Process Automation Users' Association

Recommended Practice S 2812- X-19

Published by WIB, June-01-2019

Actuated Valve Assembly

A Recommended Practice for Part turn Automated On-Off valves

VALVE WORLD AMERICAS

Conference Workshop

INTERNATIONAL INSTRUMENT USERS' ASSOCIATION

WIB

CIRCULATION

This report has been produced for use by WIB members and for anyone involved in specifying and applying industrial Actuated Valve Assemblies. The contents of this report is freely available to be used as recommended practice.

No approval or certification is intended or given. It is left to the readers' judgment to determine whether this recommended practice is suitable for its intended application.

WIB does not warrant that this document is complete or accurate. Any use of the document by the WIB members or by third parties is at the responsibility and the risk of the user. All claims for damages are excluded, except as stipulated by mandatory liability laws.

ABOUT WIB

WIB is the International Process Automation users' Association who collaborates in the sponsoring, planning and organization of instrument evaluation and study programs. They have the long term objective of encouraging improvements in the design, construction, performance and reliability of Industrial Automation systems.

Process Automation Users' Association -WIB
Prinsessegracht 26, . 2514 AP, The Hague.
The Netherlands

Disclaimer

Every effort is made to provide accurate information in this document. However WIB, nor any of its Members or authors, makes any warranty of any kind about the quality or correctness of the information included in this document. WIB will not be liable for any damages of any kind arising from the use of this document.

Comments sent by e-mail

You are invited to provide us with your personal comments or questions in an E-mail, directed to:

manager@wib.nl. We will use this information to improve the content of this document.

Actuated Valve Assembly Recommended Practice

"A Recommended Practice for Part-Turn Automated OnOff Valves"

For the purpose of this Recommended Practice (RP), the document applies the term Actuated Valve (AV) Assembly in compliance with ISO 12490 / API 6DX, a key international standard in this domain. For readers more familiar with terms like Automated On/Off Valves, Automated Block valve, etc., it means the same.

An EndUser practice, forming the **closing piece** to complete the jigsaw puzzle of international, regional and national standards & practices to size, select, assemble, test, operate & maintain actuated valve assemblies.

Why this Recommended Practice?

- The current process to size & select Fit for the Application Actuated Valve Assemblies has following major challenges:
  a) it often lacks quality valve torque data on demand
  b) it lacks unambiguous definitions of valve torque data, factors and coefficients
  c) this process is being handled by different and often uncoordinated disciplines
  d) it is often being handled as commodities, not as engineered products.
- The more standardized the sizing & selection process of the parts and their assembling, the less chance for miscommunication, misunderstanding, misinterpretation. This standardization will result in more safe and reliable equipment in our facilities.

This Recommended Practice focuses on the essential aspects to size, select and to integrate the various AV Assembly parts, including aspects that international standards currently do not cover completely.

Specific design requirements for the valve design and or actuator design are not part of this Recommended Practice.

To more effectively size and select a **Fit for the Application** Actuated Valve Assembly, the WIB Final Element Workgroup members have developed this Recommended Practice. WIB stands for Workgroup Instrumentation Evaluation ("Beoordeling" in Dutch). The WIB current membership list and website are shown on the next page.

Our goal is to get this Recommended Practice accepted as an international practice

Website: www.wib.nl

TABLE OF CONTENTS

LIST of TABLES and FIGURES

Several international standards organizations have covered different parts of the Actuated Valve Assembly domain. This WIB Recommended Practice provides the missing pieces in those standards to complete the puzzle to effectively size & select a Fit for the Application AV Assembly.

One key aspect in the sizing & selection process is to handle AV Assemblies as engineered products, as it has been done with control valves for many decades.

To align ourselves with the international standards for Control Valves (CV), as issued under the IEC series 60534 standards, this practice matches the 8 CV standards IEC604534-1 to -8. Therefore this document contains 8 sections numbered 1 to 8 as shown below. In other words, IEC60534 created 8 documents, this RP is a single document divided into 8 sections.

Which normative references are influencing the eight RP sections are indicated. The dominating reference within a section is indicated in **bold**.

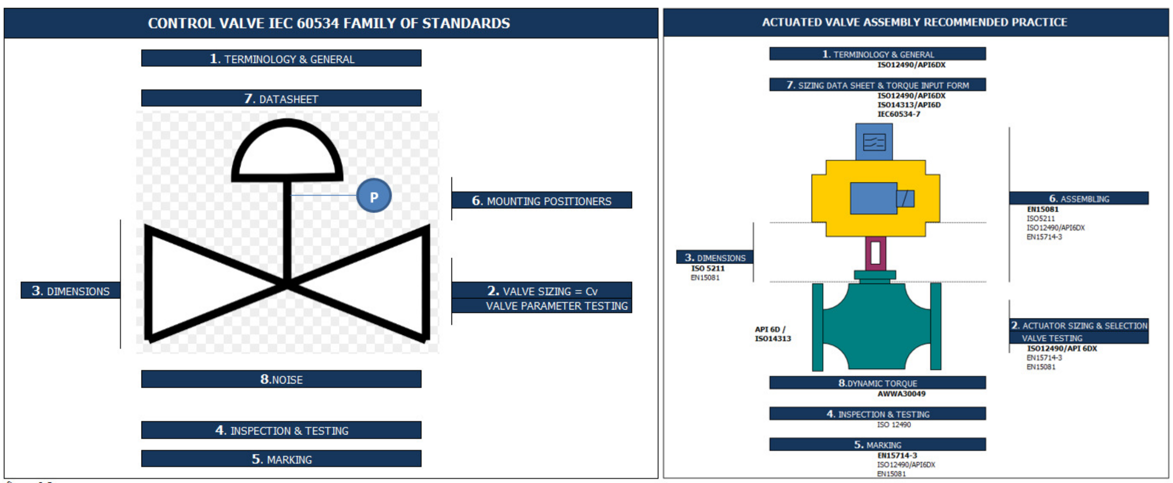
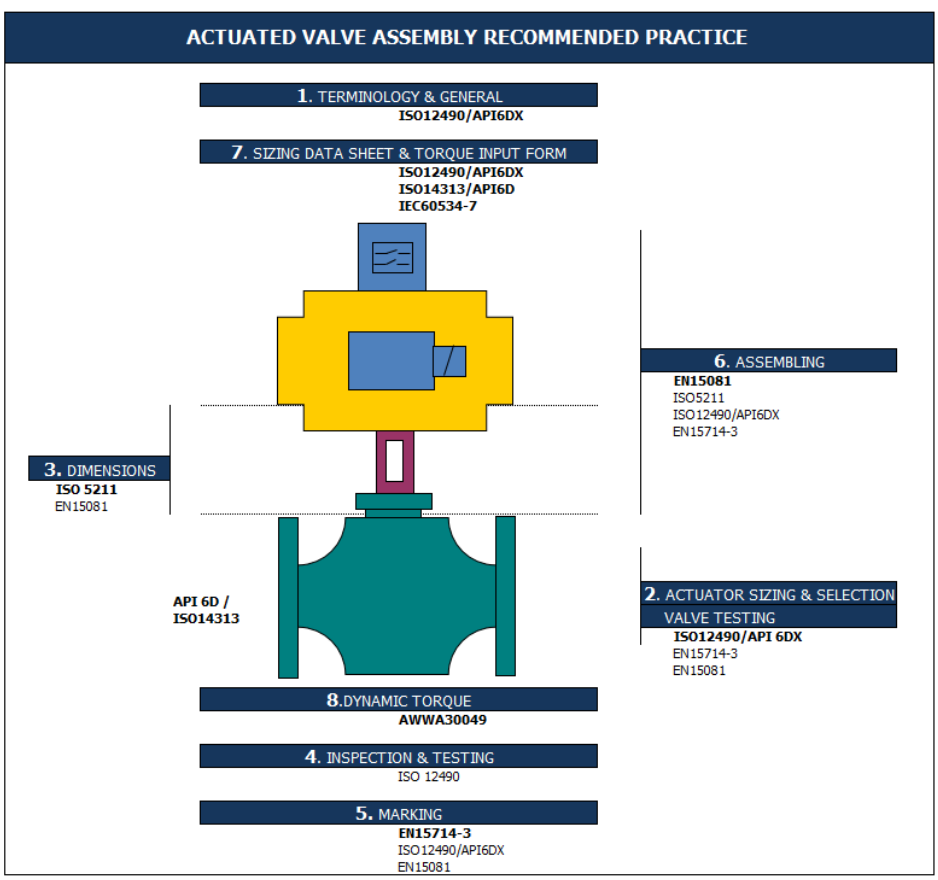


figure 0.3



SCOPE

This Recommended Practice (RP) will focus on the essential aspects to effectively size, select and integrate the various AV Assembly parts, which are currently not completely covered by international standards[1] in order to:

a) Identify the missing pieces in the current international standards
b) Specify those missing pieces
c) Reference applicable sub-clauses from the current standards. When referring to a sub-clause, all the requirements apply unless otherwise stated in this RP or otherwise agreed between the purchaser and the manufacturer/ supplier, prior to order.

This Recommended Practice defines following aspects to realize **Fit for the Application AV Assemblies**:

a) The terms & definitions required to consistently and correctly engineer, construct and operate AV Assemblies, with specific focus on **consistent torque terminology, acronyms, definitions** and **data models**,
b) The requirements to effectively **size & select** the automation package,
c) The requirements to properly address the **mechanical integrity of the AV Assembly,**
d) The requirements to effectively **assemble, test, inspect** and **maintain** the valve, the actuator, the mounting kit and the ancillaries,
e) The procedures to **obtain and document consistent quality valve torque data**,
f) How to properly use the RP valve torque input form, including the **On Demand Torque Correction Factor**
g) How to properly use the RP **Assembly sizing data sheet,** including the **data providers**

This Recommended Practice is applicable to:

a) Actuated valves fitted with part-turn **pneumatic** actuators,
b) AV Assemblies for the chemical, petrochemical and oil & gas industries,

This Recommended Practice is NOT applicable to:

a) pneumatic actuators which are an integral part of a control valve
b) valves in subsea services

This Recommended Practice does NOT define the specific requirements for the valve design and / or actuator design

Section 8. "DYNAMIC TORQUE" addresses the **Fit for the Application criteria from a fluid dynamics** viewpoint, i.e. when to apply dynamic torque data, the required coefficients and models to properly size & select the actuator and the mounting kit. This section reflects the latest knowledge on this domain and it is expected that this knowledge will expand over the years when more and more knowhow and insight becomes of use.

[1] The reader shall consult the latest edition for each of those international standards

NORMATIVE REFERENCES

For the purposes of this document, following normative references apply:

Org	Number	Organization	Type	Comments	Title	current edition	Year
ISO	ISO 2859-1	International Standards Organization	international standard		Sampling procedures for inspection by attributes -- Part 1: Sampling schemes indexed by acceptable quality level (AOL) for lot-by-lot inspection	2	1999
	ISO 5211		international standard		Industrial valves: Part-turn actuator attachments	2	2017
	ISO 12490		international standard	Idem API 6DX	Petroleum and natural gas industries – Mechanical integrity and sizing of actuators and mounting kits for pipeline valves	1	2011
	ISO 14313			Idem API 6D	Petroleum and natural gas industries – Pipeline transportation systems – Pipeline valves	24	2007
API	API 6D	American Petroleum Institute		Idem ISO 14313	Specification for Pipeline and Piping Valves	24	2014
	API 6DX			Idem ISO 12490	Actuator Sizing and Mounting Kits for Pipeline Valves	1	2012
AWWA	M49	American Water Works Association	Recommended Practice		Manual of Water Supply Practices – Quarter-Turn Valves: Head Loss, Torque, and Cavitation Analysis	3	2017
EN	EN 15081	European Standards			Industrial valves --Mounting kits for part-turn valve actuator attachment	1	2007
	EN 15714-3				Industrial valves -- Actuators – Part 3: Pneumatic part-turn actuators for industrial valves – basic requirements	1	2009

Table 0.5

1 TERMS & DEFINITIONS

1.1 General

For the purposes of this document, the following terms and definitions apply:

nr		terms and definitions	torque related	acronym / symbol	ISO 12490 / API 6DX	API 6D	ISO 5211	EN 15081	AWWA 30049	nr
1	A	actuated valve		AV	X					1
2		actuated valve assembly		AV assembly	X					2
3		actuator			X		X			3
4		actuator, part-turn			X		X	X		4
5		actuator, reduced stroke			X					5
6		actuator output torque, maximum						X		6
7		adapter flange						X		7
8	B	bracket						X		8
9		breakaway angle	X		X					9
10		breakaway torque	X		X					10
11		by agreement			X					11
12	C	coupling			X			X		12
13		coupling axial clearance						X		13
14		cycle			X					14
15	D	drive train			X	X [(1)]				15
16	I	intermediate support			X			X		16
17	M	maximum allowable stem torque	X	MAST	X			X		17
18		maximum flange torque	X	MFT			X			18
19		mechanically loaded parts			X					19
20		mounting kit			X			X		20
21	O	obturator				X				21
22	P	part-turn actuator attachment						X		22
23		pitch circle diameter		PCD	X			X		23
24		position convention							X	24
25		position seated	X						X	25
26		pressure-containing parts			X					26
27		pressure design			X					27
28		pressure, maximum operating			X					28
29		pressure, maximum rated			X					29
30		pressure, maximum supply			X					30
31		pressure, minimum supply			X					31
32	S	spigot						X		32
33		spool						X		33
34		stall torque	X		X					34
35		stem			X					35
36		stroke			X					36
37		supplier			X					37
38	T	temperature, maximum design			X					38
39		temperature, maximum operating			X					39
40		temperature, minimum design			X					40
41		temperature, minimum operating			X					41
42		torque	X						X	42
43		torque coefficient	X						X	43
44		torque safety factor	X						X	44
45		torque, design	X		X					45
46		torque, maximum	X		X					46
47		torque seated / unseated	X						X	47
48	U	unless otherwise agreed			X					48
49		unless otherwise specified			X					49
50	V	valve, top flange						X		50
51		valve shaft						X		51
52	W	Water hammer								52
		Table 1.1	12		34	1	1	9	6	

(1) The drive train definition is being revised in the API 6D to include reaction points. API 6D 3.1.13 drive train: All parts of a valve drive between the operator and the closure member that transmit or react loads, including the closure member ,but excluding the operator

a) Basically the terms & definitions as given in **ISO 12490 chapter 4** apply, 34 definitions out of 52,

b) For terms and definitions as defined also in other international standards, even if they differ, the RP applies the ISO 12490 chapter 4 terms and definitions

c) For terms and definitions **NOT** given in ISO 12490, those given in table 1.1 as marked with a white "X" in dark background apply,

d) For any terms and definitions not defined in any standard, the following as defined below in table 1.2 "AV Assembly RP specific terms & definitions" apply:

AV ASSEMBLY RP specific terms & definitions

#		ACRONYM	TERM	DEFINITION
1	A		Automation package	The mounting kit, the actuator and actuator controls
2		AV	Actuated Valve	Actuated Valve. Also called Automated Block Valve (ABV); Automated OnOff Valve (AOV), not to be confused with Air Operated Valves
3		AV Assembly	Actuated Valve Assembly	Actuated Valve Assembly. An Actuated Valve Assembly consisting of 4 basic elements: a Valve element, an Actuator element ,a Mounting Kit in between and the Actuator Controls
4			Actuated Valve Assembly sizing data sheet	The data sheet, to distinct from a specification sheet, containing all essential parameters to properly size the actuator and mounting kit
5			Actuator controls	All components to control the actuator such as solenoid, a valve controller, a switch box, a quick exhaust, boosters, etc.
6			Ambient Conditions	For example an AV Assembly in high or low ambient conditions
7	B	BDV	Blowdown Valve	Typically a Fail Open application, i.e. on demand the BDV shall move to the open position
8	C		Closed Loop Purge System	Also called the Rebreather Function.
9	D		Data Provider	Actuated Valve Assembly Data Provider. The AV Assembly sizing data sheet will indicate the data provider responsible to provide the value for a given data sheet parameter
10		DC	Diagnostic Coverage	See IEC 61508-4 Functional Safety definitions
11		DCF	Diagnostic Coverage Factor	See IEC 61508-4 Functional Safety definitions
12	E	ESDV	Emergency Shutdown Valve	Typically a Fail Close application, i.e. on demand the ESDV shall move to the closed position
13	F		Fit for the Application	Fit for the Application Actuated Valve Assembly. This means the assembly is sized, selected and designed suitable for the specific application and to function as specified.
14		FST	Full Stroke Testing	See ISA-TR96.05.01 Partial Stroke Testing of Automated Valves
15	I	IOM		Installation, Operation and Maintenance manual
16	M	MALR	Max Allowable Leakage Rate	
17	O	ODCF	On Demand Correction Factor	A correction factor to multiply a net torque value, like the BTO, to correct the net torque for specific combined process characteristics
18			Operational Characteristic	For example an AV Assembly in Long Stand Still, i.e. the time an AV Assembly is not moving
19	P	PFD	Probabilty of failure on demand	See IEC 61508-4 Functional Safety definitions
20		PST	Partial Stroke Testing	See ISA-TR96.05.01 Partial Stroke Testing of Automated Valves
21		PSV	Pressure Safety Valve	Pressure Safety Valve
22	R	RP	Recommended Practice	This EndUser AV Assembly RP document is called a Recommended Practice, to distinct from International Standards, with the goal to get accepted as a international Recommended Practice.
23	S	SIF	Safety Instrumented Function	See IEC 61508-4 Functional Safety definitions
24		SRS	Safety Requirements Specification	See IEC 61508-4 Functional Safety definitions
25	V	VC	Valve configuration	A classification of Actuated Valves for which static torque data can unambiguously be defined. The valve configuration is defined by a fixed set of parameters - see Table Annex C.1 Section 2 "Valve Configuration parameters"
26			Valve process fluid characteristic	For example an AV Assembly valve with a non-lubricating fluid, or a non-clean fluid (particles, abrasives, etc)
27			Valve signature	Also called fingerprinting. Performing a valve signature creates a benchmark of an assembled valve's performance just prior to shipment and provides a starting point for future data comparison.
28		VTIF	Valve Torque Input Form	A Recommended Practice structured form requesting the valve manufacturer torque values for a given valve configuration. To obtain consistent and complete torque data this RP has opted for a structured from approach.

Table 1.2

AV ASSEMBLY RP Data Providers

#	ACRONYM	TERM	DEFINITION
1	**AM**	**Actuator Manufacturer**	
2	**AAC**	**AV Assembly Contractor**	The organization performing the assembly activities. This can be e.g. the valve manufacturer, the valve automation center, the actuator manufacturer, as specified in the purchase order specification
3		**End User**	Also called Owner Operator
4	**EPC**	**EPC Contractor**	Engineering, Procurement and Construction Contractor
5	**MKM**	**Mounting Kit Manufacturer**	
6		**Purchaser**	
7	**VAC**	**Valve Automation Center**	
8	**VM**	**Valve Manufacturer**	

Table 1.3

1.2 Torque terminology

For the purpose of this document, following torque terms and definitions apply.

1.2.1 Torque acronyms

For the purpose of this document, following torque acronyms apply

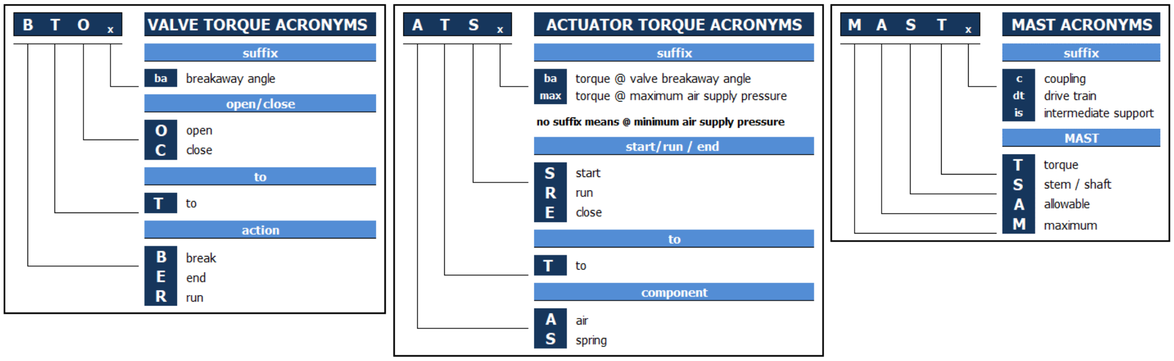


Table 1.4

1.2.2 Torque data definitions

For the purpose of this document, following torque data definitions apply.

TORQUE DATA DEFINITIONS				
symbol	definition	travel ° open	uom	clarification
Torque values				torque data at the given travel position
MAST	**M**aximum **A**llowable **S**tem **T**orque		Nm / lb-ft	The maximum torque to dimension the drive train elements to ensure the weakest link in the drive train can handle this maximum torque
Valve torques				
BTO	**Break** to Open	0	Nm / lb-ft	To break the valve open, also called Unseating Torque
RTO	**Run** to Open	min	Nm / lb-ft	Minimum torque running in opening direction
ETO	**End** to Open	90	Nm / lb-ft	To fully open the valve
BTC	**Break** to Close	90	Nm / lb-ft	To break from opening
RTC	**Run** to Close	min	Nm / lb-ft	Minimum torque running in closing direction
ETC	**End** to Close	0	Nm / lb-ft	To fully close the valve, also called Seating or Reseating Torque
Actuator torques				
ATS	Air to **Start**	0 90	Nm / lb-ft	Air torque at which the actuator spring starts to compress
ATR	Air to **Run**	min	Nm / lb-ft	Air torque at which the actuator spring is compressing
ATE	Air to **End**	90 0	Nm / lb-ft	Air torque at which the actuator spring is fully compressed
STS	Spring to **Start**	90 0	Nm / lb-ft	Spring torque at which the actuator spring starts to relax
STR	Spring to **Run**	min	Nm / lb-ft	spring torque at which the actuator spring is relaxing
STE	Spring to **End**	0 90	Nm / lb-ft	spring torque at which the actuator spring is fully relaxed
Torque Factors				torque data for a given AV assembly
SSF	Sizing **Safety Factor**	-	-	Actuated Valve Assembly Sizing Safety Factor is a dimensionless factor, expressed as a ratio, listed in the AV Assembly sizing data sheet to specify the safety margin between the valve torque value, including the ODCF, and the corresponding actuator torque value.
ODCF	**On Demand** Valve Torque **Correction Factor**	-	-	A correction factor to multiply a net torque value, like the BTO, to correct the net torque for specific combined process characteristics
Travel angle				
ba	**breakaway angle** or percent of stroke	0	-	The breakaway angle or percent of stroke is the point at which the seat breaks/makes sealing contact with the obturator. The breakaway angle or percent of stroke can be significant to actuator sizing when in excess of 5°

Table 1.5 uom = unit of measure

For terms & definitions of detailed torque components and coefficients consult the AWWA manual or Annex F "Valve Torque Essentials"

Note that torque values as defined in table 1.5 are including static based but excluding dynamic based torque components.

1.2.3 Static torque data models

This Recommended Practice covers both static and dynamic torque data models.

- ✓ Static torque data models apply when the torque caused by fluid dynamics is insignificant compared with the torque caused by friction (bearing friction, seating and unseating friction, packing & hub friction) and other static causes (hydrostatic, center of gravity, eccentricity). Generally spoken this is the case with valve sizes smaller than 24" and / or fluid velocities below 5 m/s. This split between static and dynamic can differ between valve manufacturers and between fluids. For a more precise and accurate split value the applicable valve manufacturer shall be contacted.
- ✓ Section 8 — Dynamic Torque describes and define when to apply dynamic torque models.

For the purpose of this document, following static torque data models apply:

1.2.3.1 The static torque data model for a spring-return fail-close application

STATIC TORQUE DATA MODEL
SPRING-RETURN **FAIL-CLOSE**

AV Assembly Recommended Practice

MAST	actuator **spring** torque	valve torque					actuator **cylinder** torque	
		action		θ		action		
	CLOSING				**OPENING**			p_{max}
N-m	Nm		Nm	º open	Nm		Nm	Nm
	STE	**END** TO CLOSE	**ETC**	0	**BTO**	**BREAK** TO OPEN	AT**S**	AT**S**$_{max}$
		ETC **breakaway angle**	ETC_{ba}	δ_{EC}				
				δ_{BO}	BTO_{ba}	BTO **breakaway angle**		
				10				
				20				
				30				
				40				
MAST	ST**R**	**RUN** TO CLOSE @ θº OPEN	**RTC**	45	**RTO**	**RUN** TO OPEN @ θº OPEN	AT**R**	AT**R**$_{max}$
				50				
				60				
				70				
				80				
	ST**S**	**BREAK** TO CLOSE	**BTC**	90	**ETO**	**END** TO OPEN	AT**E**	AT**E**$_{max}$

STATIC TORQUE ASSUMPTIONS
* valve dynamic torque **NOT relevant** for the application!
* travel angle convention: **closed : θ= 0º ; opened : θ=90º**

Table 1.6

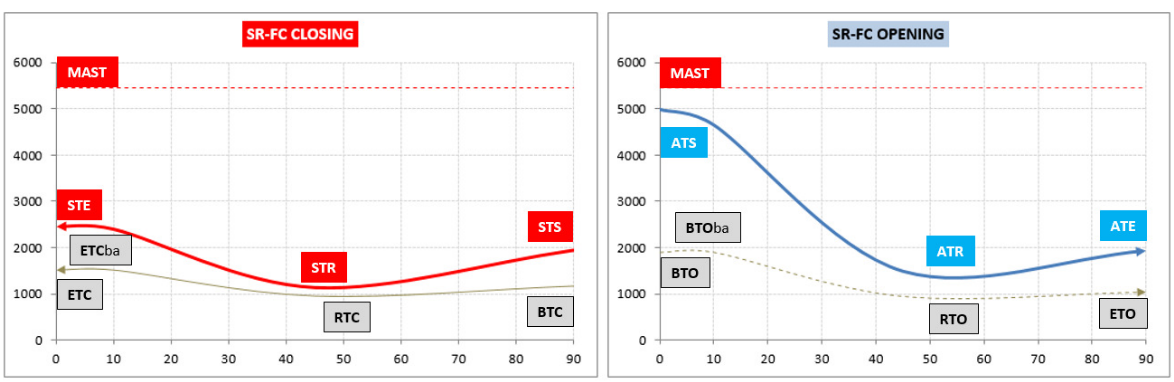


Figure 1.7 - canted Scotch Yoke

1.2.3.2 The static torque data model for a spring-return fail-open application

STATIC TORQUE DATA MODEL
SPRING-RETURN **FAIL-OPEN**

AV Assembly Recommended Practice

MAST	actuator **spring** torque	valve torque					actuator **cylinder** torque	
		action		θ		action		
		OPENING				**CLOSING**		p_{max}
N-m	Nm		Nm	º open	Nm		Nm	Nm
	ST**S**	**BREAK** TO OPEN	**BTO**	0	**ETC**	**END** TO CLOSE	ATE	AT**E**$_{max}$
				δ_{EC}	ETC_{ba}	ETC **breakaway angle**		
		BTO **breakaway angle**	BTO_{ba}	δ_{BO}				
				10				
				20				
				30				
MAST				40				
	STR	**RUN** TO OPEN @ θº OPEN	**RTO**	45	**RTC**	**RUN** TO CLOSE @ θº OPEN	ATR	AT**R**$_{max}$
				50				
				60				
				70				
				80				
	STE	**END** TO OPEN	**ETO**	90	**BTC**	**BREAK** TO CLOSE	AT**S**	AT**S**$_{max}$

STATIC TORQUE ASSUMPTIONS

* valve dynamic torque **NOT relevant** for the application!

* travel angle convention: **closed : θ= 0º ; opened : θ=90º**

Table 1.8

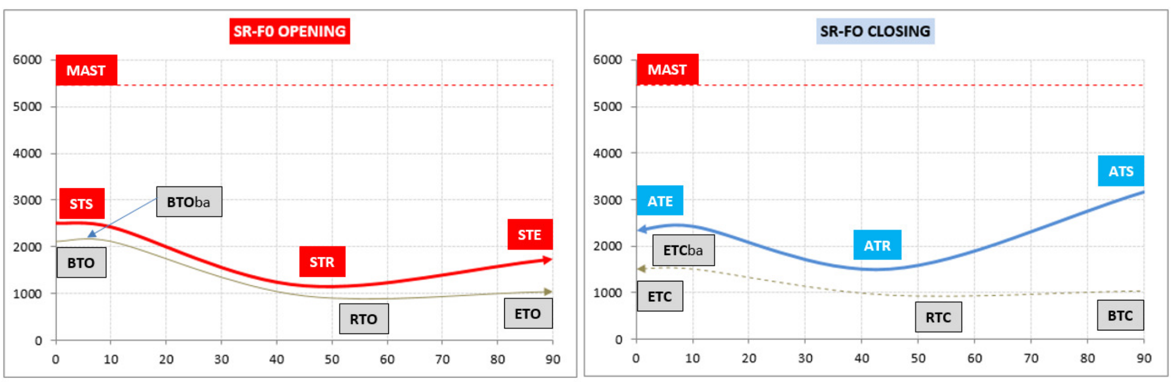


Figure 1.9 - symmetric Scotch Yoke

2 AV ASSEMBLY SIZING & SELECTION / TORQUE TEST PROCEDURES

2.1 ACTUATOR SIZING & SELECTION

Applying the sizing phase in accordance with this Recommended Practice is key to arrive at a Fit for the Application AV Assembly. Following questions are essential:

a) Who is responsible for sizing what part of the assembly?
b) Who shall provide what data?
c) What sizing method shall apply?
d) Who is responsible for the assembling?

A Valve Torque Input Form (VTIF) allows the valve manufacturer to compile and publish quality valve torque data. Section 7 "Sizing Data sheet and Valve Torque Input Form" describes details on how to apply this input form.

Torque Parameter Dependency		Symbol	uom	as a function of valve						
				Configuration	Size	dp	θ travel open [1]	Stem size & material	Obturator material	Stem / Obturator connection
static torque	value		Nm ; lb-ft	X	X	X	X			
breakaway	angle	BTOba	θ	X	X					
MAST	value	MAST	Nm ; lb-ft	X	X			X	X	X
dynamic torque	torque coeffiicent	Ctθ		X	X		X			
	flow coefficient	Cv		X	X		X			
	value		Nm ; lb-ft	X	X	X	X			

[1] travel angle convention: **closed : θ= 0º ; opened : θ=90º**

Table 2.1

Table 2.1 defines the torque dependency on valve parameters, e.g. the MAST torque value is a function of, among other things, valve configuration, valve size, valve stem size and material, valve obturator material and stem / obturator connection.

An AV Assembly sizing data sheet allows a proper sizing of the AV Assembly. For each AV Assembly parameter, the data provider is shown on the sizing data sheet. Details in Section 7 "Assembly Data sheet and Valve Torque Input Form" describe how to apply that sizing data sheet.

2.1.1 Sizing responsibilities / data providers

Following generic responsibilities apply, see also Annex B "Assembly sizing data sheet":

2.1.1.1 EndUser / Purchaser

- ✓ Select the Assembly Contractor, i.e. a Valve Automation Center or the Valve Manufacturer or the Actuation Manufacturer
- ✓ Specify the identification of a specific AV assembly,
- ✓ Specify ambient and environmental conditions,
- ✓ Specify the application data,
- ✓ Specify the process data, with a special emphasis on operational, ambient and fluid characteristics, essential to address the proper torque for those characteristics,
- ✓ Specify the valve configuration,
- ✓ Define the preferential valve differential pressures, a key parameter to determine torque values – see Annex C "VTIF – section 3",
- ✓ Specify the actuator drive medium and its min – max supply pressure
- ✓ Define the Sizing Safety Factor (SSF).

2.1.1.2 Valve Manufacturer

- ✓ Provide the guaranteed static valve torque data as a function of valve configuration, size, dp and travel in accordance with paragraph 2.2.1 “Establishing Valve Torque Data” and publish this data in accordance with paragraph 7.2 “Valve Torque Input Form” for the temperature range defined in the input form
- ✓ Provide breakaway angles as a function of valve configuration and size
- ✓ Provide MAST data as a function of, among other things, valve configuration, valve size, valve stem size and material, valve obturator material and stem / obturator connection
- ✓ Provide On Demand Torque Correction Factors as a function of operational conditions, fluid characteristics and medium temperature
- ✓ If dynamic torque is required, see paragraph 1.2.3 as well as section 8, provide the dynamic torque coefficient $Ct\theta$ and the valve flow coefficient Cv as a function of valve configuration, size and travel. And provide the dynamic torque as a function of valve configuration, size, dp and travel
- ✓ Provide valve dimensional data according to ISO 5211
- ✓ If the valve manufacturer allows exceeding the ISO 5211 flange rating for a specific valve, the valve manufacturer has to provide the justification as documented in a design file.

2.1.1.3 Actuator Manufacturer

- ✓ Provide the actuator torque data STS, STR, STE, ATS, ATR, ATE in tabulated data and/or torque/stroke curves for different air supply pressures, in accordance with EN 15714-3
- ✓ Provide actuator max operating pressure
- ✓ Provide the actuator burst pressure
- ✓ Provide actuator dimensional data according to ISO 5211

2.1.1.4 AV Assembly Contractor

The EndUser may designate a single organization responsible for delivering Fit for the Application AV Assemblies. For the purpose of this practice this organization is called the AV Assembly Contractor. The EndUser decision to designate, either the Valve Manufacturer, the Actuator Manufacturer, the Valve Automation Center or any other organization, is based on quality, experience, geographical availability as well as on other economic considerations. Responsibility shall include the appropriate warranty period.

- ✓ Provide the sizing and selection of the actuator according to table 2.2, including the actuator size and spring set, unless otherwise specified by the purchaser.
- ✓ If due to the required spring force an actuator has to be selected for which the air torque at the given air supply pressure exceeds the MAST of any drive train element, corrective measures have to be taken. For example change the valve stem material and/or use an air pressure regulator at the air inlet of the actuator (see also paragraph 6.2.5). Discuss this with the purchaser.

2.1.1.5 Mounting Kit Manufacturer

- ✓ Provide mounting kit dimensional data covering all relevant dimensions like height, thickness, hole patterns, etc.
- ✓ Provide mounting kit material data.
- ✓ Provide mounting kit performance data i.e. strength and stiffness see 6.1.3.2 Strength and Stiffness
- ✓ Provide coupling MAST data see 6.1.4 Coupling

2.1.2 Sizing considerations

The following actuator sizing method applies. Unless otherwise indicated, torque values are at minimum actuator supply pressure. If the actuator air supply is regulated and the system is protect by a PSV, then the maximum air supply pressure is that of the PSV setting (see paragraph 6.2.5):

Sizing requires comparison of actuator torque values versus valve torque factors.

Actuator sizing method			
1	Verify that maximum **air supply pressure < actuator allowable operating pressure**		
2	Verify that maximum air torque start (**ATS_{max}**) < **flange torque** as per ISO 5211		
3	Verify that spring start torque **(STS) < flange torque** as per ISO 5211		
4	Verify that maximum air torque start (**ATS_{max}**)< **minimum of all drive train elements MAST** values (obturator, stem, stem to obturator connection and mounting kit)		
5	Verify that **actuator output torque** (both spring torque and air torque) **> valve torque on demand** over the full travel in both directions. Note that the ODCF may be different for different travel positions, therefore **ODCF(ϴ)** is used in the comparison! For ODCF see section 7.2.		
	FAIL CLOSE	FAIL OPEN	comments
5.1	ATS > BTO x ODCF(ϴ) x SSF	STS > BTO x ODCF(ϴ) x SSF	
5.2	ATR_{ba} > BTO_{ba} x ODCF(ϴ) x SSF	STR_{ba} > BTO_{ba} x ODCF(ϴ) x SSF	to ensure actuator torque > valve torque at breakaway
5.3	ATR > RTO x ODCF(ϴ) x SSF	STR > RTO x ODCF(ϴ) x SSF	
5.4	ATE > ETO x ODCF(ϴ) x SSF	STE > ETO x ODCF(ϴ) x SSF	
5.5	STS > BTC x ODCF(ϴ) x SSF	ATS > BTC x ODCF(ϴ) x SSF	
5.6	STR > RTC x ODCF(ϴ) x SSF	ATR > RTC x ODCF(ϴ) x SSF	
5.7	STR_{ba} > ETO_{ba} x ODCF(ϴ) x SSF	ATR_{ba} > ETC_{ba} x ODCF(ϴ) x SSF	to ensure actuator torque > valve torque at breakaway
5.8	STE > ETC x ODCF(ϴ) x SSF	ATE > ETC x ODCF(ϴ) x SSF	
6	If ATSmax or STS > lowest value of the maximum allowable torque of stem/obturator , coupling and intermediate support, iterate between - changing **air supply pressure min/ max ratio**, - lowering **maximum air supply pressure** (see paragraph 6.2.5) - increasing the **mechanical integrity of the coupling or intermediate support**, - applying a **higher quality stem/obturator material**, - applying a **different actuator**. Note: to correctly apply the appropriate ODCF it is essential that the purchaser provide all process data and application data to the AV Assembly Contractor as listed in the AV Assembly sizing data sheet.		

Table 2.2

See also figures 1.7 and 1.9

Additional sizing considerations:

- ✓ By using travel stops significantly different from 0 and 90 º travel positions, the actuator does not supply the full torque at the travel stop. Consider this during sizing that the actuator torque is larger than the valve torque at the travel stop. See Figure Annex E-2
- ✓ Stroke damping may be required to control operating speed.
- ✓ There should be sufficient actuator power available to smoothly operate the AV Assembly as required for the application:
  - ➢ The actuator power available to drive the valve depends on both the available air supply pressure at the actuator and the air flow rate of the supply system during supplying and exhausting. Therefore it is important that the actuator pneumatic inlet- and outlet ports shall be adequately sized,
    The required air flow rate can be calculated by: Actuator Volume x Valve Travel Time
  - ➢ The air flow rate availability is necessary to properly size the complete automation package when the operating times are a critical aspect of the automated valve function,
  - ➢ When installing the AV Assembly in the field, the air supply and exhaust tubing/piping shall be adequately sized.
- ✓ The ratio between the maximum available air supply pressure and the minimum available air supply pressure is an important parameter for the actuator selection. As shown in table 2.2 the actuator sizing is based on the minimum available air supply pressure while the mechanical integrity check is based on the maximum available air supply pressure. The larger the ratio between the minimum available and the maximum available air supply pressure the more difficult to find a proper actuator. See Annex I. for some actuator calculation examples.
- ✓ When a very long travel time is required (e.g. to prevent water hammer) it may be that the RTO and RTC values are significantly higher than the RTO and RTC values for the non-adjusted (standard) travel time. If the actuator

sizing and selection is based on the non-adjusted (standard) travel time it may be that the actuator output torque is not sufficient to operate the valve properly. This may result in jerky valve movement or even stalling of the valve.

2.1.3 Sizing Safety Factor SSF

Providing a single value for the Sizing Safety Factor (SSF) is difficult. That value depends on the quality / accuracy of the provided net valve torque data as well as the quality / accuracy of the On Demand **Correction Factor** (ODCF) to correct the net torque data. The ODCF has to address the respective process challenges, i.e. Long Stand Still, Fluid Characteristics such as non-lubricating, sticking or non-clean services, as well as minimum and/or maximum fluid temperatures. As a general rule the higher the quality / accuracy of the corrected torque data, the lower the SSF can be. As a guideline, use a minimum SSF of 1.2

In case the AV Assembly Contractor disagrees with this SSF, the AV Assembly Contractor shall request the Purchaser to discuss this with the valve manufacturer and consider adjusting the On Demand Correction Factor (ODCF). Note: If the requested SSF is considered too low, it is probably better to first discuss the quality of the valve torque data and ODCF values with the valve manufacturer.

Be aware that improper assembling and installation of the AV Assembly may increase the valve torque values as established in paragraph 2.2.1.3.

2.1.4 Other selection considerations

2.1.4.1 Actuator

- ✓ Rack and Pinion style actuators are small in comparison with Scotch Yoke actuators. They will keep the overall package dimensionally small.
- ✓ In general, Rack and Pinion actuators are more cost effective but compared to Scotch Yoke actuators are limited in output torques.
- ✓ For most of the Scotch Yoke actuator designs the center of gravity is not in the center of the actuator. The spring module is much larger than the air cylinder. Consider this for the intermediate support design. Very large Scotch Yoke actuators sometimes need additional support.
- ✓ This practice does not cover all the specific design differences between the different actuator styles and their possible advantages/disadvantages.
- ✓ Due to the side loads on the yoke mechanism, high cycling SY actuators are susceptible to wearing out O-rings causing moisture ingress in the yoke mechanism, leading to corrosion and ultimate failure.
- ✓ According to ISO 12490 paragraph 13.4 the actuator manufacturer shall have proven, documented procedures and associated acceptance criteria in place that demonstrate an ability to verify and validate the performance characteristics of the actuator. The purchaser may specify additional torque testing on either prototype or production actuators. Reference also EN 15714-3.

2.1.4.2 Fast acting operations

Extreme fast acting operation of valves may be detrimental to the reliability of the valve, actuator, and associated piping. Emergency shutdown and blowdown valves in particular, must be reliable for the safety of the process, personnel, and the plant, but are often provided with actuators and controls designed for extremely fast operation. Although it may vary depending on the process and fluid, consider extreme fast operation for any operation faster than 1/3 second per nominal pipe size (NPS).

In an emergency shutdown situation, the pressure inside a pneumatic actuator is exhausted allowing the internal spring to rapidly move the valve to the fail position. The stress created by fast operation of valves can affect the entire valve assembly, including springs and travel stops of the actuator, valve-actuator couplings, adapter hardware, valve stems, guides, seats and seals. It may also affect the connected piping, cause hydraulic shock to the piping system, and reliability of actuator controls and limit switches. While actuators and valves are typically designed to withstand stresses from static loads, often there is little investigation into the dynamics of collision kinetic energy and absorbed energy of various components in a valve-actuator assembly.

Use adjustable speed controls to reduce operating speed to avoid damage. Actuators may also be equipped with pneumatic or hydraulic dampeners, which act as a shock absorber to manage high kinetic energy of the fast-moving parts. Hydraulic dampeners are most often used because of its smoother operation and overall reliability. Dampeners operate without significantly affecting the travel speed until the end of the stroke (either full open to full close for ESDVs or full close to full open for BDVs). This allows the valve to travel as fast as possible for the first 90 percent of the actuator stroke and then significantly slower for the remainder of the travel or rotation.

Ball, butterfly, gate, globe, and other valve types have different operation dynamics and permissible loading, and kinetic forces vary by valve size (increasing mass of the closure member) so there are no specific strength values that may be applied for extreme fast acting operation. But for the most part, it is most commonly the sudden loading of the closure member to seat (going closed, like in an ESDV) or the stem position stops (going open or close) or the stem drive coupling. It may also include the position stops in the actuator itself – which could be either close or open.

In a BDV, using a butterfly valve, a full stroke damper would be better when encountering high dynamic forces. It may prevent jumping or sudden movement in mid-travel positions. But for the purpose of protecting the valve and actuator through linear deceleration and minimizing loading of valve or actuator travel stops, an end of stroke damper is adequate.

Therefore, the two primary considerations are (1) review of system requirements to maximize the speed of valve operation or add hydraulic dampening, and (2) perform an analysis of dynamic forces and acceptable impact energy of the impacted valve and actuator components. When analyzing dynamic forces, note that PTFE friction coefficients are different for static conditions and for dynamic conditions – see table 2.3 from EI DuPont. The user or engineer working with the valve manufacturer initiates the system review, but the valve and actuator manufacturers must perform the dynamic force analysis. Finally perform a practical check once the valve is installed and operating.

Property Coefficient of Friction	Teflon PTFE	Teflon FEP	Teflon PFA	Teflon ETFE
-static	0.12-0.15	0.12-0.20	0.2	0.24-0.50
-dynamic	0.05-0.10	0.08-0.3	-	0.3-0.4

Table 2.3

2.1.4.3 Fail Safe Action – Spring Return and Double acting Actuators

- ✓ Process dictates the fail action of the AV Assembly, which determines the fail action of the actuator. The valve torque data is independent of the fail action of the valve assembly.
- ✓ In general and in particular for Safety related AV Assemblies (like valves part of a Safety Instrumented Function) it is highly recommended to provide the fail action with a failsafe spring. However if this is not possible, a double acting actuator can be used in combination with an air volume tank. Configure and hook up the actuator/air tank combination in such a way that if the air system to the AV Assembly fails the air tank automatically takes over the air supply to the AV Assembly.
- ✓ Design the air volume tank to provide sufficient air pressure and air volume/capacity to perform the minimum required number of valve strokes
- ✓ Monitor the air pressure in the air tank. Restore, in case of an air failure, the air supply pressure as soon as possible.
- ✓ The air volume tank design has to be designed conform the local pressure vessel regulations.
- ✓ Due to the complexity of an actuator/air tank system, avoid its use as much as possible. Only use an actuator/air tank system if there is no other valid option.
- ✓ Use the double acting actuator for fail-last applications. Use a bi-stable solenoid to derive at a fail-last drive signal.

2.2 VALVE & ACTUATOR TORQUE TEST PROCEDURES

2.2.1 Establishing Valve torque data

2.2.1.1 Valves produced in massive and repeated quantities

Currently there is no international standard specifying the procedure to establish valve torque data. The following procedure fills this gap.

The valve manufacturer shall establish the valve torque values as follows:

1) It shall be established and published **for each specific valve configuration**. The valve configuration parameters are defined in table Annex C.1 Section 2 “Valve Configuration parameters”
2) Establish the manufacturer’s premise at ambient conditions. Ambient conditions range to be within 20 to 25 ºC (68 to 77 ºF)
3) Establish the published torque values based on the torque measurement values of all production lots of at least one year of production. To establish the torque data follow the sampling procedures as described in ISO 2859-1. The published torque values shall be in accordance with AQL = 1.5; inspection level II as a minimum. Note: Since valves are produced in different lots, use these lot sizes to establish the sample rate. The published nominal torques values shall be the **upper limit**[2] value of the measured torque based on its 95% confidence interval. The valve manufacturer shall report the number of valves used to establish the published mean torque values. When, for whatever reason, not the upper limit value will be published, the valve manufacturer has to clearly state this in the VTIF (Annex C), and provide the basis for the published value.

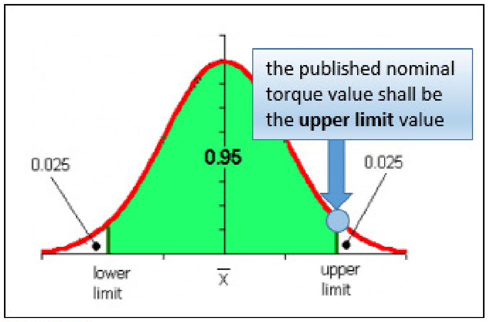


Figure 2.4

4) After item 3 is established, verity the torque values at regular intervals per calendar year to ensure the published torque values represent the current population. The verification measurements shall be available by the valve manufacturer by the end of each calendar year. The minimum sample size to do this shall be in accordance with an AQL = 1.5 (ISO 2859-1) inspection level II. This verification shall be established at least yearly or at shorter intervals if there is a change in the production process (a new type, change in materials, production moved to another location, etc.)
5) A calibrated torque measurement device shall be used to measure the valve torque. Calibrate the measurement device according to the applicable calibration plan. The minimum calibration frequency shall be 6 month or 12 month depending on the frequency of usage.
6) Measure the torque values after the valve passed the shell test according to the applicable test standard.
   To measure the torque values the following differential pressures have to be applied to the valve:
   Per valve pressure rating:
   - Torque value 1: maximum working pressure drop at ambient temperature and
   - Torque valve 2: 0.5 x maximum working pressure drop at ambient temperature.

   Example carbon steel valve according to ASME B16.34 table 2-1.1:
   - Torque value 1: Pressure drop = 19.6 Bar
   - Torque value 2: Pressure drop = 9.8 Bar

   Note: please note that the applicable differential pressures to measure the torque valves are lower than the shell test pressure according to the applicable test standard.

   If the maximum working pressure of the valve is limited by e.g. the seat construction and or seat material this maximum working pressure limit shall be respected for the torque testing. This shall be reported on the valve torque input form, see chapter 7.2
7) BTO, BTC, RTO/RTC and ETC torque values shall be measured for each run
8) MAST
   a) To calculate the MAST, the torsion shear stress calculation shall be in accordance with API 6D clause 5.20 and based on the weakest link of the valve drive train.
   b) If due to the valve construction, the MAST is not the limiting torque factor, this shall be clearly documented by the valve manufacturer. The valve manufacturer shall provide the applicable limiting torque values, e.g. maximum valve seat torque for triple eccentric butterfly valves.
   c) Provide the MAST calculations to the purchaser on request.
   d) If the MAST is calculated for a limited temperature range with respect to the published temperature range of the valve this has to be published by the valve manufacturer.
9) Valve torque data shall be reported and published as detailed in chapter 7.2 “Valve Torque Input Form” and

[2] Just as a consumer can read on the label for a bag of sugar the guaranteed **minimum** weight, the EndUser shall be able to read for an AV valve in the published technical bulletin the guaranteed **maximum** valve torque within the 95% confidence level.

Annex C.

The valve manufacturer may have established its own alternate documented test procedure to measure and publish torque data, which meets the intention of the test procedure as described in this paragraph. This data may be used if published accordingly clarifying this it is not according to this RP. On request, the valve manufacturer shall provide the alternate test procedure to the purchaser.

2.2.1.2 “One of a kind” type valves

For large and/or special valves, not repeatedly produced in series, it will be difficult to have the conditions to collect data on a significant base. In this case for each valve the static torque values BTO,RTO,ETC,BTC, RTC and ETC have to be measured, and those values are to be included in the test certificate. The test procedure shall be agreement with the purchaser.

The calculated MAST value according 2.2.1.1.- 8) shall also be provided.

2.2.1.3 Warning

Valve torque values established according to this test procedure are test-bench valve torque values without any influence of the valve assembling and/or installation.

These valve torque values can highly be influenced by amongst other things:

- ✓ Misalignment of the drive train due to improper assembly.
- ✓ Misalignment of the pipe flanges between which the valve is installed (stress on valve body)
- ✓ Downwards force on obturator caused by insufficient axial tolerances of the coupling, see par 6.1.4.3

2.2.2 Establishing On Demand Torque Correction Factor (ODCF)

ON DEMAND TORQUE CORRECTION FACTOR calculator									Scenario Manager #		45
Characteristic	Sample application data		setting	uom	CF	For which torque values applies the ODCF?					
	CF %	value				BTO	RTO	ETO	BTC	RTC	ETC
long stand still time	132%	12	5.8	month	132%	FO			FC		
Fluid Characteristics											
state / phase		Liquid									
clean service					100%	X	X	FO	X	X	X
non-clean service					140%	X	X	X	X	X	X
non-lubricating	132%	X	1		132%	X	X	X	X	X	X
sticking service					136%	X	X	X	X	X	X
slurries	152%	X			152%	X	X	X	X	X	X
					2						
temp minimum			-150	ºC	133%	X	X	X	X	X	X
temp maximum			500	ºC	131%	X	X	X	X	X	X
fluid correction factor	184%		Sum of fluid parameters			Legend **X** applicable for both FC and FO applications **FC** applicable for FC applications only **FO** applicable for FO applications only					4
ODCF	**243%**		Multiply		3						

Table 2.5

The On Demand Correction Factor (ODCF) data shall be established and published by the valve manufacturer:

Table 2.5 clarifies the 4 parts to establish ODCF data:

1. The valve manufacturer shall provide the **setting** for the characteristics Long Stand Still and for the minimum / maximum fluid temperatures,
2. The valve manufacturer shall provide the **correction factor** (CF) for all characteristics. If according to the valve manufacturer one or more characteristics are missing, these can be added on the VTIF section 7.
3. The valve manufacturer shall provide the methods how to deal with **multiple challenges**, i.e. the maximum or the sum of multiple fluid characteristics and the max, sum or multiply for the combined ODCF. See Annex H for some sample cases with combined challenges.
4. The valve manufacturer shall indicate **which of the 6 static torque values shall be multiplied** with the appropriate ODCF.

- ✓ These ODCF values shall be reported and published as detailed in Section 7.2.1 using the VTIF, Section 7. The sample forms are given in Annex C.
- ✓ In Annex D typical values as distilled from valve manufacturers websites technical information are given.
  - ➢ Currently no methods dealing with multiple challenges have been found
  - ➢ Currently no information could be found on which torque values to be multiplied with appropriate ODCF

On request of the purchaser the valve manufacturer shall provide the rationale that is used to establish the published ODCF values.

2.2.3 Actuator torque data testing

The manufacturer shall have documented procedures and associated acceptance criteria in place that demonstrate an ability to verify and validate the performance characteristics of the actuator. The purchaser may specify additional torque testing on either prototype or production actuators. See also ISO 12490 paragraph 13.4

The manufacturer/supplier provides the guaranteed minimum output torque capability of the actuator, in both directions, at specified supply pressures. Where the output torque varies with the stroke, in a non-linear relationship, provide tabulated data and/or torque/stroke curves.

See also EN 15714-3 Table 8

2.3 SUB-CLAUSES MATRIX

For this Section 2 all the relevant paragraphs of the AV Assembly domain versus the respective international standards organizations (ISO, EN) sub-clauses are documented in the matrix Table 2.6.

The reader shall consult the respective international standards sub-clauses to clarify any further details if so required.

AV Assembly RP vs International Standards sub-clauses matrix Section 2 SIZING & SELECTION TORQUE TESTING				ISO API						EN										
				2859-1		12490 6DX				15081									15714-3	
						8.1.1	8.1.2	8.1.3	13.4	4.2 - 4.4	4.5	4.10	4.11	4.12	4.13	5.1 - Table 3	5.3 - Figure 2 - Table 4	Annex A		5.3 - Table 8
Chapter	RP paragraph numbering	Subclause			AQL	Sizing general	Valve torque data	Safety factor	Torque test	Materials - Environ protect	Mounting Kit	Mech / thermal protect	Orientation	Anti-rotation means	Assembly Maintenance	Dimensions - bracket	Dimensions - Coupling	Coupling Axial clearance		Production quality
ACTUATOR SIZING & SELECTION	2 1 1 1	Responsibilities	EndUser / Purchaser			X														
	2 1 1 2		Valve Manufacturer				X													
	2 1 1 3		Actuator Manufacturer																X	
	2 1 1 4		Assembly Contractor																	
	2 1 1 5		Mounting Kit Manufact																	
	2 1 2	Sizing Considerations																		
	2 1 3	Sizing Safety Factor SSF						X												
	2 1 4 1	Selection Considerations	Actuator						X										X	
	2 1 4 2		Fast acting operations																	
	2 1 4 3		Fail safe action																	
VALVE & ACTUATOR TORQUE TEST PROCEDURES	2 2 1 1		Massive quantities																	
	2 2 1 2		One of a kind																	
	2 2 1 3		Warning																	
	2 2 2	On Demand Correction Factor																		
	2 2 3	Actuator torque data testing							X											X

Table2.6

3 DIMENSIONS

3.1 DIMENSIONS

Three international standards, ISO 5211, ISO 12490 and EN 15081, provide essential AV Assembly dimensional data:

- ✓ ISO 5211 covers:
  - ➢ **Flange** dimensions as per figure 2 and table 2
  - ➢ **Holes positioning** as per figure 3 and table 3
  - ➢ **Drive train dimensions** as per section 7 and its various tables and figures
- ✓ ISO 12490 paragraph 8.1.4 covers
  - ➢ **Stem** dimensions
  - ➢ **Stem key** dimensions
  - ➢ **Mounting pattern (top works)** dimensions.
- ✓ EN 15081 section 5 covers:
  - ➢ **Bracket** dimensions as per section 5.1, figure 1 and table 3
  - ➢ **Coupling** dimensions as per section 5.3, figure 2 and table 4
  - ➢ **Spool and adapter flange** dimensions as per section 5.4

4 AV ASSEMBLY INSPECTION & ROUTINE TESTING

Assemble, function test and inspect AV Assemblies in accordance with the latest issue purchase order specification, valve, actuator and auxiliary equipment manufacturer's drawings/instructions. Bring any conflicts between these resources to the attention of the purchaser for resolution prior to assembly.

The AV Assembly functional tests as described in this section shall be

a) Conducted with the minimum operating air supply pressure as per specification.
b) Conducted by applying both minimum and maximum solenoid voltage and/or positioner signals.

4.1.1 Visual Inspection

Perform a visual inspection of the completed AV Assembly.

a) Visually inspect the AV Assembly for damage and verify that the tubing is installed in a proper way.
b) Verify that the valve is free of foreign material.
c) Verify that all open-end connections (e.g. conduit entries, vent ports, air supply ports, valve ends, etc.) are properly plugged or covered.
d) Verify that all marking is correct, for details see section 5
e) For vented ball valves make sure that the vent-hole in the ball is in the upstream direction. See also the valve IOM.
f) Record the results

4.1.2 Open and close travel stops Inspection

Check that the travel adjustment is in accordance with valve manufacturer's recommendations and/or purchase order specifications. If manufacturer's recommendations are not available or requirements are not noted in specifications, valve travel shall be adjusted to ensure valve will not over-travel or receive excessive torque. For ball and plug valves verify that obturator seating surfaces are not impinging in the flow stream, bore should be unobstructed when valve is in full open position.

4.1.3 Function Test

To execute the function test connect the air supply and the electrical power to the AV Assembly.

While the assembly is being functionality tested and connected to the air supply, check for air leaks at end-caps, actuator drive shaft/pinion, accessory connections and tubing.

For critical applications, execute the function test at full line pressure or at least at shutdown pressure. Specify the required test pressure in the purchase order specification.

4.1.3.1 Cycle Test

Energize and de-energize the solenoid and visually inspect valve opening and closing for a minimum of (2) open/closed cycles. Ensure that the entire assembly functions smoothly and trouble free.

4.1.3.2 Travel Time Test

- ✓ Energize and de-energize the solenoid to open and close the valve and record the measured travel times.
- ✓ If specific opening and/or closing travel times are required in the purchase order specification verify that the measured valve opening and/or closing travel times comply with the purchase order specification.
- ✓ Record the test results.

It is important to distinguish "Valve Travel Time" from "Valve Response Time":

- ✓ The Valve Travel Time is the time the valve is really moving to the opening or closing position.
- ✓ The Valve Response Time is the time from the moment the solenoid is energized or de-energized till the opening or closing position is reached. The valve response time is always longer than the valve travel time.

If the Valve Response Time is required the following air pressures shall be used:

- ✓ Spring direction: maximum air supply pressure as specified in the purchase order specification
- ✓ Opposite to spring direction: minimum air supply pressure as specified in the purchase order specification.

It shall be made clear in the purchase order specification if Valve Travel Time and/or Valve Response Time has to be tested.

4.1.3.3 Fail action Test

- ✓ Signal failure test: de-energizing the solenoid and verify the AV Assembly fail action.
- ✓ Air pressure failure test: remove the air supply connection from the actuator and verify the AV Assembly fail action.
- ✓ Record the test results.

4.1.3.4 Position switches / Position transmitter Test

- ✓ If supplied, verify proper function when 0 and 100% control signals are applied.
- ✓ Record the test results

4.1.3.5 Ancillaries Test

- ✓ Functional test and verify special features as required in the purchase order specification such as pneumatic trip valves, air volume tank systems, etc.
- ✓ Record the test results

4.1.4 Drive train alignment Test

Measure and record the total indicator runout on the valve stem using a dial indicator. Measure when the assembly is in motion in both the open-to-close and the close-to-open direction. Measure directly on the valve stem. If the valve stem is not accessible, it is acceptable to take a reading on the coupling close to the valve stem connection. Please consult each valve manufacturer for their recommended total indicated runout / shaft deflection for their valve design.

Figure 4.1

4.1.5 Seat leakage Test

- ✓ If required in the purchase order specification, after completing the valve assembly a seat leakage test shall be performed to verify shutoff in the preferred flow direction unless a bi-directional test is requested. The purchaser shall define the required seat leakage tests in the purchase order specification, e.g. API 598, IEC 60534-4.
- ✓ Record the test results. Test record shall record the test standard utilized, test duration, measured results.
- ✓ For applications for which seat leakage tightness is critical, e.g. SIS final elements, a seat leakage test after completing valve assembly shall always be a requirement.

4.1.6 Valve Signature Test (also called finger print)

If required in the purchase order specification, after completing the valve assembly a valve signature test shall be performed.

The test should supply following information as a minimum:

- ✓ A graph of actuator pressure versus degree valve travel in both upwards and downwards air pressure direction
- ✓ Torque values (BTO, RTO/RTC, BTC, ETC) as derived from valve signature or via actuator air pressure measurements
- ✓ Record the test results
- ✓ For critical applications, e.g. SIS final elements, valve signature test after completing the valve assembly shall always be a requirement.

4.1.7 Compliance with specification and purchase order

Ensure that the final AV Assembly complies with this RP, the purchase order specification, the valve, actuator, and auxiliary equipment manufacturer's assembly instructions, and the referenced standards.

4.1.8 AV Assembly test report

Record all individual test results in a final test report:

- ✓ It shall be incorporated in the manufacturer/supplier's certified quality assurance program and verified (date and signature) as being completed during final inspection & testing process.
- ✓ It shall be cross-referenced to the assembly serial number plus the customer's equipment identification number and purchase order number.
- ✓ It shall be maintained by the AV Assembly Contractor for same period as traceability records.

5 MARKING

5.1.1 Assembly

The assembly should have a permanent tag securely fastened to the intermediate support containing the following information, as a minimum:

a) AV Assembly Tag number
b) Serial number of the AV Assembly.
c) Company name of the AV Assembly Contractor
d) Actuator model number
e) Valve model number

The tag material should be stainless steel or brass, attached with stainless wire or riveted to the intermediate support

5.1.2 Actuator

International standards paragraphs specify actuator markings, mandatory as well as optional markings– see table 0.4.

5.1.3 Mounting kit

International standards paragraphs specify mounting kit markings, mandatory as well as optional markings– see table 0.4.

6 ASSEMBLING

Applying the Assembling phase in accordance with this Recommended Practice is key to derive at a Fit for the Application AV Assembly.

The valve/actuator/ancillaries assembly should be designed to function under operating conditions and according to the order specification as prepared by the purchaser.

6.1 ACTUATOR / VALVE

6.1.1 ISO 5211 compliance

The attachment for part-turn actuators to the valve shall comply with ISO 5211

The ISO 5211 standard specifies:

a) flange dimensions necessary for the attachment of part-turn actuators to industrial valves or to intermediate supports,
b) driving component dimensions of part-turn actuators necessary to attach them to the driven components,
c) Reference torque values for interfaces and for couplings having the dimensions specified in this document.

NOTE The term “valve” in the standard also includes “the valve with an intermediate support”.

The attachment of the intermediate support to the valve is out of the scope of ISO 5211.

The table and sketches in table 6.1 summarize the key elements and dimensions of the actuator / valve mounting:

a) A table with flange type and corresponding maximum flange torque values per ISO 5211,
b) A table with flange type and corresponding minimum coupling axial clearances per EN 15081. Note that clearances for flanges F35 up to F100 are not yet available.
c) A schematic view of the actuator, the actuator / valve interface, the intermediate support (if any) and the valve per ISO 5211.
d) A schematic view of the mounting kit elements, i.e. the intermediate support, the coupling and the bolting parts. The intermediate support shown is a bracket, but it can be a spool or an adapter flange
e) A schematic view of the mounting kit visualizing the 6 elements (actuator, coupling, bracket, valve and bolting parts) as well as indicating the coupling axial clearance per EN 15081

When it is not possible to use a valve that is ISO 5211 compliant, the valve body design for actuator attachment shall meet the following minimum requirements:

a) Minimum four (4) tapped actuator mounting holes are required. The valve bonnet should provide a machined surface (flat and smooth surface) to allow the attachment of an intermediate support. The four (4) tapped actuator mounting holes shall be arranged in a square pattern and centered about the valve stem. Provide for valves that have a flange size corresponding to ISO 5211 flange size F25 and higher the number of mounting holes as listed in the ISO 5211. When due to the construction of the valve this is not feasible the valve manufacturer shall clearly document this and make this available to the purchaser. The documentation shall include the design verification/validation.
b) The hole locations shall not interfere with the bottom of the coupling preventing the coupling from fully engaging the valve stem when the actuator mounting bracket and bolts w/lock washers are mounted,
c) The minimum design values for the hole pattern dimensions, bolt/stud size, tap depth and location shall be based on the maximum allowable stem torque or stem-to-obturator-connection torque values whichever is governing,
d) The size and location of the actuator mounting holes shall not decrease the mechanical strength of the valve bonnet or actuator-mounting flange,
e) Purchaser to specify the type of thread and the unit of dimensions,
f) If alternative dimensions are used that are outside the scope of the ISO 5211, they shall follow the design methodology and acceptance criteria of ISO 5211 unless otherwise agreed upon.

However applying valves not in compliance with ISO 5211 is not recommended.

6.1.2 Mounting kit

ISO 12490 clause 4.13 defines the mounting kit as: components that may be comprised of combinations of the following: intermediate support, coupling, drive key(s), dowel pin and bolting. Design temperature of the mounting kit shall be in accordance to the min and max process temperature conditions as listed in the purchase order specification. Unless otherwise specified in the purchase order specification the maximum process temperature shall be used to determine the appropriate yield strength of the materials for the mounting kit.

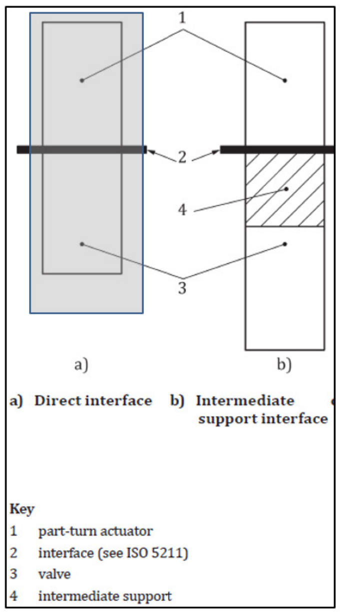
Note: the reason for using the maximum design temperature as default is that insulation work is not always done properly, sometimes the mounting kit is (partly) covered by the insulation.

ACTUATED VALVE ASSEMBLING ESSENTIALS / STANDARDS

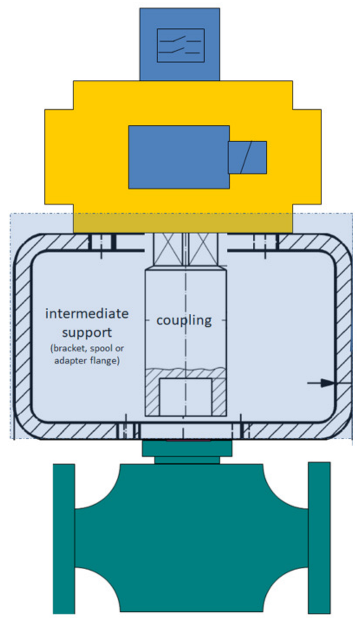
ISO 5211			EN 15081
max flange torque values			minimum coupling axial clearance
flange	torque		
	Nm	lb-in	mm
F03	32	283	1.0
F04	63	557	1.0
F05	125	1105	1.0
F07	250	2211	1.0
F10	500	4421	1.5
F12	1000	8843	1.5
F14	2000	17686	2.0
F16	4000	35371	2.0
F25	8000	70742	3.0
F30	16000	141485	3.0
F35	32000	282970	
F40	63000	557096	
F48	125000	1105350	
F60	250000	2210700	
F80	500000	4421400	
F100	1000000	8842799	

Table 6.1

ISO 5211



WIB 2789

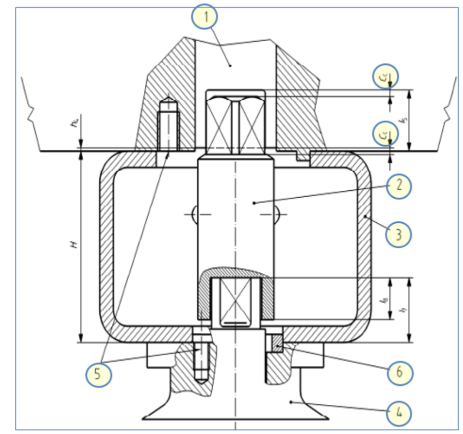


ISO 12490

mounting kit

- * intermediate support and,
- * coupling and,
- * bolting (drive key(s), dowel pin and bolting)

EN 15081



1	actuator
2	coupling (adaptor)
3	bracket
4	valve
5	mounting kit bolting
6	spigot
Cc	min coupling axial clearance

6.1.3 Intermediate Support

6.1.3.1 Style

There are different styles of intermediate support e.g. spool type, rectangular bracket, adaptor flange.

All intermediate supports (one piece, two piece welded and spool type) shall be of the “open style” and shall not be part of the valve pressure envelope, e.g. stem gland leakage must freely vent to atmosphere.

Use the open style design for the following reasons:

a) To avoid possible leakage from the valve stuffing box getting into the actuator past the shaft seal,
b) To avoid corrosion of the actuator due to the above leakage,
c) To allow for visual stuffing box inspection (fugitive emissions monitoring),
d) To allow for insulating the valve without insulating the actuator,
e) Access to packing gland bolts and mounting bolts.

As stipulated in EN 15081 clause 4.10 when using an adaptor flange as intermediate support, provide this adaptor with a suitable venting device for venting any leakage that may occur through the stem seal of the valve or from the actuator pneumatic supply. This may be obtained either by including a suitable vent or a pressure relief safety valve.

Non-welded one-piece intermediate support devices are preferred up to ISO 5211 flange size F25. Only for valve mounting patterns for which it is very impractical to use a one-piece intermediate support, a fabricated (welded) support may be used. However, this should be an exception.

For larger flange sizes a fabricated (welded) intermediate support such as a two piece or spool type supports may be used. Design spool type supports such that water (rain) can freely drain out of the bracket when mounting the AV Assembly in a horizontal or vertical position.

Mounting brackets are to be de-burred and free of sharp edges and corners.

Do not mount two (2) intermediate supports on top of each other.

The purchaser has to approve, if according to the AV Assembly Contractor there is a need to mount two intermediate supports on top of each other, e.g. a tall bracket with access to the packing gland bolts, the combination of a spool on top of an open style intermediate support allows to minimize the deflection in the open style intermediate support and provide the required height.

6.1.3.2 Strength and Stiffness

In addition to ISO 12490 clause 7.6 the mounting kit shall be designed to be installed in any mounting position unless otherwise specified in the order specification. See also EN 15081 clause 4.11. They shall be sufficiently strong by design and material selection to produce no visibly discernible off center movement- or deformation of the valve stem at the maximum load as defined in ISO 12490 clause 7.6 and the stem/coupling of the AV-assembly installed in horizontal position.

If welding on intermediate supports are required, this welding shall be in accordance with ISO 12490 clause 11.2 structural welding.

The design of the intermediate support shall meet the requirements as listed in ISO 12490 clause 7.6 and EN 15081 clause 4.5, 4.10 - 4.13 and 5.1. In addition to this, the clause 2.1 of this RP is applicable.

Provide on request the design calculations as applied by the mounting kit manufacturer to the purchaser.

6.1.3.3 Dimensions

The thickness of the intermediate support will be the result of the strength calculation as described in paragraph 6.1.3.2 with a minimum thickness as listed in EN 15081 Table 3 for the applied bracket height.

The height of the intermediate support depends on the medium temperature. For medium temperatures between -20 Deg C (-4 Deg F) up to +60 Deg C (+140 Deg F) the default intermediate support height is in accordance with EN 15081 Table 3 unless otherwise agreed upon between the purchaser and the AV Assembly Contractor. Use a cold or high temperature bracket for temperatures below or above those values.

Agree the bracket height between the purchaser and the AV Assembly Contractor. List the medium temperature in the purchase order specification.

The AV Assembly Contractor brings to the attention of the purchaser if the valve top work dimensions did not allow the use of the bracket height as listed in EN 15081 Table 3

Mounting bracket height shall allow visual observation of groove or rivets on the side of the coupling to confirm valve position. Adjust (increased) bracket and coupling dimensions to accommodate visual observation of groove or rivets in coupling when applying two inches of thermal insulation to the valve in the field. Agree this between the purchaser and the AV Assembly Contractor.

Fastener holes may be drilled, punched or precision laser cut. Do not allow manual burning of holes.

Fastener clearance holes:
- ✓ Metric fasteners: in accordance with EN 15081 Table 3. For ISO flange sizes not listed in EN 15081 Table 3, ISO 273 is applicable.
- ✓ Imperial fasteners: in accordance with ASME B18.2.8

Do not allow slotting of fastener holes to facilitate stem/shaft alignment unless otherwise specified in the purchase order specification.

6.1.3.4 Mounting

It is mandatory that the intermediate support be removable from the valve without requiring a "line opening". Therefore the use of any pressure containing part, i.e. body bonnet bolts, flange bolts, packing gland bolts, packing retaining stem nuts, etc. is not allowed and is strictly prohibited.

Removing the actuator or the intermediate support must be possible while the valve is in service. Do not allow packing gland removal to allow installation or removal of the intermediate support.
Caution: Closed valves that are torque or thrust seated will not maintain a seal when actuator is removed.

When the lever or hand wheel has to be removed from the valve in order to mount the mounting kit to the valve, the integrity of the stuffing box construction has to be secured to prevent loose packing rings etc.
Note: For some valve designs the lever or hand wheel to manually operate the valve are part of the construction of the stuffing box packing system. By removing this lever or hand wheel in order to mount the mounting kit to the valve the integrity of the stuffing box construction is lost resulting in packing leakage due to loose packing rings and or insufficient load on the packing rings.

Design the assembly intermediate supports, couplings and fasteners without special tools or modification to any assembly components. Make no modifications to any components of the valve or actuator without prior written approval from the purchaser. Intermediate support design and tolerance shall ensure suitable stem/shaft alignment and squareness without special skills or tooling during assembly.

Alignment of the drive train shall be within the runout/shaft deflection limits as given by the valve manufacturer.

Design the fasteners to have sufficient strength for forces and torques and their dimensions shall be in accordance with the applicable ISO 5211 flange dimensions (metric) or equivalent dimensions for US Standard Unified thread (imperial) MSS-SP-101.

If the maximum actuator ISO flange torque is higher than the maximum valve ISO flange torque, base the design torque for the mounting on the maximum valve ISO flange torque unless otherwise specified in the purchase order specification.

Do not allow to use ungraded fasteners to mount the intermediate support to the valve and actuator.

The frictional slip calculation method and results as used for the design of the bolted connections have to be provided on request of the purchaser.

Be cautious to mix stainless steel bracket materials and carbon/alloy steel fasteners. This is due to the fact that the thermal expansion of stainless steel is greater than carbon/alloy steel, which may lead to issues in applications with elevated temperatures.

No not use stainless steel fasteners in chloride stress corrosion situations.

Specify the required fastener material in the purchase order specification.

All fasteners shall have a lock washer. Do not allow the use of split-type lock washers.

Apply anti-seize to stainless steel threads at time of the final assembly.

Dowel pins

According to ISO 5211 clause 9 the bolted connection between the valve-intermediate support-actuator is only designed to transfer torque by static friction and is not designed for shear stresses.

However according EN 15081 clause 4.12 there are situations for which dowel pins for torque transfer may be used.

Example: Depending the used bolting material, for larger ISO flange sizes it may occur that the required bolt tightening torque to obtain the required static friction is very close to the maximum allowable yield stress of the bolts. Therefore for larger flange torque sizes the use of dowel pins should be considered to transfer the torque.

Dowel pins used for torque transfer shall be calculated and designed for that purpose. Currently there is no international standard calculation method available to design dowel pins used for torque transfer. Annex J shows an example of a calculation for a dowel pin design.

The valve, intermediate support and actuator need to have the proper accommodations to support dowel pins. Note that the use of dowel pins may affect the thickness of the intermediate support.

Dimensions of the dowel pins and the associated hole dimensions and tolerances shall be designed carefully.

Provide the calculation method and results as used for the dowel pins designs on request of the purchaser.

6.1.3.5 Materials

The purchaser selects the required material.

The intermediate support material and possible coating has to be suitable for the applicable environmental conditions (e.g. seawater coastal conditions). For more details see EN 15081 clause 4.2 - 4.4.

The use of stainless steel for intermediate supports is highly preferred, specifically for the smaller F-flange sizes up to ISO 5211 F16. This is due to better inherent corrosion resistance.

When using non-stainless steel, the intermediate support shall have an adequate corrosion protection for the applicable environmental condition. Important is a proper sandblasting to clean metal prior to apply the appropriate primer and corrosion resistant finish coating.

6.1.4 Coupling

6.1.4.1 Style

Construct couplings out of solid bar stock. Hollow shaft couplings are not allowed.

The driving end of the coupling (actuator side) shall fit the actuator drive dimensions and shall be in accordance with the applicable dimensions and tolerances as listed in ISO 5211.

The driven end of the coupling (valve side) shall fit the valve drive dimensions and shall be in accordance with the applicable dimensions and tolerances as listed in ISO 5211.

Use only couplings with a pocketed driven end (valve side) (see picture 6.2).

It is not preferred to use couplings with a slotted opening on the driven end (valve side) and reinforced with a welded ring to create a pocketed driven end (the welded ring is to prevent the coupling from spreading when under load).

The coupling should have a permanent machined groove or attached rivets that mark the position of the valve port. The mark should be visible when applying 2 inches of insulation around the valve in the field. Groove or rivets to be perpendicular to valve flow centerline when valve is closed.

6.1.4.2 Strength and stiffness

The design of the coupling shall ensure it can deliver the maximum transmissible torque to the valve shaft without visibly discernible distortion. The maximum transmissible torque shall be as equal to as or larger than the Maximum Allowable Stem Torque of the valve. Allowable stresses shall be in accordance with API 6D clause 5.20 “Drive trains”.

Because the driven end of the coupling (valve side) has a pocket to connect the coupling to the valve drive shaft, consider this as a hollow shaft from a torsions shear stress point of view. However to calculate the strength of the coupling it is not sufficient to only apply the torsion shear stress calculation for a hollow shaft.

Due to clearances between the coupling and valve drive shaft and possible very small irregularities on the surface areas, additional stresses may be introduced causing additional peak loads on the coupling.

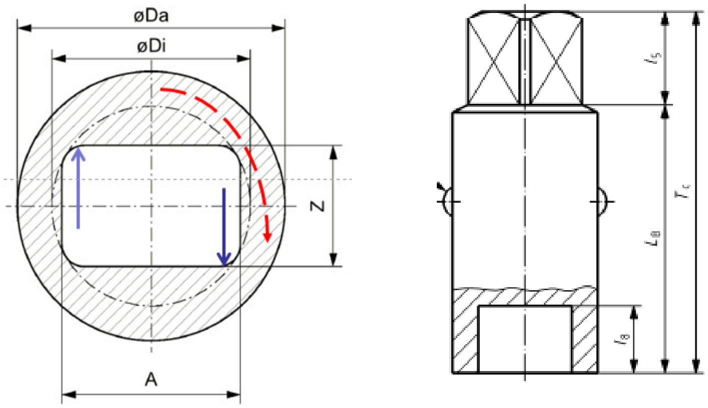


Figure 6.2

Dashed arrow: Equally distributed torque across the coupling wall (hollow shaft approach)

Solid arrow: additional forces due to clearances between coupling and valve drive shaft and possible very small irregularities on the surface areas. Assume a small contact area and determine the contact stress in that small area.

Make applicable calculations available if requested by the purchaser.

Base the drive-end engagement length l8 on the calculation of the minimum required contact area between valve stem and the coupling to deliver the maximum transmissible torque without visibly discernible distortion. Apply a safety factor of 1.5. As a rule of thumb, a minimum engagement length of 80% of the pocket depth is required

For l8, see figure 6.3

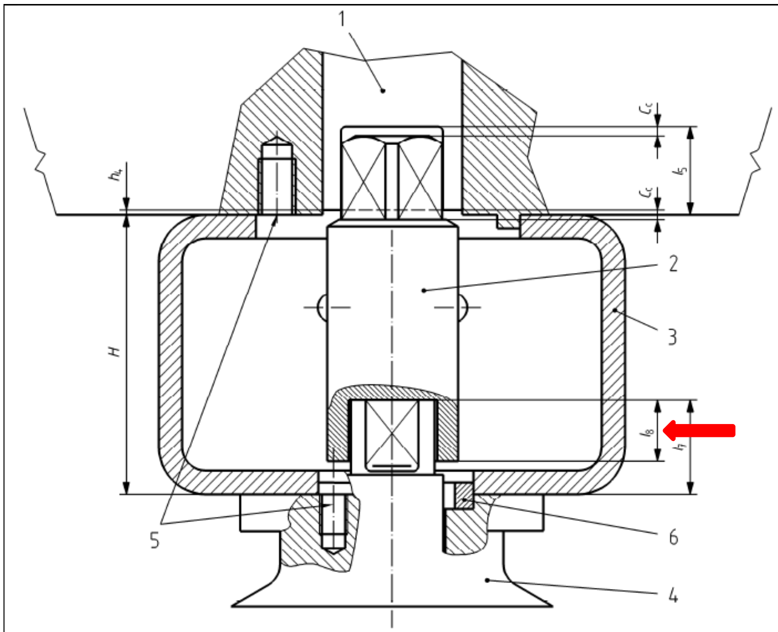


Figure 6.3

Figure 6.3 from
EN15081 – Annex A "Coupling axial clearance"

Dimension: l_8 see arrow

Key

1 Actuator
2 Coupling (adaptor)
3 Bracket
4 Valve
5 Mounting bolt
6 Spigot (integral or additional)
H Nominal rectangular bracket or spool height (see Figure 1 and Table 3)
h_4 Actuator drive clearance (as per EN ISO 5211)
l_5 Actuator drive depth
l_7 Shaft height from valve top flange
l_8 Coupling driving end engagement length
C_c Minimum coupling clearance (see Table A.1)

Driven end engagement shall meet the dimensions l5 of the appropriate drive component as listed in ISO 5211.

For l5 see the appropriate tables in ISO 5211 chapter 7.

6.1.4.3 Dimensions

The diameter of the coupling will be the result of the strength calculation, see par 6.1.4.2

Appropriate axial clearance between the coupling and the valve and actuator is required to permit secure assembly without end loading of the valve stem or actuator drive and to avoid too much clearance ("end-play").

Figure 6.3 shows the critical axial dimensions of a typical assembly. The coupling shall provide appropriate drive engagement, for both the driven and driving ends, to ensure that it transmits the rated torque. Dimensions l5 and l8 reflect those considerations. Adequate axial clearance may be achieved by the dimension Cc in the two positions indicated in figure 6.3

Axial clearance to be established in terms of dimension according to EN 15801 Annex A.

EN 15801 Annex A table A.1 lists the minimum coupling axial clearances for ISO 5211 flange sizes F03 through F30. The minimum axial clearances for ISO 5211 flange sizes F35 through F100 shall meet the intention of EN 15801 Annex A table A.1

Maximum turning dead band shall be maximum ± 0.5% (0.5 degree) unless otherwise agreed between the AV Assembly Contractor and the purchaser. Do not allow the use of setscrews to reduce dead band.

Do not allow the addition or usage of spacers to eliminate the "end-play" (axial clearance too big).

Coupling shall not interfere with valve packing adjustment. Allow to taper the coupling as needed to provide clearance of the valve packing hardware, while maintaining the minimum coupling thickness for required strength. See also clause 6.1.4.2

6.1.4.4 Materials

The coupling material requires a high yield strength with good isotropic ductility.

The coupling material and possible coating has to be suitable for the applicable environmental conditions (e.g. offshore coastal conditions). For more details see EN 15081 clause 4.4.

Specify the required material in the purchase order specification.

6.2 ANCILLARIES

6.2.1 Interface for signal transmitters and positioners.

The interface between the actuator and switchbox, position transmitter, positioner etc. shall be in accordance with EN 15714-3 paragraph 4.6.1 table 7 and figure 4 unless otherwise specified by the purchaser. This interface is also known as "Namur mount".

Fasteners to mount the interface bracket to the actuator and accessories shall be of stainless steel.

All fasteners shall have a lock washer. Apply anti-seize to stainless steel threads at time of the final assembly.

The purchaser selects the appropriate type of signal transmitter, positioner etc., which depends on the application.

6.2.2 Interface for solenoid valves.

The interface between the actuator and solenoid valve shall be in accordance with EN 15714-3 paragraph 4.5.3 figure 2 and table 5 (VDI/VDE 3845) unless otherwise specified by the purchaser.

When providing the AV-assembly with both a positioner and solenoid valve, install the solenoid valve between the positioner and the actuator. Note: if a pilot-operated solenoid valve is used, the pilot requires a separate air supply connection.

The purchaser selects the appropriate type of solenoid, which depends on the application.

6.2.2.1 Direct mount solenoids

Preferred is to mount the solenoid valve directly to the actuator. This interface is also known as "Namur mount".

The advantage of this mounting type is that there is no tubing or connectors used between the actuator and the solenoid. Another advantage of this type of mounting is an easily applying of a re-breather function. For more details, see par 6.2.3 "Re-breather function and Closed Loop Purge System".

For smaller actuators the preferred orientation of the air connection holes is horizontal to prevent interference between solenoid and other ancillaries like a switchbox. The use of special adaptors to rotate the solenoid to prevent interference is not preferred and to be avoided.

Note: If the air connection hole sizes of the actuator and the solenoid are not matching there are special adaptor plates on the market to allow direct mounting of the solenoid. Be aware that this may affect the opening and closing time of the AV Assembly.

Fasteners to mount the solenoid valve to the actuator shall be stainless steel unless otherwise specified by the purchaser.

6.2.2.2 External mount solenoids

Only use this type of mounting if the direct mount option (6.2.2.1) is not possible.

Mount the solenoid on a stainless steel mounting plate in a robust and rigid way and attached to the AV Assembly unless otherwise specified by the purchaser.

Fasteners to mount the solenoid valve to the plate and the mounting plate to the actuator shall be stainless steel unless otherwise specified by the purchaser.

To apply the re-breather function see par 6.2.3 "Re-breather function and Closed Loop Purge System".

6.2.3 Re-breather function and Closed Loop Purge System

The re-breather function provides an air purge to prevent ambient air drawn into the actuator spring chamber during the actuator spring stroke (spring return actuators).

Normally ambient air draws in the actuator spring chamber during the actuator spring stroke. The re-breather function allows the actuator spring chamber to draw in the clean air exhausted from the actuator central chamber instead of the ambient air, recycling air from the central chamber into the spring chamber during the spring stroke. This ensures that only clean, dry instrument air is present inside the actuator spring chamber.

It is highly recommended to use the re-breather function because this will significantly increase the service life of the actuator by protecting the internal components, springs and seals from corrosive outside contaminates.

Note: Providing the instrument air to the spring-chamber may increase the travel speed in fail safe position. The effect is depending on the pressure and actuator size.

For direct mount solenoid valves, apply this re-breather function by using the integral re-breather function in the solenoid.

For external mount solenoid valves the re-breather function can be obtained by using a separate re-breather block, direct mount to the actuator or by applying a "closed loop purge system".

If for external mount solenoids the separate re-breather block can be used this is the preferred method.

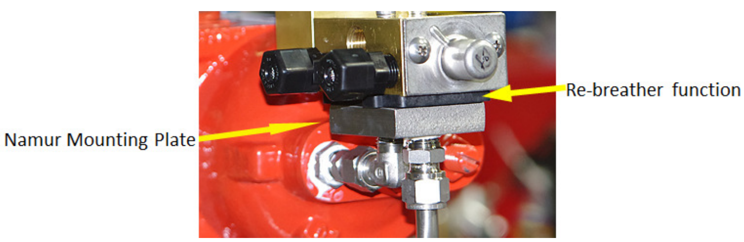


Figure 6.4

When it is not possible to use the integral re-breather function or the external re-breather block a "closed loop purge system" have to be used.

This is a "closed loop purge system" is a piped version of the re-breather block. An example of a 'closed loop purge system" is shown below:

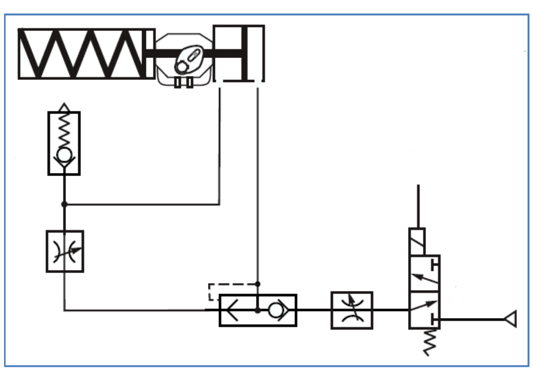


Figure 6.5

6.2.4 Bug screens

All pneumatic vent ports or drain ports open to atmosphere shall have low restriction "bug screen" protection to limit entrance of particles, dust and moisture, and be oriented and mounted to also prevent for water or condensation entrance, without possible formation of ice in cold ambient conditions.

6.2.5 Pressure regulators

If the instrument air supply pressure exceeds the burst pressure or the maximum operating pressure of the actuator a pressure regulator has to be installed. In addition, when the maximum deliverable output torque of the actuator exceeds the MAST value or the maximum allowed design torque of the valve install a pressure regulator. See also ISO 12490 clause 8.2 and 9.2.

If a Pressure Regulator has to be installed on the AV-assembly to limit the air pressure to the actuator the following text shall be stamped on a corrosion resistant warning plate, e.g. brass or stainless steel, and securely attached to the regulator (in a permanent way with a wire) for proper identification:

Imperial units:

Set at ** PSI Do not change this setting!

Metric units:

Set at ** Barg Do not change this setting!

** = the applicable air set pressure

Figure 6.6

6.2.6 Air tubing, tube fittings & piping

Install tubing in a neat and proper way, routing tubing as close to the actuator as possible, to avoid accidental bending. When running tubing, consider assembly and disassembly. Avoid diagonal short cuts. Aesthetics are important; The AV Assembly should be clean and must look good. In addition, tubing runs should not obstruct supply and signal connections.

If there is a need for air tubing on the valve assembly for connection of solenoid or positioner, the tubing shall be seamless Stainless Steel or hard drawn Monel. Stainless steel shall be the default material. Note: Namur mounted solenoids do not require air tubing.

When specifying AV Assemblies with alloy tubing (Monel) for use in corrosive areas and Regulators/Filter-Regulators are required, specify the Regulator/Filter-Regulator body material as Brass or stainless steel, rather than Aluminum.

6.2.7 Pinch Points

"Pinch Points" avoidance is mandatory around all moving parts on the valve. Install guards where "pinch points" cannot be designed out, for example on mechanical lever arms.

6.2.8 Actuator orientation

In addition to what is stated in ISO 12490 clause 7.13 for AV Assemblies used in non-clean fluid applications the preferred valve stem orientation is horizontal, this to reduce the possibility of getting particles in the bearings.

<u>Note</u>: Independent of the actuator mounting position (in-line or transverse to pipeline) the preferred direction of the top slot of the actuator drive shaft is cross-line when the valve is in the closed position and in-line when the valve is in the open position

6.2.9 Assembly support

The Assembly Contractor indicates, if due to the dimensions, weight and/or orientation of the AV Assembly additional supporting is required. The Assembly Contractor shall provide a drawing to the purchaser showing as a minimum the dimensions and weight of the AV Assembly including details for the addition support if required.

6.3 PREPARATION FOR SHIPMENT

In addition to ISO 12490 clause 16, AV Assemblies are to be shipped in a wooden crate or on a wooden pallet. Pack AV Assemblies properly to prevent shifting within the container during shipment.

AV Assemblies are to be prepared for shipping in such a manner to avoid damage or atmospheric corrosion to inside or outside surfaces, or parts, during sheltered storage and while in transit.

Identify special requirements for outdoor storage on the purchase order.

6.4 AV ASSEMBLY INSTALLATION

The way in which the AV Assembly is installed in the pipe system highly impacts the valve torque values (see also paragraph 2.2.1.3 “Warning”) The AV Assembly has to be installed in the pipe system without any stress on the valve body and in accordance with to the applicable IOM's and installation practices as provided by the valve manufacturer.

6.5 SUB-CLAUSES MATRIX

For this Section 6 all the relevant paragraphs of the AV Assembly domain versus the respective international standards organizations (ISO, EN) sub-clauses are documented in the matrix Table 6.7

The reader shall consult the respective international standards sub-clauses to clarify any further details if so required.

AV Assembly RP vs International Standards sub-clauses matrix Section 6 ASSEMBLING								ISO 12490 API 6DX						API 6D		EN 15081									EN 15714-3	
								4.13	7.6	7.13	8.2	9.2	11.2	5.20		4.2 - 4.4	4.5	4.10	4.11	4.12	4.13	5.1 - Table 3	5.3 - Figure 2 - Table 4	Annex A		4.5.3 - Figure 2 - Table 5
Chapter	RP paragraph numbering					Subclause		Definition	Mounting kit	Orientation	Sizing Method	Torque limiting	Structural welding	Drive trains		Materials - Environ protect	Mounting Kit	Mech / thermal protect	Orientation	Anti-rotation means	Assembly Maintenance	Dimensions - bracket	Dimensions - Coupling	Coupling Axial clearance		Interface pilot valves
ACTUATOR / VALVE	6	1	1			ISO 5211 compliance	axial clearance																	X		
	6	1	2			Mounting Kit	definition	X																		
	6	1	3	1		Intermediate Support	style										X	X								
	6	1	3	2			strength and stiffness		X				X				X	X	X	X	X	X				
	6	1	3	3			dimensions															X				
	6	1	3	4			mounting																			
	6	1	3	4	1		dowel pins													X						
	6	1	3	5			materials									X										
	6	1	4	1		coupling	style																			
	6	1	4	2			strength and stiffness							X												
	6	1	4	3			dimensions																X			
	6	1	4	4			mounting																			
	6	1	4	5			materials									X										
ANCILLARIES	6	2	1			Signal transmitters and positioners																				
	6	2	2			Solenoid valves																				X
	6	2	3			Re-breather function																				
	6	2	4			Bug screens																				
	6	2	5			Pressure regulators					X	X														
	6	2	6			Air tubing, tube fittings & piping																				
	6	2	7			Pinch point																				
	6	2	8			Actuator orientation				X																
	6	2	9			Assembly support																				
PREPARATION FOR SHIPMENT	6	3																								
AV ASSEMBLY INSTALLATION	6	4																								

Table 6.7

7 SIZING DATA SHEET & VALVE TORQUE INPUT FORM

To handle AV Assemblies as Engineered Products this Recommended Practice introduces two key documents:

- ✓ To compile by the purchaser for each assembly an AV Assembly **sizing data sheet** and
- ✓ To compile by the valve manufacturer for each valve configuration an AV **valve torque data input** form.

7.1 AV ASSEMBLY SIZING DATA SHEET

To size an AV Assembly, the data sheet contains all the relevant sizing parameters. It contains the following categories:

- ✓ **Identification** general information e.g. tag, service, etc.
- ✓ **Ambient conditions** specifying the ambient and environmental conditions
- ✓ **Application** specifying the application characteristic, e.g. travel time, response time, etc.
- ✓ **Process** specifying the process data in much detail.
- ✓ **Valve** detailing the valve, especially the valve configuration and the essential valve torque data
- ✓ **Mounting kit** specifying the mounting kit parameters
- ✓ **Actuator** detailing the actuator, especially the actuator torque data

All columns are self-explanatory. Column ODCF needs a clarification: On Demand Correction Factors can be given for the 6 torque parameters BTO, RTO, ETO, BTC, RTC and ETC. To know the actual torque for example BTO one needs to multiply the BTO value with the respective ODCF. See also the sample sizing data sheet in Annex H

An interactive sizing data sheet, excel format, file AVA006-SizingDataSheet.xlsx is available to use and / or customize as seen fit. The spreadsheet contains “dropdowns” making it easier to fill in the data sheet. Table Annex B.3 7.3 lists those dropdowns. Contact the WIB manager (manager@wib.nl) if of interest.

Note that this is not an equipment specification sheet to specify and purchase a complete AV Assembly.

There are potentially multiple entities involved in the process of sizing, selecting and purchasing an actuator or an actuated valve assembly. It is imperative to exchange all information as described in this practice and summarized in the sizing data sheet to all parties, to ensure that the necessary entities provide and receive the required information for the supply of the actuator, the mounting kit or the actuated valve assembly. See also ISO12490 clause 8.1.1 “Sizing – General”

7.2 VALVE TORQUE INPUT FORM

To obtain quality valve torque data, as detailed in paragraph 2.2 , this RP valve torque data input form (VTIF) should apply for each valve configuration.

The form contains 7 sections (see Annex C Table Annex C.1 and C.2) covering:

- ✓ **Section 1: Testing Information**
- ✓ **Section 2: Preferential units of measure** (uom): those uom’s will be used in the subsequent tables
- ✓ **Section 3: Valve configuration**: the essential parameters to describe the valve configuration, for which the torque data is applicable. Use a different VTIF form for each valve configuration. Table Annex C.2 shows possible parameter selections for the valve configuration.
- ✓ **Section 4: Preferential differential pressures** (dp): for each pressure rating several dp’s can be selected for which torque data has been measured
- ✓ **Section 5: Valve breakaway angles and MAST**
- ✓ **Section 6: Valve torque data**
- ✓ **Section 7: Valve On Demand Torque Correction Factors** (ODCF)

An interactive valve torque input form, excel format, file AVA002-VTIF.xlsx is available to use and / or customize as seen fit. The spreadsheet contains “dropdowns” making it easier to fill in the valve torque input form Table Annex C.3 lists those dropdowns. Contact the WIB manager (manager@wib.nl) if of interest.

7.2.1 On Demand Correction Factors input form

7.2.1.1 Characteristics

- ✓ **State / phase**: this is e.g. liquid, gas, vapor, steam mixed phase etc.
- ✓ **Long Stand Still**: operating frequency of the AV Assembly expressed in years.
- ✓ **Clean service**: this is a straightforward service, the medium has no particles, is not sticking or non-lubricating etc. A clean service has a medium for which none of the other listed characteristics are applicable.
- ✓ **Non-clean service**: this is a service for which the medium contains particles
- ✓ **Non-lubricated service**: this is a service with a non-lubricating medium like a dry-gas, industrial solvents etc.
- ✓ **Sticking service**: this is a service for which the medium is sticky
- ✓ **Slurry service**: this is a service for which the medium can be a slurry or a high viscous fluid.

8 DYNAMIC TORQUE

This Recommended Practice covers both static and dynamic torque data models. Sub clause 1.3.3 describes the static models. For the purpose of this document, following dynamic torque data models apply

COMPLETE TORQUE DATA MODEL — SPRING-RETURN **FAIL-CLOSE** — **AV Assembly** Recommended Practice

MAST	actuator **spring** torque	**valve** torque								actuator **cylinder** torque	
		action	static	θ	dynamic			static	action		
		CLOSING			C_v [1]	$C_{t\theta}$	T_θ	**OPENING**			p_{max}
N-m	N-m		N-m	º open	GPM(US)	-	N-m	N-m		N-m	N-m
MAST	ST**E**	**END** TO CLOSE	**ETC**	0	0			**BTO**	**BREAK** TO OPEN	AT**S**	AT**S**$_{max}$
		ETC **breakaway angle**	ETC_{ba}	δ_{EC}							
				δ_{BO}				BTO_{ba}	BTO **breakaway angle**		
	ST**R**	**RUN** TO CLOSE @ θº OPEN	**RTC**	10				**RTO**	**RUN** TO OPEN @ θº OPEN	AT**R**	AT**R**$_{max}$
				20							
				30							
				40							
				45							
				50							
				60							
				70							
				80							
	ST**S**	**BREAK** TO CLOSE	**BTC**	90				**ETO**	**END** TO OPEN	AT**E**	AT**E**$_{max}$

STATIC TORQUE ASSUMPTIONS
* valve dynamic torque **relevant** for the application!
* travel angle convention: **closed : θ= 0º ; opened : θ=90º**

NOTES
[1] Cv = f(θ) is needed to derive the dp, essential for the dynamic torque derivation

Table 8.1

COMPLETE TORQUE DATA MODEL — SPRING-RETURN **FAIL-OPEN** — **AV Assembly** Recommended Practice

MAST	actuator **spring** torque	**valve** torque								actuator **cylinder** torque	
		action	static	θ	dynamic [2]			static	action		
		OPENING			C_v [1]	$C_{t\theta}$	T_θ	**CLOSING**			p_{max}
N-m	N-m		N-m	º open	GPM(US)	-	N-m	N-m		N-m	N-m
MAST	ST**S**	**BREAK** TO OPEN	**BTO**	0	0			**ETC**	**END** TO CLOSE	AT**E**	AT**E**$_{max}$
				δ_{EC}				ETC_{ba}	ETC **breakaway angle**		
		BTO **breakaway angle**	BTO_{ba}	δ_{BO}							
	ST**R**	**RUN** TO OPEN @ θº OPEN	**RTO**	10				**RTC**	**RUN** TO CLOSE @ θº OPEN	AT**R**	AT**R**$_{max}$
				20							
				30							
				40							
				45							
				50							
				60							
				70							
				80							
	ST**E**	**END** TO OPEN	**ETO**	90				**BTC**	**BREAK** TO CLOSE	AT**S**	AT**S**$_{max}$

STATIC TORQUE ASSUMPTIONS
* valve dynamic torque **relevant** for the application!
* travel angle convention: **closed : θ= 0º ; opened : θ=90º**

NOTES
[1] Cv = f(θ) is needed to derive the dp, essential for the dynamic torque derivation
[2] dynamic torque is much **more challenging for blowdown** applications, because flow is trying to close the valve, so much more torque is required to open the valve!

Table 8.2

Static models apply when the torque caused by fluid dynamics is insignificant compared to the torque caused by friction (bearing friction, seating and unseating friction, packing & hub friction) and other static causes (hydrostatic, center of gravity, eccentricity). Generally spoken, this is the case with valve sizes smaller than 24" and / or fluid velocities smaller than 5 m/s. This split between static and dynamic can differ between valve manufacturers and between industries.

Dynamic models apply when the torque caused by fluid dynamics is **significant** compared with the torque caused by friction and/or other static causes.

According to the AWWA standard M49 the dynamic torque (using **water**, i.e. an **uncompressible fluid**) equation is:

$\mathbf{Td_{\theta} = Ct\theta \cdot D^3 \cdot dP_{\theta}}$,

In other words, the dynamic torque is a function of:

- ✓ The **dynamic torque coefficient,** a coefficient, measured in a flow laboratory (see Annex B "Valve Torque Essentials: - Dynamic Torque Coefficient – figure Annex B.2 to see the typical curve of that coefficient as a function of valve travel and valve symmetry. The peak of the dynamic torque coefficient is typically around 75 º open travel position.
- ✓ The **valve size to the 3rd power** ; because of this 3rd power, with valves larger than 24" dynamic torque is dominating the total torque (see Annex B "Valve Torque Essentials – figure Annex B.1
- ✓ The **differential pressure** over the valve.

The peak of the dynamic torque is typically around 30 to 40 º open travel position

Different research activities are taking place in this domain to improve our understanding of dynamic torque and to develop dynamic torque model for compressible fluids:

- ✓ UWRL, the Utah State University (USU) Utah Water Research Laboratory is a key player. They have been closely involved in the development of the AWWA dynamic torque model. They also measure dynamic torque in their water laboratory (they can handle valve sizes larger than 72"). They also perform fundamental research in applying CFD tools to predict dynamic torque rather than performing physical (expensive and time consuming) lab measurements.
- ✓ The power and specificly the nuclear industry is performing fundamental research in this area.
- ✓ Recently a presentation appeared in Valve World on "Impact of valve geometry on dynamic torque coefficient & actuator sizing"

The authors of this Recommended Practice are closely monitoring those dynamic torque activities. As soon as the research has progressed far enough, the RP will be updated with clear and concise rules when to apply dynamic torque for our industry. Until then the RP recommends to consider only dynamic torque for valves larger than 24" or when applications clearly indicate that dynamic torque models shall be used.

Some manufacturers and organizations are giving recommendations when to consider dynamic torque, such as:

- ✓ AWWA: On smaller valves, typically 6 in. (150 mm) and less, dynamic torque can be ignored, and the actuator may be sized for seating, bearing, and packing torque unless the maximum velocity exceeds 16 ft/s (5.2 m/s).
- ✓ One valve vendor documents it as: "In most applications for butterfly valves, especially 20˝ (508mm) or smaller, the maximum torque required to operate the valve will be seating/unseating torque. However, dynamic torque should be considered particularly in:
  - ➢ Control applications using larger valves (24˝ [610mm] and above) where the disc is maintained in the open position
  - ➢ Applications using larger valves (24˝ [610mm] and above)where the velocity is high (16 ft./sec [5.3m/sec]

Consult with your valve manufacturer on when you should consider dynamic torque on their valves.

The RP valve dynamic torque data input form (VDTIF) apply for each valve configuration.

The form contains several parts:

Part 1 covering (identical to table 7.4 page 36):

- ✓ Section 1: **Preferential units of measure (uom)**: the subsequent forms will be used in the subsequent tables
- ✓ Section 2: **Valve configuration**: the essential configuration data to describe the valve type. A VDTIF form shall be used for each different valve configuration

Part 2 covering (table 8.3)

- ✓ Section 3: Dynamic Torque Coefficient
- ✓ Section 4: Flow Coefficients Cv
- ✓ Section 5: Testing Information

VALVE DYNAMIC TORQUE INPUT FORM

DYNAMIC TORQUE COEFFIENT — **Section 3**

θ	Ctθ	Comments
ºopen	-	
0	0.0	
10		
20		
30		
40		
50		
60		
70		
75		
80		
90		

FLOW COEFFICIENTS — **Section 4**

valve size	ºtravel open									GPM(US)
in	10	20	30	40	50	60	70	80	90	comments
1										
1.5										
2										
2.5										
3										
4										
5										
6										
8										
10										
12										
14										
16										
18										
20										

TESTING INFORMATION — **Section 5**

Test date	:		
Test contact	:		
Test location	:		
Ambient temperature	:		ºC
Test medium	:		
Medium temperature	:		ºC
Differential pressure			bar
Torque meter type	:		
Torque meter serial number	:		
T meter calibration certificate	:		
Torque meter accuracy	:		% full scale
Production reference	:		
Production quantity	:		
	:		
	:		

Table 8.3

ANNEX A ENGINEERED PRODUCT CONSIDERATIONS

During all workshops and seminars held over the last decade, the need to treat Actuated Valve Assemblies as Engineered Products scored as the top priority item to be addressed. This note summarizes an interview with the author of the 2006 Valve World publication "the hurdle race", reflecting a summary to be used as a stepping stone for those not yet treating their Actuated Valve Assemblies as engineered products.

Why did your organization decide to treat SIS AV (Automated OnOff Valves) as engineered products?

For several reasons:

1. We were struggling with the reliability and safety of our SIS AV: incorrectly sized actuators, predominantly oversized but also undersized, treating the assemblies as black boxes.
2. We questioned ourselves why we spend so much time and money on our control valves and not on our safety critical AVs.
3. We were spending an excessive amount of money on our SIS AVs while ignoring the Long Term Cost of Ownership aspects for them.
4. We needed to comply with the IEC 61511 (SIS), which requires among other things that those SIS AVs should be "fit for the application".

What were the main challenges you faced at that time?

To name the most important ones:

1. The organizational aspects, i.e. the number of parties involved, each with their own roles and responsibilities requiring many interactions.
2. The lack of international standards to have clear and consistent terminology and definitions, to have a standard SIS AV input datasheet, to address application requirements like fluid aspects, operational aspects and ambient conditions, to fill the gaps in current standard dealing with the drive train
3. The inability to get proper valve torque data.

How did your organization managed to make this change from treating SIS AVs from commodity items to engineered products?

We performed this gradually over a period of years. More or less in chronological order:

1. To uncover the actual technical challenges we started performing root cause investigations on most of our SIS AV assemblies.
2. We raised the flag internally and externally to get support and buy-in. We called it a hurdle race in a Valve World presentation in 2006.
3. We implemented a SIS AV business process getting all parties involved and using our internal tool. Our organization already embraced the concepts of global technology teams back in the 90s, i.e. we had global technology teams for example for manual valves and for automated valves.
4. We developed fit for purpose SIS AV valve assembly prescriptive directives, addressing key items like:
    a. The strengths and weaknesses of the different valve styles in relation to application characteristics,
    b. Valve materials selections
    c. Actuator design and coating aspects
    d. Drive train aspects
    e. Torque aspects
5. Within WIB, we drove the development of a User Guideline on Valve Torque addressing terminology and definitions, a standard SIS AV input data sheet, torque testing criteria and special attention to the Break To Close on demand torque derivation.
6. We added a SIS AV module to our internal Instrumentation Sizing & Selection tool
    a. Focusing on quarter turn valves, pneumatic actuators, associated actuator controls and switchboxes
    b. Covering application characteristic an application specific requirements
    c. Covering valve and actuator torque data
    d. Covering drive train dimensional data
    e. Covering actuator coating data
    f. With dedicated import screens
    g. With an actuator selection algorithm
    h. And generating the assembly PFD data, feed for our internal SIS tool

What benefits have you realized with this approach?

Reflecting today, we were able to:

1. Create a better focus, i.e. a more optimum design, a fit for purpose design and a clear reliability focus,
2. Solve our SIS AV reliability and safety issues
3. Lower our total cost of ownership
4. Create a business process, transparent and auditable by the government

What lessons have you learned with this approach?

We are still learning as we speak, but

1. It proved easy to roll out globally to our organization, with the majority of us all embracing the approach,
2. It made it easier for the people dealing with SIS AV assembly
3. We practically resolved any issue between piping and instrumentation
4. Due to the lack of a SIS AV assembly international standard it takes a lot (too much) of time to get all the essential valve torque data.

Reflecting back, what do you think are the Critical Success Factors (CSF)s to roll out such an approach?

For us I believe the following Critical Success Factors were:

Technological CSF

1. The underlying tool we created
2. The Fit For Purpose Guidelines

Organizational CSFs:

1. The structure of our Global Technology Teams
2. The use of the tool

AV Assembly sizing data sheet - Metric units of measure

	category	ODCF (1)	parameter	* **	symbo	data value *	data value **	uom	data provider	
1	IDENTIFICATION		Tag						End User	1
2			Service						End User	2
3			P&ID						End User	3
4			Line Number						End User	4
5			Purchase Order Number / Purchase requisition						End User	5
6			Remarks						End User	6
7	AMBIENT CONDITIONS		Ambient temperature	min/max				DegC	End User	7
8			Environmental conditions						End User	8
9			Environmental conditions						End User	9
10	APPLICATION		Fail direction						End User	10
11			Travel time	open/close				s	End User	11
12			Response time	open/close				s	End User	12
13			Air supply pressure	min/max				bar(g)	End User	13
14	PROCESS		Medium						End User	14
15			State / phase						End User	15
16			Mass flowrate					kg/h	End User	16
17			Volume flowrate					m3/h	End User	17
18			Density					kg/m3	End User	18
19			Long stand still time		LSS			yr	End User (1)	19
20									End User (1)	20
21			Fluid characteristics						End User (1)	21
22									End User (1)	22
23			Fluid operating temperature	min/max				DegC	End User (1)	23
24			Max DP shutoff					bar	End User	24
25			Design pressure					bar(g)	End User	25
26										26
27	VALVE		Valve manufacturer							27
28			Valve Configuration		VC					28
29			Valve type / Model						End User	29
30			Valve design						End User	30
31			Port						End User	31
32			Shutoff flow direction						End User	32
33			Seat designation (material)						End User	33
34			If applicable, soft seated material						End User	34
35			Seating						End User	35
36			Pressure class rating						End User	36
37			Tightness class						End User	37
38			Valve size						End User	38
39			Line pressure		dp			bar	End User	39
40			Break to Open torque	net/ODCF corr	BTO			Nm	Valve manufacturer	40
41			BTO breakaway angle		BTO..			θ	Valve manufacturer	41
42			Run to Open torque	net/ODCF corr	RTO			Nm	Valve manufacturer	42
43			End to Open torque	net/ODCF corr	ETO			Nm	Valve manufacturer	43
44			Break to Close torque	net/ODCF corr	BTC			Nm	Valve manufacturer	44
45			Run to Close torque	net/ODCF corr	RTC			Nm	Valve manufacturer	45
46			ETC breakaway angle		ETC..			θ	Valve manufacturer	46
47			End to Close torque	net/ODCF corr	ETC			Nm	Valve manufacturer	47
48			Max allowable torque drive train (MAST)		MAST.			Nm	Valve manufacturer	48
49			Max allowable flange torque (ISO5211)						Valve manufacturer	49
50			Stem / top works dimensions provided Y/N?						Valve manufacturer	50
51	MOUNTING KIT		Material						Mounting Kit manufacturer	51
52			Height aspect						Mounting Kit manufacturer	52
53			Max allowable coupling torque		MAST.			Nm	Mounting Kit manufacturer	53
54			MK mechanical integrity checked & documented					Yes	AV Assembly Contractor	54
55			Installation orientation						End User	55
56										56
57	ACTUATOR		Supply pressure	min/max				bar(g)	End User	57
58			Air volume	open/close				liter	End User	58
59			Sizing Safety Factor		SSF			-	End User	59
60			Actuator drive medium						End User	60
61			Actuator drive medium quality (ISO S7)						End User	61
62			Actuator style						AV Assembly Contractor	62
63			Model						AV Assembly Contractor	63
64			Size					cm2	AV Assembly Contractor	64
65			Spring set number						AV Assembly Contractor	65
66			Spring to Start torque		STS			Nm	Actuator manufacturer	66
67			Spring to Run torque		STR			Nm	Actuator manufacturer	67
68			Spring to End torque		STE			Nm	Actuator manufacturer	68
69			Air to Start torque		ATS			Nm	Actuator manufacturer	69
70			Air to Run torque		ATR			Nm	Actuator manufacturer	70
71			Air to End torque		ATE			Nm	Actuator manufacturer	71
72			Air to Start torque @ max press		ATS...			Nm	Actuator manufacturer	72
73			Max operating pressure		MOP			bar(g)	Actuator manufacturer	73
74										74

Notes

(1) EndUser provides process challenges ; Valve manufacturer provides ODCF values based on those process challenges

Table Annex B.1 **Metric** units of measure (uom)

AV Assembly sizing data sheet - Imperial units of measure

	category	ODCF (1)	parameter	* **	symbol	data: value *	data: value **	data: uom	data provider	
1	IDENTIFICATION		Tag						End User	1
2			Service						End User	2
3			P&ID						End User	3
4			Line Number						End User	4
5			Purchase Order Number / Purchase requisition						End User	5
6			Remarks						End User	6
7	AMBIENT CONDITIONS		Ambient temperature	min/max				DegF	End User	7
8			Environmental conditions						End User	8
9			Environmental conditions						End User	9
10	APPLICATION		Fail direction						End User	10
11			Travel time	open/close				s	End User	11
12			Response time	open/close				s	End User	12
13			Air supply pressure	min/max				psi(g)	End User	13
14	PROCESS		Medium						End User	14
15			State / phase						End User	15
16			Mass flowrate					lb/h	End User	16
17			Volume flowrate					gpm	End User	17
18			Density					lb/ft3	End User	18
19			Long stand still time		LSS			yr	End User (1)	19
20									End User (1)	20
21			Fluid characteristics						End User (1)	21
22									End User (1)	22
23			Fluid operating temperature	min/max				DegF	End User (1)	23
24			Max DP shutoff					psi	End User	24
25			Design pressure					psi(g)	End User	25
26										26
27	VALVE		Valve manufacturer							27
28			Valve Configuration		VC					28
29			Valve type / Model						End User	29
30			Valve design						End User	30
31			Port						End User	31
32			Shutoff flow direction						End User	32
33			Seat designation (material)						End User	33
34			If applicable, soft seated material						End User	34
35			Seating						End User	35
36			Pressure class rating						End User	36
37			Tightness class						End User	37
38			Valve size						End User	38
39			Line pressure		dp			psi	End User	39
40			Break to Open torque	net/ODCF corr	BTO			lb-ft	Valve manufacturer	40
41			BTO breakaway angle		BTO..			θ	Valve manufacturer	41
42			Run to Open torque	net/ODCF corr	RTO			lb-ft	Valve manufacturer	42
43			End to Open torque	net/ODCF corr	ETO			lb-ft	Valve manufacturer	43
44			Break to Close torque	net/ODCF corr	BTC			lb-ft	Valve manufacturer	44
45			Run to Close torque	net/ODCF corr	RTC			lb-ft	Valve manufacturer	45
46			ETC breakaway angle		ETC..			θ	Valve manufacturer	46
47			End to Close torque	net/ODCF corr	ETC			lb-ft	Valve manufacturer	47
48			Max allowable torque drive train (MAST)		MAST.			lb-ft	Valve manufacturer	48
49			Max allowable flange torque (ISO5211)						Valve manufacturer	49
50			Stem / top works dimensions provided Y/N?						Valve manufacturer	50
51	MOUNTING KIT		Material						Mounting Kit manufacturer	51
52			Height aspect						Mounting Kit manufacturer	52
53			Max allowable coupling torque		MAST.			lb-ft	Mounting Kit manufacturer	53
54			MK mechanical integrity checked & documented					Yes	AV Assembly Contractor	54
55			Installation orientation						End User	55
56										56
57	ACTUATOR		Supply pressure	min/max				psi(g)	End User	57
58			Air volume	open/close				gallons	End User	58
59			Sizing Safety Factor		SSF			-	End User	59
60			Actuator drive medium						End User	60
61			Actuator drive medium quality (ISO S7)						End User	61
62			Actuator style						AV Assembly Contractor	62
63			Model						AV Assembly Contractor	63
64			Size					inch2	AV Assembly Contractor	64
65			Spring set number						AV Assembly Contractor	65
66			Spring to Start torque		STS			lb-ft	Actuator manufacturer	66
67			Spring to Run torque		STR			lb-ft	Actuator manufacturer	67
68			Spring to End torque		STE			lb-ft	Actuator manufacturer	68
69			Air to Start torque		ATS			lb-ft	Actuator manufacturer	69
70			Air to Run torque		ATR			lb-ft	Actuator manufacturer	70
71			Air to End torque		ATE			lb-ft	Actuator manufacturer	71
72			Air to Start torque @ max press		ATS...			lb-ft	Actuator manufacturer	72
73			Max operating pressure		MOP			psi(g)	Actuator manufacturer	73
74										74

Notes

(1) EndUser provides process challenges ; Valve manufacturer provides ODCF values based on those process challenges

Table Annex B.2 **Imperial** units of measure (uom)

Sizing data sheet parameter selections

You can find possible, but not limited to, parameter selections for the respective data sheet parameters in table Annex B.3 page (numbers refer to the respective data sheet line numbers 1 to 74.

Sizing data sheet parameter selections

10	**10. fail direction**
	fail-open
	fail-closed
	fail-last
	fail-intermediate
20-22	**20-22. Fluid Characteristics**
	non-lubricating fluid
	sticking service
	non-clean service
	clean service
29	**29. valve type / Model**
	ball valve
	butterfly valve
	plug valve
30	**30. valve design**
	floating ball
	trunnion mounted
	standard
	triple eccentric
31	**31. Port**
	full port
	reduced port
32	**32. shutoff flow direction**
	uni-directional
	bi-directional
33	**33. Seat designation (material)**
	soft seated
	metal seated
34	**34. if applicable soft seated material**
	PTFE - polytetrafluoroethylene
	RPTFE - reinforced PTFE
	PEEK - polyetherehterketone
	PCTFE - polychlorotrifluoroethylene
	UHMWPE - ultra high molecular weight polyethylene
35	**35. seating**
	position seated
	torque seated

49	**49. valve ISO 5211 flange / torque**
	F03 32 Nm
	F04 63 Nm
	F05 125 Nm
	F07 250 Nm
	F10 500 Nm
	F12 1000 Nm
	F14 2000 Nm
	F16 4000 Nm
	F25 8000 Nm
	F30 16000 Nm
	F35 32000 Nm
	F40 63000 Nm
	F48 125000 Nm
	F60 250000 Nm
	F80 500000 Nm
	F100 1000000 Nm
55	**55. stem orientation**
	vertical
	horizontal
	angle
52	**52. mounting kit height aspect**
	standard
	hot temperature
	low temperature
60	**60. actuator drive medium**
	pneumatic
	hydraulic
61	**61. drive medium quality**
	clean
	gas composition
62	**62. actuator style**
	scotch yoke
	rack and pinion

Table Annex B.3

Installation orientation parameter : line 55

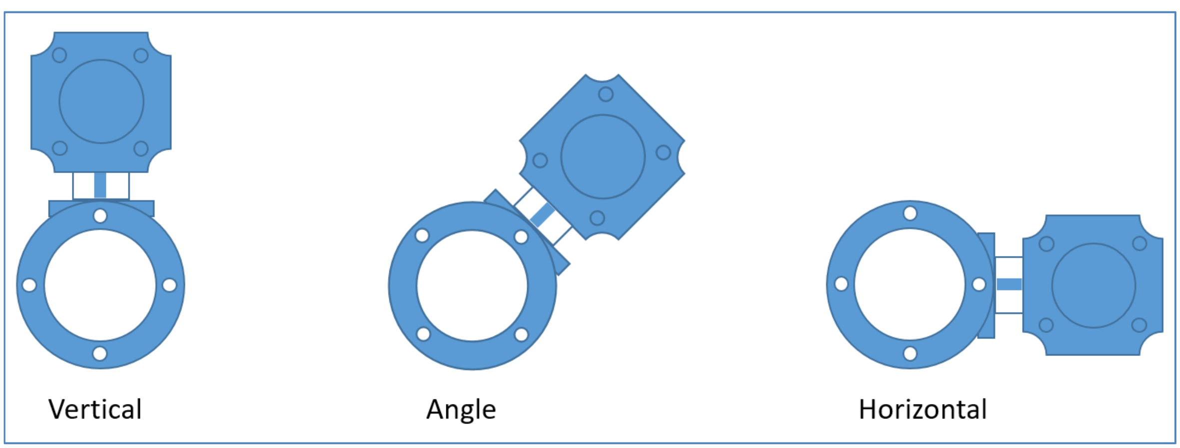


Figure Annex B.4

ANNEX C VALVE TORQUE INPUT FORM (VTIF)

Table Annex C.1

VALVE TORQUE INPUT FORM - Metric units of measure

1* To be completed in by the valve manufacturer.
2* Use **one** form per valve configuration

		comments
MANUFACTURER INFORMATION		
Corporation	:	
Company Name	:	
Manufacturer contact	:	
Issue date	:	

TESTING INFORMATION		**Section 1**
Test date	:	
Test contact	:	
Test location	:	
Ambient temperature	:	ºC
Test medium	:	
Medium temperature	:	ºC
Torque meter type	:	
Torque meter serial number	:	
T meter calibration certificate	:	
Torque meter accuracy	:	% full scale
Production reference	:	
Production quantity	:	
	:	
	:	

MANUFACTURER PREFERENTIAL units of measure		**Section 2**
Torque	: Nm	
Temperature	: ºC	
Pressure	: bar(g)	
Period	: month	
Differential pressure	: bar	
Diameter	: in	
Accuracy	: % full scale	
	:	

VALVE CONFIGURATION parameters		**Section 3**
Brand Name	:	
Valve type / Model	:	
Valve design	:	
Port	:	
Flow Direction	:	
Seat designation (material)	:	
If applicable, soft seated material	:	
Seating	:	
Stuffing box	:	
Stuffing packing material	:	
Pressure class rating	:	
Detailed model description	:	
Valid temperature range	: ºC	
	:	

PREFERENTIAL shutoff differential pressures — **Section 4**

	150#	300#	600#	900#	1500#	2500#	4500#	
	bar	bar	bar	bar	bar	bar	bar	
#1								
#2								
#3								

TORQUE DATA - Breakaway Angles + MAST — **Section 5**

valve size	breakaway angles		stem size	MAST obturator/stem material								Notes
	BTO_{ba}	ETC_{ba}		obturator	stem	obturator	stem	obturator	stem	obturator	stem	
in	θ	θ	in	Nm		Nm		Nm		Nm		
1												
1.5												
2												
3												
4												
Notes												

TORQUE DATA — **Section 6**

valve size		VALVE OPENING			VALVE CLOSING			Comments
		BTO	RTO	ETO	BTC	RTC	ETC	
in	bar	0		90	90		0	
			Nm	Nm	Nm	Nm	Nm	
1								
1 1/2								
2								
3								
4								
...								

ON DEMAND TORQUE CORRECTION FACTOR — **Section 7**

Characteristic	CF %		setting	uom	CF	BTO	RTO	ETO	BTC	RTC	ETC
						For which torque values applies the ODCF?					
long stand still time				month							
Fluid Characteristics											
state / phase											
non-lubricating fluid											
sticking service											
non-clean service											
clean service											
temp minimum				ºC							
temp maximum				ºC							
fluid correction factor											
ODCF											

Legend
X applicable for both FC and FO applications
FC applicable for FC applications only
FO applicable for FO applications only

Table Annex C.2

VALVE TORQUE INPUT FORM - Imperial units of measure

1* To be completed in by the valve manufacturer.
2* Use **one** form per valve configuration

		comments
MANUFACTURER INFORMATION		
Corporation	:	
Company Name	:	
Manufacturer contact	:	
Issue date	:	

TESTING INFORMATION — Section 1

Test date	:	
Test contact	:	
Test location	:	
Ambient temperature	:	ºF
Test medium	:	
Medium temperature	:	ºF
Torque meter type	:	
Torque meter serial number	:	
T meter calibration certificate	:	
Torque meter accuracy	:	% full scale
Production reference	:	
Production quantity	:	
	:	
	:	

MANUFACTURER PREFERENTIAL units of measure — Section 2

Torque	:	lb-ft
Temperature	:	ºF
Pressure	:	psi(g)
Period	:	month
Differential pressure	:	psi
Diameter	:	in
Accuracy	:	% full scale
	:	

VALVE CONFIGURATION parameters — Section 3

Brand Name	:	
Valve type / Model	:	
Valve design	:	
Port	:	
Flow Direction	:	
Seat designation (material)	:	
If applicable, soft seated material	:	
Seating	:	
Stuffing box	:	
Stuffing packing material	:	
Pressure class rating	:	
Detailed model description	:	
Valid temperature range	:	ºF
	:	

PREFERENTIAL shutoff differential pressures — Section 4

	150#	300#	600#	900#	1500#	2500#	4500#	
	psi	psi	psi	psi	psi	psi	psi	
#1								
#2								
#3								

TORQUE DATA - Breakaway Angles + MAST — Section 5

valve size	breakaway angles		MAST									
			stem size	obturator/stem material								Notes
	BTO_{ba}	ETC_{ba}		obturator	stem	obturator	stem	obturator	stem	obturator	stem	
in	θ	θ	in	lb-ft		lb-ft		lb-ft		lb-ft		
1												
1.5												
2												
3												
4												
Notes												

TORQUE DATA — Section 6

valve size		VALVE OPENING			VALVE CLOSING			Comments
		BTO	RTO	ETO	BTC	RTC	ETC	
in	psi	0		90	90		0	
			lb-ft	lb-ft	lb-ft	lb-ft	lb-ft	
1								
1 1/2								
2								
3								
4								
...								

ON DEMAND TORQUE CORRECTION FACTOR — Section 7

Characteristic	CF %		setting	uom	CF	For which torque values applies the ODCF?					
						BTO	RTO	ETO	BTC	RTC	ETC
long stand still time				month							
Fluid Characteristics											
state / phase											
non-lubricating fluid											
sticking service											
non-clean service											
clean service											
temp minimum				ºF							
temp maximum				ºF							
fluid correction factor											
ODCF											

Legend
X applicable for both FC and FO applications
FC applicable for FC applications only
FO applicable for FO applications only

Valve configuration parameter selections

You can find possible, but not limited to, parameter selections for the respective Valve configuration parameters in table Annex C.3

VALVE CONFIGURATION parameter selections	
type / model	design
ball valve	floating ball
butterfly valve	trunnion mounted
plug valve	standard
	triple eccentric
flow direction	
bidirectional	seat designation (material)
shaft Side	soft seated
disc Side	metal seated
port	seating
full port	position seated
reduced port	torque seated
if applicable, soft seated material	
PTFE	polytetrafluoroethylene
RPTFE	reinforced PTFE
PEEK	polyetherehterketone
PCTFE	polychlorotrifluoroethylene
UHMWPE	ultra high molecular weight polyethylene

Table Annex C.3

ANNEX D ON DEMAND CORRECTION FACTOR (ODCF) TYPICALS

The ODCF has to address the respective process challenges, i.e. Long Stand Still, Fluid Characteristics such as non-lubricating, sticking or non-clean services, as well as minimum and/or maximum fluid temperatures.

This paragraph is a compilation of ODCF data as published in online available technical bulletins and online available assembly sizing software:

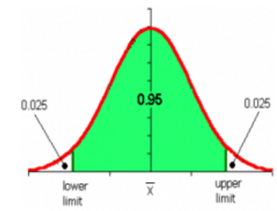
- ✓ 100+ technical bulletins contain ODCF data
- ✓ Following information has been compiled for each ODCF value:
  - ➢ the value, or a min / max value in case a range is given
  - ➢ the valve configuration for the ODCF value, in as much detail as possible, e.g. ball valve, floating ball, soft seated, full port. Lined, etc…
  - ➢ the ODCF characteristic, i.e. operational, fluid and temperature
  - ➢ the service such as normal service, particles, non-lubricating, dirty, etc.
  - ➢ the phase (liquid, gas, solid) and
  - ➢ the fluid
- ✓ With few exceptions no ODCF distinctions for valve size or rating could be found
- ✓ None of the bulletins detail how the data is derived, i.e. there is no opportunity to validate the data quality
- ✓ For operational challenges "setting", i.e. when to apply the ODCF, have been collected,:
  - ➢ mean value: 5.4 months
  - ➢ sigma: 5.15 month
  - ➢ 95% confidence interval data lies between 0.25 months and 16 months
- ✓ For temperature challenges not enough data has been found the present the "setting" values statistically.
- ✓ The basis for this typical ODCF statistics is an ODCF = 1 for clean fluid, specifically clean water to compare against other fluid challenges.. Some sources uses oil as the basis, i.e. highly lubricated with corresponding fluid challenges. Some data sources uses an ODCF higher than 1 as the basis, with corresponding fluid challenges. Where possible those data points have been adjusted to have an ODCF =1 as the basis. Consult the WIB organization for any details.
- ✓ Except for a few bulletins, no ODCF combination rules or algorithms are given, i.e. how to derive at the on demand correction factor if the application has more than one challenge.
- ✓ None of the technical bulletins indicate which torque values need to be multiplied with this ODCF, e.g. if the application requires an Long Stand Still ODCF of 1.4, which of the 6 torque values (BTO, RTO, ETO, BTC, RTC, ETC) need multiplication by 1.4.
- ✓ About 130 ODCF could be distilled, and 108 ODCF values are used to generate the typical listing. For each value the source is known but made anonymous.

ID	type	typedetail	seat	port	line	characteristic	phase	fluid	service	ODCF
17	ball valve	ball valve, floating	ball valve, seat soft			1. operational characteristic	0. no phase data		normal	1.20
19	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	1. liquid		crystallizing	1.70
20	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	1. liquid	slurries	viscous	1.70
21	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	1. liquid	pulp & paper	sticking	1.60
22	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	1. liquid		particles	1.20
23	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	1. liquid		particles	1.60
24	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	4. vapor	steam	normal	1.90
25	ball valve	ball valve, floating	ball valve, seat metal			2. fluid characteristic	4. vapor	steam	normal	2.20
26	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	2. gas		dirty	1.20
27	ball valve	ball valve, floating	ball valve, seat soft			3. temperature characteristic	0. no phase data		cryogenic	1.40
28	ball valve	ball valve, floating	ball valve, seat soft			3. temperature characteristic	0. no phase data		high temperature	1.20
42	butterfly valve				butterfly valve, lined	2. fluid characteristic	2. gas		non-lubricating	1.20
43	butterfly valve				butterfly valve, lined	2. fluid characteristic	1. liquid		non-lubricating	1.30
46	ball valve	ball valve, floating	ball valve, seat soft			1. operational characteristic	0. no phase data		normal	1.50
49	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	1. liquid	slurries	viscous	2.00
50	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	1. liquid	chlorine	chlorine	1.50
51	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	2. gas		non-lubricating	1.30
52	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	2. gas	natural gas	dirty	1.50
53	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	1. liquid	oil	lubricating	0.80
54	ball valve	ball valve, floating	ball valve, seat soft			3. temperature characteristic	0. no phase data		cryogenic	1.50
55	ball valve	ball valve, floating	ball valve, seat soft			1. operational characteristic	0. no phase data		ESDV	2.00
57	ball valve	ball valve, floating	ball valve, seat soft			2. fluid characteristic	4. vapor	steam	non-lubricating	1.20
62	ball valve	ball valve, trunnion	ball valve, seat metal			2. fluid characteristic	1. liquid	slurries	particles	1.50
63	ball valve	ball valve, trunnion	ball valve, seat metal			2. fluid characteristic	1. liquid		particles	1.20
64	ball valve	ball valve, trunnion	ball valve, seat metal			2. fluid characteristic	5. solid	powder	non-lubricating	2.00
65	ball valve	ball valve, trunnion	ball valve, seat metal			2. fluid characteristic	1. liquid	catalyst	catalyst	1.30
66	ball valve	ball valve, trunnion	ball valve, seat metal			2. fluid characteristic	4. vapor	steam	superheated	1.30
67	ball valve	ball valve, trunnion	ball valve, seat metal			2. fluid characteristic	4. vapor	steam	normal	1.20
68	ball valve	ball valve, trunnion	ball valve, seat metal			2. fluid characteristic	1. liquid	oil	lubricating	0.80
69	ball valve	ball valve, floating		ball valve, port standard		1. operational characteristic	0. no phase data		ESDV	2.00
70	ball valve	ball valve, floating		ball valve, port standard		2. fluid characteristic	1. liquid	water	dirty	1.80
71	ball valve	ball valve, floating		ball valve, port standard		2. fluid characteristic	1. liquid	chlorine	chlorine	1.50
72	ball valve	ball valve, floating		ball valve, port standard		2. fluid characteristic	4. vapor	steam	saturated	1.20
73	ball valve	ball valve, floating		ball valve, port standard		2. fluid characteristic	3. gas, wet		clean	1.20
74	ball valve	ball valve, floating		ball valve, port standard		2. fluid characteristic	2. gas	natural gas	dirty	1.50
75	ball valve	ball valve, trunnion				2. fluid characteristic	0. no phase data		dirty	1.25
76	ball valve	ball valve, trunnion				2. fluid characteristic	2. gas		non-lubricating	1.25
79	ball valve	ball valve, trunnion	ball valve, seat soft			3. temperature characteristic	0. no phase data		cryogenic	1.20
80	ball valve	ball valve, trunnion	ball valve, seat metal			2. fluid characteristic	0. no phase data		non-lubricating	1.30
83	butterfly valve	butterfly valve, double offset	butterfly valve, seat soft			2. fluid characteristic	2. gas		non-lubricating	1.25
84	butterfly valve	butterfly valve, double offset	butterfly valve, seat soft			2. fluid characteristic	1. liquid	slurries	viscous	1.25
86	butterfly valve	butterfly valve, double offset	butterfly valve, seat soft			3. temperature characteristic	0. no phase data		cryogenic	1.20

Table Annex D.1

TYPICAL
ODCF
ON DEMAND CORRECTION FACTOR
online published data
statistics

characteris	2. fluid characteristic
service	(Multiple Items)
phase	(All)
fluid	(All)
type	(All)
type detail	(All)
seat	(All)
port	(All)
line	(All)
sigma	0.19
sigma p	0.19
cnt	65



1.00	1.02	1.40	1.77	1.80

CAT	characteristic	service	phase	fluid	valve	min	mu	max	sigma	sigmap	cnt	min	μ - 2σ	μ	μ + 2σ	max
A						0.75	1.38	2.20	0.25	0.25	**329**	0.75	0.87	1.38	1.88	2.20
B	1. operational characteristic					1.00	1.32	2.00	0.29	0.29	**43**	1.00	0.74	1.32	1.90	2.00
	2. fluid characteristic					0.75	1.40	2.20	0.25	0.25	**258**	0.75	0.89	1.40	1.90	2.20
	3. temperature characteristic					1.10	1.32	2.00	0.17	0.16	**28**	1.10	0.98	1.32	1.65	2.00
C					ball valve	0.75	1.42	2.20	0.26	0.26	**233**	0.75	0.91	1.42	1.94	2.20
					ball valve floating	0.80	1.45	2.20	0.25	0.25	**163**	0.80	0.95	1.45	1.95	2.20
					ball valve, trunnion	0.80	1.34	2.00	0.26	0.25	**36**	0.80	0.83	1.34	1.85	2.00
					butterfly valve	1.00	1.24	1.67	0.17	0.17	**88**	1.00	0.90	1.24	1.59	1.67
					butterfly valve, double offset	1.20	1.28	1.50	0.10	0.09	**8**	1.20	1.08	1.28	1.47	1.50
					butterfly valve, triple offset	1.07	1.29	1.67	0.20	0.20	**21**	1.07	0.89	1.29	1.70	1.67
					plug valve	1.50	1.63	2.00	0.23	0.22	**8**	1.50	1.16	1.63	2.09	2.00
D	1. operational characteristic				ball valve	1.10	1.36	2.00	0.30	0.29	**31**	1.10	0.77	1.36	1.95	2.00
					ball valve floating	1.10	1.38	2.00	0.32	0.32	**24**	1.10	0.73	1.38	2.03	2.00
					ball valve, trunnion	1.10	1.18	1.30	0.10	0.08	**4**	1.10	0.98	1.18	1.37	1.30
					butterfly valve	1.00	1.15	1.35	0.11	0.10	**11**	1.00	0.93	1.15	1.37	1.35
E	2. fluid characteristic				ball valve	0.75	1.44	2.20	0.26	0.26	**183**	0.75	0.93	1.44	1.95	2.20
					ball valve floating	0.80	1.48	2.20	0.24	0.24	**123**	0.80	1.00	1.48	1.96	2.20
					ball valve, trunnion	0.80	1.36	2.00	0.27	0.26	**31**	0.80	0.83	1.36	1.90	2.00
					butterfly valve	1.00	1.25	1.67	0.18	0.18	**68**	1.00	0.89	1.25	1.61	1.67
					butterfly valve, double offset	1.25	1.25	1.25	0.00	0.00	**4**	1.25	1.25	1.25	1.25	1.25
					butterfly valve, triple offset	1.07	1.32	1.67	0.21	0.21	**15**	1.07	0.89	1.32	1.75	1.67
F		non-clean				1.00	1.40	1.80	0.19	0.19	**65**	1.00	1.02	1.40	1.77	1.80
		non-lubricating				1.05	1.32	2.00	0.21	0.21	**46**	1.05	0.89	1.32	1.74	2.00
		sticking				1.04	1.36	1.80	0.21	0.21	**29**	1.04	0.93	1.36	1.78	1.80
		slurries				1.04	1.52	2.00	0.29	0.28	**39**	1.04	0.95	1.52	2.10	2.00
		dirty				1.20	1.47	1.80	0.19	0.18	**8**	1.20	1.09	1.47	1.85	1.80
		particles				1.00	1.39	1.69	0.18	0.18	**35**	1.00	1.02	1.39	1.76	1.69
		abrasives				1.05	1.38	1.69	0.19	0.19	**22**	1.05	1.00	1.38	1.77	1.69
		crystallizing				1.25	1.56	2.00	0.19	0.19	**23**	1.25	1.18	1.56	1.95	2.00
		polymers				1.04	1.37	2.00	0.23	0.23	**27**	1.04	0.90	1.37	1.84	2.00
		lubricating				0.75	0.78	0.80	0.03	0.02	**6**	0.75	0.73	0.78	0.83	0.80
G			liquid			0.80	1.43	2.00	0.27	0.27	**42**	0.80	0.88	1.43	1.98	2.00
			gas			1.13	1.34	1.50	0.14	0.14	**18**	1.13	1.05	1.34	1.63	1.50
			solid			1.60	1.80	2.00	0.20	0.16	**3**	1.60	1.40	1.80	2.20	2.00
H				oil		0.80	0.82	0.85	0.03	0.02	**3**	0.80	0.76	0.82	0.87	0.85
				steam		1.20	1.42	2.20	0.33	0.31	**11**	1.20	0.76	1.42	2.08	2.20
				chlorine		1.50	1.50	1.50	0.00	0.00	**3**	1.50	1.50	1.50	1.50	1.50
I	3. temperature characteristic	cryogenic				1.10	1.33	2.00	0.20	0.20	**16**	1.10	0.92	1.33	1.74	2.00
		high temp				1.15	1.31	1.50	0.11	0.10	**12**	1.15	1.10	1.31	1.52	1.50
					max	1.60	1.80	2.20	0.33	0.32	**329**					
					mu	1.04	1.35	1.81	0.20	0.19	**54**					
					min	0.75	0.78	0.80	0.00	0.00	**3**					

non-clean = dirty + particles + abrasives

Table Annex D.2

- ✓ To generate this typical ODCF list, Microsoft Excel pivoting has been applied – see Table Annex D.2
- ✓ Categories A to I are created to derive at some typicals. Note however that for some statistics the sample size is too small to correctly apply the average and upper / lower limits statistics
  - ➢ Category A: all data
  - ➢ Category B: data by characteristics operational, fluid and temperature
  - ➢ Category C: all data by valve type
  - ➢ Category D: operational characteristic data by service and valve type
  - ➢ Categories E –H: fluid characteristic data by service, fluid and phase
  - ➢ Category I: temperature characteristic data by service
- ✓ Many more detailed typical categories are of interest; unfortunately, the sample size for many is too low to yield a meaningful result.

ANNEX E TRAVEL TIME / RESPONSE TIME / TRAVEL STOPS

It is important to distinguish “Valve Travel Time” from “Valve Response Time”:

- ✓ The valve travel time is the time the valve is really moving to the opening or closing position
- ✓ The valve response time is the time from the moment the solenoid is energized or de-energized till the opening or closing position is reached. The valve response time is always longer than the valve travel time

If the Valve Response Time is required the following air pressures shall be used:

- ✓ Spring direction: maximum air supply pressure as specified in the purchase order specification
- ✓ Opposite to spring direction: minimum air supply pressure as specified in the purchase order specification.

It shall be made clear in the purchase order specification if Valve Travel Time and/or Valve Response Time has to be tested.

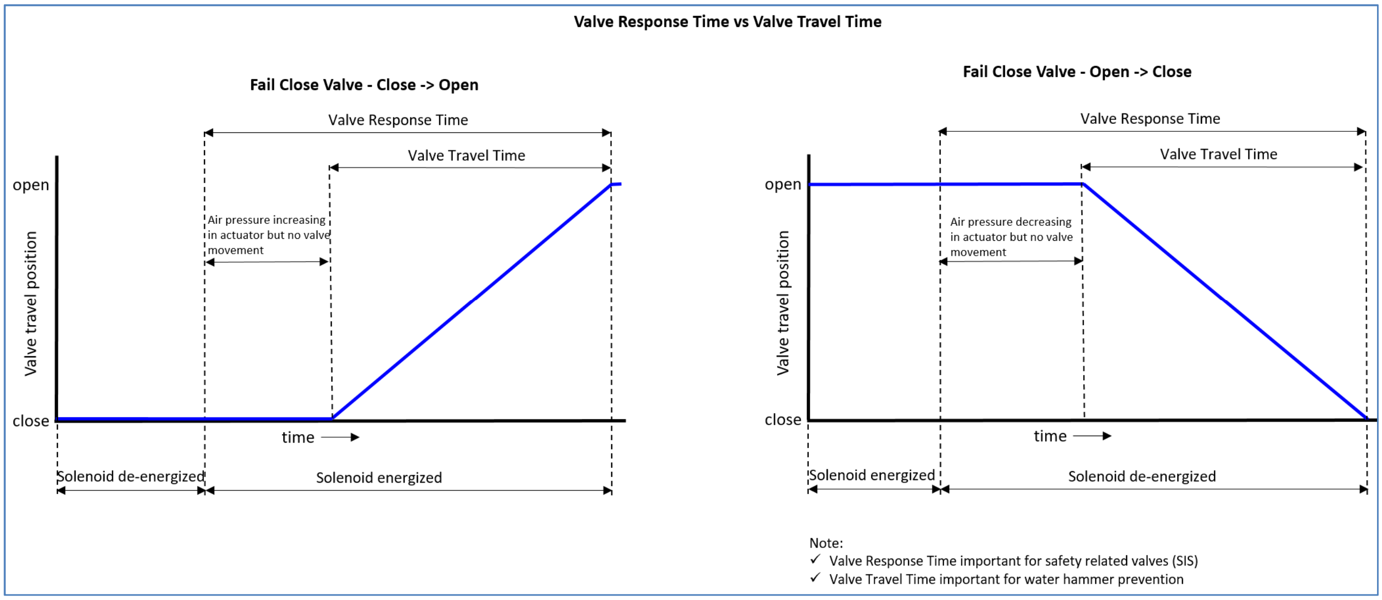


Figure Annex E-1

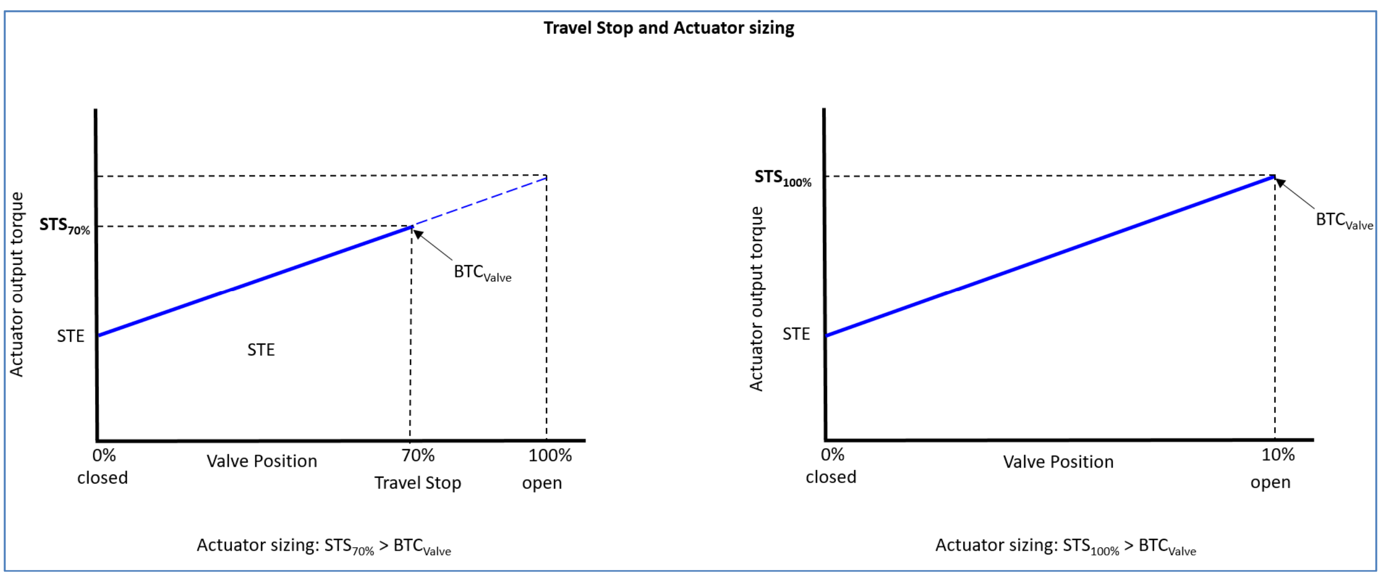


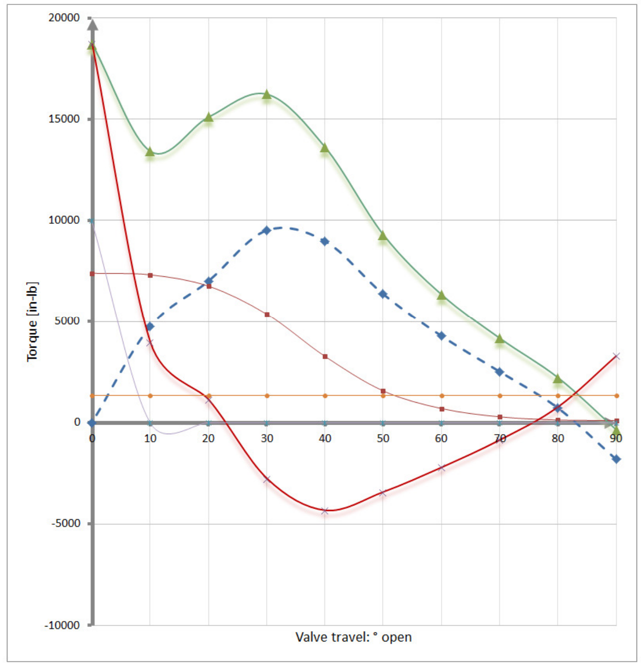
Figure Annex E-2

VALVE TORQUE COMPONENTS

VALVE TORQUE COMPONENTS — **AV Assembly** Recommended Practice

degrees open	flow resistance coefficient	dynamic torque coefficient	approach velocity	pressure (head) loss		**dynamic** torque	**bearing** friction torque	**seating / unseating** torque	**packing & hub** torque	total **opening** torque	total **closing** torque	**actuator sizing** torque
°		-		ft H2O	psi	in-lb	in-lb	in-lb	in-lb	in-lb	in-lb	in-lb
										MRST	MRST	AST
θ	$K_{v\theta}$	$C_{t\theta}$	V_{θ}	$\Delta H_{v\theta}$	$\Delta P_{v\theta}$	$T_{d\theta}$	$T_{b\theta}$	$T_{s\theta}$	$T_{ph\theta}$	$T_{to\theta}$	$T_{tc\theta}$	
90		-0.321		0.9	0.41	-1809	111	0	1350	-348	3271	4088
80		0.0969		1.2	0.54	726	134	0	1350	2210	758	2763
70		0.125		3.4	1.46	2519	290	0	1350	4159	-880	5199
60		0.08		8.9	3.87	4282	699	0	1350	6331	-2233	7914
50		0.0511		20.8	9.02	6368	1572	0	1350	9290	-3447	11612
40		0.0341		44	19.06	8985	3276	0	1350	13610	-4359	17013
30		0.0219		72.5	31.43	9514	5373	0	1350	16237	-2790	20296
20		0.0128		91.3	39.60	7007	6760	0	1350	15116	1103	18895
10		0.008		99	42.90	4744	7320	0	1350	13414	3926	16768
0		0		100	43.35	0	7396	9965	1350	18711	18711	23389

d_s	3	in	Shaft diameter
D_d	24	in	Disc diameter
C_f	0.25	-	Friction factor
C_{sc}	16	lb/in	Seating torque coefficient - constant
C_{sp}	0.03	lb/in/psi	Seating torque coefficient - pressure dependent
C_{usc}	16	lb/in	Unseating torque coefficient - constant
C_{usp}	0.03	lb/in/psi	unseating torque coefficient - pressure dependent
$W_{d\&s}$	450	lb	Weight disc + shaft
T_{cg}	0	in-lb	Center of gravity torque
T_p	1350	in-lb	Packing & hub torque
T_s	9965	in-lb	Seating torque
T_{us}	9965	in-lb	Unseating torque
K_{sys}	44.42	-	System flow resistance coefficient
AF	1.25	-	application factor



AWWA M49 3rd edition 2017 Torque Calculation Methodology Example pages 73-75

Table Annex F.1

In a quarter-turn valve, **valve torque is the turning effort needed to rotate the valve's closure member (ball, cone, disc, or plug) or hold it in position**. Torque varies with system conditions, valve design, and closure member position.

Within the AWWA Manual M49 torque calculations are broken into 10 separate torque components and each is derived from a first-principles approach. The 10 separate torque components classifies into two categories: passive or friction-based and active or dynamically generated.

These 10 components are listed in the Table below

Table Annex F.2

Table 3-1 Torque Component Category

Item No.	Torque Component	Torque Category
1	Seating (and/or unseating) friction torque	Passive or friction-based
2	Packing friction torque	
3	Hub seal friction torque	
4	Bearing friction torque	
5	Thrust bearing friction torque	
6	Weight and center of gravity torque	Active or dynamically generated
7	Buoyancy torque	
8	Lateral offset or eccentricity torque	
9	Dynamic or fluid dynamic torque	
10	Hydrostatic unbalance torque	

Items 5 (thrust bearing torque) and 7 (buoyancy torque) are generally considered as negligible for the scope of valves within this Recommended Practice.

The components of hub seal friction torque (item 3), weight and center of gravity torque (item 6), lateral off set or eccentricity torque (item 8), and hydrostatic unbalance torque (item 10) may not be applicable depending on the valve design and installation variables. In addition, packing friction (item 2) and hub seal friction (item 3) may be considered as a single torque. Seating (and/or unseating) friction torque (item 1), packing friction torque (item 2), bearing friction torque (item 4), and dynamic or fluid dynamic torque (item 9) should always be included in operating torque calculations for ball, butterfly, and plug valves.

The **passive torque components are friction-related** and, in general, are either constant for a given valve or directly dependent on the differential pressure. These components always oppose actuator motion and are generally considered essentially the same magnitude in either direction of operation (opening or closing) except for seating and unseating. Seating and unseating torque may be evaluated separately or considered the same when differences are small.

The **active or dynamic torque components** are generated in the valve by the effects of the internal fluid media (water) or gravity acting on the valve. These components may oppose or assist the actuator's operation. Because dynamic torque generally tends to close the valve, the actuator may act as a brake to control the speed of the closing stroke but must also overcome this torque in the opening stroke.

The separate actuating torque methodology provided here is generally used for valves of larger sizes. Actuator sizing in valves 12 in. (300 mm) and smaller is driven primarily by the passive/friction-based torque requirements as the active torque components are a small fraction of the total required operating torque. The transition point at which the dynamically generated torque components become the major part of the total required torque depends on many factors of the valve design. However, it can be generally stated that this transition occurs in the 14-in. (350mm) to 30-in. (900-mm) range for this scope. Actuator sizing for valves larger than 30 in. (750 mm) is often significantly based on the dynamic flow conditions.

On the basis of this and the fact that the smaller-sized valves are easily tested and grouped into a smaller range of required actuator torque over the full span of the design pressure and flow rate, this complex calculation methodology may be replaced by a simple calculation based on size and pressure using curve-fitting techniques of test data. In the smaller sizes, the manufacturer may provide curve-fit equations, graphical, or tabulated information.

This separate effects methodology becomes increasingly important in the larger valve sizes, say ≈18 in. (450 mm) and larger, and at very high fluid line velocities (greater than 16 ft/s or 4.9 m/s). It is economically or physically infeasible to test many large-diameter valves, and using separate effects calculations, model test data, and grouping of the test data is necessary. The modeling techniques of dimensionless coefficients, hydraulic similitude, grouping, interpolation, and extrapolation are not discussed in this manual.

The friction-based torque components are either constant or related to the valve diameter to the second power (D^2). Because the dynamic torque component is a function of the valve diameter to the third power (D^3), it becomes the major torque affecting the actuator sizing of the larger valves. This is why the maximum operating flow rate or fluid line velocity is needed for actuator sizing of larger valve sizes.

The hydrostatic unbalance torque is also of great importance (if it exists) to larger valve sizes as it is a function of the diameter to the fourth power (D^4) although it can be ignored as insignificant in valves ≈36 in. (900 mm) and smaller. It is seldom seen under actual operating conditions, but its influence can be very significant in valve sizes larger than 36 in. (900 mm) when it is present.

This separate effects methodology is then best applicable for determining the required actuator torque for the larger sizes of valves when the torque components are determined individually (rather than by curve-fitting techniques of the total torque) as the combination of both the operating shutoff differential pressure and maximum operating flow rate (or line velocity) has a significant effect on results.

For calculating those 10 components, the reader refers to the AWWA manual M49. The RP associated spreadsheet AVA004 provides sample calculations and graphs and allows the reader to customize it.

VALVE TORQUE COEFFICIENTS

There are valve torque coefficients for

- ✓ Constant passive or friction-based torque components, and for
- ✓ Travel dependent active or dynamically generated torque components

Below some sample torque coefficients

Coefficient of Friction, Cf

The shaft bearing material supports the shaft and disc in the valve body, allowing rotation. One requires the static coefficient of friction for the bearing and shaft or trunnion material couple to calculate valve bearing friction torque. Consult the valve or bearing manufacturer or other mechanical engineering references and handbooks for typical friction coefficients.

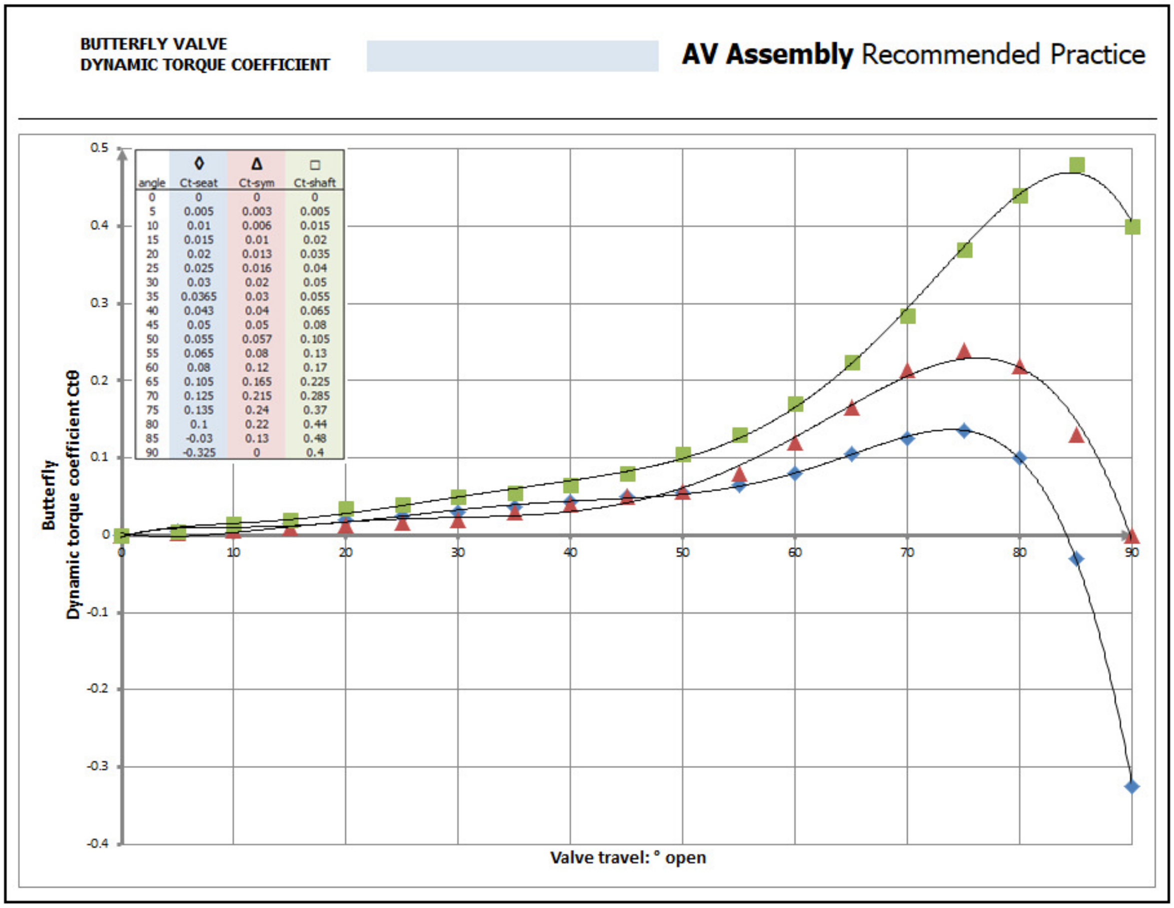
Seating/Unseating Torque Coefficients

Seat designs are as numerous as valve manufacturers, and each has its own torque characteristics.

The AWWA M49 manual presents first-principles methodology for predicting seating and unseating torque through use of seating and unseating coefficients that can be derived from tests for any type of seat. These coefficients may vary with seat material, temperature, and valve pressure rating. Seating torque and unseating torque may be considered to be the same. However, some designs, such as double- or triple-offset designs, may have separate values or coefficients for seating and unseating as well as for each flow direction. Sometimes the total unseating torque refers as the "break to open torque."

Dynamic Torque Coefficient Ctθ

Below sample dynamic torque coefficient graphs for butterfly valves with symmetrical and offset closure members.



angle	◊ Ct-seat	Δ Ct-sym	□ Ct-shaft
0	0	0	0
5	0.005	0.003	0.005
10	0.01	0.006	0.015
15	0.015	0.01	0.02
20	0.02	0.013	0.035
25	0.025	0.016	0.04
30	0.03	0.02	0.05
35	0.0365	0.03	0.055
40	0.043	0.04	0.065
45	0.05	0.05	0.08
50	0.055	0.057	0.105
55	0.065	0.08	0.13
60	0.08	0.12	0.17
65	0.105	0.165	0.225
70	0.125	0.215	0.285
75	0.135	0.24	0.37
80	0.1	0.22	0.44
85	-0.03	0.13	0.48
90	-0.325	0	0.4

Table Annex F.3

The maximum coefficient of dynamic torque (which reflects a constant pressure drop at all travel positions) occurs at approximately the 65°to 80°open position. In contrast, the maximum total dynamic torque normally occurs at an intermediate travel position between 0°(closed) and 50°(open) where the differential pressure is high (that is, pressure drop varies with valve position).

Dynamic torque coefficients for a symmetrical closure member are normally independent of flow direction. They are functions of closure member geometry, valve travel, and pressure drop.

Dynamic torque coefficients for a single-off set butterfly valve disc, as shown in the graph above (Table Annex F.3) on the previous page, depend on flow direction through the valve as well as disc geometry, valve travel, and pressure drop across the butterfly valve disc. The dynamic torque coefficient at the open position may be negative (giving the closure member a tendency to open) when the valve is installed with the seat upstream. The butterfly valve single-offset disc torque coefficient can also change sign near the 85°position. If the valve is positioned at an angle at which the torque direction is unstable (when Ct crosses zero at angles other than 90) for extended periods, fatigue damage caused by torque reversals and vibration may occur, and prolonged modulation in this valve position should be avoided.

ANNEX G MAINTENANCE CONSIDERATIONS

Always consider the maintenance requirements of any AV Assembly when designing and/or ordering the mounting kit. Specially consider the following:

a) Access to the fixings that connect the valve and actuator to the mounting kit: the mounting kit should have sufficient clearance to allow the installation and removal of fasteners using standard commercial tooling.
b) Access to external adjustment mechanisms of the valve gland: some part-turn valves require periodic adjustment to prevent fugitive emissions.
c) Access to valve lubrication facility: some plug valves require periodic lubrication in order to maintain a consistent torque requirement and prevent seizure.
d) Actuator and accessories arrangement in relation to valve/pipeline flanges: the kit should be of sufficient height to allow suitable access for assembly, valve adjustment, and valve/pipeline insulation.
e) Mounting brackets, couplings and fasteners shall allow access for routine valve servicing—Gland adjustment, plug lubrication, leak testing, etc.

Assembling / disassembling aspects:

a) For standard assembling and disassembling procedures, no special tools should be required.
b) Standard assembling and disassembling procedures should never create unsafe situations, where parts under pressure could become projectiles. For example cap removal: to release spring energy completely before thread disengagements, bolts should be long enough. Spring modules shall allow safe installation or removal of spring modules in the field without special tools. Actuator design must insure spring tension is fully released prior to removal of the spring module
c) When the lever or hand wheel is removed in order to mount the actuator on the valve, the integrity of the stuffing box construction has to be secured i.e. no loose packing rings etc.

Maintenance strategies

Just as for control valves determine also for Actuated Valve Assemblies appropriate maintenance strategies, commonly based on the criticality of the AV Assembly. In general, the more critical the valve the more stringent the planned preventive maintenance (PPM) and spare part strategy should be. When an AV Assembly is part of a process system with regulatory PPM and testing requirements like Burner Management Systems or Safety Instrumented Systems, fulfill these regulatory requirements as a minimum.

There is a tendency in the market to increase scheduled turnaround intervals. For several plants today, this can be 8 to10 years and even more. This may result in a situation that the turnaround interval time exceeds the service life of some of the AV Assembly equipment. If equipment cannot be repaired or replaced while the AV Assembly is in service this may result in an unplanned plant outage or even worse in injuries, fatalities etc. This has to be part of the decision making process to determine the turnaround interval time. Examples can be limited service life of solenoid valves, boosters, quick exhausts, grease (lubricant) in actuators etc. Check the appropriate IOMs from the different manufacturers/suppliers. Precautions should be taken to prevent that the service life of the equipment is exceeded during the turnaround interval time, specifically for safety related AV Assemblies.

Due to the nature of how an AV Assembly is operating, the majority of the dangerous failures are “hidden failures”, which means that these failures will not be revealed until there is an demand on the AV Assembly. An FMEDA will help to identify the different failure modes and related failure mechanisms and to determine the appropriate maintenance strategies and actions.

Stroke testing

Stroke testing may be used to demonstrate that the AV Assembly is able to reach the safe state on demand.

There are two different ways of stroke testing:

- ✓ Full Stroke Test (FST): timed movement of the AV Assembly from one position to the other position e.g. fully open to fully closed or fully closed to fully open
- ✓ Partial Stroke Test (PST): a test that initiates travel of the AV Assembly towards a designated safe state but limits travel distance to an intermediate or partial stroke position (based on preset time period).

See ISA TR96.05.01 for more details

When using the FST or PST in the PFD calculations in order to extend the proof test interval of the SIS final element the appropriate Diagnostic Coverage level has to be determined:

- ✓ Quantify the AV Assembly failure data, including the analysis of the failure scenario’s for the given application. Understand the AV Assembly failure scenarios, including the split between safe/unsafe failures.
- ✓ Based on this failure rate data, quantify the Diagnostic Coverage for the total AV Assembly for the given application by using the FST/PST

Note: an FMEDA will help to determine the different failure modes and related failure mechanisms.

Sometimes PST manufacturers provide generic DC factors. However, like as stated in ISA TR96.05.01 keep in mind that these DC factors are not necessarily applicable for all applications and require adjustment for specific applications and valve types. This is important to understand, because the DC factor has to be accurate as this is a part of the PFD calculation.

The diagnostic coverage (DC) as used in the PDF calculation is based on the alarm settings coming from the FST or PST. When an alarm is generated during the FST or PST that the stroke test failed, this implies that the AV Assembly is (possibly) not able to execute the safety function.

The alarm indicating the FST or PST failed is the alarm providing the DC credits in the PFD calculation.

Correct alarm settings are essential for success:

- ✓ Alarm settings too narrow: causing nuisance alarms and can lead to spurious trips.
- ✓ Alarm setting too wide: no alarm generated when required and, what is even more important, an undeserved credit is taken for the use of the FST or PST. This means that the calculated PFD values are not valid anymore. This can lead to an unsafe situation or even worse in injuries or fatalities.

Please note that because of the fact the DC factor is part of the PFD calculation, there is not much playroom to adjust the alarm settings. The DC factor has to be accurate as soon as the AV Assembly is put into service. A procedure (Operating Discipline) has to be in place describing the corrective actions that have to be taken if the FST or PST fails.

Proof test for AV Assembly in SIS application

A proof test is a periodic test to reveal undetected (hidden) failures in a SIF and if necessary to restore the AV Assembly to its designed functionality by repair or replacement.

A proof test consists of:

- ✓ Visual inspection
- ✓ Function test (including response time test)
- ✓ Seat leakage test
- ✓ Functional Margin (See ISA TR96.05.01 paragraph 8.3 for a detailed description)

Seat Leakage Test

The test criterion for the seat leakage test is the Maximum Allowable Leakage Rate (MALR) as specified in the Safety Requirement Specification (SRS document). The pass/fail criterion for the Seat Leakage Test has to be such that when the AV Assembly passes the test the seat tightness is sufficient to fulfill the safety requirements until the next proof test.

Functional Margin

As defined in ISA TR96.05.01 the Functional Margin is the actual difference between the torque required to move a valve to its required safety position and the capability of the actuator to move it to that position.

The Functional Margin can be determined by measuring the actuator pressures with an operating AV Assembly.

For Long Stand Still (LSS) applications, AV Assemblies will be in the same position (open or closed position) for a longer time period. To be able to measure this LSS 'sticking effect' it is important to measure the Functional Margin during the first AV Assembly stroking after the LSS period. Measuring this 'sticking' effect with subsequent stroking's after the LSS period is not possible.

To determine the Functional Margin, one can perform this pressure test manually or automatically.

Example of an actuator pressure measurement test:

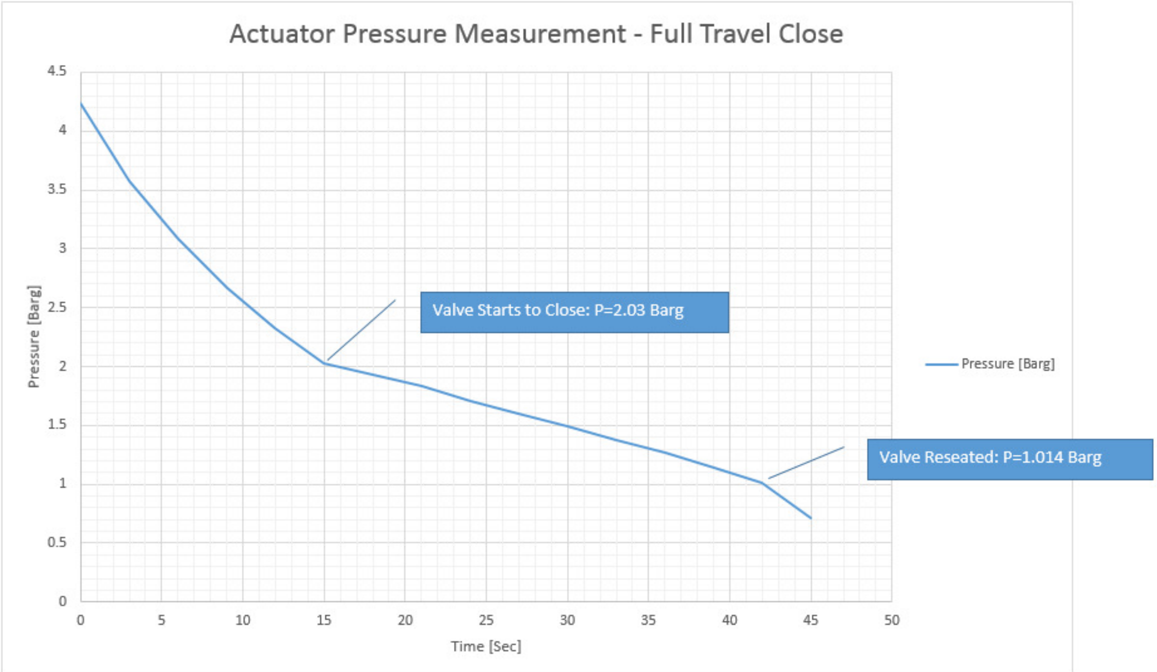


Figure Annex G.1 Actuator pressure measurement

The pass/fail criterion for the Functional Margin has to be such that when the AV Assembly passes the test, there is sufficient actuator output torque left to fulfill the safety requirements until the next proof test.

To document the proof test according to IEC 61511, among other things document the “as found” and “as left” conditions of the AV Assembly. When replacing the existing AV Assembly with a new one, it is highly recommended to still proof test the existing valve and document the “as found” results.

SIZING DATA SHEET

AV Assembly Sizing Data Sheet - Metric units of measure (uom)

	category	ODCF (1)	parameter	* **	symbol	data value *	data value **	data uom	data provider	
1	IDENTIFICATION		Tag			Tag123V			End User	1
2			Service			Feed to boiler 1			End User	2
3			P&ID			PID 456			End User	3
4			Line Number			Line-100-ABV			End User	4
5			Purchase Order Number / Purchase requisition			PO 789			End User	5
6			Remarks			nothing special			End User	6
7	AMBIENT CONDITIONS		Ambient temperature	min/max		-10	50	DegC	End User	7
8			Environmental conditions			outdoor			End User	8
9			Environmental conditions			corrosive			End User	9
10	APPLICATION		Fail direction			**fail-closed**			End User	10
11			Travel time	open/close		10	5	s	End User	11
12			Response time	open/close		20	8	s	End User	12
13			Air supply pressure	min/max		4	10	bar(g)	End User	13
14	PROCESS		Medium			hydrocarbon + tar			End User	14
15			State / phase						End User	15
16			Mass flowrate			100000		kg/h	End User	16
17			Volume flowrate			125		m3/h	End User	17
18			Density			900		kg/m3	End User	18
19		1.32	Long stand still time		LSS	1.0		yr	End User (1)	19
20		1.4				non-clean service			End User (1)	20
21		1.32	Fluid characteristics			non-lubricating			End User (1)	21
22									End User (1)	22
23		1	Fluid operating temperature	min/max				DegC	End User (1)	23
24			Max DP shutoff					bar	End User	24
25			Design pressure			30		bar(g)	End User	25
26										26
27	VALVE		Valve manufacturer			V02			End User	27
28			Valve configuration		VC	V02.002			End User	28
29			Valve type / Model			ball valve			End User	29
30			Valve design			trunnion mounted			End User	30
31			Port			full port			End User	31
32			Shutoff flow direction						End User	32
33			Seat designation (material)			soft seated			End User	33
34			If applicable, soft seated material			NA			End User	34
35			Seating			position			End User	35
36			Pressure class rating			150			End User	36
37			Tightness class						End User	37
38			Valve size			10"			End User	38
39			Line pressure		dp	20		bar	End User	39
40		1.4	Break to Open torque	net/ ODCF corr	BTO	1105	1547	Nm	Valve manufacturer	40
41			BTO breakaway angle		BTO	10		°	Valve manufacturer	41
42		1.4	Run to Open torque	net/ ODCF corr	RTO	635	889	Nm	Valve manufacturer	42
43		1.4	End to Open torque	net/ ODCF corr	ETO	695	973	Nm	Valve manufacturer	43
44		1.72	Break to Close torque	net/ ODCF corr	BTC	695	1195	Nm	Valve manufacturer	44
45		1.4	Run to Close torque	net/ ODCF corr	RTC	635	889	Nm	Valve manufacturer	45
46			ETC breakaway angle		ETC	10		°	Valve manufacturer	46
47		1.4	End to Close torque	net/ ODCF corr	ETC	885	1239	Nm	Valve manufacturer	47
48			Max allowable torque drive train (MAST)		MAST	**5466**		Nm	Valve manufacturer	48
49			Max allowable flange torque (ISO5211)			**F16**	**4000 Nm**		Valve manufacturer	49
50			Stem / top works dimensions provided Y/N?			**No**			Valve manufacturer	50
51	MOUNTING KIT		Material						Mounting Kit manufacturer	51
52			Height aspect			hot temperature			Mounting Kit manufacturer	52
53			Max allowable coupling torque		MAST	**5466**		Nm	Mounting Kit manufacturer	53
54			MK mechanical integrity checked & documented			No			AV Assembly Contractor	54
55			Stem orientation			vertical			End User	55
56										56
57	ACTUATOR		Supply pressure	min/max		5	6	bar(g)	End User	57
58			Air volume	open/close				liter		58
59			Sizing Safety Factor		SSF	**1.15**		-	End User	59
60			Actuator drive medium			pneumatic			End User	60
61			Actuator drive medium quality (ISO S7)			clean			End User	61
62			Actuator style			scotch yoke			AV Assembly Contractor	62
63			Model			A03:A:s020-0360-2-3			AV Assembly Contractor	63
64			Size			100		inch2	AV Assembly Contractor	64
65			Spring set number			2-3			AV Assembly Contractor	65
66			Spring to Start torque		STS	**4117**		Nm	Actuator manufacturer	66
67			Spring to Run torque		STR	1873		Nm	Actuator manufacturer	67
68			Spring to End torque		STE	2725		Nm	Actuator manufacturer	68
69			Air to Start torque		ATS	3618		Nm	Actuator manufacturer	69
70			Air to Run torque		ATR	1534		Nm	Actuator manufacturer	70
71			Air to End torque		ATE	2024		Nm	Actuator manufacturer	71
72			Air to Start torque @ max press		ATS	**4918**		Nm	Actuator manufacturer	72
73			Max operating pressure		MOP	10		bar(g)	Actuator manufacturer	73
74										74

Notes

(1) EndUser provides process challenges ; Valve manufacturer provides ODCF values based on those process challenges

Clear auto entries

The AV Assembly prototype (*) generated (**) the sizing data sheet

(*) appling prototype version ASST3.53

(**) fields in light shadow are auto generated

Below some print screens details for this example application.

- **The On Demand Correction Factor.**

ON DEMAND TORQUE CORRECTION FACTOR calculator						Scenario Manager #					41
Characteristic	Sample application data		setting	uom	CF	For which torque values applies the ODCF?					
	CF %	value				BTO	RTO	ETO	BTC	RTC	ETC
long stand still time	132%	12	5.8	month	132%	FO			FC		
Fluid Characteristics											
state / phase		Liquid									
clean service					100%	X	X	FO	X	X	X
non-clean service	140%	X			140%	X	X	X	X	X	X
non-lubricating	132%	X			132%	X	X	X	X	X	X
sticking service					136%	X	X	X	X	X	X
slurries					152%	X	X	X	X	X	X
temp minimum			-150	ºC	133%	X	X	X	X	X	X
temp maximum			500	ºC	131%	X	X	X	X	X	X
fluid correction factor	140%		Max of fluid parameters			Legend **X** applicable for both FC and FO applications					
ODCF	**172%**		Sum			**FC** applicable for FC applications only **FO** applicable for FO applications only					

- **The valve selection and valve torque data**

1. Valve selection

1a. Valve configuration	:	V02.002
*1 type - design		ball valve - trunnion mounted
*2 rating - port - direction		150 - full port -
*3 seat - seating - shaft & soft		soft seated - position - 1.4462 - NA
*4 flange		F16 **4000** Nm
1b. Valve size	:	10"
1c. Valve shutoff pressure	:	barg
1d. stem matl	:	1.4462
1e. Valve fail safe action	:	**FC**

Θ	2. VALVE torque data correction	coeff	net torque	ODCF	sizing SF	corrected torque
0	BTO		**1105**	1.47	1.5	2437
10	BTOba					2437
45	RTO	0.40	635	1.47		1400
90	ETO	0.65	695	1.47		1532
90	BTC	1.00	695	1.88		1960
45	RTC	0.50	635	1.47		1400
10	ETCba					1951
0	ETC	0.75	885	1.47		1951
					MAST	5466
					MAST/BTO	4.95
					MAST/FLANGE	1.37

- **The actuator selection**

3. ACTUATOR sizing & selection data

Actuator supply pressure **min** 5.0 Refresh table **max** 6.0 Pmax/min 20%

# of Actuators found 28

	alias	model	rank	pres	STS	STR	STE	ATS	ATS max	ATR	ATE	weight	SSet	f
20	A03	A03:A:s020-0360-2-3	45	5	**4117**	1873	2725	3618	**4918**	1534	2024	277	2-3	1300
1	A11	A11:04000:3-2	33	5	2363	1929	1494	2221	3047	1678	1135	147	3-2	826
2	A10	A10:04000:5-6	31	5	2401	2005	1608	1982	2700	1585	1188	150	5-6	718.45
3	A10	A10:04000:5-5	31	5	2183	1823	1462	2128	2846	1768	1407	150	5-5	718.45
4	A10	A10:05000:5-6	34	5	2724	2374	2023	2481	3381	2131	1781	169	5-6	900.43
5	A10	A10:05000:5-5	34	5	2476	2158	1839	2665	3565	2347	2028	169	5-5	900.43
6	A10	A10:05000:4-5	34	5	2229	1943	1656	2849	3749	2563	2276	169	4-5	900.43
7	A10	A10:05000:4-4	34	5	1981	1727	1472	3033	3933	2779	2524	169	4-4	900.43
8	A03	A03:A:s015-0335-3-2	34	5	2383	1102	1641	2518	3368	1152	1692	203	3-2	850
9	A03	A03:A:s015-0335-3-3	34	5	2519	1169	1748	2407	3257	1077	1532	203	3-3	850
10	A03	A03:C:s015-0335-3-2	34	5	1943	1134	2456	3884	**4734**	1071	1301	203	3-2	850
11	A03	A03:A:s015-0360-3-2	40	5	2381	1101	1639	3175	**4158**	1525	2388	220	3-2	983
12	A03	A03:A:s015-0360-3-3	40	5	2517	1168	1746	3064	**4047**	1450	2228	220	3-3	983
13	A03	A03:A:s020-0285-2-1	36	5	2446	1122	1653	2325	3140	1024	1426	228	2-1	815
14	A03	A03:A:s015-0385-3-2	40	5	2379	1100	1637	3879	**5003**	1922	3135	234	3-2	1124
15	A03	A03:A:s015-0385-3-3	40	5	2515	1167	1744	3768	**4892**	1848	2975	234	3-3	1124
16	A03	A03:A:s020-0300-2-1	34	5	2444	1121	1652	2764	3667	1275	1891	240	2-1	903
17	A03	A03:C:s020-0300-2-1	34	5	1993	1156	2467	**4261**	**5164**	1188	1454	240	2-1	903
18	A03	A03:A:s020-0335-2-1	45	5	2441	1119	1648	3875	**5001**	1903	3070	259	2-1	1126
19	A03	A03:A:s020-0335-2-2	45	5	3178	1457	2145	3357	**4483**	1522	2206	259	2-2	1126
20	A03	A03:A:s020-0360-2-3	45	5	**4117**	1873	2725	3618	**4918**	1534	2024	277	2-3	1300
21	A03	A03:A:s020-0360-2-4	45	5	**4745**	2167	3172	3152	**4452**	1178	1288	277	2-4	1300
22	A03	A03:A:s020-0360-3-1	45	5	**4787**	2223	3327	2992	**4292**	1124	1238	277	3-1	1300
23	A03	A03:A:s020-0385-3-1	48	5	**4784**	2221	3324	3923	**5409**	1674	2226	292	3-1	1486
24	A03	A03:A:s025-0285-1-1	50	5	2523	1120	1574	3360	**4366**	1563	2345	338	1-1	1006
25	A03	A03:A:s025-0300-1-1	50	5	2522	1119	1573	3902	**5016**	1870	2920	352	1-1	1114
26	A03	A03:A:s025-0300-1-2	50	5	3930	1697	2298	3146	**4260**	1170	1270	352	1-2	1114
27	A03	A03:A:s025-0300-3-1	50	5	3981	1854	2786	2637	3751	1032	1210	352	3-1	1114
28	A03	A03:A:s025-0335-3-1	50	5	3977	1851	2782	**4010**	**5401**	1827	2666	367	3-1	1391

❖ Torque curves with margin analysis

Selected ODCF scenario **41**

Process Conditions On Demand Correction Factors		
Operational		
Medium		Max of fluid parameters
ODCF		Sum

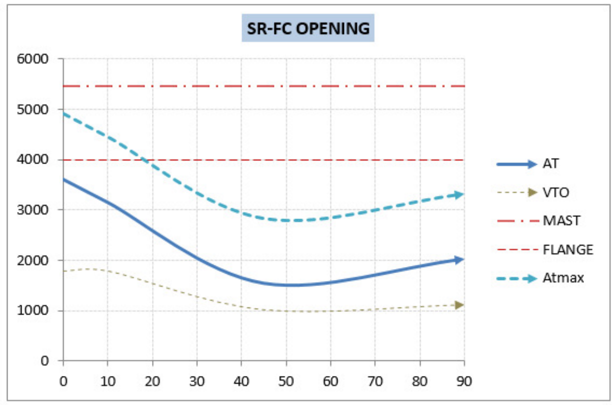
ESDV					
FAIL-CLOSE					
CLOSING			OPENING		
BTC	RTC	ETC	BTO	RTO	ETO
132%					
140%	140%	140%	140%	140%	140%
1.72	1.40	1.40	1.40	1.40	1.40

SR - FC ESDV Emergency ShutDown Valve

S	θ	VALVE		θ	A
		CLOSING	OPENING		
STE	**0**	ETC	BTO	**0**	ATS
		ETCba ↑	↓ BTOba		
STR		RTC	RTO		ATR
STS	**90**	BTC	ETO	**90**	ATE

CLOSING					OPENING					
MARGIN	ST	VTC	θ	MAST	θ	VTO	AT	MARGIN	FLANGE	Atmax
91%	2725	1425	**0**	5466	**0**	1779	3618	103%	4000	4918
78%	2536	1425	10	5466	10	1779	3155	77%	4000	4455
83%	1873	1022	45	5466	45	1022	1534	50%	4000	2834
199%	4117	1375	**90**	5466	**90**	1119	2024	81%	4000	3324

MARGIN	Σ
min - avg	
81%	
119%	200%



4. Margin analysis

FC									
CLOSE				OPEN				avg	Σ
E	oa	R	S	S	oa	R	E		
0	10	45	90	0	10	45	90		
91%	78%	83%	199%	103%	77%	50%	81%	119%	200%

ON DEMAND CORRECTION FACTOR sample cases

Below some sample ODCF cases to better clarify this form and to visualize the effects of multiple challenges and the impact of calculation methods on the result:

- ✓ The Valve manufacturer provides the settings, the correction factors (CF), for which torque characteristics a CF applies and the methods how to deal with multiple challenges, i.e. highest, sum or multiply..

- ✓ Case 1 :

  Assume a Long Stand Still of 12 months, i.e. the valve will not move during 12 months; no challenging fluid

  ➢ ODCF = 1.32

ON DEMAND TORQUE CORRECTION FACTOR								Scenario Manager #			Case 1
Characteristic	Application data		setting	uom	CF	For which torque values applies the ODCF?					
	CF %	value				BTO	RTO	ETO	BTC	RTC	ETC
long stand still time	132%	12	5.8	month	132%	FO			FC		
Fluid Characteristics											
state / phase		Liquid									
clean service					100%	X	X	FO	X	X	X
non-clean service					140%	X	X	X	X	X	X
non-lubricating					132%	X	X	X	X	X	X
sticking service					136%	X	X	X	X	X	X
slurries					152%	X	X	X	X	X	X
temp minimum			-150	ºC	133%	X	X	X	X	X	X
temp maximum			500	ºC	131%	X	X	X	X	X	X
fluid correction factor			Max of fluid parameters			Legend **X** applicable for both FC and FO applications **FC** applicable for FC applications only **FO** applicable for FO applications only					
ODCF	**132%**		Sum								

- ✓ Case 2a – Max / Sum :

  Assume a Long Stand Still of 12 months, i.e. the valve will not move during 12 months; assume a non-lubricating fluid and sticking service; no challenging fluid temperatures

  Fluid method: max of fluid parameters **; Combined method: sum**

  ➢ ODCF = 1.68

ON DEMAND TORQUE CORRECTION FACTOR								Scenario Manager #			Case 2a
Characteristic	Application data		setting	uom	CF	For which torque values applies the ODCF?					
	CF %	value				BTO	RTO	ETO	BTC	RTC	ETC
long stand still time	132%	12	5.8	month	132%	FO			FC		
Fluid Characteristics											
state / phase		Liquid									
clean service					100%	X	X	FO	X	X	X
non-clean service					140%	X	X	X	X	X	X
non-lubricating	132%	X			132%	X	X	X	X	X	X
sticking service	136%	X			136%	X	X	X	X	X	X
slurries					152%	X	X	X	X	X	X
temp minimum			-150	ºC	133%	X	X	X	X	X	X
temp maximum			500	ºC	131%	X	X	X	X	X	X
fluid correction factor	136%		Max of fluid parameters			Legend **X** applicable for both FC and FO applications **FC** applicable for FC applications only **FO** applicable for FO applications only					
ODCF	**168%**		Sum								

- ✓ Case 2b – Sum / Multiply :

  Assume a Long Stand Still of 12 months, i.e. the valve will not move during those 12 months ; assume a non-lubricating fluid and sticking service ; no challenging fluid temperatures

  Fluid method: sum of fluid parameters**; Combined method: multiply**

  ➢ ODCF = 2.22

ON DEMAND TORQUE CORRECTION FACTOR								Scenario Manager #			Case 2b
Characteristic	Application data		setting	uom	CF	For which torque values applies the ODCF?					
	CF %	value				BTO	RTO	ETO	BTC	RTC	ETC
long stand still time	132%	12	5.8	month	132%	FO			FC		
Fluid Characteristics											
state / phase		Liquid									
clean service					100%	X	X	FO	X	X	X
non-clean service					140%	X	X	X	X	X	X
non-lubricating	132%	X			132%	X	X	X	X	X	X
sticking service	136%	X			136%	X	X	X	X	X	X
slurries					152%	X	X	X	X	X	X
temp minimum			-150	ºC	133%	X	X	X	X	X	X
temp maximum			500	ºC	131%	X	X	X	X	X	X
fluid correction factor	168%		Sum of fluid parameters			Legend **X** applicable for both FC and FO applications **FC** applicable for FC applications only **FO** applicable for FO applications only					
ODCF	**222%**		Multiply								

ANNEX I SAMPLE ACTUATOR SIZING & SELECTIONS

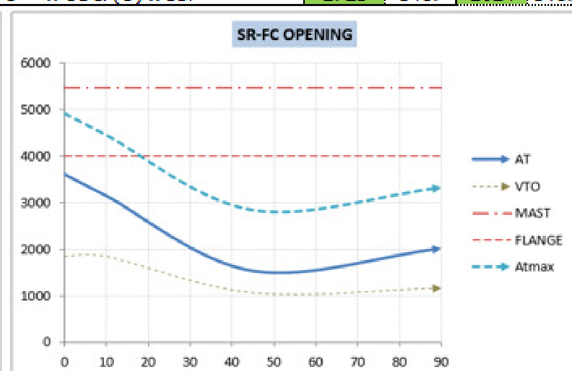
The following 3 sample cases have been verified using the Sizing & Selection Matrix of table 2.2.

Application	Torque		net	FC	FO	uom
- ball valve	Sizing Safety Factor	SFF	1.2			
- trunnion mounted	Break to Open	BTO	1105	1856	2281	Nm
- 150# rating	break to Open @ ba	BTOba	1105	1856	2281	Nm
- 10" size	Run to Open	RTO	635	1067	1067	Nm
- soft seated	End to Open	ETO	695	1168	1168	Nm
- ISO flange F16, 4000 Nm	Break to Close	BTC	695	1434	1168	Nm
- pmax/pmin = 6.0 / 5.0 barg or 20% pressure rang	Run to Close	RTC	635	1067	1067	Nm
- breakaway angle 10°	End to Close	ETCba	835	1487	1487	Nm
	End to Close	ETC	835	1487	1487	Nm

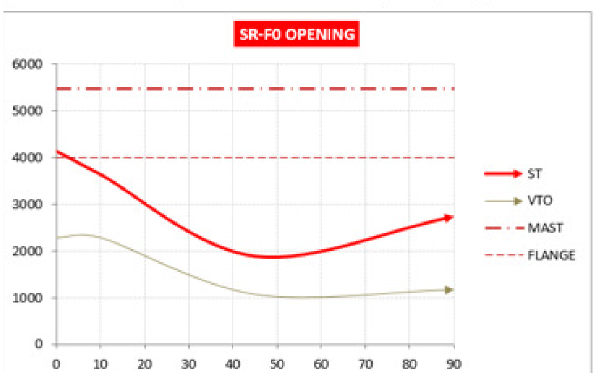
Case 1				
Scotch Yoke Actuator	Air to Start @ pmax	ATSmax	4918	Nm
- size 360	Air to Start	ATS	3618	Nm
- 2/3 springs	Air to Run	ATR	1534	Nm
	Air to End	ATE	2024	Nm
	Spring to Start	STS	4117	Nm
	Spring to Run	STR	1873	Nm
	Spring to End	STE	2725	Nm

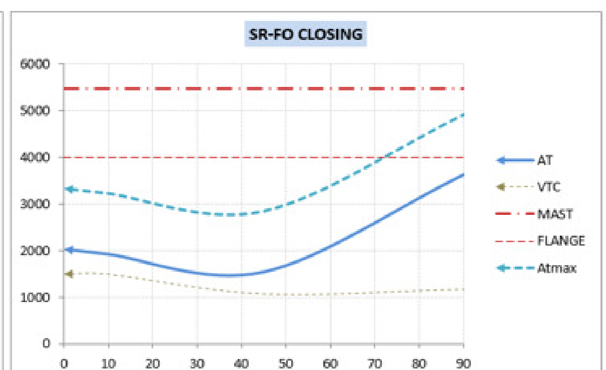
1	Maximum air supply pressure < actuator allowable operating pressure	10	12	barg
2	Maximum air torque start (ATS_{max}) < ISO 5211 flange torque as per ISO 5211	**4918**	4000	Nm
3	Spring start torque (STS) < ISO 5211 flange torque as per ISO 5211	**4117**	4000	Nm
4	Maximum air torque start (ATS_{max})< minimum of all drive train elements MAST values	4918	5466	Nm
5	Actuator spring torque > valve torque on demand over the full travel in both directions.			
	Actuator air torque > valve torque on demand over the full travel in both directions.			

	FAIL CLOSE	FAIL OPEN	FC		FO	
5.1	ATS > BTO x ODCF(Θ) x SSF	STS > BTO x ODCF(Θ) x SSF	3618	1856	4117	2281
5.2	ATR_{ba} > BTO_{ba} x ODCF(Θ) x SSF	STR_{ba} > BTO_{ba} x ODCF(Θ) x SSF	3155	1856	3618	2281
5.3	ATR > RTO x ODCF(Θ) x SSF	STR > RTO x ODCF(Θ) x SSF	1534	1067	1873	1067
5.4	ATE > ETO x ODCF(Θ) x SSF	STE > ETO x ODCF(Θ) x SSF	2024	1168	2725	1168
5.5	STS > BTC x ODCF(Θ) x SSF	ATS > BTC x ODCF(Θ) x SSF	4117	1434	3618	1168
5.6	STR > RTC x ODCF(Θ) x SSF	ATR > RTC x ODCF(Θ) x SSF	1873	1067	1534	1067
5.7	STR_{ba} > ETO_{ba} x ODCF(Θ) x SSF	ATR_{ba} > ETC_{ba} x ODCF(Θ) x SSF	2536	1487	1915	1487
5.8	STE > ETC x ODCF(Θ) x SSF	ATE > ETC x ODCF(Θ) x SSF	2725	1487	2024	1487



FC									
CLOSE				OPEN				avg	Σ
E	oa	R	S	S	oa	R	E		
0	10	45	90	0	10	45	90		
83%	71%	76%	187%	95%	70%	44%	73%	110%	183%





FO									
OPEN				CLOSE				avg	Σ
S	ba	R	E	E	ba	R	S		
0	10	45	90	0	10	45	90		
81%	59%	76%	133%	36%	29%	44%	210%	115%	151%

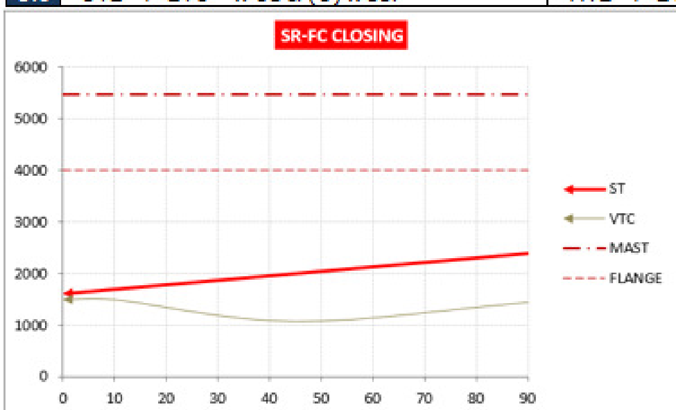
Conclusion: Can not be selected because of violating rules 2 and 3!

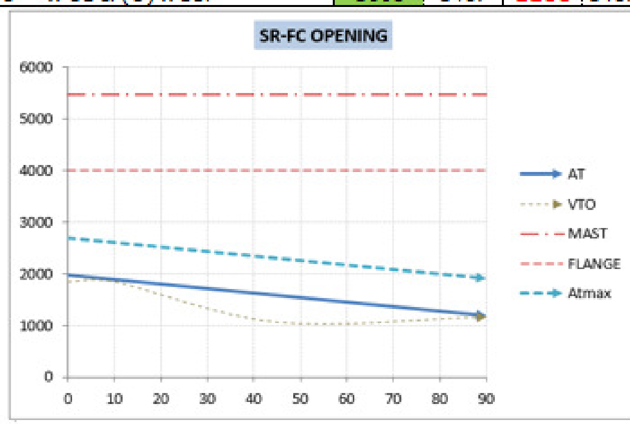
Application	Torque		net	FC	FO	uom
- ball valve	Sizing Safety Factor	SFF	1.2			
- trunnion mounted	Break to Open	BTO	1105	1856	2281	Nm
- 150# rating	break to Open @ ba	BTOba	1105	1856	2281	Nm
- 10" size	Run to Open	RTO	635	1067	1067	Nm
- soft seated	End to Open	ETO	695	1168	1168	Nm
- ISO flange F16, 4000 Nm	Break to Close	BTC	695	1434	1168	Nm
- pmax/pmin = 6.0 / 5.0 barg or 20% pressure rang	Run to Close	RTC	635	1067	1067	Nm
- breakaway angle 10°	End to Close	ETCba	835	1487	1487	Nm
	End to Close	ETC	835	1487	1487	Nm

Case 2				
	Air to Start @ pmax	ATSmax	2700	Nm
Rack and Pinion Actuator	Air to Start	ATS	1982	Nm
- size 4000	Air to Run	ATR	1585	Nm
- 5/6 springs	Air to End	ATE	1188	Nm
	Spring to Start	STS	2401	Nm
	Spring to Run	STR	2005	Nm
	Spring to End	STE	1608	Nm

1	Maximum air supply pressure < actuator allowable operating pressure	10	12	barg
2	Maximum air torque start (ATS_{max}) < ISO 5211 flange torque as per ISO 5211	2700	4000	Nm
3	Spring start torque (STS) < ISO 5211 flange torque as per ISO 5211	2401	4000	Nm
4	Maximum air torque start (ATS_{max})< minimum of all drive train elements MAST values	4918	5466	Nm
5	Actuator spring torque > valve torque on demand over the full travel in both directions.			
	Actuator air torque > valve torque on demand over the full travel in both directions.			

	FAIL CLOSE	FAIL OPEN	FC		FO	
5.1	ATS > BTO x ODCF(Θ) x SSF	STS > BTO x ODCF(Θ) x SSF	1982	1856	2401	2281
5.2	ATR_{ba} > BTO_{ba} x ODCF(Θ) x SSF	STR_{ba} > BTO_{ba} x ODCF(Θ) x SSF	1894	1856	2313	2281
5.3	ATR > RTO x ODCF(Θ) x SSF	STR > RTO x ODCF(Θ) x SSF	1585	1067	2005	1067
5.4	ATE > ETO x ODCF(Θ) x SSF	STE > ETO x ODCF(Θ) x SSF	1188	1168	1608	1168
5.5	STS > BTC x ODCF(Θ) x SSF	ATS > BTC x ODCF(Θ) x SSF	2401	1434	1982	1168
5.6	STR > RTC x ODCF(Θ) x SSF	ATR > RTC x ODCF(Θ) x SSF	2005	1067	1585	1067
5.7	STR_{ba} > ETO_{ba} x ODCF(Θ) x SSF	ATR_{ba} > ETC_{ba} x ODCF(Θ) x SSF	1696	1487	1276	1487
5.8	STE > ETC x ODCF(Θ) x SSF	ATE > ETC x ODCF(Θ) x SSF	1608	1487	1188	1487





FC									
CLOSE				OPEN				avg	Σ
E	oa	R	S	S	oa	R	E		
0	10	45	90	0	10	45	90		
8%	14%	88%	67%	7%	2%	49%	2%	21%	23%

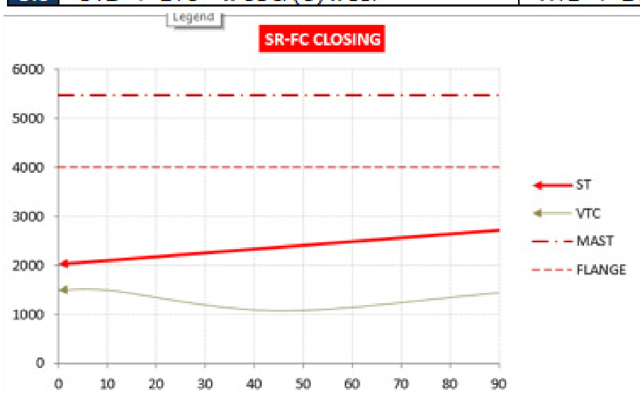
Conclusion: Can be selected for FC application, but not for FO application because of violating rules 5.7 and 5.8

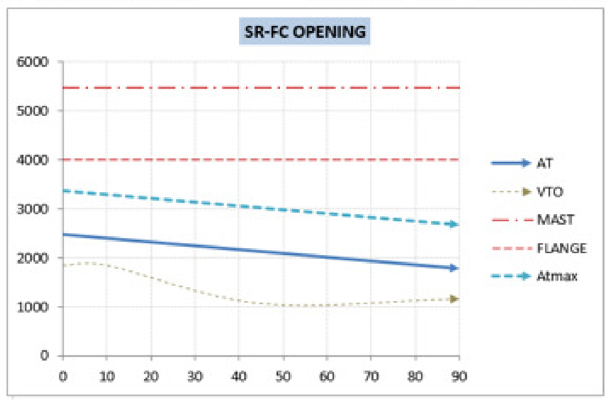
Application	Torque		net	FC	FO	uom
- ball valve	Sizing Safety Factor	SFF	1.2			
- trunnion mounted	Break to Open	BTO	1105	1856	2281	Nm
- 150# rating	break to Open @ ba	BTOba	1105	1856	2281	Nm
- 10" size	Run to Open	RTO	635	1067	1067	Nm
- soft seated	End to Open	ETO	695	1168	1168	Nm
- ISO flange F16, 4000 Nm	Break to Close	BTC	695	1434	1168	Nm
- pmax/pmin = 6.0 / 5.0 barg or 20% pressure rang	Run to Close	RTC	635	1067	1067	Nm
- breakaway angle 10°	End to Close	ETCba	835	1487	1487	Nm
	End to Close	ETC	835	1487	1487	Nm

Case 3				
	Air to Start @ pmax	ATSmax	3381	Nm
Rack and Pinion Actuator	Air to Start	ATS	2481	Nm
- size 5000	Air to Run	ATR	2131	Nm
- 5/6 springs	Air to End	ATE	1781	Nm
	Spring to Start	STS	2724	Nm
	Spring to Run	STR	2374	Nm
	Spring to End	STE	2023	Nm

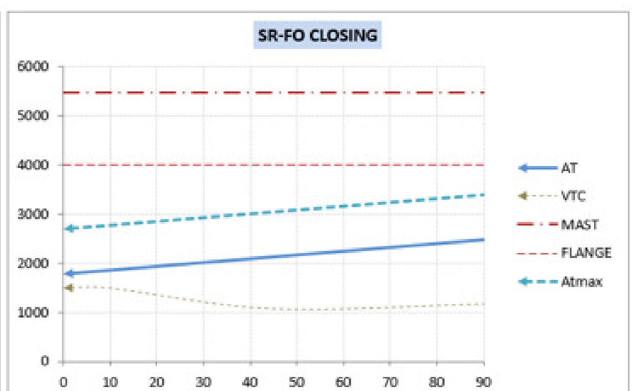
1	Maximum air supply pressure < actuator allowable operating pressure	10	12	barg
2	Maximum air torque start (ATS_{max}) < ISO 5211 flange torque as per ISO 5211	3381	4000	Nm
3	Spring start torque (STS) < ISO 5211 flange torque as per ISO 5211	2724	4000	Nm
4	Maximum air torque start (ATS_{max})< minimum of all drive train elements MAST values	4918	5466	Nm
5	Actuator spring torque > valve torque on demand over the full travel in both directions.			
	Actuator air torque > valve torque on demand over the full travel in both directions.			

	FAIL CLOSE	FAIL OPEN	FC		FO	
5.1	ATS > BTO x ODCF(Θ) x SSF	STS > BTO x ODCF(Θ) x SSF	2481	1856	2724	2281
5.2	ATR_{ba} > BTO_{ba} x ODCF(Θ) x SSF	STR_{ba} > BTO_{ba} x ODCF(Θ) x SSF	2403	1856	2646	2281
5.3	ATR > RTO x ODCF(Θ) x SSF	STR > RTO x ODCF(Θ) x SSF	2131	1067	2374	1067
5.4	ATE > ETO x ODCF(Θ) x SSF	STE > ETO x ODCF(Θ) x SSF	1781	1168	2023	1168
5.5	STS > BTC x ODCF(Θ) x SSF	ATS > BTC x ODCF(Θ) x SSF	2724	1434	2481	1168
5.6	STR > RTC x ODCF(Θ) x SSF	ATR > RTC x ODCF(Θ) x SSF	2374	1067	2131	1067
5.7	STR_{ba} > ETO_{ba} x ODCF(Θ) x SSF	ATR_{ba} > ETC_{ba} x ODCF(Θ) x SSF	2101	1487	1859	1487
5.8	STE > ETC x ODCF(Θ) x SSF	ATE > ETC x ODCF(Θ) x SSF	2023	1487	1781	1487





FC									
CLOSE				OPEN				avg	Σ
E	oa	R	S	S	oa	R	E		
0	10	45	90	0	10	45	90		
36%	41%	122%	90%	34%	29%	100%	53%	53%	87%



FO									
OPEN				CLOSE				avg	Σ
S	ba	R	E	E	ba	R	S		
0	10	45	90	0	10	45	90		
19%	16%	122%	73%	20%	25%	100%	112%	56%	76%

Conclusion: Can be selected for both FC and FO applications

	DOWEL PIN CALCULATION	**N°:**		
		Page:	**1/2**	29-05-19

Dowel Pin is a mechanical component suitable to align two pieces and useful to transmit the torque. This sheet defines the mathematical method (based on engineering good practice regulations) useful to calculate the PIN dimension to avoid any twist effect between valve and the actuator.

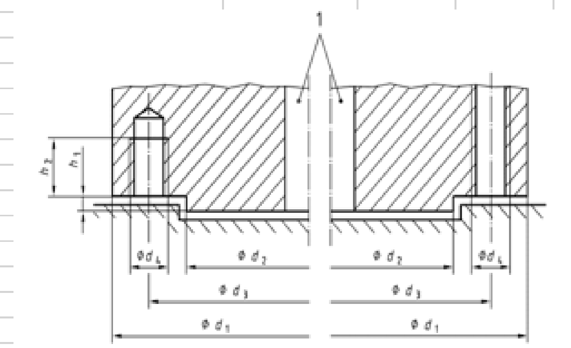
References: Design of machine elements - V.B. Bhandari - 3° edition
Mechanical Manual - 8°Edition (2011) - Hoepli

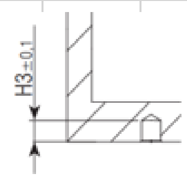
Hypothesis

- **no friction between Actuator and Valve ISO flanges (Worst case)**
- **no deformation**
- **Dimension and data referred on ISO 5211**
- **N°3 Dowel PIN for defined positioning between valve and actuator**
- **Minimum Dowel Pin Yield strength = 190 Mpa**

Editable cell

Information data





Iso Flange (5211) type	Max. flange Torque [Nm]	Ød$_3$	N°3 PIN - D$_{pin}$	H$_{3\ min}$
F05	125	50	5	4
F07	250	70	6	4
F10	500	120	8	6
F12	1000	125	10	7
F14	2000	140	12	8
F16	4000	165	16	11
F25	8000	254	18	13
F30	16000	298	25	18
F35	32000	356	30	21
F40	63000	406	40	28
F48	125000	483	50	35
F60	250000	603	65	46

-if the yield stress of dowel pin material is lower than yield stress of ISO flange, the Crushing calculation is always verified with "H3$_{min}$" = 0,7*pin diameter.

Dowel Pin Calculation

Dowel Pin Material		Stainless Steel			
Minimum Ultimate tensile strength	R_m	515	Mpa	Iso Flange	
Minimum Yield strength	Rp_{02}	190	Mpa	F30	
Safety factor on ultimate tensile strength	S_m	1.8			
Safety factor on yield strength	S_y	1.25			
Design Torque	C	16000	Nm		
Center distance	d_3	298	mm		
Number of Dowel pin	N	3			
Dowel pin dimension	D_{pin}	25	mm		

Formule

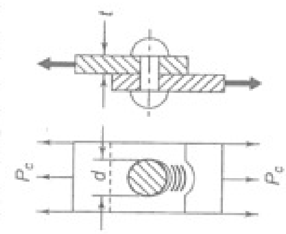
$$\tau_a = \frac{min\left(Rp_{02}/S_y ; R_m/S_m\right)}{\sqrt{3}} \qquad F_s = \frac{C * 1000}{N * \frac{d_3}{2}} \qquad A_p = \frac{\pi D_{pin}^2}{4} \qquad \tau = \frac{F_s}{A_p} \qquad SF = \frac{\tau_a}{\tau} > 1$$

Allowable shear	τ_a	88	Mpa
Shear Force	F_s	35794	N
PIN area	A_p	490.9	mm^2
Shear stress	τ	73	Mpa
Safety factor > 1 OK	SF_1	1.20	OK

Crushing Failure of plate (ISO Flange) (calculation

This type of failure occurs when the compressive stress between the shank of the dowel pin and plate exceeds the yield stress in compression.

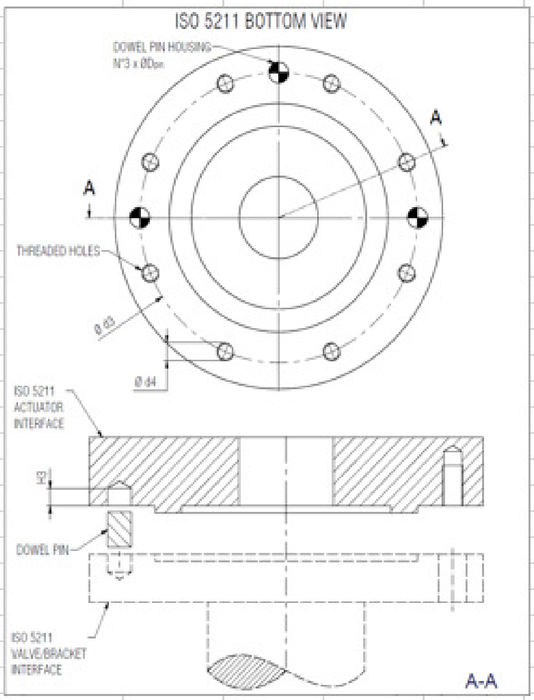
ISO Flange Material		Stainless Steel	
Minimum Ultimate tensile strength	R_m	515	Mpa
Minimum Yield strength	Rp_{02}	190	Mpa
Safety factor on ultimate tensile strength	S_m	1.8	
Safety factor on yield strength	S_y	1.25	
Thickness	t	12.5	



Formule

$$\sigma_a = min\left({}^{Rp_{02}}/_{S_y} ; {}^{Rm}/_{S_m} \right) \qquad \sigma_c = \frac{F_s}{D_{pin} \cdot t} \qquad SF = \frac{\sigma_a}{\sigma_c} > 1$$

Allowable stress	σ_a	152	Mpa
Plate stress	σ_c	115	Mpa
Safety factor > 1 OK	SF_2	1.33	OK



ANNEX K AV ASSEMBLY PUBLICATIONS ARCHIVE

AV Assembly aspects have been presented and discussed at conferences, workshops and seminars since 2015. Below a summary of those activities. The material used in those events is publicly available.

AV Assembly Publications

#	year		file type	# slides pages	file size Mb	author	title	Focus: GENERAL	**A**ctuators	**D**ynamic torque	**E**ngineered Product	**E**xtreme fast stroking operation	**P**rototyping	**R**ecommended Practice	**R**eliability	
1	1993	Waternet	pdf	5		W Rahmeyer	Using coefficients to predict dynamic flow torque for quarter-turn valves			X						
2	2006	Valve World Conference 2006 Maastricht	ppt	12	0.15	K Meliefste	Sizing and selection of Automated On/Off Valves, a hurdle race!" An end-user perspective				X					
3		NRC/ASME Symposium on valve and pump testing	pdf	13	0.7	*	Dynamic Torque Models for Quarter-Turn Air-Operated Valves			X						
4	2013	Utah State University Digital Commons@USU	pdf	94	1.4		Transient Effects on Dynamic Torque for Butterfly Valves			X						
5						R Mason	Unique Operating Dynamics of Trunnion-Mounted Ball Valves			X						
6	2016	Valve World Conference 2016 Dusseldorf	ppt	67	60	*	SIS valve assemblies reliability prediction - Part I Pneumatic Heavy Duty Actuators		X			X			X	
7	2017	Industrial Valve Summit IVS 2017	ppt	49	3	*	ESDV reliability prediction workshop				X	X			X	
8	2017	Valve World Americas Conference 2017	ppt	75	30	*	ESDV Assembly reliability prediction workshop				X	X			X	
9						S Allen						X				
10			pdf			A Kassab	Impact of rotary control ball valve geometry on dynamic torque coefficient & actuator sizing			X						
11	2017	AV Assembly Seminar #1 @ Puffer Sweiven	*			*	Automated Valves Reliability Prediction Seminar - ESDV assemblies	X		X	X	X			X	
12	2018	AV Assembly Seminar #2 @ Emerson Automation	*			*	AV Assemblies - Recommended Practice			X				X		
13	2018	Texas A&M 2019 instrumention symposium	ppt			HH / KM	(SIS) Actuated Valve Assemblies							X		
14			ppt			J Holstrom	AV Assembly Challenges			X						
15	2018	Namur Haubtsitzung 2018	ppt			K Meliefste	WIB AV Assembly RP							X		
16	2018	Industrial Valves magazine	pdf			AV / HH	How to solve the AV Assembly Torque Requirement Puzzle?						X	X		
17	2018	Valve World Conference 2018 Dusseldorf	ppt			H Hinssen	WIB AV Assembly RP / CONVAL 11 compliant prototype						X	X		
18	2019	AV Assembly Seminar #3 @ ExxonMobil Houston	*			*	AV Assembly initiatives proceedings						X	X		
19	2019	Texas A&M 2019 instrumention symposium	ppt			HH / KM	AV Assembly initiatives						X	X		