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Version-No.:	*1*
Date:	*2017-08-03*
Product:	*Spring return and double acting pneumatic rack and pinion actuator*
Model:	*Series FieldQ*
Customer/Manufacturer:	***Emerson Automation Solutions*** *Asveldweg 11* *7556 BR Hengelo* *The Netherlands*
Order No. / Date:	*Emerson order dated 2017-02-10*
Test Specifications:	*IEC 61508: 2010 Part 1÷7* *Functional Safety of Electrical/Electronic/Programmable Electronic Safety Related Systems*
Test Institute:	***TÜV Rheinland Italia S.r.l.*** *Via Enrico Mattei, 3* *20010 Pogliano Milanese (MI)*
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This document is only valid in its entirety and separation of any part is not allowed.

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FAILURE RATES CALCULATION REPORT OF SPRING RETURN AND DOUBLE ACTING PNEUMATIC RACK AND PINION ACTUATORS

1 PURPOSE AND SCOPE

This report summarises the results of a failure rates evaluation of spring return and double acting pneumatic rack and pinion actuators series FieldQ.

An evaluation is performed, according to IEC 61508-2, to evaluate the λ values (random HW failure rates) of the product.

The random HW failure rates evaluation according to IEC 61508-2 is only one of the steps to be taken to achieve functional safety certification according to IEC 61508 of a device.
For full functional safety certification purposes all the requirements of IEC 61508 (Part 1÷7) shall be considered.

NOTES:

- The elements of the control panel are not part of the assessment.

2 REFERENCE DOCUMENTS

2.1 Standards

No.	Reference	Title
[N1]	IEC 61508: 2010 Part 1÷7	Functional Safety of Electrical/Electronic/Programmable Electronic Safety Related Systems
[N2]	IEC 61511: 2016 Part 1÷3	Functional Safety – Safety Instrumented Systems for the process industry sector

2.2 Databases

No.	Reference	Title
[N3]	RiAC NPRD-2016	Non electronic Parts Reliability Data
[N4]	RiAC FMD-97/2013	Failure Modes/Mechanism Distributions
[N5]	NSWC	Handbook of Reliability Prediction Procedures for Mechanical Equipment
[N6]	Exida	Safety Equipment Reliability Handbook
[N7]	OREDA	Offshore Reliability Data

NOTES:

- For databases, where there is no indication of the publishing date it means that the reference is the latest edition.

3 INSPECTION DOCUMENTS

3.1 Documentation provided by the customer

No.	Reference	Title
[D1]	Emerson drawing no. VA-ED-003-2440 Rev. 00	General assembly FieldQ QS350/QD350
[D2]	Emerson drawing no. VA-ED-003-2491 Rev. 00	General assembly FieldQ QS600/QD600
[D3]	Emerson letter dated 2017-08-01	FMEDA results range expansion

3.2 Documentation generated by TÜV Rheinland

No.	Reference	Title
[R1]	17029 – FS 28717071	Random failure analysis

4 ABBREVIATIONS

β	Beta common cause factor
λ_{NE}	Failure rate of no effect failures
λ_{D}	Failure rate of dangerous failures
λ_{DU}	Failure rate of undetected dangerous failures
λ_{DD}	Failure rate of detected dangerous failures
λ_{S}	Failure rate of safe failures
λ_{SU}	Failure rate of undetected safe failures
λ_{SD}	Failure rate of detected safe failures
DC	Diagnostic Coverage factor
FIT	Failure In Time ($1x10^{-9}$ failures per hour)
FMEDA	Failure Mode Effect and Diagnostic Analysis
HFT	Hardware Fault Tolerance
High demand mode	Mode, where the frequency of demands for operation made on a safety-related system is greater than one per year
Low demand mode	Mode, where the frequency of demands for operation made on a safety-related system is no greater than one per year
MRT	Mean Repair Time
PFD	Probability of Failure on Demand
PFD_{AVG}	Average Probability of Failure on Demand
PFH	Probability of Failure per Hour
PST	Partial Stroke Test
SFF	Safe Failure Fraction
SIF	Safety Instrumented Function
SIL	Safety Integrity Level
SIS	Safety Instrumented System
TI	Test Interval for Proof Test (Full-Stroke)
TI_{D} (TI_{PS})	Test Interval for Diagnostic Test (Partial-Stroke)
Type A element	“Non-Complex” element (using discrete components)
Type B element	“Complex” element (using micro controllers or programmable logic)

5 DESCRIPTION OF PRODUCT

5.1 Scope of calculation / types

This report is related to spring return and double acting pneumatic rack and pinion actuators series FieldQ.

Detailed information are included in [D1] and [D2].

5.2 Architecture

The product has a single channel configuration, HFT=0.

5.3 Classification

The product can be classified as Type A device according to [N1], for use in Low Demand Mode applications.

NOTES:

- The classification refers to the actuator itself. The classification remains Type A even in case the valve-actuator assembly is equipped with a (non-interfering) PST device, according to the definition included in [N1] Part 2, par. 7.4.4.1.2.

6 SAFETY FUNCTION(S)

The safety function is defined as follows:

a. *When an unsafe condition is detected in a plant by a process sensor, the controller, via the control panel, drives the actuator to <u>close</u> the shut-down valve, venting air via the control system; or*
b. *When an unsafe condition is detected in a plant by a process sensor, the controller, via the control panel, drives the actuator to <u>open</u> the blow-down valve, venting air via the control system.*

NOTES:

- Considering the functioning of the actuator to perform the safety function(s), the two safety functions can be considered equivalent.
- In case of spring return actuator, the safety action is always performed by the spring.

The choice of the safety function to be implemented is responsibility of the system integrator.

7 DETERMINATION OF RANDOM FAILURE RATES

7.1 Procedure

The determination of random failure rates is performed with a Failure Modes, Effects and Diagnostic Analysis (FMEDA), integrated with field feedback, according to the approach of IEC 61508-2 par. 7.4.4.3.3, using the Bayesian approach.
The FMEDA is based on the documentation (drawings with components lists) provided by the Manufacturer and is documented in [R1].

The procedure used for the determination of random hardware failures is the following:

1. FMEDA of the product, with classification of failure modes (see the failure categories in subclause 10.3 of the present document)
2. Evaluation of λ_{BB} values (literature data)
3. Evaluation of field feedback
4. Integration between literature data and field feedback, using the Bayesian approach

7.2 Assumptions

The following assumptions are used for the evaluation of random hardware failures:

- Failure rates are considered constant for the lifetime.
- Failure rates and failure modes in the FMEDA are taken from databases [N3]÷[N7].
- A single component failure fails the entire product, except for redundant configurations.
- Propagation of failures is considered not relevant, unless a clear propagation path is present: in this case, the failure is considered a single failure, with failure rate corresponding to the failure rate of the first failure.
- The components that are not part of the safety function and cannot influence the safety function are excluded from the evaluation.
- After a proof test, the product will be “as new”. The PFD_{AVG} is calculated in the hypothesis of perfect proof test performed by trained, skilled and competent personnel. See also the remarks in par. 8.
- The “rate” of systematic failures is controlled and minimised by the management of the safety lifecycle of the system.
- The installation, commissioning, operational and maintenance instruction are correctly applied by the final customer.
- The stress levels considered are average for an industrial environment (ground fixed).

7.3 Description of the failure categories

In order to judge the failure behaviour of the product, the following definitions for the failure of the product were considered:

Safe Failure	Failure of an element and/or subsystem and/or system that plays a part in implementing the safety function that: a. results in the spurious operation of the safety function; or b. increases the probability of the spurious operation of the safety function
Dangerous Failure	Failure of an element and/or subsystem and/or system that plays a part in implementing the safety function that: a. prevents a safety function from operating when required (demand mode) or causes a safety function to fail (continuous mode); or b. decreases the probability that the safety function operates correctly when required
No Effect Failure	Failure of an element that plays a part in implementing the safety function but has no direct effect on the safety function
No Part Failure	Failure of a component that plays no part in implementing the safety function

GENERAL NOTES:

1. Failures of components of the pneumatic chamber which can generate spurious trips shall be correctly classified as “No Part” and not “Safe”, being related to components that “play no part in implementing the safety function” (see definition 3.6.16 of IEC 61508-4)
2. According to definitions 3.6.13 and 3.6.14 of IEC 61508-4, the no part and no effect failures are not used for SFF calculations.
3. According to definitions 3.6.8, 3.6.13, 3.6.14 of IEC 61508-4, the safe, no part and no effect failures do not contribute to PFD_{AVG} calculations.

SPECIFIC NOTES:

1. According to the above definitions (in particular definitions 3.6.8 and 3.6.13 of IEC 61508-4), no Safe Failures are possible in a Single Acting actuator: each failure mode of the actuator itself shall be classified as “Dangerous” or “No Effect” (failures which can generate the spurious operation of the safety function are only external to the actuator itself, or are related to components that “plays no part in implementing the safety function”, e.g. components of the pneumatic chamber, and so, according to definition 3.6.13 of IEC 61508-4, they cannot be used for the calculation of the SFF): hence **λ_S=0 for each type of Single Acting actuator**.
2. According to the above definitions (in particular definitions 3.6.8 and 3.6.13 of IEC 61508-4), no Safe Failures are possible in a Double Acting actuator: each failure mode of the actuator itself shall be classified as “Dangerous” or “No Effect” (failures which can generate the spurious operation of the safety function are only external to the actuator itself, and even in the case of loss of power supply the actuator “stays put”): hence **λ_S=0 for each type of Double Acting actuator**.
3. For this reason, according to definitions 3.6.15 of IEC 61508-4 we have:
    - SFF=0 without external diagnostic tests
    - SFF>0 with external diagnostic tests according to definition 3.8.7 of IEC 61508-4

7.4 Determination of numerical values

FMEDA

The FMEDA was performed according to the following procedure:

a. complete definition of the product;
b. identification of all potential items and their failure modes;
c. evaluation of each potential failure mode in terms of end system effect;
d. identification of the failure detection methods and compensating provisions for each failure mode (if possible);
e. association of a Failure Category to each failure mode.
f. association of a Failure Rate / Failure Distribution to each item / Failure Mode.

The complete FMEDA is included in documents [R1].

Classification of failures

Each single failure mode was classified, in document [R1], according to the description of the failure categories included in subclause 7.3 of the present document.

Evaluation of λ values, of SFF and PFD_{AVG}

Evaluation of λ values

The complete calculations for the evaluation of λ values are included in document [R1].

Evaluation of SFF

The formula for SFF is the following:

$$SFF = \frac{\lambda_S + \lambda_{DD}}{\lambda_S + \lambda_D}$$

Evaluation of PFD_{AVG}.

According to document [N1], the following formula is used to estimate the PFD_{AVG} value:

$$PFD_{AVG} = \lambda_{DU} \cdot \left(\frac{TI}{2} + MRT \right) + \lambda_{DD} \cdot \left(\frac{TI_D}{2} + MRT \right)$$

8 OVERALL RESULT

The analysis gives the results summarised in the following Tables.

Series	**λ_D [1/h]**	**$\lambda_{DD(PST)}$ [1/h]**
QS40, QS65, QS100, QS150, QS200, QS350	9,54E-08	8,68E-08
QD40, QD65, QD100, QD150, QD200, QD350	9,07E-08	8,50E-08
QS600, QS950, QS1600	9,34E-08	8,25E-08
QD600, QD950, QD1600	9,13E-08	8,31E-08

Table 1: Dangerous failure rates

SPECIFIC NOTES:

1. In case of double acting actuators, the internal chamber is considered for safety action.
2. According to the definitions 3.6.8 and 3.6.13 of IEC 61508-4, no Safe Failures are possible in a Single Acting actuator: each failure mode of the actuator itself shall be classified as "Dangerous" or "No Effect" (failures which can generate the spurious operation of the safety function are only external to the actuator itself, or are related to components that "plays no part in implementing the safety function", e.g. components of the pneumatic chamber, and so, according to definition 3.6.13 of IEC 61508-4, they cannot be used for the calculation of the SFF): hence **λ_S=0 for each type of Single Acting actuator**.
3. According to the definitions 3.6.8 and 3.6.13 of IEC 61508-4, no Safe Failures are possible in a Double Acting actuator: each failure mode of the actuator itself shall be classified as "Dangerous" or "No Effect" (failures which can generate the spurious operation of the safety function are only external to the actuator itself, and even in the case of loss of power supply the actuator "stays put"): hence **λ_S=0 for each type of Double Acting actuator**.
4. For this reason, according to definitions 3.6.15 of IEC 61508-4 we have:
    - SFF=0 without external diagnostic tests
    - SFF>0 with external diagnostic tests, carried out according to definition 3.8.7 of IEC 61508-4

Test Interval Frequency (months)				
6	12	24	36	48
2,11E-04	4,20E-04	8,38E-04	1,26E-03	1,67E-03

Table 2a: PFD_{AVG} values according to IEC 61508 for different values of TI (no Partial Stroke Test) – Models QS40, QS65, QS100, QS150, QS200, QS350

		Proof test interval (months)				
		6	12	24	36	48
PST interval (months)	1	5,28E-05	7,16E-05	1,09E-04	1,47E-04	1,84E-04
	2	8,45E-05	1,03E-04	1,41E-04	1,78E-04	2,16E-04
	3	1,16E-04	1,35E-04	1,73E-04	2,10E-04	2,48E-04
	6		2,30E-04	2,68E-04	3,05E-04	3,43E-04
	9				4,00E-04	
	12			4,58E-04	4,95E-04	5,33E-04

Table 2b: PFD_{AVG} values according to IEC 61508 for different values of TI (with Partial Stroke Test) – Models QS40, QS65, QS100, QS150, QS200, QS350

Test Interval Frequency (months)				
6	12	24	36	48
2,01E-04	3,99E-04	7,97E-04	1,19E-03	1,59E-03

Table 3a: PFD_{AVG} values according to IEC 61508 for different values of TI (no Partial Stroke Test) – Models QD40, QD65, QD100, QD150, QD200, QD350

		Proof test interval (months)				
		6	12	24	36	48
PST interval (months)	1	5,17E-05	7,01E-05	1,07E-04	1,44E-04	1,81E-04
	2	8,27E-05	1,01E-04	1,38E-04	1,75E-04	2,12E-04
	3	1,14E-04	1,32E-04	1,69E-04	2,06E-04	2,43E-04
	6		2,25E-04	2,62E-04	2,99E-04	3,36E-04
	9				3,92E-04	
	12			4,48E-04	4,85E-04	5,22E-04

Table 3b: PFD_{AVG} values according to IEC 61508 for different values of TI (with Partial Stroke Test) – Models QD40, QD65, QD100, QD150, QD200, QD350

Test Interval Frequency (months)				
6	12	24	36	48
2,07E-04	4,12E-04	8,21E-04	1,23E-03	1,64E-03

Table 4a: PFD_{AVG} values according to IEC 61508 for different values of TI (no Partial Stroke Test) – Models QS600, QS950, QS1600

		Proof test interval (months)				
		6	12	24	36	48
PST interval (months)	1	5,02E-05	6,81E-05	1,04E-04	1,40E-04	1,75E-04
	2	8,03E-05	9,82E-05	1,34E-04	1,70E-04	2,05E-04
	3	1,10E-04	1,28E-04	1,64E-04	2,00E-04	2,36E-04
	6		2,19E-04	2,54E-04	2,90E-04	3,26E-04
	9				3,81E-04	
	12			4,35E-04	4,71E-04	5,07E-04

Table 4b: PFD_{AVG} values according to IEC 61508 for different values of TI (with Partial Stroke Test) – Models QS600, QS950, QS1600

Test Interval Frequency (months)				
6	12	24	36	48
2,02E-04	4,02E-04	8,02E-04	1,20E-03	1,60E-03

Table 5a: PFD_{AVG} values according to IEC 61508 for different values of TI (no Partial Stroke Test) – Models QD600, QD950, QD1600

		Proof test interval (months)				
		6	12	24	36	48
PST interval (months)	1	5,05E-05	6,85E-05	1,05E-04	1,41E-04	1,77E-04
	2	8,08E-05	9,88E-05	1,35E-04	1,71E-04	2,07E-04
	3	1,11E-04	1,29E-04	1,65E-04	2,01E-04	2,37E-04
	6		2,20E-04	2,56E-04	2,92E-04	3,28E-04
	9				3,83E-04	
	12			4,38E-04	4,74E-04	5,10E-04

Table 5b: PFD_{AVG} values according to IEC 61508 for different values of TI (with Partial Stroke Test) – Models QD600, QD950, QD1600

NOTES:

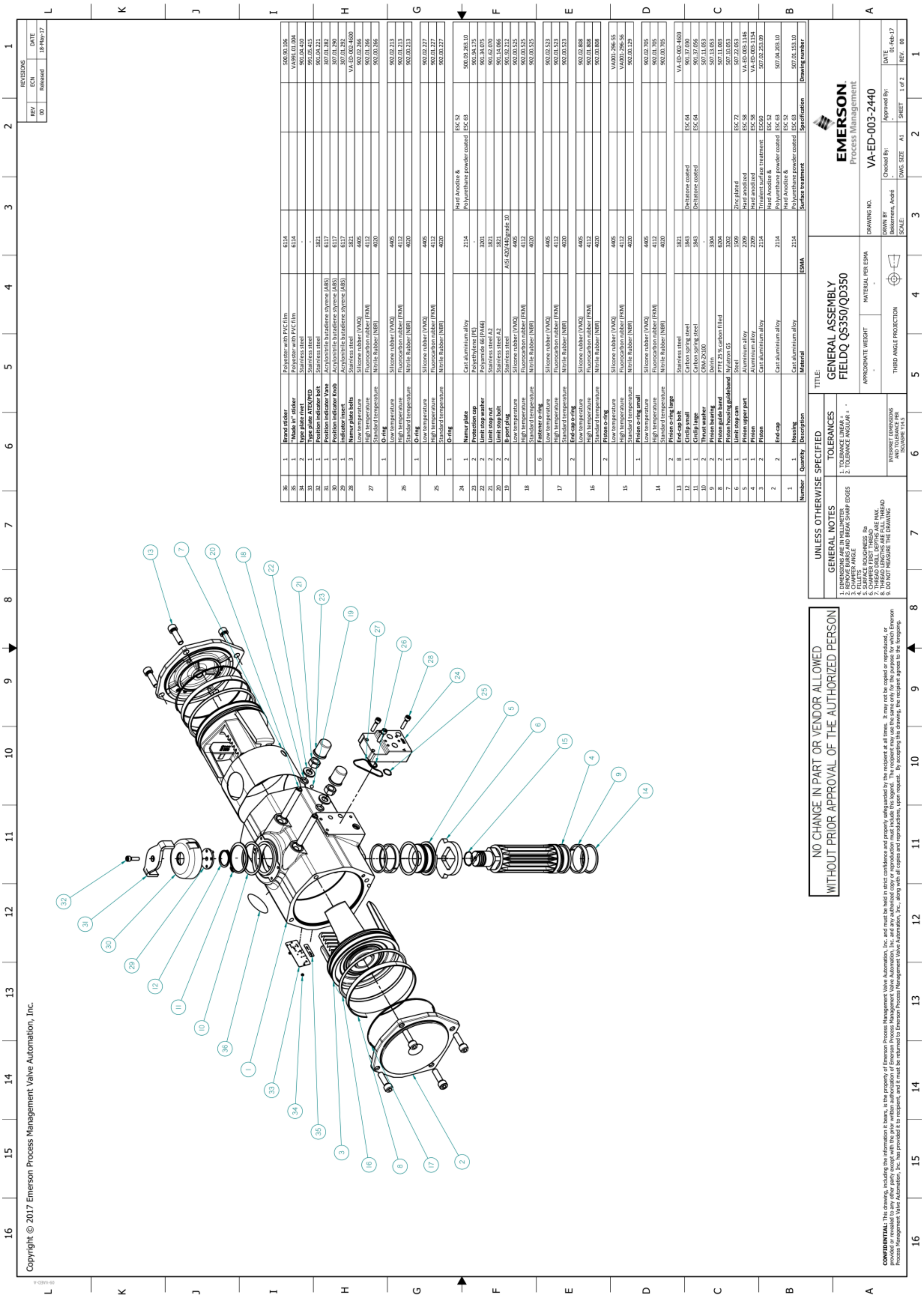
- The above values of PFD_{AVG} are calculated for MRT=24 h and Proof Test Coverage=100%. For other values of MRT, TI, TI_D and/or non-perfect Proof Test, the PFD_{AVG} values must be re-calculated.

The results of this report can be used for the assessment of a complete Safety Instrumented System.

9 STATUS OF THE DOCUMENT

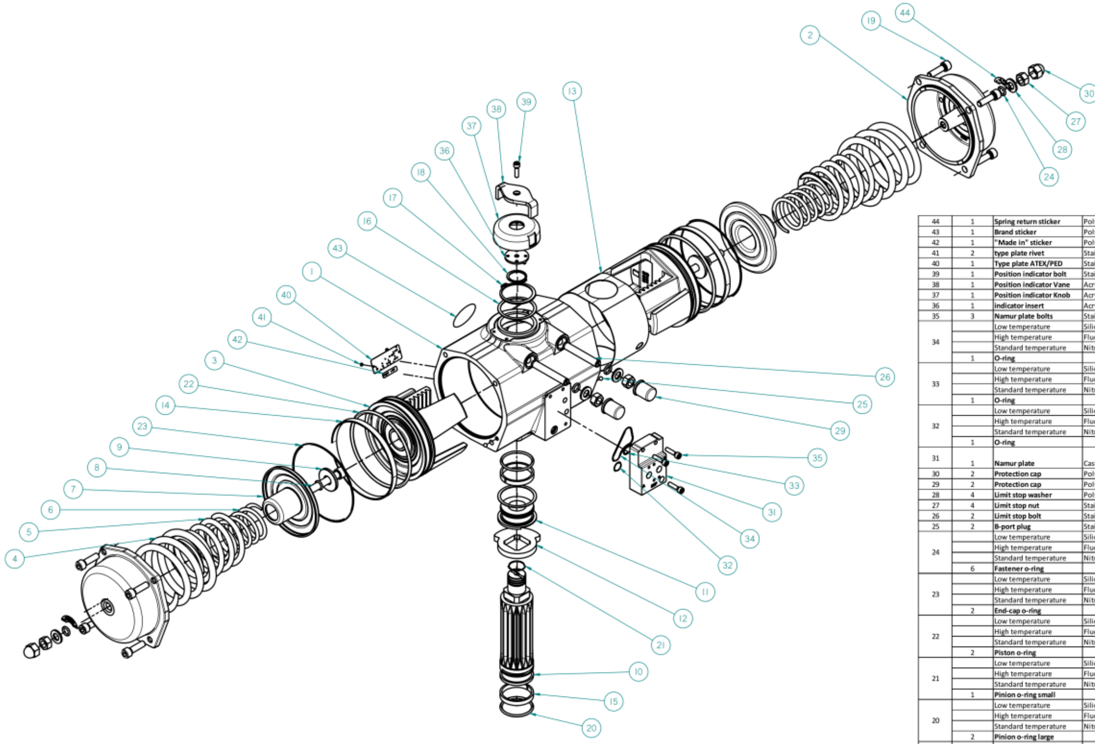
History:	R 1:	Modification of par. 8 according to customer's request: • Inclusion of list of models • Inclusion of PFD_{AVG} results with Partial Stroke Test	Date: 2017-08-03
	R 0:	Initial release	Date: 2017-06-29
Release status:	Released to client		
Author(s):	Carlo Tarantola		

ANNEX A DRAWINGS, PARTS LISTS



Number	Quantity	Description	Material	ESMA	Surface treatment	Specification	Drawing number
36	1	**Brand sticker**	Polyester with PVC film	6114			500.90.106
35	1	**"Made in" sticker**	Polyester with PVC film	6114			VA991.01.004
34	2	**type plate rivet**	Stainless steel	-			901.04.410
33	1	**Type plate ATEX/PED**	Stainless steel	-			991.05.415
32	1	**Position indicator bolt**	Stainless steel	1821			901.04.221
31	1	**Position indicator Vane**	Acrylonitrile butadiene styrene (ABS)	6117			307.01.282
30	1	**Position indicator Knob**	Acrylonitrile butadiene styrene (ABS)	6117			307.01.290
29	1	**indicator insert**	Acrylonitrile butadiene styrene (ABS)	6117			307.01.292
28	3	**Namur plate bolts**	Stainless steel	1821			VA-ED-002-4600
27		Low temperature	Silicone rubber (VMQ)	4405			902.02.266
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.266
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.266
	1	**O-ring**					
26		Low temperature	Silicone rubber (VMQ)	4405			902.02.213
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.213
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.213
	1	**O-ring**					
25		Low temperature	Silicone rubber (VMQ)	4405			902.02.227
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.227
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.227
	1	**O-ring**					
24	1	**Namur plate**	Cast aluminium alloy	2114	Hard Anodize & Polyurethane powder coated	ESC 52 ESC 63	500.03.263.10
23	2	**Protection cap**	Polyethylene (PE)	-			901.94.175
22	2	**Limit stop washer**	Polyamide 66 (PA66)	3201			901.34.075
21	2	**Limit stop nut**	Stainless steel A2	1821			901.62.070
20	2	**Limit stop bolt**	Stainless steel A2	1821			901.14.066
19	2	**B-port plug**	Stainless steel	AISi 420/440 grade 10			901.92.212
18		Low temperature	Silicone rubber (VMQ)	4405			902.00.525
		High temperature	Fluorocarbon rubber (FKM)	4112			902.00.525
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.525
	6	**Fastener o-ring**					
17		Low temperature	Silicone rubber (VMQ)	4405			902.02.523
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.523
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.523
	2	**End-cap o-ring**					
16		Low temperature	Silicone rubber (VMQ)	4405			902.02.808
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.808
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.808
	2	**Piston o-ring**					
15		Low temperature	Silicone rubber (VMQ)	4405			VA001-296-55
		High temperature	Fluorocarbon rubber (FKM)	4112			VA001-296-56
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.129
	1	**Pinion o-ring small**					
14		Low temperature	Silicone rubber (VMQ)	4405			902.02.705
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.705
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.705
	2	**Pinion o-ring large**					
13	8	**End-cap bolt**	Stainless steel	1821			VA-ED-002-4603
12	1	**Circlip small**	Carbon spring steel	1843	Deltatone coated	ESC 64	901.37.030
11	1	**Circlip large**	Carbon spring steel	1843	Deltatone coated	ESC 64	901.37.056
10	2	**Thrust washer**	CRM-ZX100	-			507.11.053
9	2	**Pinion bearing**	Delrin	3304			507.13.053
8	2	**Piston guide band**	PTFE 25 % carbon filled	6204			507.11.003
7	1	**Piston housing guideband**	Nylatron GS	3202			507.10.053
6	1	**Limit stop cam**	Steel	1509	Zinc plated	ESC 72	507.22.053
5	1	**Pinion upper part**	Aluminium alloy	2209	Hard anodized	ESC 58	VA-ED-003-1146
4	1	**Pinion**	Aluminium alloy	2209	Hard anodized	ESC 58	VA-ED-003-1154
3	2	**Piston**	Cast aluminium alloy	2114	Trivalent surface treatment	ESC60	507.02.253.09
2	2	**End-cap**	Cast aluminium alloy	2114	Hard Anodize & Polyurethane powder coated	ESC 52 ESC 63	507.04.203.10
1	1	**Housing**	Cast aluminium alloy	2114	Hard Anodize & Polyurethane powder coated	ESC 52 ESC 63	507.01.153.10

REVISIONS		
REV	ECN	DATE
00	Released	18-May-17



Number	Quantity	Description	Material	ESMA	Surface treatment	Specification	Drawing number
44	1	**Spring return sticker**	Polyester with PVC film	6114			991.02.002
43	1	**Brand sticker**	Polyester with PVC film	6114			500.90.106
42	1	**"Made in" sticker**	Polyester with PVC film	6114			VA991.01.004
41	2	**type plate rivet**	Stainless steel	-			901.04.410
40	1	**Type plate ATEX/PED**	Stainless steel	-			991.05.415
39	1	**Position indicator bolt**	Stainless steel	1821			901.04.221
38	1	**Position indicator Vane**	Acrylonitrile butadiene styrene (ABS)	6117			307.01.282
37	1	**Position indicator Knob**	Acrylonitrile butadiene styrene (ABS)	6117			307.01.290
36	1	**indicator insert**	Acrylonitrile butadiene styrene (ABS)	6117			307.01.292
35	3	**Namur plate bolts**	Stainless steel	1821			VA-ED-002-4600
34		Low temperature	Silicone rubber (VMQ)	4405			902.02.266
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.266
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.266
	1	**O-ring**					
33		Low temperature	Silicone rubber (VMQ)	4405			902.02.213
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.213
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.213
	1	**O-ring**					
32		Low temperature	Silicone rubber (VMQ)	4405			902.02.227
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.227
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.227
	1	**O-ring**					
31	1	**Namur plate**	Cast aluminium alloy	2114	Hard Anodize & Polyurethane powder coated	ESC 52 ESC 63	500.03.263.10
30	2	**Protection cap**	Polyethylene (PE)	-			901.94.075
29	2	**Protection cap**	Polyethylene (PE)	-			901.94.175
28	4	**Limit stop washer**	Polyamide 66 (PA66)	3201			901.34.075
27	4	**Limit stop nut**	Stainless steel A2	1821			901.62.070
26	2	**Limit stop bolt**	Stainless steel A2	1821			901.14.066
25	2	**B-port plug**	Stainless steel	AISi 420/440 grade 10			901.92.212
24		Low temperature	Silicone rubber (VMQ)	4405			902.00.525
		High temperature	Fluorocarbon rubber (FKM)	4112			902.00.525
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.525
	6	**Fastener o-ring**					
23		Low temperature	Silicone rubber (VMQ)	4405			902.02.523
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.523
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.523
	2	**End-cap o-ring**					
22		Low temperature	Silicone rubber (VMQ)	4405			902.02.808
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.808
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.808
	2	**Piston o-ring**					
21		Low temperature	Silicone rubber (VMQ)	4405			VA001-296-55
		High temperature	Fluorocarbon rubber (FKM)	4112			VA001-296-56
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.129
	1	**Pinion o-ring small**					
20		Low temperature	Silicone rubber (VMQ)	4405			902.02.705
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.705
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.705
	2	**Pinion o-ring large**					
19	8	**End-cap bolt**	Stainless steel	1821			VA-ED-002-4603
18	1	**Circlip small**	Carbon spring steel	1843	Deltatone coated	ESC 64	901.37.030
17	1	**Circlip large**	Carbon spring steel	1843	Deltatone coated	ESC 64	901.37.056
16	2	**Thrust washer**	CRM-ZX100	-			507.11.053
15	2	**Pinion bearing**	Delrin	3304			507.13.053
14	2	**Piston guide band**	PTFE 25 % carbon filled	6204			507.11.003
13	1	**Piston housing guideband**	Nylatron GS	3202			507.10.053
12	1	**Limit stop cam**	Steel	1509	Zinc plated	ESC 72	507.22.053
11	1	**Pinion upper part**	Aluminium alloy	2209	Hard anodized	ESC 58	VA-ED-003-1146
10	1	**Pinion**	Aluminium alloy	2209	Hard anodized	ESC 58	VA-ED-003-1154
9	2	**Washer**	Carbon steel	1418	zinc plated	ESC 72	901.31.073
8	2	**springpack bolt**	Stainless steel	1821			901.22.070
7	2	**spring retainer**	Carbon steel	1451	Zinc plated	ESC 54	507.09.003
6	2	**Innner spring**	Spring steel	1519	Electrophoresic coated	-	507.08.003
5	2	**Middle spring**	Spring steel	1519	Electrophoresic coated	-	507.07.003
4	2	**Outer spring**	Spring steel	1519	Electrophoresic coated	-	507.06.003
3	2	**Piston**	Cast aluminium alloy	2114	Trivalent surface treatment	ESC60	507.02.253.09
2	2	**End-cap**	Cast aluminium alloy	2114	Hard Anodize & Polyurethane powder coated	ESC 52 ESC 63	507.05.203.10
1	1	**Housing**	Cast aluminium alloy	2114	Hard Anodize & Polyurethane powder coated	ESC 52 ESC 63	507.01.153.10

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WITHOUT PRIOR APPROVAL OF THE AUTHORIZED PERSON

UNLESS OTHERWISE SPECIFIED

GENERAL NOTES
1. DIMENSIONS ARE IN MILLIMETER
2. REMOVE BURRS AND BREAK SHARP EDGES
3. CHAMFER ANGLE
4. FILLETS
5. SURFACE ROUGHNESS Ra
6. CHAMFER FIRST THREAD
7. THREAD DRILL DEPTHS ARE MAX.
8. THREAD LENGTHS ARE FULL THREAD
9. DO NOT MEASURE THE DRAWING

TOLERANCES
1. TOLERANCE LINEAR ±
2. TOLERANCE ANGULAR ± °

INTERPRET DIMENSIONS AND TOLERANCE PER ISO/ASME Y14.5

TITLE:
GENERAL ASSEMBLY
FIELDQ QS350/QD350

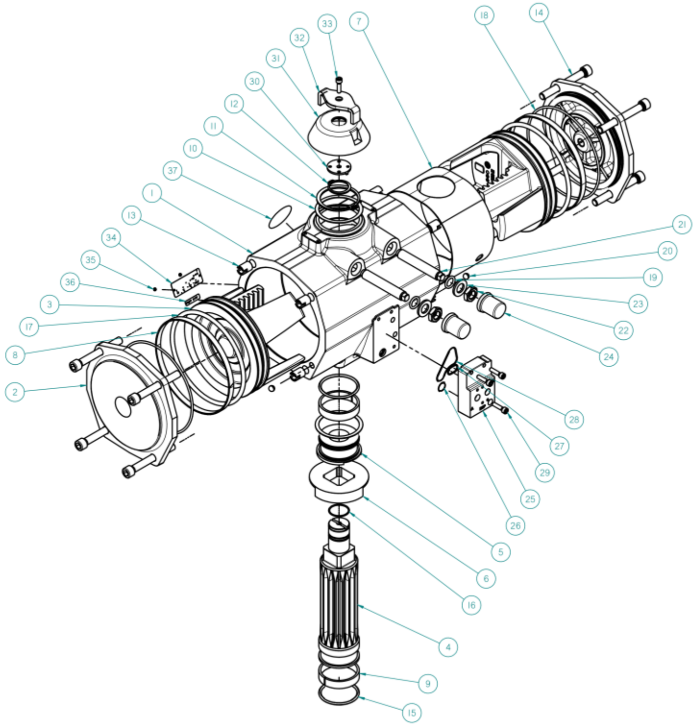
APPROXIMATE WEIGHT: -
MATERIAL PER ESMA: -
THIRD ANGLE PROJECTION

EMERSON
Process Management

DRAWING NO. VA-ED-003-2440

DRWN BY	Checked By:	Approved By:	DATE
Bekkernens, André	-	-	01-Feb-17
SCALE:	DWG. SIZE A1	SHEET 2 of 2	REV. 00

REVISIONS		
REV	ECN	DATE
00	Released	18-May-17



Number	Quantity	Description	Material	ESMA	Surface treatment	Specification	Drawing number
37	1	**Brand sticker**	Polyester with PVC film	6114			500.90.106
36	1	**"Made in" sticker**	Polyester with PVC film	6114			VA991.01.004
35	2	**type plate rivet**	Stainless steel	-			901.04.410
34	1	**Type plate ATEX/PED**	Stainless steel	-			VA991.05.415
33	1	**Position indicator bolt**	Stainless steel	1821			901.04.221
32	1	**Position indicator Vane**	Acrylonitrile butadiene styrene (ABS)	6117			307.01.282
31	1	**Position indicator Knob**	Acrylonitrile butadiene styrene (ABS)	6117			307.01.291
30	1	**indicator insert**	Acrylonitrile butadiene styrene (ABS)	6117			307.01.292
29	3	**Namur plate bolts**	Stainless steel	1821			VA-ED-002-4600
28		Low temperature	Silicone rubber (VMQ)	4405			902.02.266
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.266
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.266
	1	**O-ring**					
27		Low temperature	Silicone rubber (VMQ)	4405			902.02.213
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.213
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.213
	1	**O-ring**					
26		Low temperature	Silicone rubber (VMQ)	4405			902.02.227
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.227
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.227
	1	**O-ring**					
25	1	**Namur plate**	Cast aluminium alloy	2114	Hard Anodize & Polyurethane powder coated	ESC 52 ESC 63	500.03.263.10
24	2	**limit stop cover**	Polyethylene (PE)	-			901.94.185
23	2	**Limit stop washer**	Polyamide 66 (PA66)	3201			901.34.085
22	2	**Limit stop nut**	Stainless steel A2	1821			901.04.044
21	2	**Limit stop bolt**	Stainless steel A2	1821			901.14.091
20	2	**B-port plug**	Stainless steel	AISi 420/440 grade 10			901.92.213
19		Low temperature	Silicone rubber (VMQ)	4405			
		High temperature	Fluorocarbon rubber (FKM)	4112			
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.714
	2	**Limit stop o-ring**					
18		Low temperature	Silicone rubber (VMQ)	4405			
		High temperature	Fluorocarbon rubber (FKM)	4112			
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.698
	2	**End-cap o-ring**					
17		Low temperature	Silicone rubber (VMQ)	4405			
		High temperature	Fluorocarbon rubber (FKM)	4112			
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.907
	2	**Piston o-ring**					
16		Low temperature	Silicone rubber (VMQ)	4405			
		High temperature	Fluorocarbon rubber (FKM)	4112			
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.101
	1	**Pinion o-ring small**					
15		Low temperature	Silicone rubber (VMQ)	4405			
		High temperature	Fluorocarbon rubber (FKM)	4112			
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.740
	2	**Pinion o-ring large**					
14	8	**End-cap bolt**	Stainless steel	1821			VA-ED-002-4606
13	8	**housing insert**	Hardened steel	-	Zinc plated	ESC 11	901.83.070
12	1	**Circlip small**	Carbon spring steel	1843	Deltatone coated	ESC 64	901.37.035
11	1	**Circlip large**	Carbon spring steel	1843	Deltatone coated	ESC 64	901.37.068
10	2	**Thrust washer**	CRM-ZX100	-			508.11.053
9	2	**Pinion bearing**	Delrin	3304			508.13.053
8	2	**Piston guide band**	PTFE 25 % carbon filled	6204			508.11.003
7	1	**Piston housing guideband**	Nylatron GS	3202			508.10.053
6	1	**Limit stop cam**	Steel	1509	Zinc plated	ESC 72	508.22.054
5	1	**Pinion upper part**	Aluminium alloy	2209	Hard anodized	ESC 58	VA-ED-003-1158
4	1	**Pinion**	Aluminium alloy	2209	Hard anodized	ESC 58	VA-ED-003-1160
3	2	**Piston**	Cast aluminium alloy	2114	Trivalent surface treatment	ESC60	508.02.053.09
2	2	**End cap**	Cast aluminium alloy	2114	Hard Anodize & Polyurethane powder coated	ESC 52 ESC 63	508.04.203.10
1	1	**Housing**	Cast aluminium alloy	2114	Hard Anodize & Polyurethane powder coated	ESC 52 ESC 63	508.01.153.10

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UNLESS OTHERWISE SPECIFIED

GENERAL NOTES
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3. CHAMFER ANGLE
4. FILLETS
5. SURFACE ROUGHNESS Ra
6. CHAMFER FIRST THREAD
7. THREAD DRILL DEPTHS ARE MAX.
8. THREAD LENGTHS ARE FULL THREAD
9. DO NOT MEASURE THE DRAWING

TOLERANCES
1. TOLERANCE LINEAR ±
2. TOLERANCE ANGULAR ± °

INTERPRET DIMENSIONS AND TOLERANCE PER ISO/ASME Y14.5

TITLE:
GENERAL ASSEMBLY
FIELDQ QS600/QD600

APPROXIMATE WEIGHT -

MATERIAL PER ESMA Error: No reference

THIRD ANGLE PROJECTION

EMERSON. Process Management

DRAWING NO. VA-ED-003-2491

DRWN BY	Checked By:	Approved By:	DATE
Bekkernens, André	-	-	02-Feb-17
SCALE:	DWG. SIZE A1	SHEET 1 of 2	REV. 00

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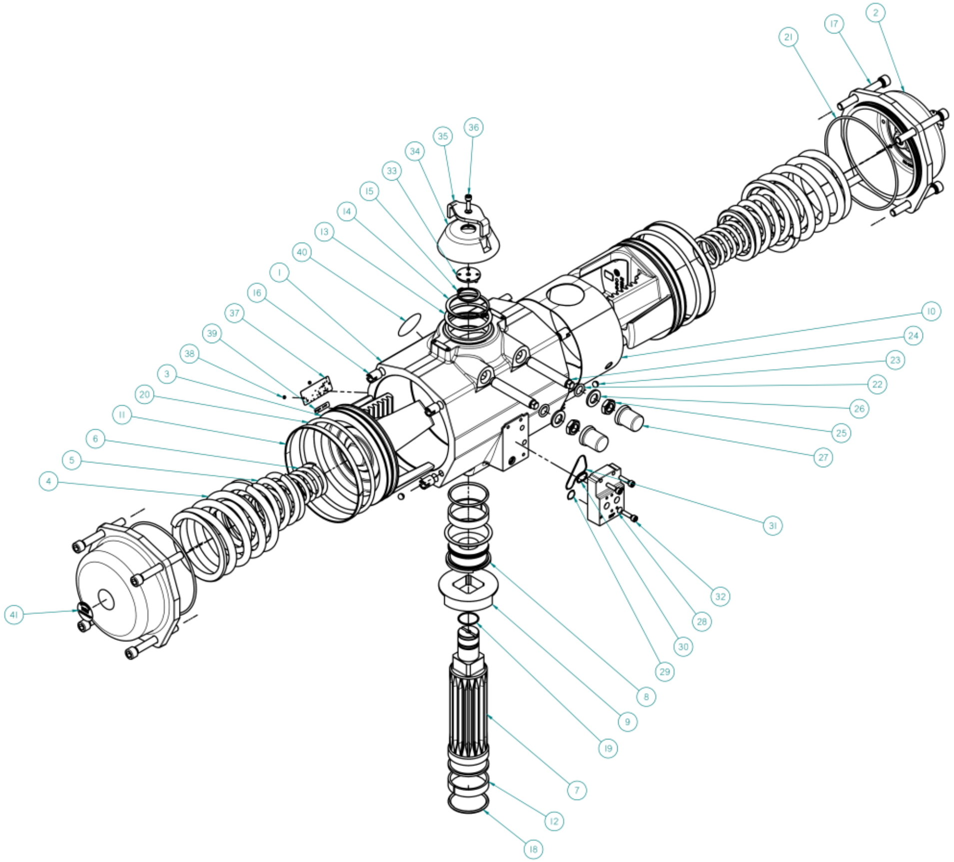
REVISIONS		
REV	ECN	DATE
00	Released	18-May-17



Number	Quantity	Description	Material	ESMA	Surface treatment	Specification	Drawing number
41	1	**Spring return sticker**	Polyester with PVC film	6114			991.02.001
40	1	**Brand sticker**	Polyester with PVC film	6114			500.90.106
39	1	**"Made in" sticker**	Polyester with PVC film	6114			VA991.01.004
38	2	**type plate rivet**	Stainless steel	-			901.04.410
37	1	**Type plate ATEX/PED**	Stainless steel	-			VA991.05.415
36	1	**Position indicator bolt**	Stainless steel	1821			901.04.221
35	1	**Position indicator Vane**	Acrylonitrile butadiene styrene (ABS)	6117			307.01.282
34	1	**Position indicator Knob**	Acrylonitrile butadiene styrene (ABS)	6117			307.01.291
33	1	**indicator insert**	Acrylonitrile butadiene styrene (ABS)	6117			307.01.292
32	3	**Namur plate bolts**	Stainless steel	1821			VA-ED-002-4600
31		Low temperature	Silicone rubber (VMQ)	4405			902.02.266
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.266
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.266
	1	**O-ring**					
30		Low temperature	Silicone rubber (VMQ)	4405			902.02.213
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.213
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.213
	1	**O-ring**					
29		Low temperature	Silicone rubber (VMQ)	4405			902.02.227
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.227
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.227
	1	**O-ring**					
28	1	**Namur plate**	Cast aluminium alloy	2114	Hard Anodize & Polyurethane powder coated	ESC 52 ESC 63	500.03.263.10
27	2	**limit stop cover**	Polyethylene (PE)	-			901.94.185
26	2	**Limit stop washer**	Polyamide 66 (PA66)	3201			901.34.085
25	2	**Limit stop nut**	Stainless steel A2	1821			901.04.044
24	2	**Limit stop bolt**	Stainless steel A2	1821			901.14.091
23	2	**B-port plug**	Stainless steel	AISi 420/440 grade 10			901.92.213
22		Low temperature	Silicone rubber (VMQ)	4405			902.02.714
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.714
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.714
	2	**Limit stop o-ring**					
21		Low temperature	Silicone rubber (VMQ)	4405			902.02.698
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.698
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.698
	2	**End-cap o-ring**					
20		Low temperature	Silicone rubber (VMQ)	4405			902.02.907
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.907
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.907
	2	**Piston o-ring**					
19		Low temperature	Silicone rubber (VMQ)	4405			902.02.101
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.101
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.101
	2	**Pinion o-ring small**					
18		Low temperature	Silicone rubber (VMQ)	4405			902.02.740
		High temperature	Fluorocarbon rubber (FKM)	4112			902.01.740
		Standard temperature	Nitrile Rubber (NBR)	4020			902.00.740
	2	**Pinion o-ring large**					
17	8	**End-cap bolt**	Stainless steel	1821			VA-ED-002-5281
16	8	**housing insert**	Hardened steel	-	Zinc plated	ESC 72	901.83.070
15	1	**Circlip small**	Carbon spring steel	1843	Deltatone coated	ESC 64	901.37.035
14	1	**Circlip large**	Carbon spring steel	1843	Deltatone coated	ESC 64	901.37.068
13	2	**Thrust washer**	CRM-ZX100	-			508.11.053
12	2	**Pinion bearing**	Delrin	3304			508.13.053
11	2	**Piston guide band**	PTFE 25 % carbon filled	6204			508.11.003
10	1	**Piston housing guideband**	Nylatron GS	3202			508.10.053
9	1	**Limit stop cam**	Steel	1509	Zinc plated	ESC 72	508.22.054
8	1	**Pinion upper part**	Aluminium alloy	2209	Hard anodized	ESC 58	VA-ED-003-1158
7	1	**Pinion**	Aluminium alloy	2209	Hard anodized	ESC 58	VA-ED-003-1160
6	2	**Innner spring**	Spring steel	1519	Electrophoresic coated	-	508.08.003
5	2	**Middle spring**	Spring steel	1519	Electrophoresic coated	-	508.07.003
4	2	**Outer spring**	Spring steel	1519	Electrophoresic coated	-	508.06.003
3	2	**Piston**	Cast aluminium alloy	2114	Trivalent surface treatment	ESC60	508.02.053.09
2	2	**End cap**	Cast aluminium alloy	2114	Hard Anodize & Polyurethane powder coated	ESC 52 ESC 63	508.05.203.10
1	1	**Housing**	Cast aluminium alloy	2114	Hard Anodize & Polyurethane powder coated	ESC 52 ESC 63	508.01.153.10

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UNLESS OTHERWISE SPECIFIED

GENERAL NOTES

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4. FILLETS
5. SURFACE ROUGHNESS Ra
6. CHAMFER FIRST THREAD
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8. THREAD LENGTHS ARE FULL THREAD
9. DO NOT MEASURE THE DRAWING

TOLERANCES

1. TOLERANCE LINEAR ±
2. TOLERANCE ANGULAR ± °

INTERPRET DIMENSIONS AND TOLERANCE PER ISO/ASME Y14.5

TITLE:
GENERAL ASSEMBLY
FIELDQ QS600/QD600

EMERSON. Process Management

APPROXIMATE WEIGHT	MATERIAL PER ESMA	DRAWING NO.	VA-ED-003-2491		
-	Error: No reference				
THIRD ANGLE PROJECTION		DRWN BY Bekkernens, André	Checked By: -	Approved By: -	DATE 02-Feb-17
		SCALE:	DWG. SIZE A1	SHEET 2 of 2	REV. 00