model matrix

3.4 Definitions and Acronyms

ADC	Analog to Digital Converter
CCW	Couter-clockwise
CW	Clockwise
OEM	Original Equipment Manufacturer – the complete vehicle manufacturer.
PWM	Pulse Width Modulation – method for controlling position and sending feedback of actual position using varying duty cycle square waveform. Besides the external control interface, PWM may also be used in varying the speed of the motor within the actuator.
POR	Power-On Reset – reset of the control that occurs when power is applied to the actuator.
Safety Angle	Position the actuator will move to if unable to detect valid control input.

4 Product overview

The PWM controlled valve actuator is part of Robertshaw’s automotive valve product and uses a motor to rotate the valve stem to the angle commanded by the PWM signal sent from the vehicle’s controller. A block diagram of the valve actuator is shown in Figure 2 with detailed description in the following sections.

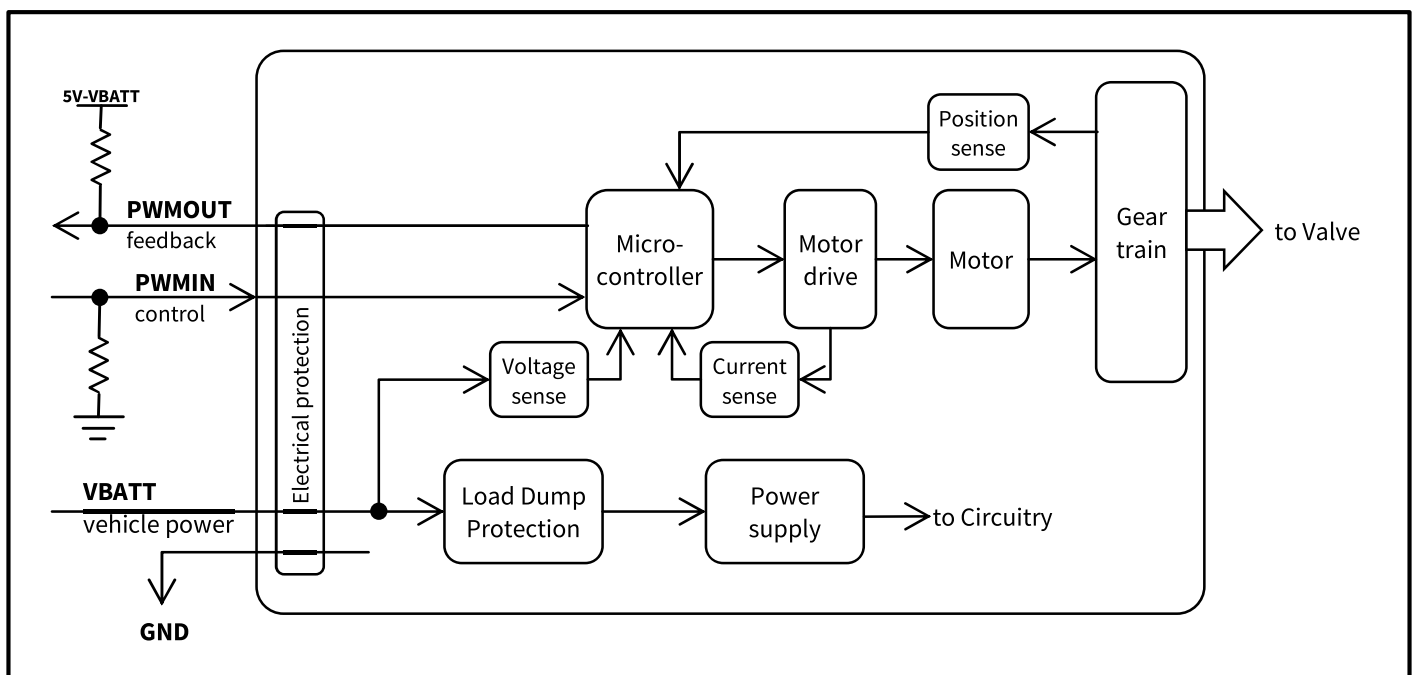


Figure 2: PWM valve actuator block diagram

4.1 Functional operation

The PWM valve actuator is a rotary valve actuator intended to automotive vehicle applications. Positioning control is achieved by driving a Pulse Width Modulated (PWM) square waveform into the actuator’s PWMIN signal. The valve

actuator rotates the output shaft based on the duty cycle of the PWMIN signal. Real-time feedback of the actual actuator position is provided by the PWM duty cycle of the PWMOUT signal. See Section 4.1 for details on the signals.

The range of motion for the PWM actuator is determined by the Robertshaw part number. Refer to the Model Matrix in Section 3.3.

4.2 PWM control and feedback signals

4.2.1 PWMIN control operation

The actuator is commanded to move based on the duty cycle of the PWMIN signal waveform, i.e., the % of time the waveform is High vs. Low as shown in Figure 3. When the PWMIN duty cycle is at the minimum, the actuator rotates to its full counter-clockwise position and when the duty cycle is at the maximum, the actuator rotates to its full clockwise position. In between the minimum and maximum, the actuator will position the output angle as a linear function of the PWM duty cycle as shown in Figure 4.

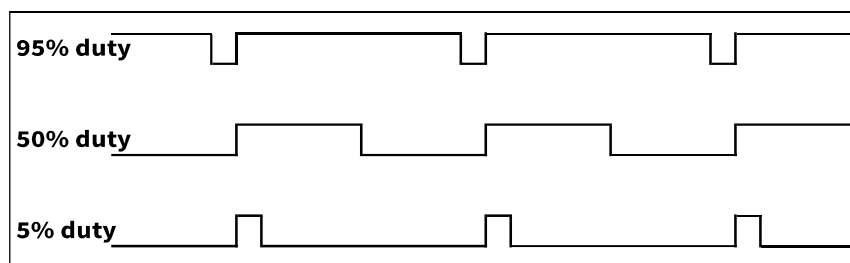


Figure 3: PWM duty cycle example

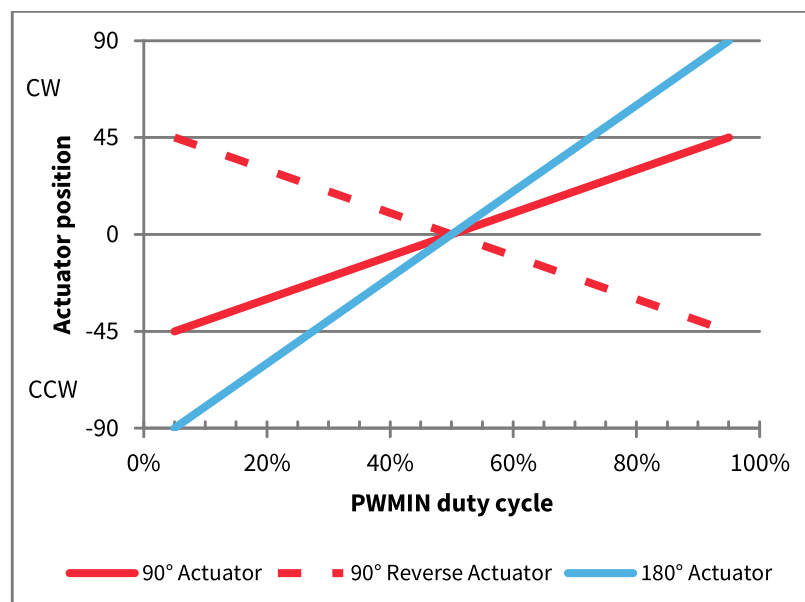


Figure 4: PWMIN positioning relationship examples

4.2.2 PWMOUT feedback

The PWMOUT signal is an output PWM signal which may be monitored by the vehicle to determine the actual actuator position. The signal operates the same as PWMIN with the waveform duty cycle proportional to the actuator position.

Actuator position	PWMOUT duty cycle
0% range (full CCW)	5%
50% range (center)	50%
100% range (full CW)	95%

Table 2: PWMOUT position relationship

4.3 Performance parameters

Actuator start-up time to begin acting upon PWMIN control is less than 5 seconds from power-up.

Actuator positioning speed is 10°/sec. or faster, depending on temperature and valve loading. Consult with Robertshaw if positioning speed parameters are needed for a specific valve.

4.4 Error conditions

4.4.1 Battery voltage out of range

When the VBATT supply voltage falls outside the acceptable range defined in Table 3, the motor is turned off and does not go to the desired position.

4.4.2 Motor current high

Control logic will disable the motor for 45 seconds if all of the following conditions are present while driving the motor:

- 1) Motor current limit exceeded for >3 seconds.
- 2) Positioning feedback is not within 10 degrees of either end stop.

4.4.3 Safety Angle positioning

If Safety Angle is enabled, the actuator will automatically move to a “fail-safe” position if unable to detect a valid PWMIN control signal for over 3 seconds. The PWMIN signal is considered invalid if outside the parameters defined in Table 4.

Refer to the valve specification drawing to determine if a Safety Angle is enabled for a given model.

If Safety Angle is not enabled for a valve, the actuator will remain in the position defined by the last valid PWMIN control signal received.

The valve actuator will automatically exit Safety Angle state when a valid PWMIN signal has been detected for approximately 250ms. At this point the actuator will move to the position defined by the PWMIN signal.

5 Electrical specifications

The table below lists the operating parameters for the electrical interface signals on the PWM valve actuator.

Symbol	OPERATING CONDITION	MIN	NOM	MAX	UNITS
V _{OPR}	Operating voltage range (VBATT) Voltage outside this range will cause repositioning to stop and microcontroller may reset.	9	12	16	VDC
V _{PROT}	Voltage outside this range may activate protection devices and lead to permanent damage over time.	-16		+30	VDC
I _{IDLE}	Idle current Draw on VBATT when no repositioning underway. Does not include external pullup current		10		mA
I _{RUN}	Running current Draw on VBATT when repositioning motor is active. Does not include external pullup current		50	75	mA
I _{MAX}	Stall current, MAX@VBATT@ 9V NOM@ VBATT@12V Draw on VBATT at peak motor current/ stall. Does not include external pullup current.		230	450	mA
I _{SLEEP}	Sleep mode is not supported by PWM actuator		n/a		

Table 3: Electrical specifications

5.1 PWMIN control signal

The external circuit driving the PWMIN signal should either actively drive the waveform between high (VBATT) and low (GND) states or for driving circuit which only drives high, an external 2.4-10K ohm resistor is required to pull down PWMIN to GND.

If duty cycle falls outside the range of 3% to 97%, then the actuator will stay at its current position.

Symbol	OPERATING CONDITION	MIN	NOM	MAX	UNITS
V _{IL}	PWMIN input, low	GND - 0.3V	0	0.7	Volts
V _{IH}	PWMIN input, high	4.5	V _{BATT}	V _{BATT} + 2.0V	Volts
I _{PWMIN}	I _{PWMIN} sustained input high current, External Driver Sourcing, V _{PWMIN} = 16V			2.0	mA
	I _{PWMIN} sustained input low current, External Driver sinking, V _{PWMIN} = 0.7V			-1.0	mA
F _{100HZ} ¹	100Hz PWMIN frequency range Outside this range, PWMIN is considered "invalid" and will trigger Safety Angle action as described in Section 4.4.3, if enabled.	95	100	105	Hertz

¹ Check valve specification for relevant PWM frequency parameter.

Symbol	OPERATING CONDITION	MIN	NOM	MAX	UNITS
F _{250HZ} ¹	250Hz PWMIN frequency range Outside this range, PWMIN is considered “invalid” and will trigger Safety Angle action as described in Section 4.4.3, if enabled.	215	250	265	Hertz
D _{OP}	PWMIN waveform duty cycle operating range Outside this range, no further movement toward end stops will occur.	5	-	95	%
D _{VAL}	PWMIN waveform valid range Outside this range, PWMIN is considered “invalid” and will trigger Safety Angle action as described in Section 4.4.3, if enabled.	3	-	97	%
D _{TOL}	Positioning accuracy			3	degrees
D _{THRESH}	Repositioning threshold Changes of less than D _{THRESH} will be ignored to avoid excessive resposiitoning of valve.	-	1	-	%
T _{WAIT}	Waiting time after reposition completes before accepting new positon.	20	25	30	msec
T _{RISE}	PWMIN rise time ² F _{100HZ} / F _{250HZ}	-	-	50 / 20	uS
T _{FALL}	PWMIN fall time ² F _{100HZ} / F _{250HZ}	-	-	50 / 20	uS

Table 4: PWMIN electrical parameters

5.2 PWMOUT position feedback signal

PWMOUT is an open-drain driver, requiring an external 2.4K ohm pull-up resistor to generate the “high” level of the PWMOUT signal. The signal should be pulled up to a voltage rail in the range of 5V to VBATT.

The PWMOUT waveform nominal frequency depends on the valve model. Refer to the valve specification drawing for PWM frequency used.

Symbol	OPERATING CONDITION	MIN	NOM	MAX	UNITS
V _{OL}	PWMOUT output, low (I _{PWMOUT} =12.5mA)	GND	-	1.05	Volts
V _{OH}	PWMOUT output, high ³	4.5		V _{BATT} + 2.0V	Volts
I _{PWMOUT}	PWMOUT sink current	-	-	20	mA
F _{100HZ} ⁴	100Hz PWMOUT frequency range	95	100	105	Hertz
F _{250HZ} ⁴	250Hz PWMOUT frequency range	212	250	263	Hertz
D _{RANGE}	PWMOUT waveform duty cycle, nominal	5	-	95	%
D _{TOL}	PWMOUT tolerance with respect to output shaft position.	-	-	2	degrees
T _{RISE}	PWMOUT rise time (w/2.4k pullup)	0	15	50 ⁵	uS
T _{FALL}	PWMOUT fall time (w/2.4k pullup)	0	10	50 ⁵	uS

2 Based on rise/fall time max mismatch, and 0.5% change from desired duty cycle.

3 PWMOUT output signal requires an external pull-up resistor to establish “high” level. This specification assumes a 2.4K ohm pullup to VBATT.

4 Check valve specification for relevant PWM frequency parameter.

5 Loading on PWMOUT signal may affect rise/fall times.

Table 5: PWMOUT electrical parameters

6 Firmware configuration options

The following items may be configured in the control firmware at the Robertshaw factory to meet valve body or OEM requirements. They are not intended to be reconfigured by the OEM or in-vehicle.

Defaults listed below refer to the Firmware default values, and factory ship defaults may be different. Refer to the valve specification drawing for the pre-programmed values set at the Robertshaw factory.

Parameter	Description	Firmware options
PWM frequency	Nominal frequency of PWMIN/PWMOUT signal waveform.	100 Hz (default) 250 Hz 500 Hz
Operating angular range	Total angular range actuator will operate through in relation to 5-95% duty cycle of PWM signal. See Section 4.2 for details. NOTE: Angular range selected must be compatible with mechanical stops in actuator and valve body. See Section 7 for details.	90° (default) 180°
Direction	The valve moves Clockwise in proportion to increasing PWMIN duty cycle. Setting REVERSE flips operation to move Counter-clockwise for increasing duty cycle as shown in Figure 4. Both PWMIN and PWMOUT are affected by this setting.	Normal (default) REVERSE
Safety Angle	Actuator will automatically move to this position upon loss of valid PWMIN signal. If Safety Angle is undefined, the actuator will remain in last commanded position if PWMIN signal lost. See Section 4.4.3 for details.	Undefined (default) -45° for 90° actuator +45° for 90° actuator -90° for 180° actuator +90° for 180° actuator

Table 6: Firmware configuration options

7 Mechanical specifications

Figure 1 shows rotation orientation and the location of the electrical interface connector. Refer to the valve specification drawing for complete product dimensions.

The valve actuator contains mechanical stops to ensure the actuator does not over-travel and potentially damage the valve. Table 7 lists the mechanical stop angles for each model of valve travel range.

Actuator operational range	CCW mechanical stop	CCW max. operational angle	Center angle	CW max. operational angle	CW mechanical stop
80°	-70°	-40°	0°	40°	70°
90°	-70°	-45°	0°	45°	70°
104°	-70°	-52°	0°	52°	70°
126°	-70°	-63°	0°	63°	70°
130°	-70°	-65°	0°	65°	70°
180°	-95°	-90°	0°	90°	95°

Table 7: Actuator mechanical stop angles

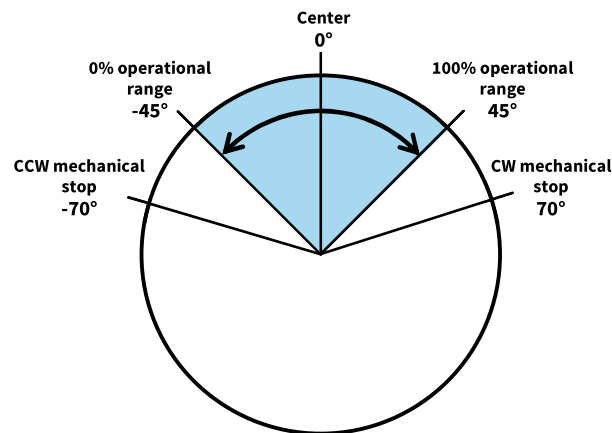


Figure 5: Example mechanical stop for 90° actuator

7.1 Connector pinout

The valve actuator is designed with a 2x3 connector pin arrangement. The center pin locations B/E are not placed. Refer to Figure 1 for relative connector pin locations and the table below for the pin definitions.

Signal	Function	Pin	Pin	Function	Signal
PWMIN	PWM control input	D	C	Vehicle ground	GND
--	No pin – Reserved	E	B	No pin – Reserved	--
PWMOUT	PWM position feedback output	F	A	Vehicle power	VBATT

7.2 Mating connector

This valve actuator has been designed to mate with Aptiv 6-way Metri-Pack 150 Series connector on the vehicle wiring harness. Seals for the Aptiv 12052848 connector body and all pin positions must be installed on the cable as recommended by Aptiv in order for the valve actuator to obtain environmental sealing.

8 Regulatory agency standards

The PWM valve actuator is designed to meet the following EMC standards requirements. Compliance testing is up to the automotive vehicle OEM to conduct for the complete vehicle.

ISO 11452-5 ESA Electromagnetic Immunity	ISO 7637-2 DC Motor Acting as a Generator
CISPR 25 ESA Radiated Emissions	100 µH Wire Harness Inductance test
SAE J1113-26 AC Power Line Electric Fields (50/60 Hz)	ISO 7637-2 Wire Harness Inductive Switching
ISO 7637-2 Negative Switching Spikes	ISO 11452-5 ESA Electromagnetic Immunity
ISO 7637-2 Positive Switching Spikes	CISPR 25 ESA Radiated Emissions
ISO 7637-2 Parallel Inductive Load Switching	SAE J1113-26 AC Power Line Electric Fields (50/60 Hz)
ISO 7637-3 Negative Mutual Coupling	ISO 7637-2 Negative Switching Spikes
ISO 7637-3 Positive Mutual Coupling	ISO 7637-2 Positive Switching Spikes

9 Environmental specifications

OPERATING CONDITIONS	MIN	NOM	MAX	UNITS
Operating Temperature	-40		85	°C
Storage Temperature Range	-50		105	°C
Humidity (non-condensing)	0		95	% RH
IP rating		IP69K		
Product life test rating Cycle defined as movement from one end limit to the other and return.		100,000		cycles

Table 8: Environmental specifications

IP69K sealing of the actuator is dependent on the correct wiring harness connector used as defined in Section 7.2 and the connector properly seated and latched on the valve actuator.

Repositioning duty cycle is dependent on mechanical loading from valve. Consult with Robertshaw for specific duty cycle requirements.

10 References

- [1] Robertshaw H42M-93xx-xxx PWM valve specification drawings
- [2] Robertshaw H45M-83xx-xxx PWM valve specification drawings
- [3] Aptiv Metri-Pack 150 series connector https://www.aptiv.com/en/solutions/connection-systems/catalog/product?language=en&id=CONN-METRI-PACK-150_en