Treating of “Automated Valve Assemblies” as “Engineered Products”

ANDREAS VOGT

What does the implementation of Recommended Practice S2812-X-19 or ISO/TC 153 N 425, ISO/NP 5115 in practice mean for the various groups involved such as valve and actuator manufacturers, integrators, and end-users of automated valve assemblies?

In June 2019, the “Recommended Practice S2812-X-19” (hereinafter referred to as RP) was published by the WIB at the Valve World Americas Conference in Houston [1]. The RP is entitled „Actuated Valve Assembly - A Recommended Practice for Part turn Automated On-Off valves“ and addresses the issue (including the definition of the general conditions) of sizing, selection, and the mechanical integrity of automated valve assemblies widely used in many industries.

NEW MODULE FOR CONVAL

Since F.I.R.S.T. has comprehensively supported the development of the RP both in principle and with functional prototypes, it is a matter of course that a module will soon be available in CONVAL® that fully maps the RP. Recognizing the importance of the issue for the worldwide community, the ISO has taken up the task of developing an international ISO standard with RP as a basis [2]. At this point, the ISO even goes one step further than the RP in considering electric actuators, as the RP is limited to pneumatic (and in a broader context hydraulic) actuators.

I have already published a paper on this topic in Industrial Valves, so I will not go into all the details of the RP here but only give an overview. The focus will be on the requirements for the implementation of the RP in practice, from the various perspectives. The viewpoint of the manufacturers of the valves, the actuators, possible integrators as well as that of the end-users.

THE CORRECT DESIGN OF ACTUATORS

Recently I gave two webinars on this topic at the virtual „Forum Industriearmaturen“ and during the introduction, I made a small poll among the participants. Each one of the webinar participants confirmed that they had cases of valves in their practice that did not open or close when required or even sheared off the stem. For me a clear indication of the importance of the topic for the industrial valve user community.

If one were to summarise the objectives of the RPs in a few sentences, it could be described as follows:

- If you automate rotary valves as shut-off valves, you have to find the right actuator for the required torque, which is derived from the valve and application data.
- On the one hand, this actuator should have enough torque and an adequate safety margin to operate the valve safely under all expected conditions.
- On the other hand, it should not be oversized, and not just for cost reasons. It must not be designed in such a way that the torque delivered may damage the valve, seat, or stem.
- The design should take into account all relevant data and conditions of the equipment used and the application itself.
- The selection made should be documented comprehensively, completely, and uniformly so that it can be traced at any time.

9		Environmental conditions			corrosive			End user
Application								
		Requested acting mode			Spring return			End user
10		Valve fail safe action			Fail close			End user
11		Travel time	open/close		10,0	5,0	s	End user
12		Response time	open/close		20,0	8,0	s	End user
13		Air supply pressure	min/max		4,0	10,0	bar(g)	End user
Process								
14		Medium			hydrocarbon + tar			End user
15		State / phase						End user
16		Mass flow rate				100.000,0	kg/h	End user
17		Volume flow rate				125,0	m^3/h	End user
18		Density				900,0	kg/m^3	End user
19	1,3	Long standstill time				11,0	month(s)	End user (1)
20	1,4	Non-clean service			Yes			End user (1)
		Slurries			No			End user (1)
		Chrystallizing or polymerizing media			No			End user (1)
		Lubricating liquid			No			End user (1)
		Sticky, non-lubricating liquid			No			End user (1)
		Non-lubricating dry gas			No			End user (1)
23		Fluid operation temp.	min/max	t1,min	10,0	40,0	°C	End user (1)
24		Max. shut off pressure (valve closed)		Δp		80,0	bar	End user
25		Design pressure				28,987	bar(g)	End user
Valve								
27		Valve manufacturer			Sern			End user
28		Valve series			Full port, class 150			End user
29		Valve type			Ball valve			End user
30		Valve design			Trunnion mounted			End user
31		Port type			Full port			End user
32		Flow direction						End user
33		Seat sealing type			Soft seated			End user
34		Seat material						End user
35		Seating method			Position seated			End user
36		Pressure rating			Class 150			End user
37		Tightness rate/class						End user
38		Selected valve size			10"			End user
40	1,4	Break to open torque	net/ODCF corr.	BTO	1.105,0	1.547,0	Nm	Valve mfr
41		Breakaway angle		θ		10,0	°	Valve mfr
42	1,4	Run to open torque	net/ODCF corr.	RTO	635,0	889,0	Nm	Valve mfr
43	1,4	End to open torque	net/ODCF corr.	ETO	695,0	973,0	Nm	Valve mfr
44	1,82	Break to close torque	net/ODCF corr.	BTC	695,0	1.264,9	Nm	Valve mfr
45	1,4	Run to close torque	net/ODCF corr.	RTC	635,0	889,0	Nm	Valve mfr
47	1,4	End to close torque	net/ODCF corr.	ETC	885,0	1.239,0	Nm	Valve mfr
48		Max. allowable stem torque		MAST		5.466,0	Nm	Valve mfr
49		Max. flange torque		f,max		4.000,0	Nm	Valve mfr
50		Stem / top works dimensions provided			No			Valve mfr
Mounting kit								
51		Material						Mounting Kit mfr
53		Max. allowable coupling torque		MAST,c			Nm	Mounting Kit mfr
54		MK mechanical integrity checked and documented			No			Mounting Kit mfr

Figure 1: "Automated Valve Data Sheet", extract

When you look at the RP it quickly becomes clear that the approach described makes perfect sense by itself, but immediately raises many more questions and demands on the groups involved. I have already outlined these in the DIAM 2019 lecture program [3]. It should not be forgotten that RP was initially conceived from the perspective and driven by the needs of end-users in the process industry. However, to implement it, a profound acceptance, transparency, and openness on the part of the manufacturers of actuators and especially valves are required.

AUTOMATED VALVES AND ENGINEERED PRODUCTS

But first to the question "Why all this?". In short, because today automated valves are not treated as "Engineered

Maximum Allowable Stem Torque (MAST)

Table B - Analytical calculations based on Roark formulas

Stem	Unit	316/316L A479 S31600/ S31603	17-4PH A564 H1150D S17400	Alloy C22 B574 N06022	Alloy 20 B473 N08020	Monel 400 A164 N04400	Duplex A479 S31803	Super Duplex A479 S32750	254 SMO A479 S31254	Titanium Gr.2 B348 R50400	Inconel 718 B637 N07718
½"	Nm	9.90	29.02	12.98	8.20	8.20	15.37	17.59	10.41	9.39	35.34
	inch*lbs	87.64	256.89	114.84	72.53	72.53	136.00	155.64	92.18	83.11	312.80
1"	Nm	22.63	66.34	29.66	18.73	18.73	35.12	40.20	23.80	21.46	80.78
	inch*lbs	200.33	587.17	262.50	165.79	165.79	310.86	355.76	210.69	189.97	714.97
1½"	Nm	39.61	116.10	51.90	32.78	32.78	61.46	70.34	41.66	37.56	141.37
	inch*lbs	350.58	1027.55	459.38	290.13	290.13	544.00	622.57	368.71	332.44	1251.19
2½"	Nm	137.22	402.20	179.80	113.56	113.56	212.93	243.68	144.32	130.12	489.73
	inch*lbs	1214.50	3559.73	1591.41	1005.10	1005.10	1884.56	2156.78	1277.31	1151.68	4334.49
3"	Nm	230.59	675.85	302.15	190.83	190.83	357.80	409.49	242.51	218.66	822.95
	inch*lbs	2040.85	5981.81	2674.22	1688.98	1688.98	3166.84	3624.27	2146.41	1935.29	7283.74
3" DD	Nm	202.29	592.93	265.07	167.41	167.41	313.90	359.24	212.76	191.83	721.98
	inch*lbs	1790.44	5247.85	2346.10	1481.75	1481.75	2778.27	3179.58	1883.05	1697.83	6390.03
6"	Nm	792.20	2321.95	1038.05	655.61	655.61	1229.27	1406.83	833.17	751.22	2827.32
	inch*lbs	7011.52	20551.01	9187.51	5802.64	5802.64	10879.95	12451.49	7374.19	6648.86	25023.88

Figure 2: MAST (Maximum Allowable Stem Torque)

Product". Safety, application, and possible further factors remain unclear and the procurement of valve, coupling, and the actuator is often in different hands. As a result, they are not considered as assemblies and responsibilities for the final delivered solution often remain unclear. The RP clearly defines the responsibilities for the required data and keeps them in the documentation, the "Automated Valve Data Sheet". There, the right-hand column

Modellnummer	Maximales Drehmoment Nm	3 BAR ASYMMETRISCH Abtriebsdrehmoment (Nm) BTO	RTO	ETO	BTC	RTC	ETC
~~xxxxxxx~~	9.000	2.327	908	1.289	1.229	895	2.528
~~xxxxxxx~~	9.000	3.304	1.290	1.830	1.754	1.278	3.607
~~xxxxxxx~~	9.000	4.730	1.847	2.620	2.513	1.830	5.167
~~xxxxxxx~~	9.000	6.269	2.448	3.472	3.340	2.433	6.867
~~xxxxxxx~~	9.000	8.030	3.135	4.448	4.286	3.122	8.812
~~xxxxxxx~~	18.000	5.637	2.229	3.122	2.995	2.238	6.157
~~xxxxxxx~~	18.000	7.471	2.955	4.138	3.980	2.974	8.183
~~xxxxxxx~~	18.000	9.570	3.785	5.300	5.107	3.816	10.502
~~xxxxxxx~~	18.000	11.896	4.705	6.589	6.357	4.750	13.071
~~xxxxxxx~~	18.000	14.441	5.665	7.921	7.664	5.625	15.794
~~xxxxxxx~~	32.000	9.808	3.830	5.433	5.212	3.797	10.715
~~xxxxxxx~~	32.000	12.564	4.906	6.960	6.677	4.864	13.728
~~xxxxxxx~~	32.000	15.618	6.098	8.651	8.319	6.060	17.102
~~xxxxxxx~~	32.000	19.069	7.446	10.563	10.173	7.410	20.914
~~xxxxxxx~~	32.000	22.877	8.933	12.672	12.219	8.901	25.121
~~xxxxxxx~~	32.000	27.046	10.561	14.982	14.459	10.533	29.725

Figure 3: Different torques

clearly shows who is responsible for the data (**Figure 1**). Nothing is surprising on the end-user side, the data can all be obtained from the process engineering department and the valve manufacturer. However, if you want to choose a suitable actuator, you will need a lot more information about the valve, the mounting kit, and the potential actuator.

Ideally, as implemented in CONVAL®, the requirements of the process are specified, supplemented by information on factors (media properties, long standstill times, etc.) that could further influence the torque requirement, a valve is selected from the database and, after entering a safety factor for the design, the appropriate actuator can be selected.

This ideal case, however, requires that valve and actuator manufacturers have determined and published the required key parameters of their devices and that these are also stored in the database. Of course, manual input is always possible if the data is not available in the database. On the actuator side, this is standard, usually the data on torques, flange design according to ISO 5211, etc. are published in full [4]. Even if these have not yet been captured in the database, the entry is quickly completed with just a few values, taken directly from the documentation of the actuator manufacturer.

With the valves, the situation is different for a variety of reasons. Things like the MAST (Maximum Allowable Stem Torque) can still be found, depending on the stem material (**example Figure 2**), as they are more or less easy to calculate by the manufacturer [5]. The flange class according to ISO 5211 is also no problem. However, RP still expects, for the calculation of the required torque of the valve, six different torques (**as shown in Figure 3 as an example**) matching the differential pressure. Furthermore, a breakaway angle as well as correction factors for the application are required.

PENT-UP DEMAND FOR TECHNICAL DATA

Sometimes, however, the maximum torque is the only information available. There are rules of thumb (for each valve style) like e.g. BTO, ETC = 100%, RTO, RTC=40%-50%, ETO, BTC=70%, but these should be used with caution and do not conform to the RP or the upcoming ISO standard.

In practice, however, there are unfortunately hardly any publicly available and fully documented torques, so that there seems to be a considerable backlog demand on the part of the valve manufacturers.

The situation is similar for the correction factors for the application conditions (defined as ODCFs in the RP). Some manufacturers specify factors for different situations (**example Figure 4**), but these do not necessarily corres-

Corrections factors - special application

Emergency shut-down (ESD) service	1.8
IEC 61508 SIL complaint installation	1.8
Cryogenic applications (below -60 °C)	1.5
Valves operated less than once a day	1.5
Control valves	1.5

Corrections factors - Media

Gas, dirty (natural gas)	1.5
Gas , dry	1.3
Chlorine	1.5
Viscous slurry (cp>100)	2.0
Oil, thermal oil, lubricant	0.8

Figure 4: Various correction factors

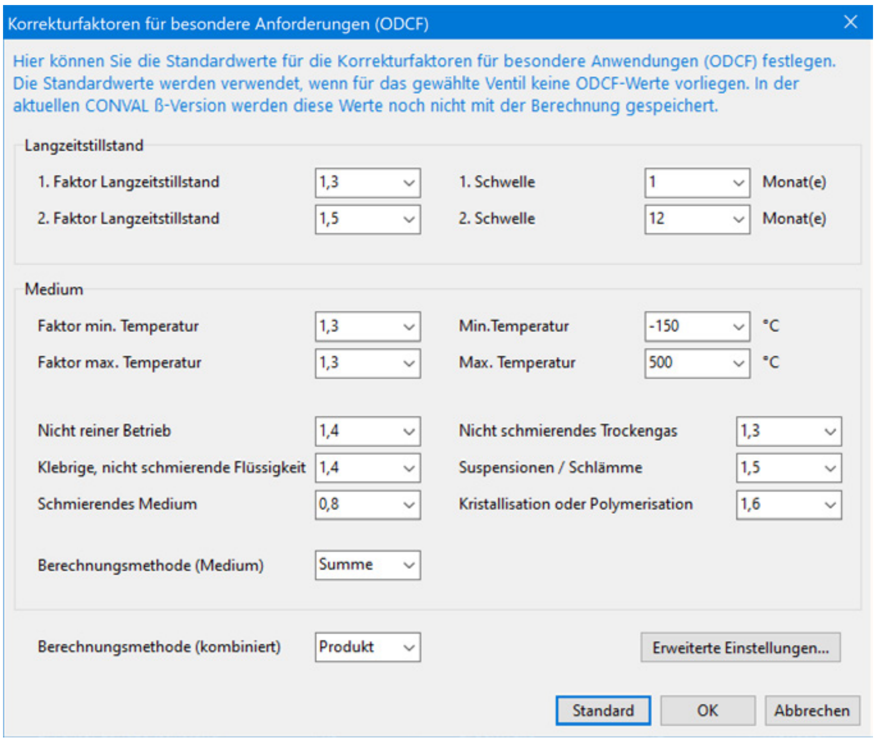

Figure 5: Correction factors for special requirements

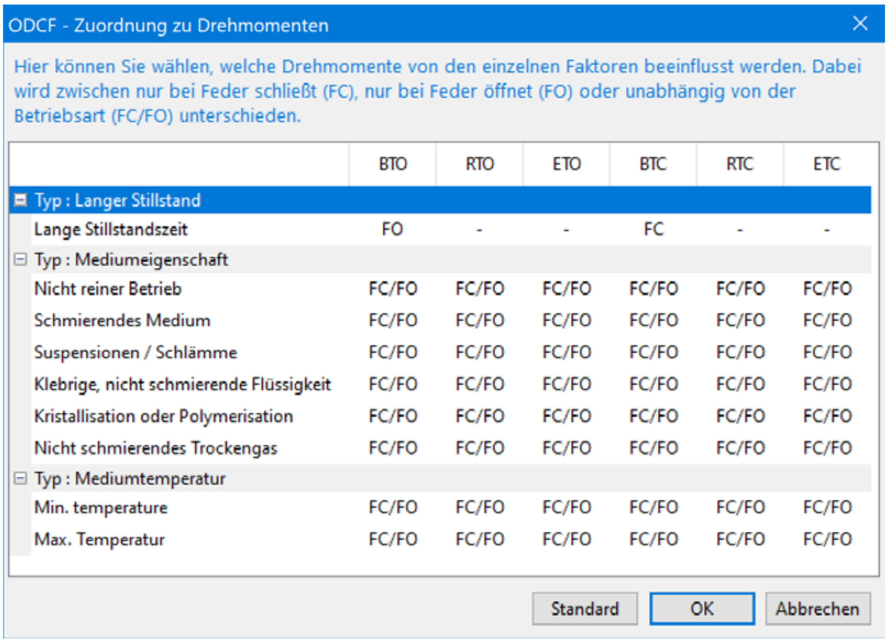

Figure 6: Assignment to torques

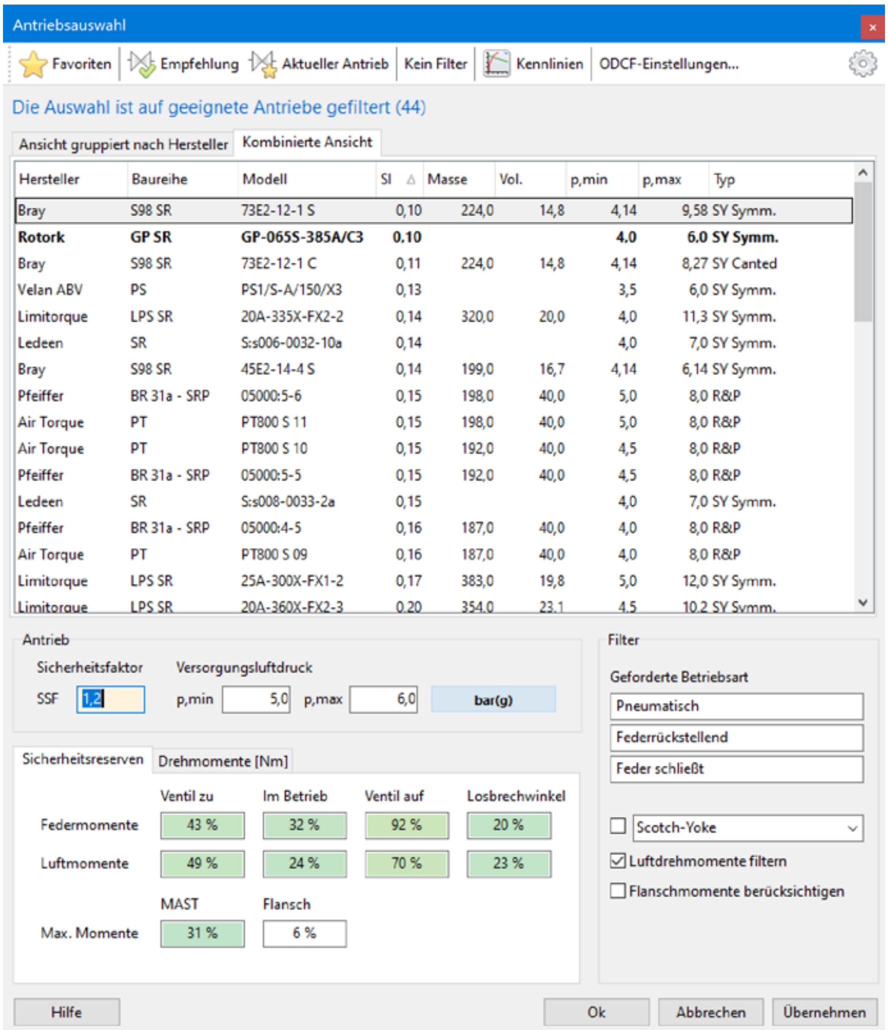

Figure 7: Easy actuator selection

pond to the system of factors in the ODCFs and certainly do not define how to proceed when several factors come together (add, increase, multiply, etc.). As defined by the RP, CONVAL® allows each manufacturer of valves to configure these factors for each valve series and to define how they are handled individually. This applies to the factors and their application limits (see Figure 5) as well as to the question to which torque the factor should be applied (see Figure 6). For example, by default (RP recommendation) the factor for long standstill times for the safety function "spring closes" is only applied to the BTC, for "spring opens" only to the BTO. In the case of series-production valves (larger number of pieces/year), there is a chance to obtain this data from the manufacturer, but in the case of so-called "one of a kind", i.e. unique valves specially designed for the case, the effort and cost to determine the data are enormously high. In this case, the user can only make progress through intensive cooperation with the manufacturer.

RP CONFORMS ACTUATOR SELECTION IS POSSIBLE

The described situation makes it very clear how detailed the determination of the required torques for the safe operation of the valve is implemented in the RP and will soon be required by ISO. It is obvious which hurdles still have to be overcome before an end-user, or whoever has to find the right actuator for a valve, can simply follow the RP and comply with the ISO.

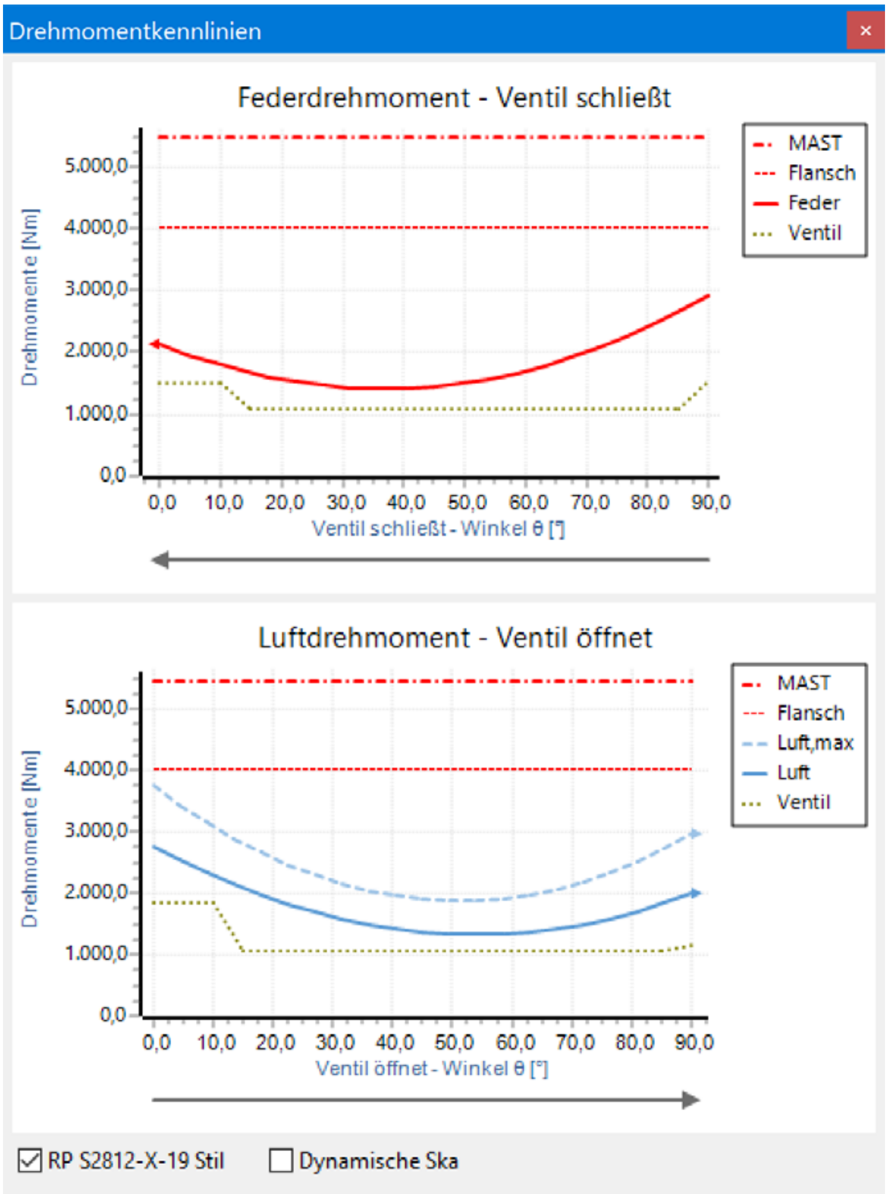

Figure 8: Graphical representation of the selected actuator

But once the hurdles have been overcome and the necessary data made available, these can, in combination with a software module such as in CONVAL®, make design, selection, and documentation considerably easier, more reliable, and reproducible.

If all the data is available, a suitable actuator, automatically rated and sorted by a "Suitability Index" (KPI for the suitability of the actuator for the application) is suggested and the selection is clearly structured (**Figure 7**) and graphically supported (**Figure 8**).

It is clear that the path is well described and tools for implementation will soon be available.

However, based on decades of practical experience in the field of control valves, I assume that it will still take considerable time and effort until device data is generally available and of good quality.

But that should not prevent us from embarking on this approach now.

LITERATURE

[1] WIB – "The International Process Automation Users' Association" www.WIB.nl

[2] ISO/TC 153 N 425, ISO/NP 5115 "Industrial valves - Part-turn valve actuation"

[3] Vulkan Verlag - IndustrialValves, Issue 2018/2019, "How to solve the Actuated Valve (AV) Assembly Torque Requirement Puzzle?", free Download www.industriearmaturen.de/en

[4] DIAM Leipzig 2019 - Von der "Automated Valve assemblies Recommended Practice" (AVRP) zum ISO Standard – „Was steckt drin für Hersteller von Ventilen, von Antrieben und den Endanwender"

[5] DIN EN ISO 5211 - Industriearmaturen - Anschlüsse von Schwenkantrieben

[6] Roark's Formulas for Stress and Strain

Author

ANDREAS VOGT
F.I.R.S.T. Gesellschaft für technisch-wissenschaftliche Softwareanwendungen mbH
42908 Wermelskirchen
Tel.: +49 2196 88778-12
a.vogt@firstgmbh.de