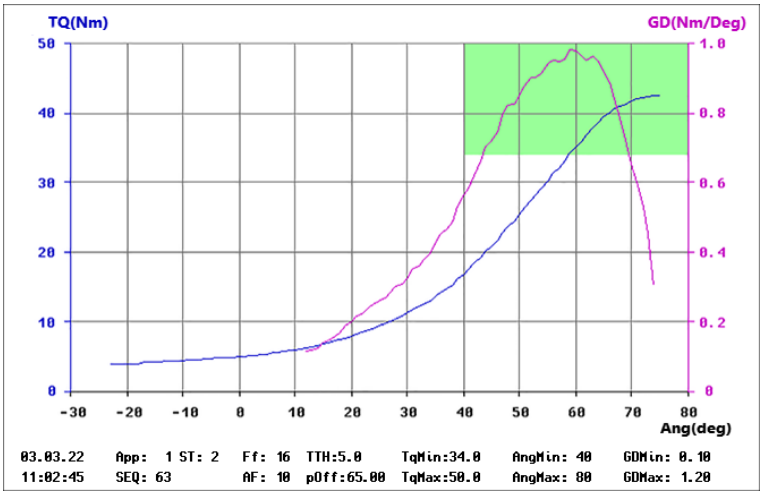
Programming Manual
P1730PM-EN
REV Q | 2024-12

Fastening Sequences



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Content

1 About this Document

This document is intended for qualified employees responsible for installation, procedural, processing and quality technology (administrators, maintenance technician, service).
It contains information about fastening sequences for electrically powered tools.

The original language of this document is German.

Symbols in the Text

italic	Menu options (e.g., Diagnostics) input fields, check boxes, radio buttons or dropdown menus.
>	Indicates selection of a menu option from a menu, e.g., *File* > *Print*.
<...>	Specifies switches, pushbuttons or the keys of an external keyboard, e.g., <F5>.
`Courier`	Indicates Filenames and paths, e.g., `setup.exe`.
•	Indicates lists, level 1.
–	Indicates lists, level 2.
a) b)	Indicates options.
➢	Indicates results.
1. (...) 2. (...)	Indicates action steps.
►	Indicates single action steps.

Abbreviations

Abbreviations	Description
Abbrev.	Abbreviation
OK	Result is OK. The result is within the target value tolerances.
TQ	Torque
NOK	Result is not in order. The result is outside the target value tolerances.
AN	Angle

2 Basic Fastening Sequences

Torque controlled tightening

With torque-controlled tightening, the fastener is tightened to a target torque. The target torque and the thread ratio produce a clamping force.

The required torque depends on the friction underneath the fastener head and the friction between the threads. Because this friction depends on the material pair and possibly on friction-reducing lubricants, the tightening angle must also be monitored and limited by appropriate minimum and maximum limits.

This sequence is simple to use in practice and supplies good repeating clamping force accuracy as long as the basic conditions (friction) do not change too much. If there is a higher requirement for the accuracy or if corresponding basic conditions change, a process with better clamp force reproducibility should be used.

Angle-controlled fastening sequence (exceeding the yield point)

An angle controlled tightening is an indirect measurement of fastener elongation. Because plastic deformation of the fastener is achieved, this process attains its maximum accuracy only if the joint is pretightened and then further tensioned to a specified angle in the plastic range of the fastener. Because the yield point is always reached or exceeded in this case, fluctuations in the clamping force attained result only from the variation of the yield point of the fasteners of one batch of fasteners.

The highest accuracy is reached when the yield point of the fastener material is exceeded. Plastic deformation of the fastener is tolerated, but limits its fitness for reuse, however.

A tightening factor is not required for this method because the fasteners are dimensioned according to the minimum pretensioning force. The fastener material is optimally utilized in this context. The tightening factor is assumed here to be "1".

Yield-point-controlled fastening sequence

Yield-point-controlled fastening sequences are based on the fact that when the yield point of the fastener material is reached, the tightening torque no longer increases on a linear basis as the angle increases. The joint is first tightened to an intermediate pretensioning force in order to bring all mating surfaces into contact. Then, the rate of change of torque vs. angle or gradient is calculated via an adjustable chord length. As soon as this gradient hits a certain amount of the maximum value when the yield point of the fastener material is reached, tightening process is terminated.

In this way, the clamping force achieved in the tightening of a fastener becomes largely independent of friction effects. Only the range of the yield point of the fastener material still has a substantial effect on the clamping force. The re-usability of fasteners tightened with "yield point control" is practically unaffected.

A tightening factor is not required for this method since the bolts are dimensioned according to the minimum tensioning force. The fastener material is optimally utilized in this context.

The text in this document is a shortened summary of excerpts from VDI 2230 and is meant for general information only.

The fastening sequences described on the following pages are fully or partially implemented in the Cleco controllers and represent the tightening methods discussed above as well as extended and combined versions of these.

Assignment of fastening sequences to tool series

The following table shows which fastenign sequence are suitable for which tool series.

Se-quence	Tool Series									
	18/48, 67, BB with mPro400GC	18/48, 67, NeoTek, BD with mPro400GCD	NeoTek, BD with mPro300GCD	BTS	BTi	LiveWire	CellCore	CellTek	CellClutch	I-Wrench
1	x[1]									
10	x	x	x	x	x					
11	x	x	x	x	x	x	x	x		
13	x	x	x	x	x					
15	x			x						
16	x	x	x	x	x	x				
20	x	x	x	x	x					
21	x[1]									
30	x	x	x	x	x	x	x	x		x
31	x	x	x	x	x	x	x	x		
32	x	x	x	x	x	x	x	x		
33	x	x	x	x	x					
35	x[1]	x[1]	x[1]							
41	x	x	x	x	x	x	x	x		
46	x	x	x	x	x	x	x	x		
47	x[1]	x[1]	x[1]			x				
48	x	x	x	x	x	x	x	x		
49	x[1]									
50	x	x	x	x	x	x	x	x		x
51	x	x	x	x	x	x	x	x		
56	x	x	x	x	x	x[2]		x[2]		
63	x	x	x	x	x			x		x
73	x	x	x	x	x			x		
75	x	x	x	x	x			x		
78	x	x	x	x	x			x		
80	x	x	x	x	x	x	x	x		
94	x[1]									
97									x	

[1] Special controller software version required
[2] Only angle shut off supported

3 Fastening Sequences

3.1 Sequence 10: Engagement Stage

The engagement stage improves the secure engagement of socket and fastener head. During this stage, the tool is alternately operated in both directions.

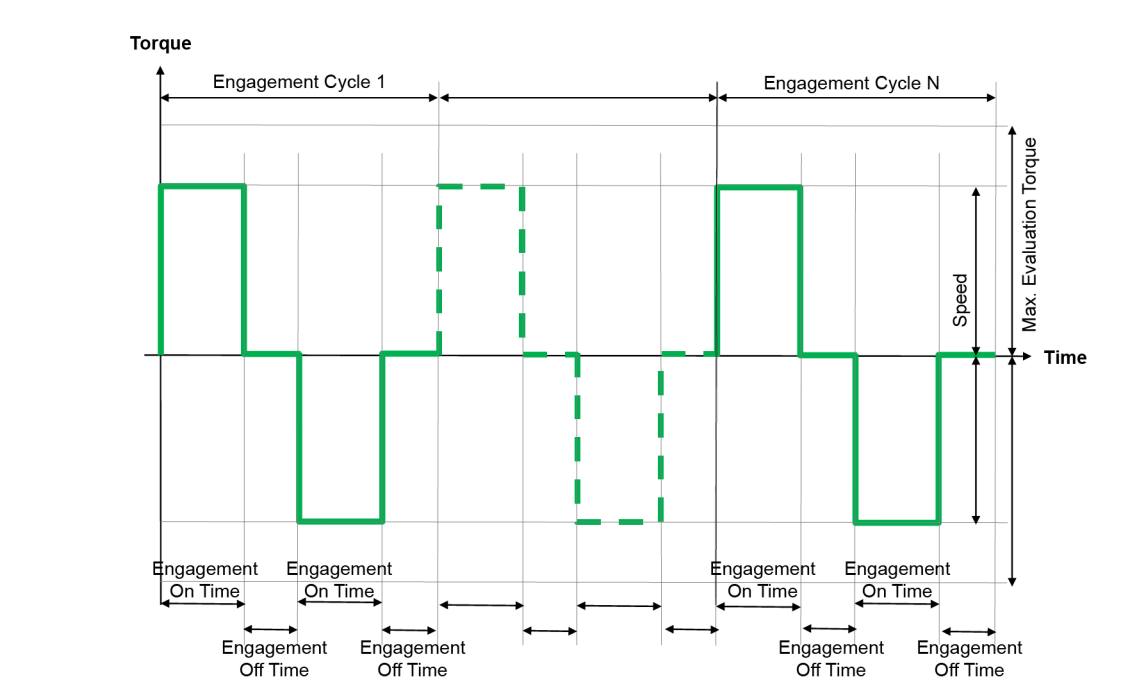

Fig. 3-1: Sequence 10

The *Engagement On Time* determines the duration of the clockwise/counterclockwise movement of the tool, the *Engagement Off Time* determines the pause after each movement. An engagement cycle consists of clockwise rotation – pause – counterclockwise rotation.

Via the installed transducer, the torque occurring during the rundown operation is recorded and processed in the controller. When the *Maximum Evaluation Torque* is reached or after the engagement cycle is completed, the tool is stopped. The last torque to be measured is fed to the controller.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects.	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage.	± Maximum speed	n (rpm)
Engagement On Time	The tool remains switched off throughout this time	Max. 0 … 29 000	tF off (ms)
Engagement Off Time	The tool remains switched on throughout this time	Max. 0 … 29 000	tF on (ms)
Engagement Cycles	Number of engagement stage cycles	1 … 250	N
Maximum Evaluation Torque	Maximum torque at which the engagement stage is terminated.	0 … 1 × TQ calibration value[1]	TqEmax
Maximum Tightening Time	Safety Shut-off	Applies for all tools of a tool group in this stage	

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

3.2 Sequence 11: High Speed Rundown

Shut-off torque controlled fastening up to a specified programmable torque target. This fastening sequence can be used as a fast pretightening stage for fasteners with long thread engagement, or as a way to decrease overall fastening cycle time (takt time).

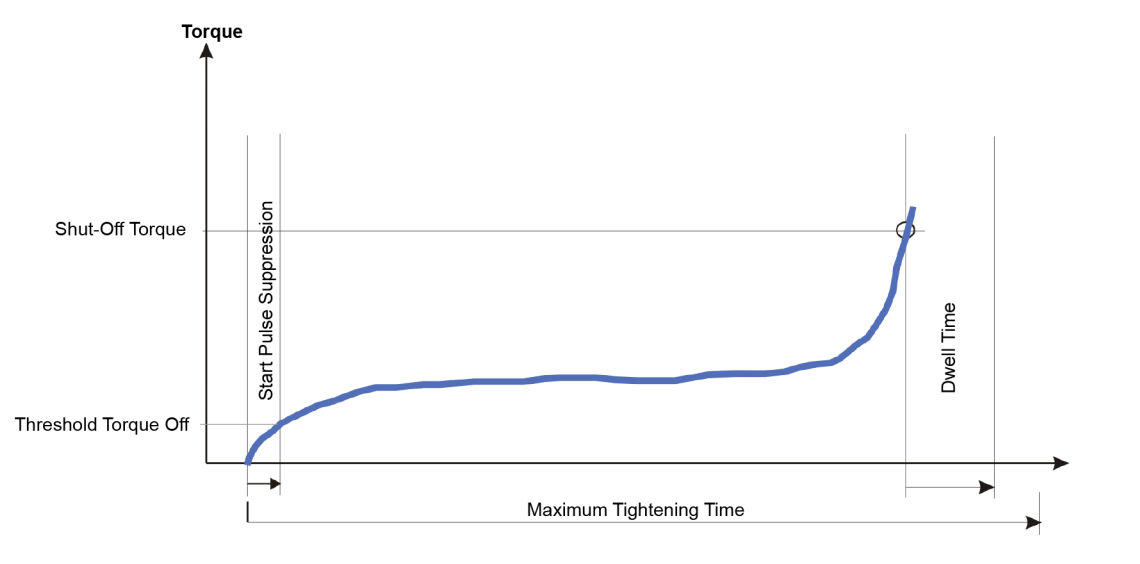

Fig. 3-2: Sequence 11

The torque occurring during the fastening sequence is measured by the installed transducer and processed in the controller. When the *Shut-Off Torque* is reached, the tool is stopped. Then, the peak torque is recorded during the dwell time and fed to the controller as the tightening torque of the fastener together with the evaluation of the rundown.

There are no high or low torque limits, nor is there any evaluation of angle of the fastener rotation.

When the *Trigger Torque* is reached, the torque trace is recorded and can be viewed via the trace function.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Shut-off Torque for the high speed rundown	0 … 1 × TQ calibration value[1]	TqP
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage.	± Maximum speed	n (rpm)
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1 × TQ capacity	TqTr
Maximum Tightening Time	Safety Shut-off	Applies for all tools of a tool group in this stage	

3.3 Sequence 13: Prevailing Torque Monitored

Shut-off torque controlled fastening up to a specified programmable torque target with partially monitored torque limits during tightening and subsequent torque analysis.

This fastening sequence can be deployed as a rapid pre-tightening stage with controlled rundown monitoring and subsequent evaluation.

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

In phase 1, it is possible, for example, to check for an "already tightened" fastener. In Phase 2 the correct engagement of the threads or the correct fastener length and/or thread depth can be checked. Moreover, an exact determination of the snug point is possible. At the snug point, two or more parts of the bolted joint are brought into contact.

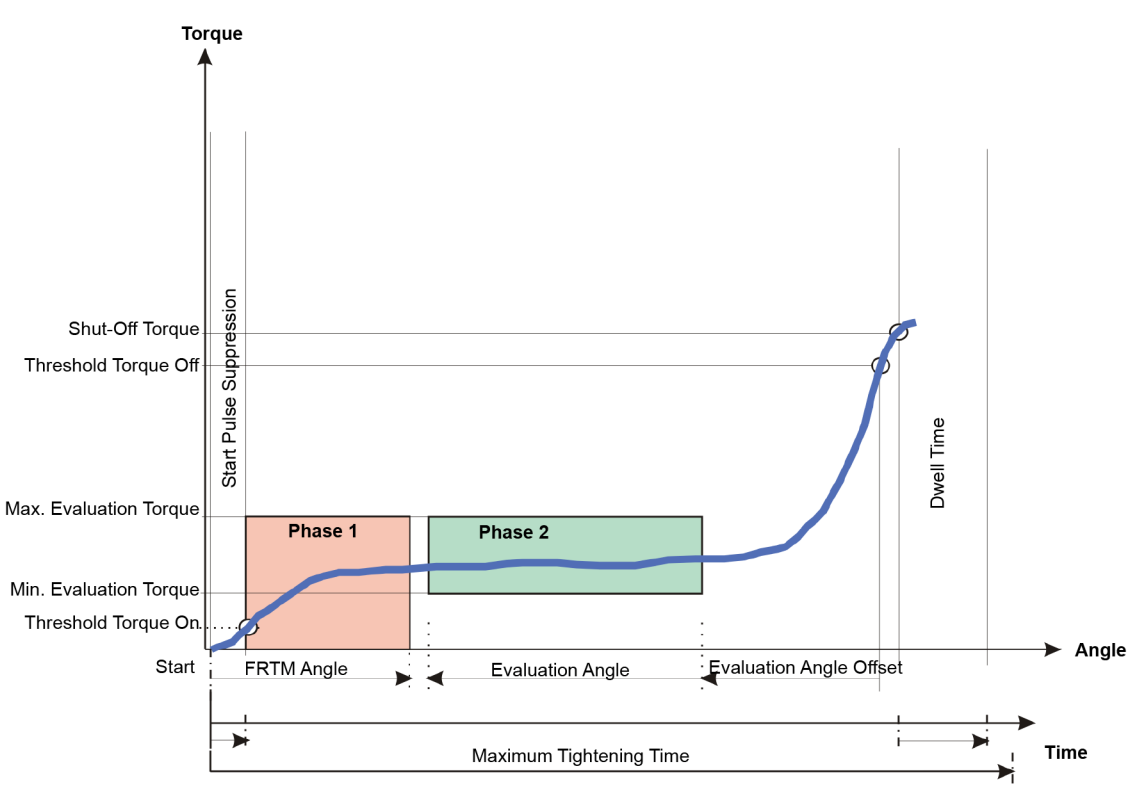

Fig. 3-3: Sequence 13

The torque occurring during the fastening sequence is measured by the installed transducer and processed in the controller. From the start of the tool until the FRTM Angle is reached, the torque is monitored. When the *Maximum Evaluation Torque* is exceeded in the phase (Phase1), the fastening sequence is canceled immediately with NOK.

If no error is measured in Phase 1, the fastening process continues to run without interruption. When *Shut-Off Torque* is reached, the tool is stopped. Then the peak torque is measured during the dwell time and transmitted to the controller as fastener tightening torque together with the evaluation of the rundown.

In the evaluation phase (Phase2) the recorded values between the *Threshold Torque On* and the *Threshold Torque Off* are evaluated. Torque values which, beginning with *Threshold Torque Off* are within the Evaluation Angle Offset remain out of consideration. Torque values in the next range of the Evaluation Angle, are checked to see if they exceed *Maximum Evaluation Torque* or fall below *Minimum Evaluation Torque*.

Starting from the recorded rundown data, within the Evaluation Angle going above or below the torque values can also be tolerated. The toleration can be limited with the parameters *Above Limit* and/or *Below Limit*. In relation to the total number of recorded rundown data and the number of measured values that lie outside of *Maximum Evaluation Torque* or *Minimum Evaluation Torque* , either a warning (P2M<, P2M>) or an NOK fault message (P2UN, P2UE, P2UU) is displayed on the controller.

The remaining rundown data, if available, remain unaffected. If the sum of *Evaluation Angle* and *Evaluation Angle Offset* is greater than the count of the existing measured values, the fault message **FSMUE: Insufficient rundown data and NOK is output**.

After the *Trigger Torque* is reached, the torque trace is recorded and can be viewed via the trace function. In some cases, the recording begins earlier due to system requirements.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Shut-off Torque for this high speed run-down	0 … 1 × TQ calibration value[1]	TqP
Threshold Torque Off	Threshold torque off, end of recording for subsequent evaluation (phase 2)	0 … 1.2 × TQ calibration value[1]	TqThOff
Threshold Torque On	Beginning of the monitored range (beginning of angle counting)	0 … 1 × TQ calibration value[1]	TqThOn
Evaluation Angle	Range evaluated in phase 2	0 … 9 999	Ang-FRTM (deg)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects.	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage.	± Maximum speed	n (rpm)
FRTM Angle	Duration of the monitored range from the tool start in phase 1	0 … 9 999	Ang-FRTM (deg)
Snug Point Detection	*See Retroactive Snug Point Detection – Sequence 13, page 75*		
Maximum Evaluation Torque	Maximum torque in the monitored range, upper limit value in phase 1 and phase 2	0 … 1 × TQ calibration value[1]	TqEmax
Minimum Evaluation Torque	Minimum torque in the monitored range, lower limit in phase 2	0 … 1 × TQ calibration value[1]	TqEmin
Evaluation Angle Offset	Range not evaluated in phase 2	0 … 9 999	AngEoff (deg)
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ calibration value	TqTr
Above Limit	Portion of tolerated measured values that are above the upper limit in relation to the total count of the recorded measured values within the Evaluation Torque without triggering NOK (Phase 2)	0 …100	pAb (%)
Below Limit	Portion of tolerated measured values that are below the lower limit in relation to the total tally of the recorded measured values within the Evaluation Torque without triggering NOK (Phase 2)	0 …100	pBe (%)
Maximum Tightening Time	Safety Shut-off	Applies for all tools of a tool group in this stage.	

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

3.4 Sequence 20: Torque controlled

Shut-off torque controlled fastening sequence, with torque min and max limits. Angle limits are not used with this tightening sequence.

This fastening sequence can also be used as a fast pretightening stage. This sequence is primarily used when angle detection or control is not required.

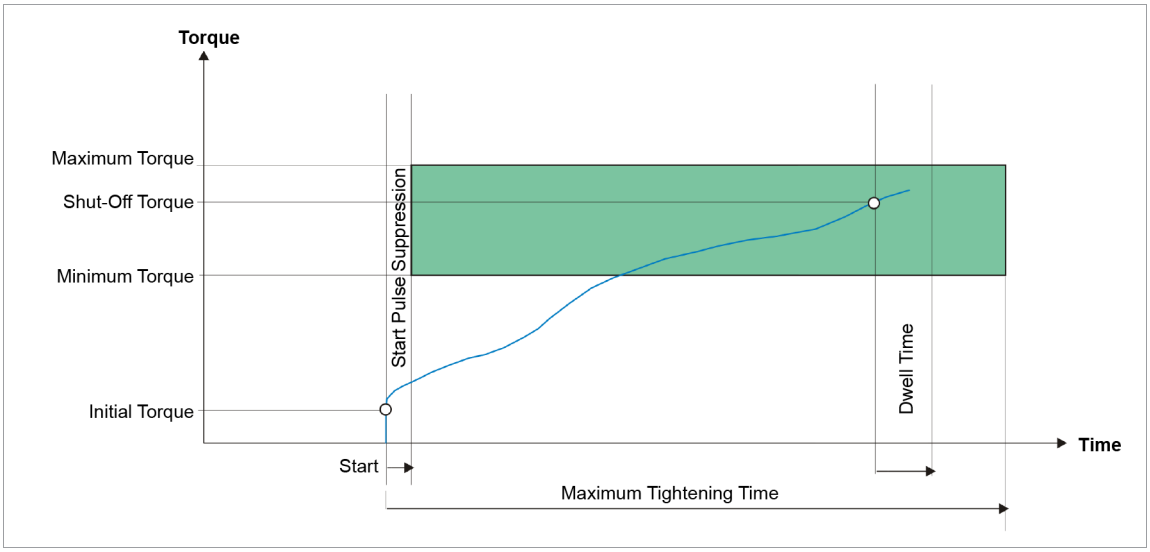

Fig. 3-4: Sequence 20

The torque occurring during the fastening sequence is measured by the installed transducer and processed in the controller. When the *Shut-Off Torque* is reached, the tool is stopped. Then, the peak torque is recorded during the dwell time and fed to the controller as the tightening torque of the fastener together with the evaluation of the rundown.

When the *Trigger Torque* is reached, the torque trace is recorded and can be viewed via the trace function.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Shut-off Torque of the stage	0 … 1 × TQ calibration value[1]	TqP
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage	± Maximum speed	n (rpm)
Maximum Torque	High limit of torque reached	0 … 1.2 × TQ calibration value[1]	TqMax
Minimum Torque	Low limit of torque reached	0 … 1 × MD-Kalibrierwert[1]	TqMin
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ capacity	TqTr
Maximum Tightening Time	Safety Shut-off	Applies for all tools of a tool group in this stage	
Hold Torque	After reaching the shut-off value, the torque is maintained (speed 0 rpm)		

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

3.5 Sequence 30: Torque controlled with Angle monitoring

Shut-off torque controlled fastening sequence with torque control and tightening angle monitoring. This fastening sequence assumes a fast pretightening stage.

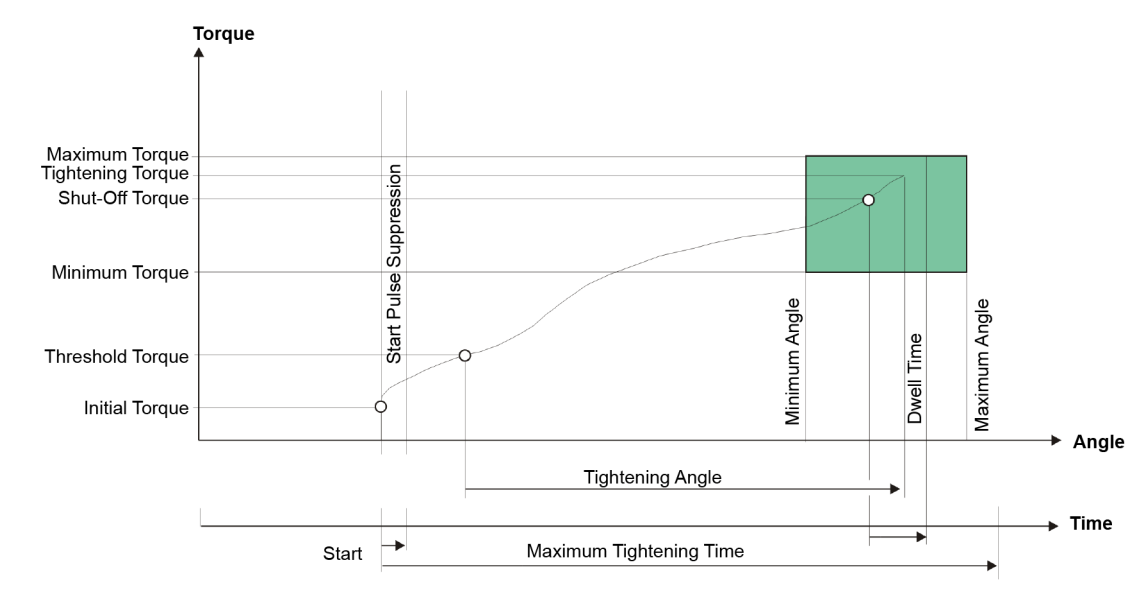

Fig. 3-5: Sequence 30

Via the installed transducer, the torque and the tightening angle occurring during the fastening sequence are measured and processed in the controller. After the *Threshold Torque* s reached, the tightening angle is measured. When the *Shut-Off Torque* Then, during the dwell time, the dwell angle and the peak torque are measured and fed to the controller as tightening torque along with the evaluation of the fastening sequence. Peak torque and the tightening angle must be within the specified limits in order for the rundown to be evaluated as OK. If the maximum tightening angle is exceeded before the shut-off torque is achieved, the rundown is stopped and evaluated as NOK.

When the *Trigger Torque* is reached, the torque trace is recorded and can be viewed via the trace function.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Shut-off Torque of the stage	0 … 1 × TQ capacity	TqP
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage	± Maximum speed	n (rpm)
Maximum Angle	High limit for angle reached and safety shut-off value	0 … 9 999	AngMax (deg)
Maximum Torque	High limit of torque reached	0 … 1.2 × TQ capacity	TqMax
Minimum Angle	Low limit of angle reached	0 … 9 999	AngMin (deg)
Minimum Torque	Low limit of torque reached	0 … 1 × TQ calibration value[1]	TqMin
Threshold Torque	Beginning of angle counting	0 … 1.2 × TQ capacity	TqTh

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

Parameter	Explanation	Range of values	Abbrev.
Maximum Tightening Time	Safety Shut-off	The max fastening time applies for all tools of a tool group in this stage.	
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ capacity	TqTr
Hold Torque	After reaching the shut-off value, the torque is maintained (speed 0 1/min)		

3.6 Sequence 31: Torque controlled with Advanced monitoring

Shut-off torque controlled sequences with torque and angle control. This sequence has four setup modes: Default, Screw in Metric Thread, Screw in Self-Grooving, Screw in Self-Tap and Final. This sequence uses reverse analysis to evaluate of the fastening sequence over two monitoring periods.

Sequence as final tightening

This sequence can be used as a single-stage final tightening process.

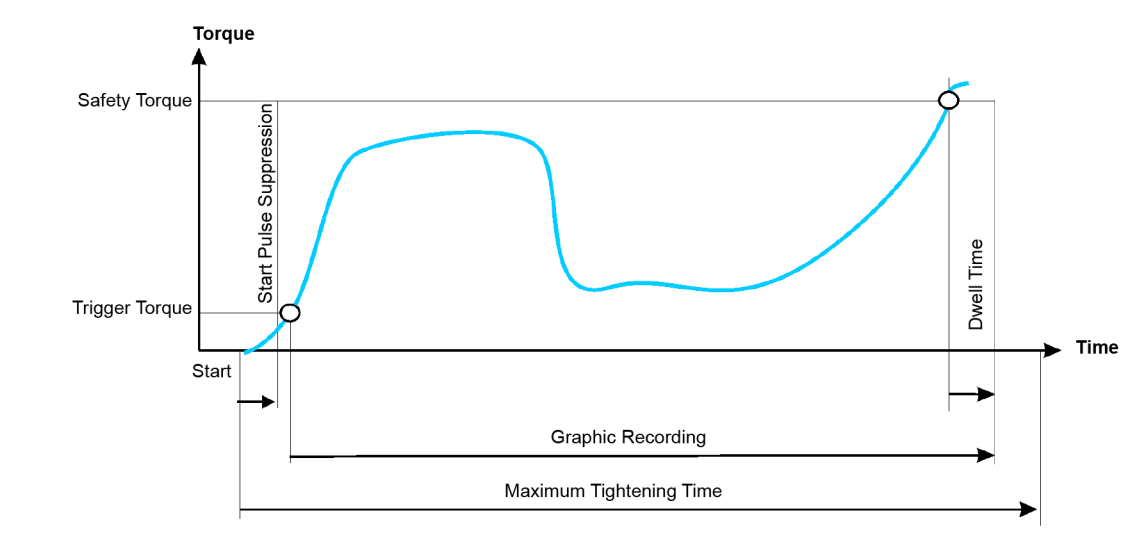

Fig. 3-6: Illustration Time / Graphic recording

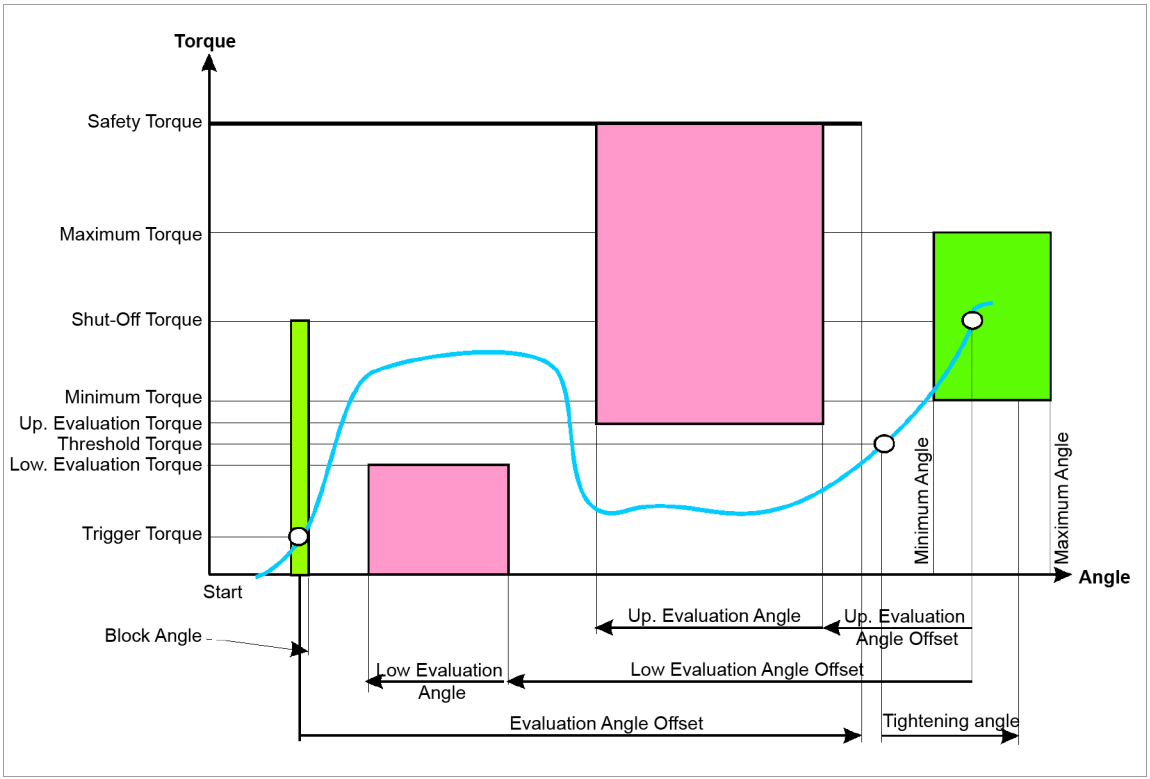

Fig. 3-7: Illustration Angle / Torque

This tightening sequence offers five different modes for selection.

Mode	Description
Default	General standard setting; all parameters are active; without any special application
Pretighten - Metric Thread	General application for metric threads; the lower range for evaluation is inactive
Pretighten - Self-Grooving	General application for grooving threads; Evaluation Angle Offset suppressed
Pretighten - Self-Tapping	General application for self-tapping threads with torque safety shut-off of the self-tapping area; in this area the torque can be higher than the final shut-off torque
Final	Essentially corresponds to Sequence 30

The subsequent description refers to the default setting.

After ending the fastening operation, a reverse analysis of the torque trace can be carried out. This reverse analysis starts at the shut-off point (the dwell time is not considered) and is achieved using two separate angle ranges.

These angle ranges can be determined independently of each other by programming the end of the range (*Upper Evaluation Angle Offset*/*Lower Evaluation Angle Offset*) and the length of the range (*Upper Evaluation Angle*/*Lower Evaluation Angle*). The sequence of the two Evaluation Angles can be freely chosen and can partially or completely overlap.

The torque curve is thus checked in the *Upper Evaluation Angle* to see if the Upper Evaluation Torque is exceeded and in the *Lower Evaluation Angle* to see if there is a drop below the Lower Evaluation Torque. If *Above Limit* or *Below Limit* occur, the fastening sequence is rated as NOK.

Within the *Upper Evaluation Angle*, the highest torque value within the *Lower Evaluation Angle* of the lowest torque value is measured and the statistical evaluation is supplied. The Evaluation Torque values can be deactivated by setting the associated Evaluation Angle on zero.

In the area of the block angle, which begins immediately following the start pulse suppression, the torque must not exceed the shut-off torque; otherwise, the drive is stopped and a NOK evaluation occurs. This is

used to identify rundowns that are performed on a tightened bolt. This detection can be deactivated by setting the block angle to zero.

After the *Trigger Torque* is reached, the torque trace for the graphics display is recorded (1 torque value per degree). These values are also the basis for the reverse analysis.

Program the trigger torque in such a way that the torque trace that is relevant for the reverse analysis is recorded no matter what.

If there are not enough torque values for a reverse analysis, a fault message with NOK evaluation is output. The torque trace can be output and analyzed via the trace function.

A *Evaluation Angle Offset* can be programmed that begins after the *Trigger Torque* is reached. During the *Evaluation Angle Offset* the threshold and shut-off torque detection is deactivated and reactivated only after the *Evaluation Angle Offset* is ended.

In the *Evaluation Angle Offset*, the monitored torque must not be greater than the *Shut-Off Torque*, but the *Safety Torque* must not be exceeded. If the safety torque that applied in the sequence from the end of the *Evaluation Angle Offset* to the shut-off torque, the tool is stopped. An error message is generated with a NOK result. The *Evaluation Angle Offset* can be deactivated by setting it to zero. If the *Block Angle* and the *Evaluation Angle Offset* intersect, the shut-off torque is valid as a cancellation criterion up to the end of the block angle.

Angle counting starts when the *Threshold Torque* is reached if detection of the threshold torque has not been deactivated by the *Block Angle* or *Evaluation Angle Offset*.

If *Threshold Torque* ≤ *Trigger Torque*, the angle counting begins as soon as the threshold torque is reached and is also continued in the *Evaluation Angle Offset*. angle tracing and any redundancy monitoring occurs after the drive starts.

After the shut-off via the Shut-Off Torque, the torque the occurs or the associated angle is compared to the *Minimum Torque*/*Maximum Torque* and *Minimum Angle*/*Maximum Angle* and evaluated as OK/NOK accordingly. In addition, the reverse analysis is performed.

For the angle redundancy, primarily with hand tools, a time monitoring can be activated that measures the time from when the *Threshold Torque* reached until the shut-off point. This time must be within the limits *Minimum Time After TqTh* and *Maximum Time After TqTh* . If it falls below the minimum time in the Shut-Off Value, the rundown is evaluated as NOK, and the error message TTT< is output. If the maximum time is exceeded, the rundown is terminated, the error message TTT> is output and the result is NOK.

In the case of a nut slip-off, the measured value does not correspond to the angle that was applied to the fastener. A detection of this problem can be activated. The parameters *Nut Slip Off Torque Minimum* and *Nut Slip Off Angle Minimum* are used for this. If the torque drops back below the *Nut Slip Off Torque Minimum* after reaching the threshold torque, a special angle count is started for the detection of the nut slip-off. This is stopped again after the *Nut Slip Off Torque Minimum* is exceeded. Should this angle count exceed the *Nut Slip Off Angle Minimum* , the JUMP fault message is generated and the rundown is assessed as NOK.

A second speed parameter, *Final Speed*, can be selected for the speed. If this is parameterized (not equal to 0), the speed is reduced to the *Final Speed* starting from the *Threshold Torque* from the standard speed up to the switch-off torque. The final speed must be lower than the standard speed.

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Torque at which the drive is stopped and the dwell time begins; valid outside of the *Evaluation Angle Offset*	0 … 1 × TQ capacity	TqP
Upper Evaluation Angle Offset	End point of the *Upper Evaluation Angle*, related to the shut-off point (reverse)	0 … 9 999	AngEoffup (deg)
Lower Evaluation Angle Offset	End point of the *Lower Evaluation Angle*, related to the shut-off point (reverse)	0 … 9 999	AngEoffo (deg)

Parameter	Explanation	Range of values	Abbrev.
Evaluation Angle Offset	Angle range starting at the *Trigger Torque*, in which the *Shut-Off Torque* and *Threshold Torque* are invalid	0 … 9 999	AngEoff (deg)
Upper Evaluation Angle	Duration of the monitored range for exceeding the Up. Evaluation Torque	0 … 9 999	AngEup (deg)
Lower Evaluation Angle	Duration of the monitored range for falling below the Lower Evaluation Torque	0 … 9 999	AngElo (deg)
Upper Evaluation Torque	High torque limit in the Up. Evaluation Angle that must not be exceeded in reverse analysis	0 … 1 × TQ calibration value[1]	TqEup
Lower Evaluation Torque	Low torque limit in the Low. Evaluation Angle that must not be understepped in reverse analysis	0 … 1.2 × TQ calibration value[1]	TqElo
Block Angle	Angle, beginning at the end of start pulse suppression, in which the torque must be lower than the shut-off torque	0 … 9 999	AngBl (deg)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary reject	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage	± Maximum speed	n (rpm)
Final Speed	Speed upon reaching the shut-off torque. Must be less than Speed. Cutoff is deactivated when FinalSpeed = 0 or Final Speed ≥ Speed.	± Maximum speed	n2
Maximum Angle	High limit for angle reached and safety shut-off value	0 … 9 999	AngMax (deg)
Maximum Torque	High limit of torque reached	0 … 1.2 × TQ capacity	TqMax
Maximum Time After TqTh	Time that may lapse after threshold torque maximum (TTH). If this time is exceeded, there is a shut-off with the error message TTT>		tMax (ms)
Minimum Time After TqTh	Time that must pass in the Shut-Off Value after threshold torque (TTH) minimum is reached. If the time is less, an error message TTT< is output.		tMin (ms)
Minimum Angle	Low limit of angle reached	0 … 9 999	AngMin (deg)
Minimum Torque	Low limit of torque reached	0 … 1 × TQ calibration value[1]	TqMin
Nut Slip Off Torque Minimum	Minimum torque, below which the angle count for the nut slip-off is started. If exceeded again, the angle count for the nut slip-off is reset again.		TqMinNS (Nm)
Nut Slip Off Angle Minimum	Angle at which, if exceeded, a nut slip off is measured		AngMin (deg)
Threshold Torque	Beginning of the angle counting; valid outside the Evaluation Angle Offset and block angle	0 … 1.2 × TQ capacity	TqTh

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

Parameter	Explanation	Range of values	Abbrev.
Maximum Tightening Time	Safety Shut-off	The max fastening time applies for all tools of a tool group in this stage	
Safety Torque	Monitoring torque valid after the start pulse suppression has finished and during the rundown above which the drive is immediately stopped	0 … 1.2 × TQ capacity	TqSa
Trigger Torque	Beginning of storing torque values for the trace display, reverse analysis and Evaluation Angle Offset	0 … 1.2 × TQ capacity	TqTr

Validity of individual parameters

Parameter	Start	End	Evaluation sequence	Suppressed in
Threshold Torque	After start pulse suppression	Shut-off point reached	1	Block Angle, Evaluation Angle Offset
Safety torque shut-down			2	–
Shut-Off Torque			3	Block Angle, Evaluation Angle Offset
Trigger Torque			4	–

When the values are equal, the sequence for evaluation causes a higher priority for evaluation, for instance, of the threshold torque before the trigger torque. The threshold torque and thus angle counting are activated when the trigger torque and threshold torque have the same numeric values, even if a Evaluation Angle Offset is defined.

Parameter	Start	End	Deactivation
Evaluation Angle Offset	Block Angle	After Evaluation Angle Offset degreeAfter start pulse suppression	Evaluation Angle Offset = 0
Block Angle	After Start Pulse Suppression	After Block Angle degree	Block Angle = 0
Speed	With tool start	a) Shut-off point when Final Speed After block angle degree= 0 b) Threshold torque when Final Speed > 0	–
Final Speed	From threshold torque	Final SpeedShut-off point	Final Speed = 0 or Final Speed ≥ Speed

Parameters that are analyzed in reverse, i.e. starting from the shut-off point.

Parameter	Start	End	Deactivation
Upper Evaluation Angle Offset	Shut-off point	Shut-off point minus Upper Evaluation Angle Offset	---
Lower Evaluation Angle Offset	Shut-off point	Shut-off point minus Upper Evaluation Angle Offset	---
Upper Evaluation Angle	Shut-off point minus Upper Evaluation Angle Offset	Shut-off point minus Upper Evaluation Angle Offset minus Upper Evaluation Angle	Upper Evaluation Angle = 0

Parameter	Start	End	Deactivation
Lower Evaluation Angle	Shut-off point minus Lower Evaluation Angle Offset	Shut-off point minusLower Evaluation Angle Offset minus Lower Evaluation Angle	Lower Evaluation Angle = 0
Upper Evaluation Torque	Valid in the Up. Evaluation Angle		Upper Evaluation Angle = 0
Lower Evaluation Torque	Valid in the Low. Evaluation Angle		Lower Evaluation Angle = 0

3.7 Sequence 50: Angle controlled with Torque monitoring

Shut-off angle controlled fastening sequence with tightening angle monitoring and torque control. This fastening sequence assumes a fast pretightening stage.

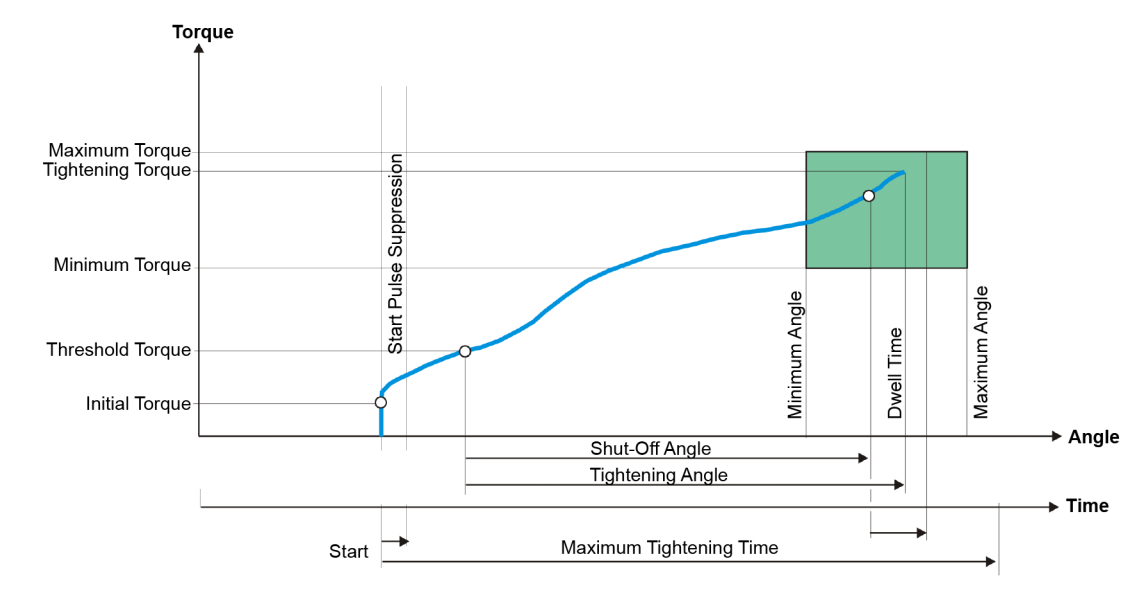

Fig. 3-8: Sequence 50

The torque occurring during the fastening sequence as well as the tightening angle is measured by the installed transducer and processed in the controller. When the *Shut-Off Angle* is reached, the tool is stopped. Then, the dwell angle and the peak torque are recorded during the dwell time, and the tightening values of the fastener, together with the result of the rundown, are fed to the controller. If the maximum torque parameter is exceeded before the angle shut-off is achieved, the tightening is stopped and evaluated as a NOK.

When the programmable trigger torque of a tool is reached, recording of the torque curve starts and the curve can be displayed via the trace function.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Angle	Shut-off Angle for the stage	0 … 9 999	AP (deg)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects.	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage	± Maximum speed	n (rpm)
Maximum Angle	High limit of angle reached	0 … 9 999	AngMax (deg)

Parameter	Explanation	Range of values	Abbrev.
Maximum Torque	High limit for torque reached and safety shut-off value	0 … 1.2 × TQ capacity	TqMax
Minimum Angle	Low limit of angle reached	0 … 9 999	AngMin (deg)
Minimum Torque	Low limit of torque reached	0 … 1 × TQ calibration value[1]	TqMin
Threshold Torque	Beginning of angle counting	0 … 1,2 × TQ capacity	TqTh
Maximum Tightening Time	Safety Shut-off	The max. fastening time applies for all tools of a tool group in this stage	
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ capacity	TqTr
Hold Torque	After reaching the shut-off value, the torque is maintained (speed 0 1/min)		
Peak Torque Evaluation	Special function	The peak torque must be between TqMax and TqMin.	

Peak torque evaluation (Special function)

If the peak torque evaluation is activated, the rundown is terminated as soon as the shut-off angle is reached. It is checked whether the peak torque is between the *Minimum Torque* (TqMin) and *Maximum Torque* (TqMax). If the peak torque exceeds the Maximum Torque, the rundown is immediately stopped with a NOK error.

Note

Peak torque evaluation only evaluates the peak torque, not the shut-off torque.
Screws can loosen.
► Use this function only for test rundowns.

If the peak torque evaluation is activated, the graphical representation of the torque graph changes.

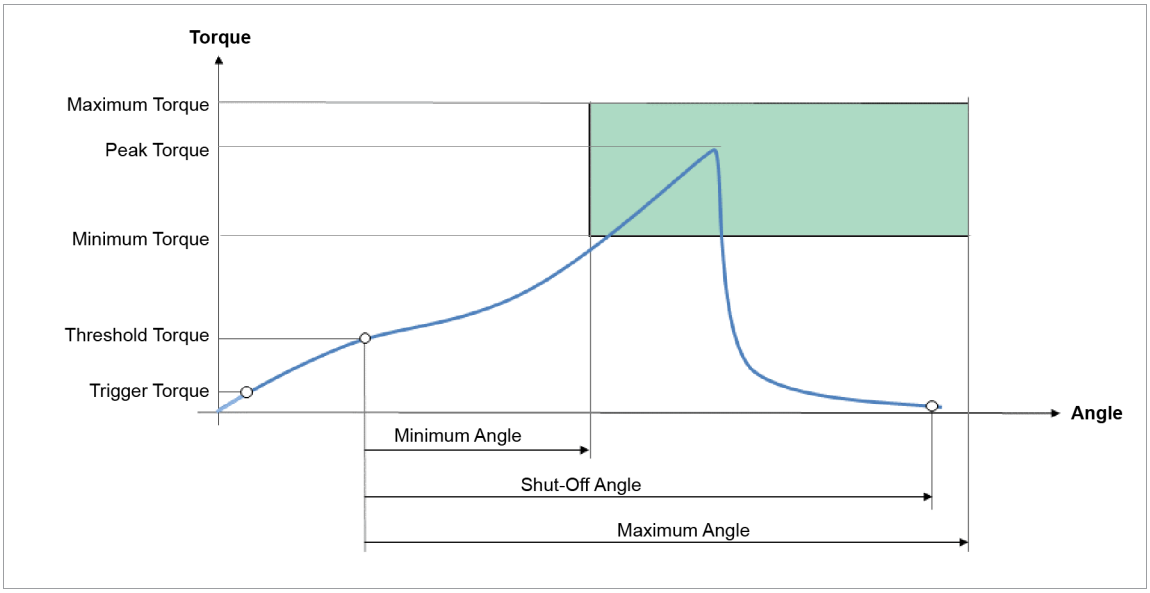

Fig. 3-9: Special function sequence 50 with peak torque evaluation

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

3.8 Sequence 51: Angle controlled with Advanced Monitoring

Shut-off angle controlled fastening sequence with tightening angle monitoring and torque control. By reverse analysis enables an evaluation of the fastening sequence over two monitoring ranges, *see chapter 3.6 Sequence 31: Torque controlled with Advanced monitoring, page 14*.

Sequence as final tightening

This sequence can be used as a single-stage final tightening process.

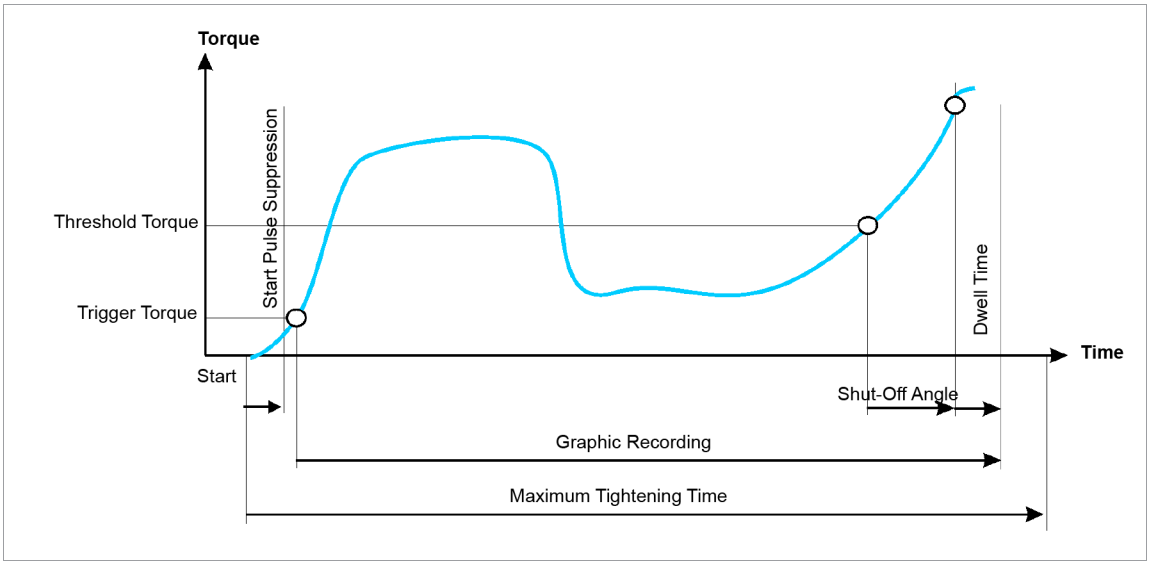

Fig. 3-10: Illustration Time- / Graphic recording

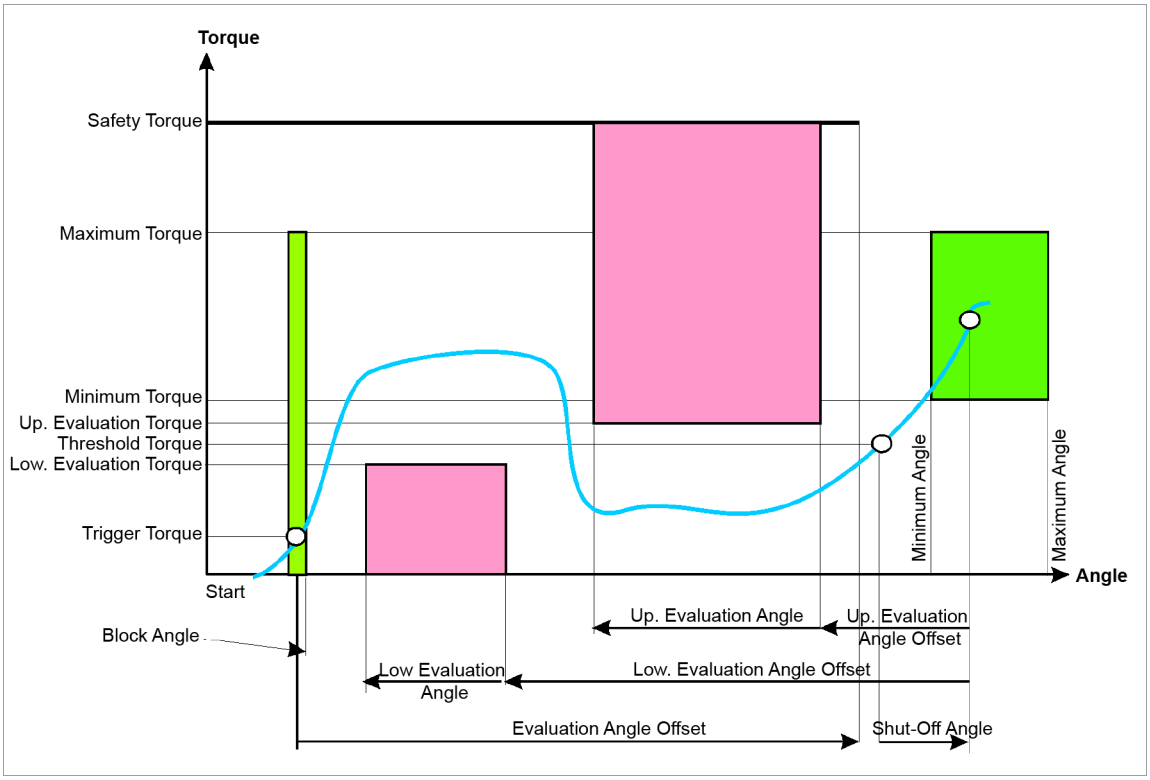

Fig. 3-11: Illustration Angle / Torque

This tightening sequence offers five different modes for selection.

Mode	Description
Default	General standard setting; all parameters are active; without any special application

Mode	Description
Pretighten - Metric Thread	General application for metric threads; the lower range for evaluation is inactive
Pretighten - Self-Grooving	General application for grooving threads; Evaluation Angle Offset suppressed
Pretighten - Self-Tapping	General application for self-tapping threads with torque safety shut-off of the self-tapping area; in this area the torque can be higher than the final shut-off torque
Final	Essentially corresponds to Sequence 30

The subsequent description refers to the default setting.

After ending the fastening operation, a reverse analysis of the torque trace can be carried out. This reverse analysis starts at the shut-off point (the dwell time is not considered) and is achieved using two separate angle ranges.

These angle ranges can be determined independently of each other by programming the end of the range (*Upper Evaluation Angle Offset*/*Lower Evaluation Angle Offset*) and the length of the range (*Upper Evaluation Angle*/*Lower Evaluation Angle*). The sequence of the two Evaluation Angles can be freely chosen and can partially or completely overlap.

The torque curve is thus checked in the *Upper Evaluation Angle* to see if the Upper Evaluation Torque is exceeded and in the *Lower Evaluation Angle* to see if there is a drop below the Lower Evaluation Torque. If *Above Limit* or *Below Limit* occur, the fastening sequence is rated as NOK.

Within the *Upper Evaluation Angle*, the highest torque value within the *Lower Evaluation Angle* of the lowest torque value is measured and the statistical evaluation is supplied. The Evaluation Torque values can be deactivated by setting the associated Evaluation Angle on zero.

In the area of the block angle, which begins immediately following the start pulse suppression, the torque must not exceed the shut-off torque; otherwise, the drive is stopped and a NOK evaluation occurs. This is used to identify rundowns that are performed on a tightened bolt. This detection can be deactivated by setting the block angle to zero.

After the *Trigger Torque* is reached, the torque trace for the graphics display is recorded (1 torque value per degree). These values are also the basis for the reverse analysis.

Program the trigger torque in such a way that the torque trace that is relevant for the reverse analysis is recorded no matter what.

If there are not enough torque values for a reverse analysis, a fault message with NOK evaluation is output. The torque trace can be output and analyzed via the trace function.

A *Evaluation Angle Offset* can be programmed that begins after the *Trigger Torque* is reached. During the *Evaluation Angle Offset* the threshold and shut-off torque detection is deactivated and reactivated only after the *Evaluation Angle Offset* is ended.

In the *Evaluation Angle Offset*, the monitored torque must not be greater than the *Shut-Off Torque*, but the *Safety Torque* must not be exceeded. If the safety torque that applied in the sequence from the end of the *Evaluation Angle Offset* to the shut-off torque, the tool is stopped. An error message is generated with a NOK result. The *Evaluation Angle Offset* can be deactivated by setting it to zero. If the *Block Angle* and the *Evaluation Angle Offset* intersect, the shut-off torque is valid as a cancellation criterion up to the end of the block angle.

Angle counting starts when the *Threshold Torque* is reached if detection of the threshold torque has not been deactivated by the block angle or Evaluation Angle Offset.

If the *Threshold Torque* ≤ *Trigger Torque*, the angle count begins as soon as the threshold torque is reached and is also continued in the Evaluation Angle Offset. The angle tracing and any redundancy monitoring occurs after the drive starts.

After the shut-off via the Shut-Off Angle, the torque the occurs or the associated angle is compared to the *Minimum Torque*/*Maximum Torque* and *Minimum Angle*/*Maximum Angle* and evaluated as OK/NOK accordingly. In addition, the reverse analysis is performed.

A second speed parameter, *Final Speed*, can be selected for the speed. If this is parameterized (not equal to 0), the speed is reduced to the *Final Speed* starting from the *Threshold Torque* from the standard speed up to the switch-off torque. The final speed must be lower than the standard speed.

Anti-Necking (AN) alert the operator when the elasticity limit has been detected during the fastening process and a permanent elongation (necking) of the tool occurs. The objective of this necking detection is to shut the tool off, if the fastener stretches beyond a pre-determined *AN Tq Threshold*. If the fastener starts to stretch beyond the elastic limit, torque will start to decrease by the percentage *AN drop Percent of Peak TQ*. If the reduced torque is continued for a defined number of degrees *Min. Angle AN*, the tool shuts down.

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Angle	Angle at which the drive is stopped and the dwell time begins	0 … 9 999	AP (deg)
Upper Evaluation Angle Offset	End point of the Up. Evaluation Angle, related to the shut-off point (reverse)	0 … 9 999	AngEof-fup (deg)
Lower Evaluation Angle	End point of the Low. Evaluation Angle, related to the shut-off point (reverse)	0 … 9 999	AngEof-flo (deg)
Evaluation Angle Offset	Angle range starting at the trigger torque, in which the maximum torque and threshold torque are invalid	0 … 9 999	AngEoff (deg)
Upper Evaluation Angle	Duration of the monitored range for exceeding the Up. Evaluation torque	0 … 9 999	AngEup (deg)
Lower Evaluation Angle	Duration of the monitored range for falling below the Lower Evaluation Torque	0 … 9 999	AngElo (deg)
Upper Evaluation Torque	High torque limit in the Up. Evaluation Angle that must not be exceeded in reverse analysis	0 … 1 × Torque calibration[1]	TqEup
Lower Evaluation Torque	Low torque limit in the Low. Evaluation Angle that must not be understepped in reverse analysis	0 … 1 × Torque calibration[1]	TqElo
Block Angle	Angle, beginning at the end of start pulse suppression, in which the torque must be lower than the maximum torque	0 … 9 999	AngBl (deg)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects.	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage	± Maximum speed	n (rpm)
Final Speed[2]	Speed upon reaching the maximum torque. Must be less than Speed. Cutoff is deactivated when Final Speed = 0 or Final Speed ≥ Speed.	± Maximum speed	n2
Maximum Angle	High limit of angle reached	0 … 9 999	AngMax (deg)
Maximum Torque	High limit of torque reached	0 … 1.2 × Torque calibration	TqMax

[1] Subsequent plausibility test related to the tool capacity (software-dependent)
[2] The maximum torque is normally not reached; the torque shut-off value is lower than the maximum torque, so that Final Speed must not be fully cut off.

Parameter	Explanation	Range of values	Abbrev.
Maximum Time After TqTh	Time that may lapse after threshold torque maximum (TTH). If this time is exceeded, there is a shut-off with the error message TTT>		tMax (ms)
Minimum Time After TqTh	Time that must pass in the Shut-Off Value after threshold torque (TTH) minimum is reached. If the time is less, an error message TTT< is output.		tMin (ms)
Minimum Angle	Low limit of angle reached	0 … 9 999	AngMin (deg)
Minimum Torque	Low limit of torque reached	0 … Torque calibration	TqMin
Nut Slip Off Torque Minimum	Minimum torque below which the angle count for the nut slip-off is started. If it is exceeded again, the angle counting for the nut slip-off is reset		TqMinNS (Nm)
Nut Slip Off Angle Minimum	Angle at which, if exceeded, a nut slip off is measured		AngMinNS (deg)
Threshold Torque	Beginning of the angle counting; valid outside the Evaluation Angle Offset and block angle	0 … 1.2 × Torque capacity	TqTh
Safety Torque	Monitoring torque valid after start pulse suppression has finished and during the rundown, and the value at which the drive is stopped when it is exceeded	0 … 1.2 × Torque calibration	TqSa
Maximum Tightening Time	Safety Shut-off	The max fastening time applies for all tools of a tool group in this stage	
Trigger Torque	Beginning of storing torque values for the trace display, reverse analysis and for Evaluation Angle Offset	0 … 1.2 × Torque capacity	TqTr
AN Tq Threshold	Threshold torque at which necking detection begins	Threshold Torque ... Maximum Torque	TqThAN (Nm)
AN drop Percent of Peak TQ	Percentage by which the torque drops at least (relative to the previous maximum torque)	1 ... 99	ppTqAN (%)
Min. Angle AN	Number of degrees after which the tool is switched off when the AN drop Percent of Peak TQ is undershot	1 ... 999	AngMinAN (deg)

Validity of individual parameters

Parameter	Start	End	Evaluation sequence	Suppressed in
Threshold Torque	After start pulse suppression	Shut-off point reached	1	Block Angle, Evaluation Angle Offset
Safety torque shut-down			2	–
Shut-Off Torque			3	Block Angle, Evaluation Angle Offset
Trigger Torque			4	–

When the values are equal the sequence for evaluation causes a higher priority for evaluation, for instance, of the threshold torque before the trigger torque, i.e. the threshold torque and thus angle counting

are activated when the trigger torque and threshold torque have the same numeric values, even if a Evaluation Angle Offset is defined.

Parameter	Start	End	Deactivation
Evaluation Angle Offset	Trigger Torque	After Evaluation Angle Offset degree	Evaluation Angle Offset = 0
Block Angle	After start pulse suppression	After block angle degree	Block Angle = 0
Speed	With tool start	a) Shut-off point when Final Speed = 0 b) Threshold Torque when Final Speed > 0	---
Final Speed	From threshold torque	Shut-off point	Final Speed = 0 or Final Speed ≥ Speed

Parameters that are analyzed in reverse, i.e. starting from the shut-off point

Parameter	Start	End	Deactivation
Upper Evaluation Angle	Shut-off point minus Upper Evaluation Angle Offset	Shut-off point minus Upper Evaluation Angle Offset minus Upper Evaluation Angle	Upper Evaluation Angle = 0
Upper Evaluation Angle Offset	Shut-off point	Shut-off point minus Upper Evaluation Angle Offset	---
Upper Evaluation Torque	Valid in the Up. Evaluation Angle		Upper Evaluation Angle = 0
Lower Evaluation Angle	Shut-off point minus Lower Evaluation Angle Offset	Shut-off point minus Lower Evaluation Angle Offset minus Lower Evaluation Angle	Lower Evaluation Angle = 0
Lower Evaluation Angle Offset	Shut-off point	Shut-off point minus Upper Evaluation Angle Offset	---
Lower Evaluation Torque	Valid in the low Evaluation Angle		Lower Evaluation Angle = 0

3.9 Sequence 63: Gradient controlled with Yield Point Detection

Yield point controlled fastening sequence with shut-off based on a percentage of the maximum gradient. Torque control, tightening angle monitoring and gradient monitoring. This fastening sequence assumes a fast pretightening stage.

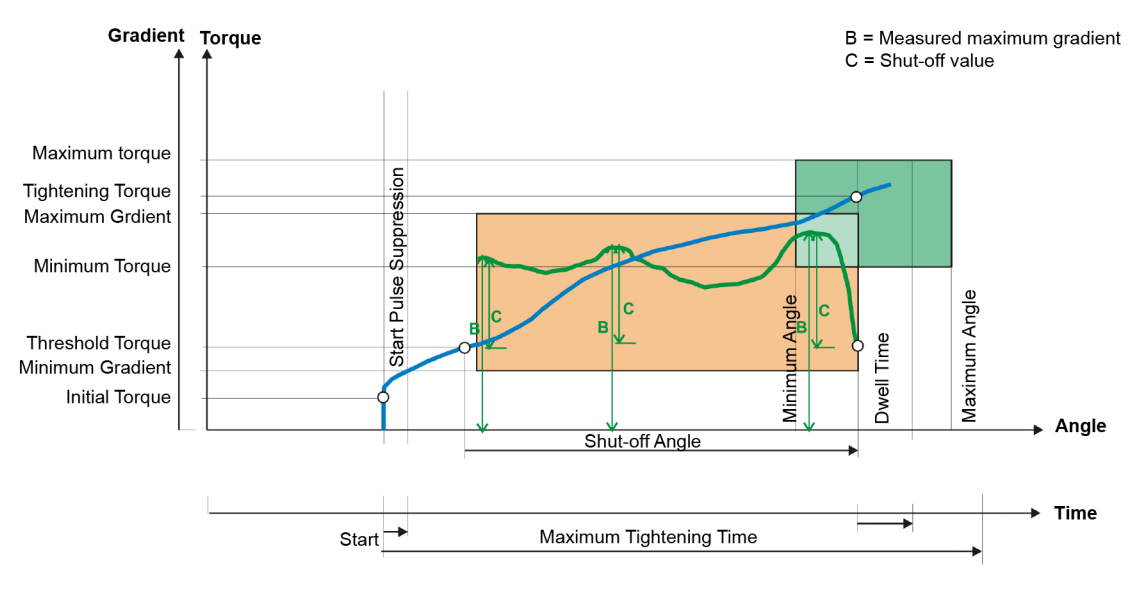

Fig. 3-12: Sequence 63

The torque occurring during the rundown operation as well as the angle are measured via the installed transducer and processed by the controller. When the turnoff yield point is reached, the tool is stopped.

Shut-off gradient= (100% - % Shut-Off Value) × Maximum Gradient. The Maximum Gradient is determined during the run time.

Then, the dwell angle and peak torque are recorded during the dwell time, and the tightening values of the fastener, together with the rundown evaluation, are fed to the controller.

When the *Trigger Torque* is reached, the torque trace is recorded and can be viewed via the trace function.

If the maximum torque, or maximum angle parameters are exceeded before the percentage gradient shut-off point is reached, the tightening operation is stopped and the rundown evaluated as NOK.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
% Shut-Off Value (Shut-off gradient)	Percentage amount of the measured maximum gradient. The Maximum Gradient is determined during the run time. Shut-off gradient = (100% - % Shut-Off Value) × Maximum Gradient	0 … 100	pOff (%)
Angle Averaging Filter	Spacing in angle impulses of the filtered rundown data used for gradient calculation	1 … 30	AF (grd)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects.	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage.	± Maximum speed	n (rpm)
Maximum Gradient	Upper limit and safety shut-off value of the gradient	-99.99 … 99.99	GdMax
Maximum Angle	High limit for angle reached and safety shut-off value	0 … 9 999	AngMax (deg)

Parameter	Explanation	Range of values	Abbrev.
Maximum Torque	High limit for torque reached and safety shut-off value	0 … 1.2 × TQ capacity	TqMax
Minimum Gradient	Lower limit and safety shut-off value of the gradient	-99.99 … 99.99	GdMin
Minimum Angle	Low limit of angle reached	*Angle Averaging Filter* … 9 999	AngMin (deg)
Minimum Torque	Low limit of torque reached	0 … 1 × Torque calibration value[1]	TqMin
Threshold Torque	Beginning of angle counting and gradient calculation	0 … 1.2 × TQ capacity	MS
Maximum Tightening Time	Safety Shut-off	Applies for all tools of a tool group in this stage	
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ capacity	MT

3.10 Sequence 73: Torque controlled with Angle & Gradient Monitoring

Shut-off torque controlled fastening sequence with torque control, tightening angle monitoring and gradient monitoring. This fastening sequence assumes a fast pretightening stage.

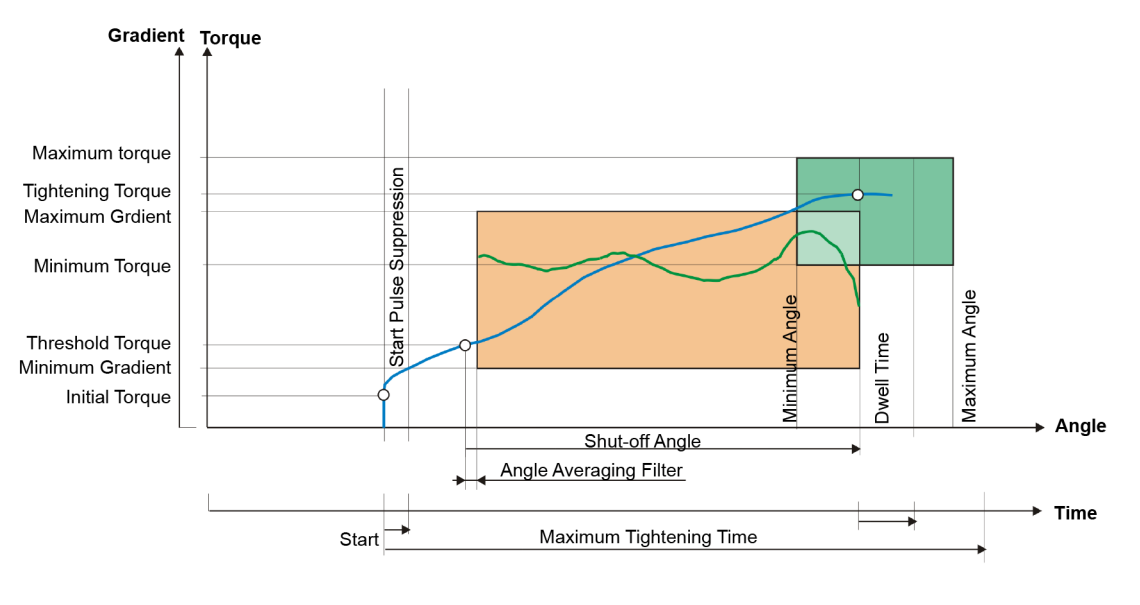

Fig. 3-13: Sequence 73

The torque occurring during the rundown operation as well as the angle are detected via the installed transducer and processed by the controller.

The gradient calculation starts after the *Threshold Torque* + *Angle Averaging Filter* ends with the *Shut-Off Torque*.

When the *Shut-Off Torque* is reached, the tool is stopped. Then, the dwell angle and peak torque are recorded during the dwell time, and the tightening values of the fastener, together with the rundown evaluation, are fed to the controller.

When the *Trigger Torque* of a tool is reached, the torque trace is recorded and can be viewed via the trace function.

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Shut-off Torque of the stage	0 … 1 × TQ capacity	TqP
Angle Averaging Filter	Spacing in angle impulses of the filtered rundown data used for gradient calculation	1 … 30	AF (grd)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage	± Maximum speed	n (rpm)
Maximum Gradient	Upper limit of the gradient occurring	0 … 99.99	GdMax
Maximum Angle	High limit for angle reached and safety shut-off value	0 … 9 999	AngMax (deg)
Maximum Torque	High limit of torque reached	0 … 1.2 × TQ capacity	TqMax
Minimum Gradient	Lower limit of the gradient occurring	-99.99 … 99.99	GdMin
Minimum Angle	Low limit of angle reached	Angle Averaging Filter … 9 999	AngMin (deg)
Minimum Torque	Low limit of torque reached	0 … 1 × TQ calibration value[1]	TqMin
Threshold Torque	Beginning of angle counting and gradient calculation	0 … 1.2 × TQ capacity	TqTh
Maximum Tightening Time	Safety Shut-off	Applies for all tools of a tool group in this stage	
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ capacity	TqTr

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

3.11 Sequence 75: Angle controlled with Torque & Gradient monitoring

Shut-off angle controlled fastening sequence with torque control, tightening angle monitoring and gradient monitoring. This fastening sequence assumes a fast pretightening stage.

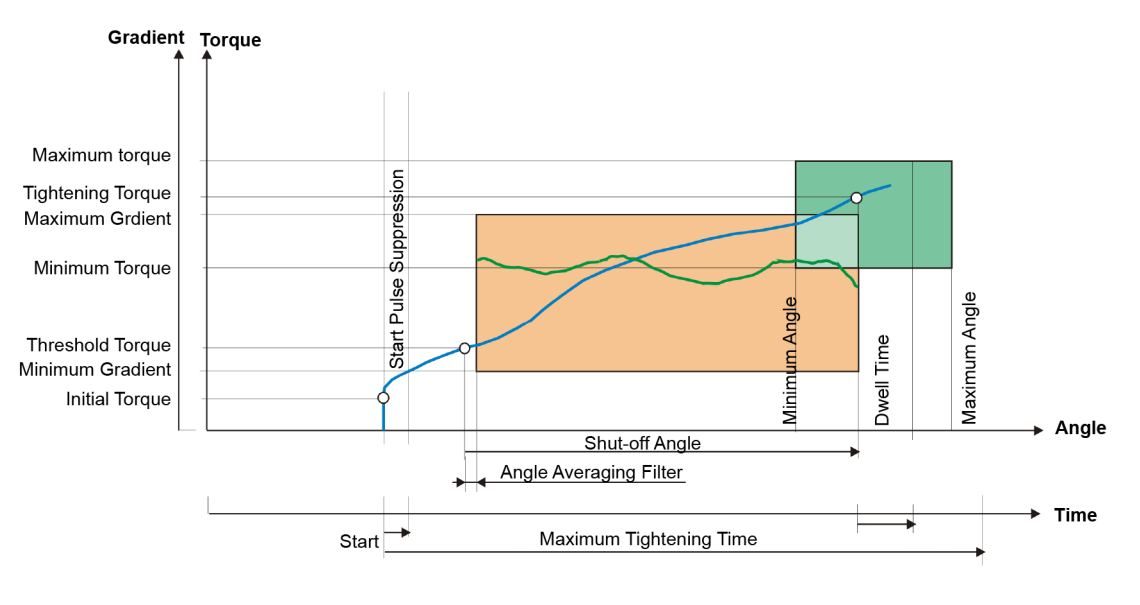

Fig. 3-14: Sequence 75

The torque occurring during the rundown operation as well as the angle are measured via the transducer built into the tool and processed by the controller.

The gradient calculation starts after the *Threshold Torque* + *Angle Averaging Filter* ends with the *Shut-Off Torque*.

When the *Shut-Off Angle* is reached, the tool is stopped. Then, the dwell angle and peak torque are recorded during the dwell time, and the tightening values of the fastener, together with the rundown evaluation, are fed to the controller.

When the *Trigger Torque* of a tool is reached, the torque trace is recorded and can be viewed via the trace function.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Angle	Shut-off Angle for the stage	0 … 9 999	AP (deg)
Angle Averaging Filter	Spacing in angle impulses of the filtered rundown data used for gradient calculation	1 … 30	AF (grd)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage	± Maximum speed	n (rpm)
Maximum Gradient	Upper limit of the gradient occurring	0 … 99.99	GdMax
Maximum Angle	High limit of angle reached	0 … 9 999	AngMax (deg)
Maximum Torque	High limit for torque reached and safety shut-off value	0 … 1.2 × TQ capacity	TqMax
Minimum Gradient	Lower limit of the gradient occurring	-99.99 … 99.99	GdMin
Minimum Angle	Low limit of angle reached	Angle Averaging Filter … 9 999	AngMin (deg)

Parameter	Explanation	Range of values	Abbrev.
Minimum Torque	Low limit of torque reached	0 … 1 × TQ capacity[1]	TqMin
Threshold Torque	Beginning of angle counting and gradient calculation	0 … 1.2 × TQ capacity	TqTh
Maximum Tightening Time	Safety Shut-off	The max fastening time applies for all tools of a tool group in this stage	
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ capacity	TqTr

3.12 Sequence 78: Torque & Angle controlled with Gradient monitoring

Shut-off torque controlled and shut-off angle controlled fastening sequence with torque control, tightening angle monitoring and gradient monitoring. This fastening sequence assumes a fast pretightening stage.

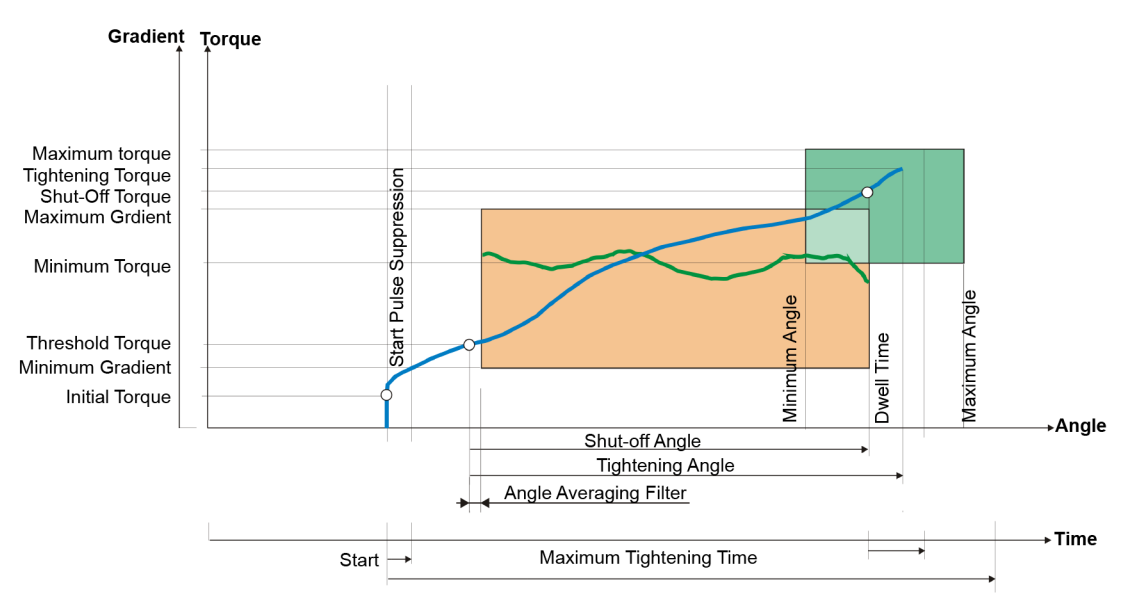

Fig. 3-15: Sequence 78

The torque occurring during the rundown operation as well as the angle are measured via the installed transducer and processed by the controller.

The gradient calculation starts after the *Threshold Torque* + *Angle Averaging Filter* ends with the *Shut-Off Torque*.

When the *Shut-Off Torque* or *Shut-Off Angle* is reached, the tool is stopped. Then, the dwell angle and peak torque are recorded during the dwell time, and the tightening values of the fastener, together with the rundown evaluation, are fed to the controller.

When the *Trigger Torque* of a tool is reached, the torque trace is recorded and can be viewed via the trace function.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Shut-off Torque of the stage	0 … 1 × TQ calibration value[2]	TqP
Shut-Off Angle	Shut-off Angle for the stage	0 … 9 999	AP (deg)

[1] Subsequent plausibility test related to the tool capacity (software-dependent)
[2] Subsequent plausibility test related to the tool capacity (software-dependent)

Parameter	Explanation	Range of values	Abbrev.
Angle Averaging Filter	Spacing in angle impulses of the filtered rundown data used for gradient calculation	1 … 30	AF
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage	± Maximum speed	n (rpm)
Maximum Gradient	Upper limit of the gradient occurring	0 … 99.99	GdMax
Maximum Angle	High limit of angle reached	0 … 9 999	AngMax (deg)
Maximum Torque	High limit of torque reached	0 … 1.2 × TQ capacity	TqMax
Minimum Gradient	Lower limit of the gradient occurring	-99.99 … 99.99	GdMin
Minimum Angle	Low limit of angle reached	*Angle Averaging Filter* … 9 999	AngMin (deg)
Minimum Torque	Low limit of torque reached	0 … 1 × TQ calibration value[1]	TqMin
Threshold Torque	Beginning of angle counting and gradient calculation	0… 1.2 × TQ capacity	TqTh
Maximum Tightening Time	Safety Shut-off	Applies for all tools of a tool group in this stage	
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ capacity	TqTr

3.13 Sequence 80: Torque/Angle controlled

Shut-off torque and shut-off angle controlled fastening sequence with tightening angle monitoring and torque control. This fastening sequence assumes a fast pretightening stage.

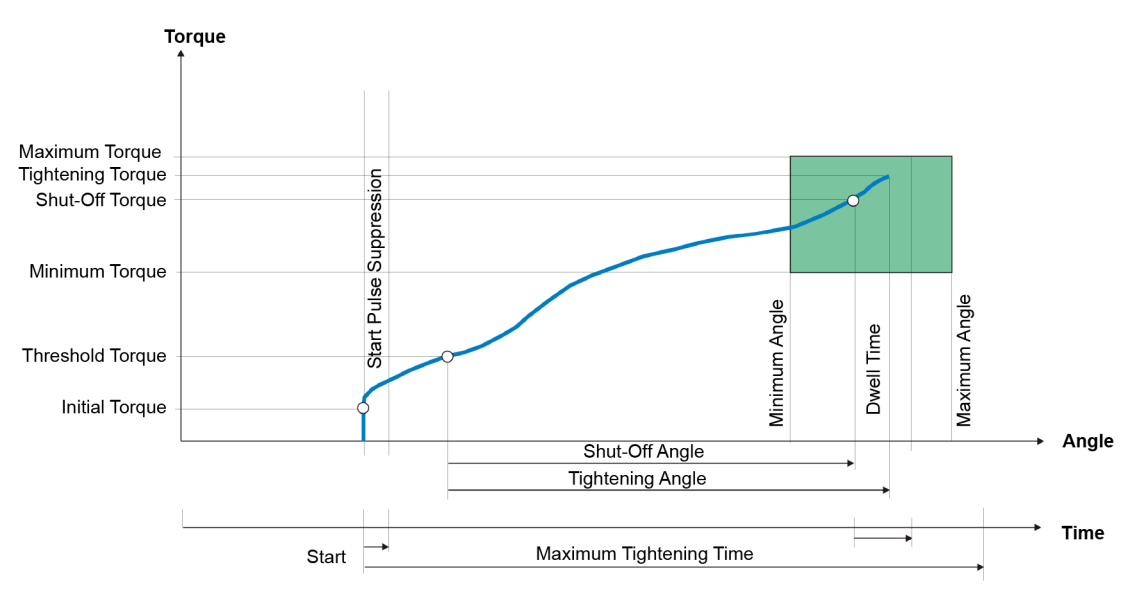

Fig. 3-16: Sequence 80

The torque occurring during the fastening sequence as well as the tightening angle is measured by the installed transducer and processed in the controller. When the *Shut-Off Torque* or *Shut-Off Angle* is reached, the tool is stopped. Then, the dwell angle and the peak torque are recorded during the dwell time, and the tightening values of the fastener, together with the result of the rundown, are fed to the controller.

When the programmable trigger torque of a tool is reached, recording of the torque curve starts and the curve can be displayed via the trace function.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Shut-off Torque of the stage	0 … 1 × TQ calibration value[1]	TqP
Shut-Off Angle	Shut-off Angle for the stage	0 … 9 999	AP (deg)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects.	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage	± Maximum speed	n (rpm)
Maximum Angle	High limit of angle reached	0 … 9 999	AngMax (deg)
Maximum Torque	High limit of torque reached	0 … 1.2 × TQ capacity	TqMax
Minimum Angle	Low limit of angle reached	0 … 9 999	AngMin (deg)
Minimum Torque	Minimum torque, low limit of torque reached	0 … 1 × TQ calibration value[1]	TqMin
Threshold Torque	Beginning of angle counting	0 … 1.2 × TQ capacity	TqTh
Maximum Tightening Time	Safety Shut-off	Applies for all tools of a tool group in this stage	
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ capacity	TqTr
Shut-off by TQ and ANG	• Activated: Tool switches off as soon as Shut-Off Torque and Shut-Off Angle are reached. If the maximum torque/angle is exceeded, the tool switches off immediately. • Deactivated: Tool switches off as soon as Shut-Off Torque or Shut-Off Angle is reached		

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

4 Back-off Fastening Sequence

4.1 Sequence 41: Back-off, Angle controlled

Shut-off angle controlled fastening sequence with back-off angle monitoring.

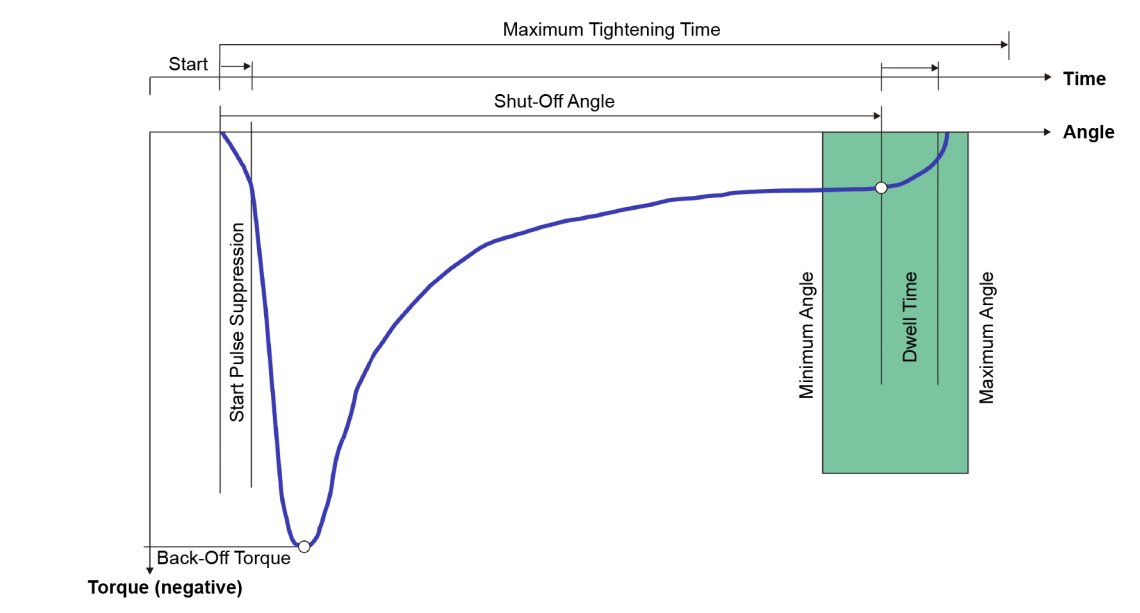

Fig. 4-1: Torque trace over angle

The tightening angle occurring during the fastening sequence is measured by the installed transducers and processed in the controller. The angle is counted after the start.

When the *Shut-Off Angle* is reached, the tool is stopped. Then, the dwell angle is measured during the dwell time and the back-off angle of the bolt, together with the evaluation of the back-off, is fed to the controller.

The Back-Off Torque is defined as being the torque that must act upon a fastening joint in the specified direction in order to overcome the total of the pressing and frictional forces and thus back-off the fastening joint.

The following parameters are entered into the controller:

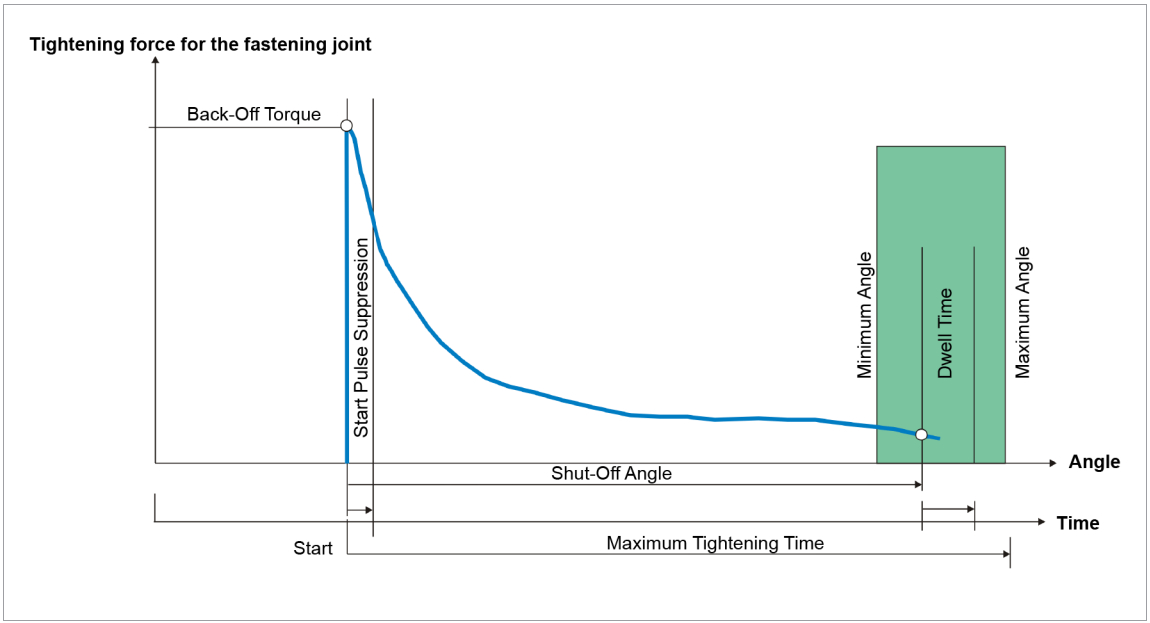

Fig. 4-2: Pretensioning force over angle

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Angle	Back-off angle	0 … 9 999	AP (deg)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage	± Maximum speed	n (rpm)
Maximum Angle	High limit of angle reached	0 … 9 999	AngMax (deg)
Minimum Angle	Low limit of angle reached	0 … 9 999	AngMin (deg)
Maximum Tightening Time	Safety Shut-off	Applies for all tools of a tool group in this stage	

4.2 Sequence 46: Back-off, Torque & Angle controlled

Fastening sequence for freely programmable parameter values.
Shut-off angle and shut-off torque controlled releasing strategy with angle and torque monitoring.

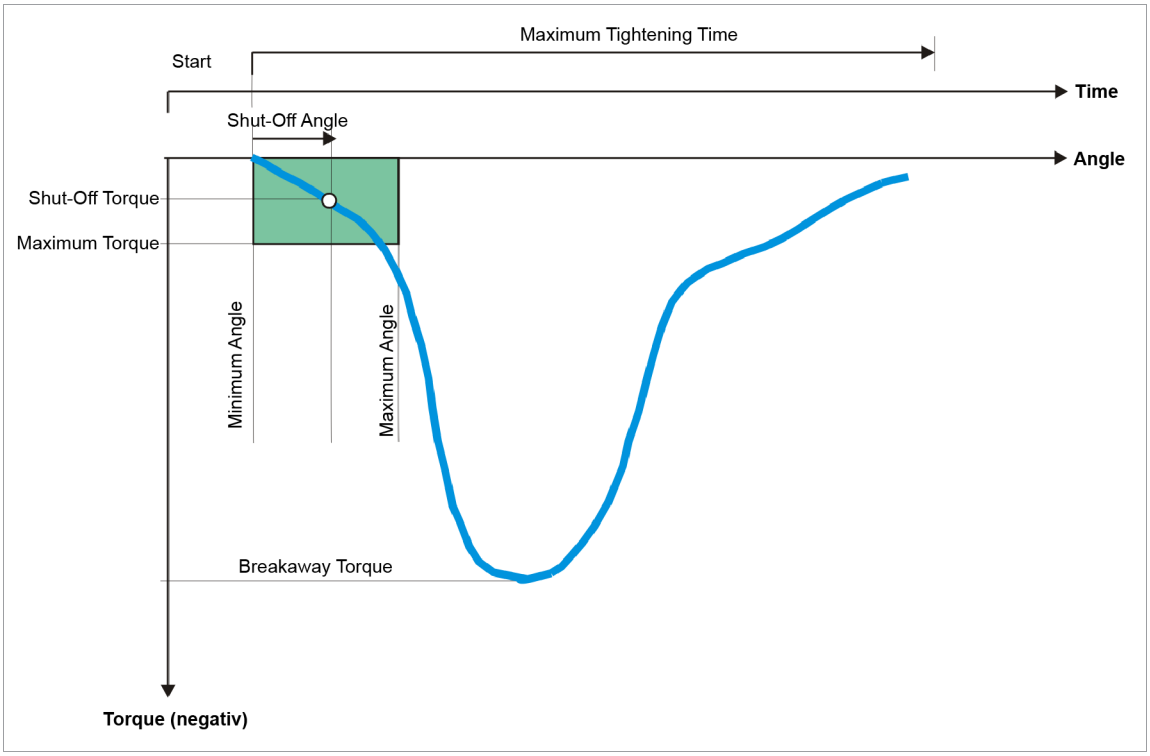

Fig. 4-3: Sequence 46

Often during the rundown there are jams between the fastener head and the socket. As a result, the tool can then be separated from the work piece only with difficulty and this results in subsequent failures in the automatic sequence. To alleviate this situation, it is possible to relax the socket with this sequence by counterclockwise rotation of the socket.

In the controller a relax stage can be implemented as the last action in the automatic fastening sequence. This should enable the easy separation of the socket from the workpiece. To do this, the nutrunner unit is reversed. The releasing stage, which can be switched on/off, has pre-determined parameters for this that cannot be adjusted.

Sequence 46 should be used for the individual adjustment. What is important here is that the socket is released, but under no circumstances is the fastener loosened. This would in turn cause binding. Moreover, the screwed joint can be released again. The angle range that is passed through for the release depends

on the mechanical structure of the nutrunner unit. The stiffer the tightening mechanics and the more closely fitting the machined parts (socket, square...), the smaller the release angle.

The Breakaway torque is the force that must act on a fastening joint in the expected direction in order to overcome the sum of the compressive and frictional forces to release the fastening joint.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Prevents the back-off of the screwed joint	0 … 1.2 x TQ capacity	TqP
Shut-Off Angle	Release (back-off angle)	0 … 9 999	AP (deg)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
Speed	Programmable maximum tool speed allowed for stage	± Maximum speed	n (rpm)
Maximum Angle	High limit for angle reached and safety shut-off value	0 … 9 999	AngMax (deg)
Maximum Torque	High limit for torque reached and safety shut-off value	0 … 1.2 × TQ capacity	TqMax
Minimum Angle	Low limit of angle reached	0 … 9 999	AngMin (deg)
Maximum Tightening Time	Safety Shut-off	Applies for all tools of a tool group in this stage	

4.3 Sequence 47: Back-off, until residual torque

Shut-off torque controlled back-off strategy with back-off angle and residual torque monitoring
Sequence 47 is software dependent and is only available for LiveWire tools with software versions S169251-160.4 or S169252-162.2 and newer. It is used to ensure that a defined Residual Torque (Shut-Off Torque) is reached when loosening a screw connection.

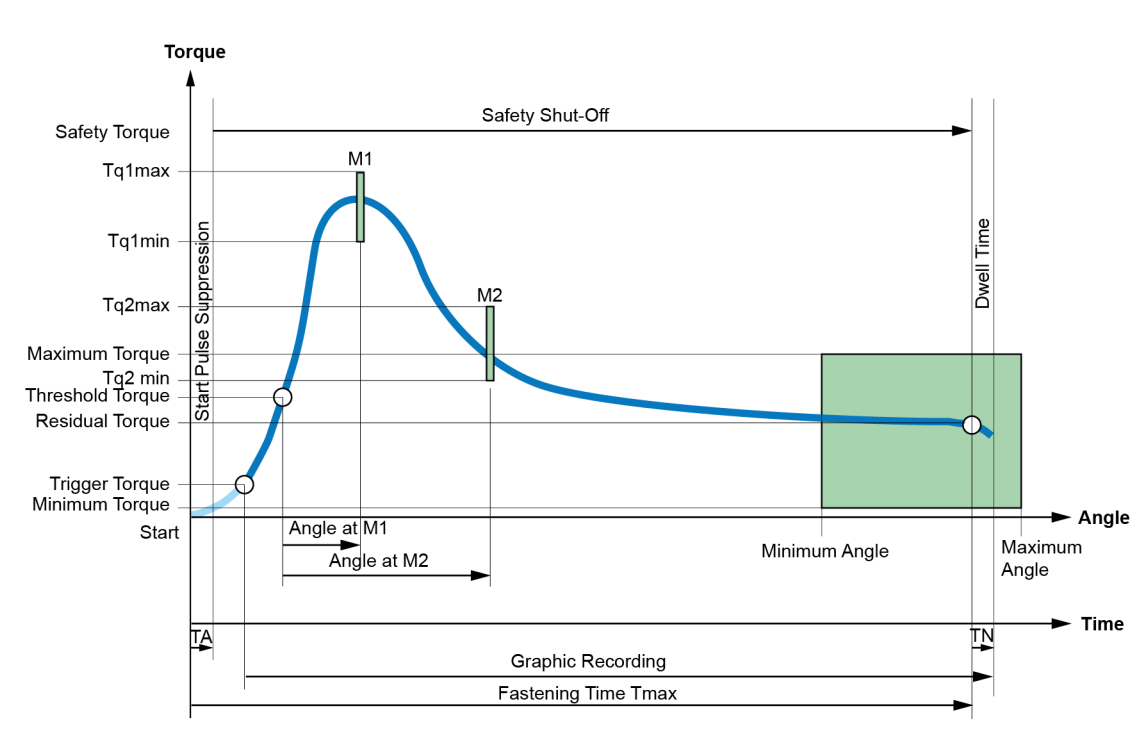

Fig. 4-4: Sequence 47

When current redundancy is activated, the first 90° rotation is at reduced speed of 10 rpm.

The safety shut-off starts after the *Start Pulse Suppression*.

When the *Trigger Torque* is reached, the torque curve is recorded and can be displayed using the graphic function.

When the Threshold Torque is reached, the Maximum Angle, *Angle at M1* and the *Angle at M2* are counted and the back-off torque shut-off is activated.

The tool is switched off as soon as the Residual Torque is reached. To prevent premature shut-off of the back-off process, the Threshold Torque must be greater than the Residual Torque. The tool would shut-off immediately if the Threshold Torque was less than the Residual Torque.

When the Residual Torque is reached, the dwell angle and the dwell torque are recorded during the Dwell Time.

Dwell Time

If a *Dwell Time* is parameterized, the dwell angle and the dwell torque are recorded after the Residual Torque has been reached. Within an angle degree, only the highest torque value is recorded. Since only the increasing torques are considered in the Dwell Time, the final torque result and the lowest point of the graph can be above the Residual Torque.

Example: Rundown with parameterized Dwell Time. The Residual Torque is 1.00 Nm.

	Measured value: Residual Torque not reached yet	**Measured value: Residual Torque reached, Dwell Time starts**	**Measured value: Dwell Time finished**
Angle	31,2°	31,4°	32,7°
Torque	1.02 Nm	0.99 Nm	1.01 Nm
Result		The preliminary result in the Residual Torque is 0.99 Nm.	The final result is 1.01 Nm.
		The angle 31° has the result 1.02 Nm (highest value in the angle degree).	The angle 32° has the result 1.02 Nm.

➢ The final result is 1.01 Nm, because the torque has increased during the Dwell Time. The last graphic point is set to the final result.

Torque Gates

Two torque gates (M1 and M2) can be defined, which provide additional monitoring of the back-off strategy.

The gates stand for an angle at which a minimum and a maximum torque (*Tq1min*, *Tq1max* or *Tq2min*, *Tq2max*) may not be exceeded. The gates M1 and M2 are defined by Angle at M1 and Angle at M2, from the threshold torque.

If the torque at these gates is not within the corresponding limits, the tool is stopped. The tool result is evaluated with NOK and an error message is displayed. Depending on the displayed error, the corresponding parameter must be adjusted:

Error message	**Description**	**Measure**
M1<	Torque M1 is too low.	► Enter a lower value at *Minimum Torque Tq1*. ► Change *Angle at M1*.
M1>	Torque M1 is too high.	► Enter a higher value at *Maximum Torque Tq1*. ► Change *Angle at M1*.
M2<	Torque M2 is too low.	► Enter a lower value at *Minimum Torque Tq2*. ► Change *Angle at M2*.

Error message	Description	Measure
M2>	Torque M2 is too high.	► Enter a higher value at *Maximum Torque Tq2*. ► Change *Angle at M2*.

The chronological order of the two gates is arbitrary, i.e. M1 can be before or after M2 or even on M2. Torque control in the gates can be deactivated individually by setting the parameter *Angle at M1* or *Angle at M2* to zero. If zero is parameterized for *Tq1min* or *Tq2min*, the minimum torque in this gate is not checked. In this case the error M1</M2< does not occur, even if the torque is e.g. -0.2 Nm.

Parameter

The following parameters must be parameterized for the rundown:

Parameter	Explanation	Range of values	Abbrev.
Residual Torque (Shut-Off Torque)	Torque as target value, when reaching this value the tool is stopped and the Dwell Time starts.	0 … TQ calibration	TqP
Minimum Torque	Lower limit value of the torque reached at the shut-off point. If the torque is not reached, the stage is evaluated as NOK (TQ<).	0 … Residual Torque	TqMin
Maximum Torque	Upper limit value of the torque reached at the shut-off point. If the torque is exeeded, the stage is evaluated as NOK (TQ>).	0 … 1.2 × TQ capacity	TqMax
Minimum Angle	Lower limit value of the angle reached at the shut-off point. If the angle is not reached, the stage is evaluated as NOK (ANG<).	0 … 9 999	AngMin (deg)
Maximum Angle	Upper limit value of the angle reached at the shut-off point. If the angle is exeeded, the stage is evaluated as NOK (ANG>).	0 … 9 999	AngMax (deg)
Trigger Torque	Start of storing the torque values for the graphical view	0 … Safety Torque	TqTr
Threshold Torque	Beginning of angle counting	Residual Torque … Safety Torque	TqTh
Speed	Speed on the tool, which is within the range of the maximum speed specified in the tool constants.	0 … maximum tool speed	n (rpm)
Torque Averaging Filter	Used to calculate the average torque value to avoid interference peaks. This number of torque values is used to form an average immediately after recording, equating to filtering and damping. As soon as a new measured value has been recorded, the oldest value is eliminated and the average recalculated. The other evaluation factors (shutoff, evaluation, graph) are calculated with these averages. A filtering factor of 1 means no averaging.	1, 2, 4, 8, 16, 32	Ff
Safety Torque	Monitoring torque valid after expiration of the Start Pulse Suppression and during the rundown. If this torque is exceeded, the tool is stopped immediately.	0 … 1.2 × TQ calibration	TqSa

Parameter	Explanation	Range of values	Abbrev.
Angle at M1	Angle value at which it is checked that the torque is still in its range between Tq1max and Tq1min. If the torque is outside the allowed range, this will cause the sequence to be aborted and an NOK evaluation (M1>, M1<) for the stage.	0 … 9 999	AngM1 (deg)
Angle at M2	Angle value at which it is checked that the torque is still in its range between Tq2max and Tq2min. If the torque is outside the allowed range, this will cause the sequence to be aborted and an NOK evaluation (M2>, M2<) for the stage.	0 … 9 999	AngM2 (deg)
Minimum Torque Tq1	Lower limit of achieved torque when Angle at M1 is reached. Understepping this value will cause an NOK evaluation (M1<) for the stage.	0 … 1.2 × TQ calibration	Tq1min
Maximum Torque Tq1	Upper limit of achieved torque when Angle at M1 is reached. Exceeding this value will cause an NOK evaluation (M1>) for the stage.	Residual Torque … Safety Torque	Tq1max
Minimum Torque Tq2	Lower limit of achieved torque when Angle at M2 is reached. Understepping this value will cause an NOK evaluation (M2<) for the stage.	0 … TQ calibration	Tq2min
Maximum Torque Tq2	Upper limit of achieved torque when Angle at M2 is reached. Exceeding this value will cause an NOK evaluation (M2>) for the stage.	Residual Torque … Safety Torque	Tq2max
Fastening Time	Maximum fastening time which is measured from the start until the residual torque is reached.	0 … 9 999	Tmax (ms)

4.4 Sequence 48: Back-off, advanced monitoring

Shut-off angle controlled back-off strategy with back-off angle and residual torque monitoring. 2 gates can be defined at which the torque must not fall below a minimum and exceed a maximum torque.

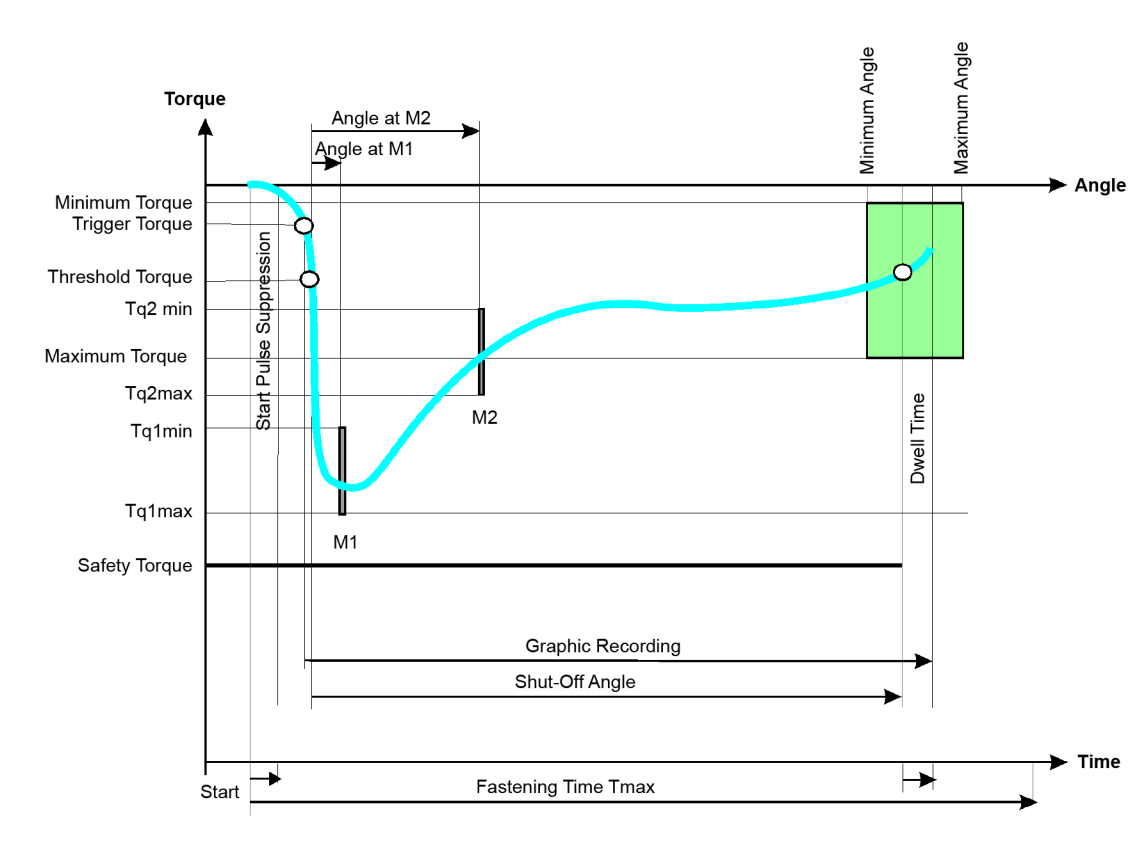

Fig. 4-5: Sequence 48

The angle of rotation occurring during the fastening sequence is measured by the installed transducers and processed in the controller. When the *Threshold Torque* is reached, the angle is counted.

When the *Angle Averaging Filter* is reached, the tool is stopped. Then, the dwell angle is measured during the dwell time and the back-off angle of the bolt, together with the evaluation of the back-off, is fed to the controller.

One check is carried out at each of the two gates M1 and M2 in order to determine whether Tq1min, Tq1max or Tq2min, Tq2max torque limits are undershot or exceeded, respectively. Gates M1 and M2 are defined by the angle at M1 and the angle at M2 starting from the threshold torque.

Should the torque at these gates not be within the corresponding min/max limits, the drive is stopped and the tool result is evaluated as NOK.

The time sequence of the two gates can be freely chosen, i. e. M1 can be before or after M2 or even on M2. The torque control at gates M1 and M2 can be individually deactivated by setting the angle at M1, or M2 to zero.

The torque at M1 and M2, as well as the maximum torques in the rundown, are measured and the results are included in the statistical evaluation.

When the *Trigger Torque* is reached, the torque trace is recorded and can be viewed via the trace function.

When current redundancy is activated, the first 90° rotation is at reduced speed of 10 rpm

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	tMeas (ms)
Speed	Programmable maximum tool speed allowed for stage	0 … 90° ±10 rmp	n (rpm)
Shut-Off Angle	Angle at which the drive is stopped and the dwell time begins	0 … 9 999	AP (deg)
Maximum Angle	High limit for angle reached at the shut-off point and safety shut-off value	0 … 9 999	AngMax (deg)
Maximum Torque	High limit of torque reached in the shut-off point	0 … 1.2 × TQ capacity	TqMax
Maximum Torque Tq1	Maximum torque allowed at M1	0 … 1.2 × TQ calibration	Tq1max
Maximum Torque Tq2	Maximum torque allowed at M2	0 … 1.2 × TQ calibration	Tq2max
Minimum Angle	Low limit of angle reached in the shut-off point	0 … 9 999	AngMin (deg)
Minimum Torque	Low limit of torque reached in the shut-off point	0 … TQ calibration	TqMin
Minimum Torque Tq1	Minimum torque allowed at M1	0 … 1.2 × TQ calibration	Tq1min
Minimum Torque Tq2	Minimum torque allowed at M2	0 … TQ calibration	Tq2min
Threshold Torque	Beginning of angle counting	0 … 1.2 × TQ capacity	TqTh
Fastening Time	Maximum fastening time which is measured from the start until the residual torque is reached	0 … 9 999 ms	Tmax (ms)
Safety Torque	Monitoring torque valid after the start pulse suppression has finished and during the rundown above which the tool is immediately stopped	0 … 1.2 × TQ calibration	TqSa
Trigger Torque	Start of storing the torque values for the graphical view	0 … 1.2 × TQ capacity	TqTr
Angle at M1	Angle at which the torque is checked at a position between Tq1max and Tq1min; at a position outside of the range Tq1min to Tq1max, the tool is stopped	0 … 9 999	AngM1 (deg)
Angle at M2	Angle at which the torque is checked at a position between Tq2max and Tq2min; at a position outside of the range Tq2min to Tq2max, the tool is stopped	0 … 9 999	AngM2 (deg)

5 Special Fastening Sequences

5.1 Sequence 15: DTM, Drag Torque Measurement

The Drag Torque Measurement is initiated like a normal rundown cycle and completely performed by the controller. The Drag Torque Measurement is divided into four phases, that are called up in succession and run through. In the individual phases, the following functions are executed.

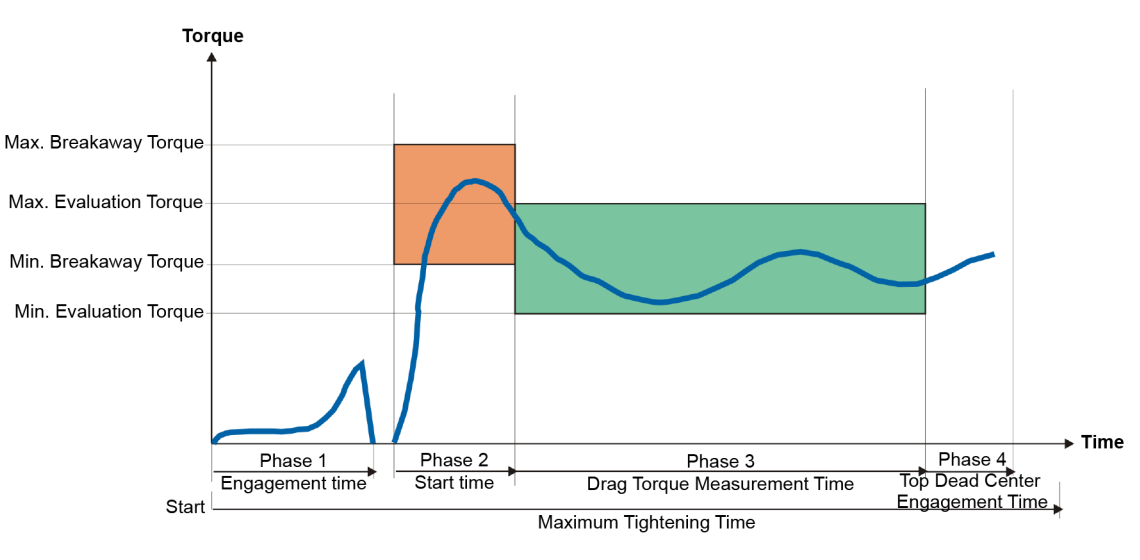

Fig. 5-1: Sequence 15

Phase 1: Engagement

The tool is started and turns until an external I/O signal (Engagement Initiator) indicates that the entrainment device (usually the socket) is engaged. The torque and the tightening angle during the fastening sequence are measured by the installed transducer and processed in the controller. Depending on the programmed input signals, the tool can also be stopped, if a fault is detected (Workpiece out of position). If Engagement Initiator and Workpiece out of position are not defined in the I/O map and enabled before tool start is enabled, this error message will appear and tool will not run.

For safety reasons, the tool is stopped and canceled if there is a NOK evaluation in all phases when the maximum Breakaway Torque is exceeded.

Phase 2: Start time

Before the tool is started, the signal Workpiece out of position must be set. In this phase, the breakaway torque is checked. It must be within the limit values *Breakaway Torque Minimum* and *Breakaway Torque Maximum*. If this applies, the sequence continuously transitions into phase 3; otherwise, there is an immediate stoppage of the tool. If the *Breakaway Torque Minimum* is not exceeded, the sequence transitions into phase 3 an event (MDS<) occurs at the end of the sequence.

Phase 3: Drag Torque Measurement Time

During the Drag Torque Measurement Time, the torque is checked to see if it exceeds or falls below *Minimum Evaluation Torque* and *Maximum Evaluation Torque*, respectively, and records the maximum and minimum frictional torque that occurs. After the measuring time has elapsed, the Drag Torque Measurement Time is finished and the sequence is continuously transitioned into phase 4.

Phase 4: Engage top dead center (move to a defined end position)

During phase 4, the tool continues to turn until an external I/O signal indicates that the top dead center position has been reached (OTINI, top dead center).

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Start Time	Time to overcome the breakaway and to monitor the back-off torque, determines the duration of phase 2	0 … 60 000	tSt (ms)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
Speed	Speed preselection; in the range of maximum speed prescribed in the tool constants, depending on the next parameters	± Maximum speed	n (rpm)
Maximum Evaluation Torque	Upper Evaluation Torque during the measuring time (phase 3)	0 … 1 × TQ calibration[1]	TqEmax
Breakaway Torque Maximum	Safety shut-off torque during the start time (phase 2)	0 … 1 × TQ calibration[1]	TqBMax
Measuring Time	Time in which the frictional torque is checked, determines the duration of phase 3	0 … 60 000	tMeas (ms)
Minimum Evaluation Torque	Upper Evaluation Torque during the measuring time (phase 3)	0 … 1 × TQ calibration[1]	TqEmin
Breakaway Torque Minimum	Lower limit of the breakaway torque for evaluation in the start time (phase 2)	0 … 1 × TQ calibration[1]	TqBMin
Maximum Tightening Time	Safety Shut-off	Applies for all tools of a tool group in this stage	
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ capacity	TqTr

For the correct execution of this fastening sequence, the input signals Engagement Initiator, Top Dead Center Initiator (OTINI) and Workpiece out of position must be programmed in the controller. The signals Engagement Initiator and Top Dead Center Initiator (OTINI) must be assigned to the tightening module as direct signals.

5.2 Sequence 16: Set Position

Event-dependent rotation. This sequence is used to stop the tool according to a known angle shut-off value past a certain position (Engagement Initiator) in order to achieve, for example, an exact Top Dead Center (TDC) position of a machining workpiece. In this stage, the trace function is not supported.

After reaching the initiator position, the angle counting begins. If the programmed shut-off angle is reached, the tool stops. The angle shut-off values reached are stored into the OK/NOK evaluation. An evaluation of the torque value achieved is not provided.

For safety reasons, the tool is stopped if the Maximum Torque is exceeded and the evaluation will be NOK.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Angle	Shut-off Angle for the stage	0 … 9 999	AP (deg)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

Parameter	Explanation	Range of values	Abbrev.
Speed	Speed preselection; in the range of maximum speed specified in the tool constants	± Maximum speed	n (rpm)
Maximum Angle	Maximum angle, high limit for angle reached and shut-off value	0 … 9 999	AngMax (deg)
Maximum Torque	Maximum torque, high limit of torque reached and shut-off value	0 … 1.2 × TQ capacity	TqMax
Minimum Angle	Minimum angle, low limit of angle reached	0 … 9 999	AngMin
Maximum Tightening Time	Safety Shut-off	Applies for all tools of a tool group in this stage	

For the proper execution of this sequence, the input signal Engagement Initiator must be programmed in the controller.

► Add or assign an input signal to the tightening module as a direct signal in the programming of the I/O map.

5.3 Sequence 21: Counterholder Function

This sequence is used for torque reaction bracing of rundowns. The counter-tool applies the counter-torque to the corresponding tool. In this sequence, the trace function is not supported.

The torque reaction bracing is initiated like a normal rundown cycle and is executed completely by the controller. When this sequence is started, the counter-tool is activated with the speed "0".

If the max. torque is achieved during the torque reaction bracing, the tool shuts off with an NOK result. The torque shut-off values reached go into the OK/NOK evaluation. An evaluation of the torque value is not provided.

If the corresponding tool has finished the rundown, the torque reaction bracing operation of the counter-tool is also finished.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
Corresp. Tool	Tool against which there must be torque reaction bracing	1 … 32	Tool
Maximum Torque	High limit of torque reached	0 … 1.2 × TQ capacity	TqMax
Minimum Torque	Low limit of the torque reached	0 … 1.2 × TQ capacity	TqMin
Maximum Tightening Time	Safety Shut-off	This applies for all tools of a tool group in this stage	

5.4 Sequence 32: Prevailing Torque, compensated

Shut-off-torque-controlled fastening sequence with torque control and angle monitoring taking into account tapping forces, press-in forces, frictional torque and tapping torque which are often referred to as press-in torque.

Tapping forces, press-in forces, frictional torque and tapping torque are losses that are not entered into the desired pretensioning force of the rundown.

While tightening in the fasteners, the press-in torque is determined and added to the programmed target torque. Thus, the press-in torque differences are not incorporated into the target torque dispersion.

This fastening sequence can be used for rundowns that pull in additional form-fitting components, such as bearings, when tightening. These press-in forces can be very different and thereby influence the range of the rundown. This range is countered by individual determination of these forces during the rundown.

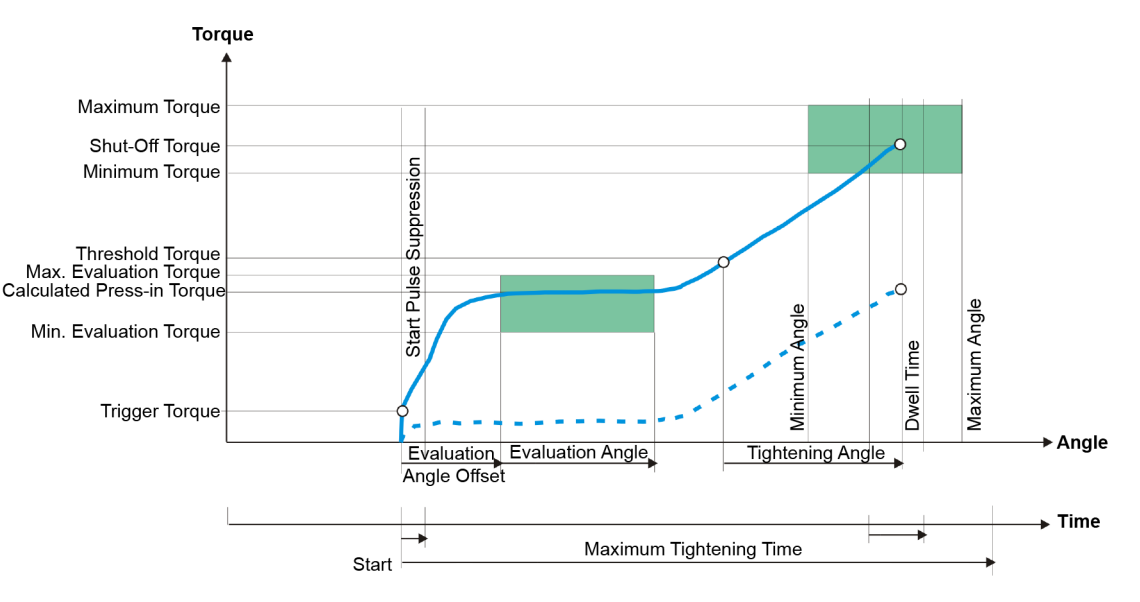

Fig. 5-2: Sequence 32

In this fastening sequence, an average torque value is calculated over a defined range. This compensates for the prevailing torque detected.

The torque occurring during the rundown operation as well as the angle are measured via the installed transducer and processed by the controller. When the search criterion *Trigger Torque* is reached, the Evaluation Angle Offset begins. The programmed max torque must not be exceeded. If this occurs, a fastening sequence is immediately terminated and evaluated as NOK.

The programmable *Evaluation Angle* is appended to the *Evaluation Angle Offset*. The torque must not exceed the programmable *Maximum Evaluation Torque* or fall below the programmable *Minimum Evaluation Torque*. If it does, the fastening sequence is immediately terminated and evaluated with NOK.

When the Evaluation Angle is finished, an arithmetic average calculation of the achieved torque values is made over the range of the Evaluation Angle. The resulting torque is added to the programmed Shut-Off Value and the torque limit values for further processing of the rundown. The detection of the threshold torque is deactivated until the Evaluation Angle is finished.

In the range of the Evaluation Angle, another *Maximum Evaluation Torque Range* is evaluated. The difference between the maximum and minimum torque that occurs must not exceed the *Maximum Evaluation Torque Range*. If this occurs, the fastening sequence is immediately terminated and evaluated as NOK. If not errors otherwise occur, the rundown continues up until the newly determined shut-off torque (programmed shut-off torque + press-in torque).

If the newly determined threshold torque is exceeded, the angles are counted. For the subsequent evaluation of the fastening joint, the newly determined torque limit values are also used. Because the Shut-Off Value changes with each new rundown, torque statistics cannot be executed with this fastening sequence. The results of the rundown that are reached are determined by the measuring board on the main software.

In addition, a second speed can be programmed that becomes effective after a likewise programmable *Switching Angle*. If the *Switching Angle* is exceeded, a speed changeover is executed.

If the *Shut-Off Torque* is reached, the fastening sequence is terminated.

Then, the dwell angle and peak torque are recorded during the dwell time, and fed as tightening values of the fastener, together with the rundown evaluation, to the controller.

When the *Trigger Torque* is reached, the torque trace is recorded and can be viewed via the trace function.

The max angle is used as a safety shut-off. A maximum rundown time is programmed as an additional safety shut-off. This becomes generally effective for all tools of a Application (fastening sequence) in this stage.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Shut-off Torque of the stage	0 … 1.2 × TQ calibration value[1]	MP
Evaluation Angle Offset	Angle range at the beginning of the trigger torque in which the threshold torque is not valid	0 … 9 999	AngEoff (deg)
Evaluation Angle	Duration of the monitored range for determination of the press-in torque	0 … 9 999	AngE (deg)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects.	1, 2, 4, 8, 16, 32	Ff
Speed	Speed preselection; in the range of maximum speed specified in the tool constants	± Maximum speed	n (rpm)
Final Speed	Speed preselection; in the range of maximum speed specified in the tool constants	± Maximum speed	n2 (rpm)
Maximum Evaluation Torque	Upper torque limit in the Evaluation Angle, which must not be exceeded	0 … 1.2 × TQ calibration value[1]	TqEmax
Maximum Angle	High limit for angle reached and safety shut-off value	0 … 9 999	AngMax (deg)
Maximum Torque	High limit of torque reached	0 … 1.2 × TQ calibration value[1]	TqMax
Minimum Evaluation Torque	Lower torque limit in the Evaluation Angle, below which the torque must not fall	0 … 1 × TQ calibration value[1]	TqEmin
Minimum Angle	Low limit of angle reached	0 … 9 999	AngMin (deg)
Minimum Torque	Low limit of torque reached	0 … 1 × TQ calibration value[1]	TqMin
Threshold Torque	Beginning of angle counting	0 … 1.2 × TQ calibration value[1]	TqTh
Maximum Tightening Time	Safety Shut-off	The max fastening time applies for all tools of a tool group in this stage	
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ capacity	TqTr
Switching Angle	Specified angle for the speed changeover, starting when the final rotation is in effect	0 … 9 999	AnCo

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

Parameter	Explanation	Range of values	Abbrev.
Maximum Evaluation Torque Range	Admissible maximum deviation of the maximum and minimum torque in the Evaluation Angle	0 … 1.2 × TQ calibration value[1]	TqErange

5.5 Sequence 33: Pulse Torque Recovery

Shut-off torque controlled fastening sequence with maintenance of the torque and automatic retightening. This fastening sequence assumes a faster pretensioning or a final tightening.

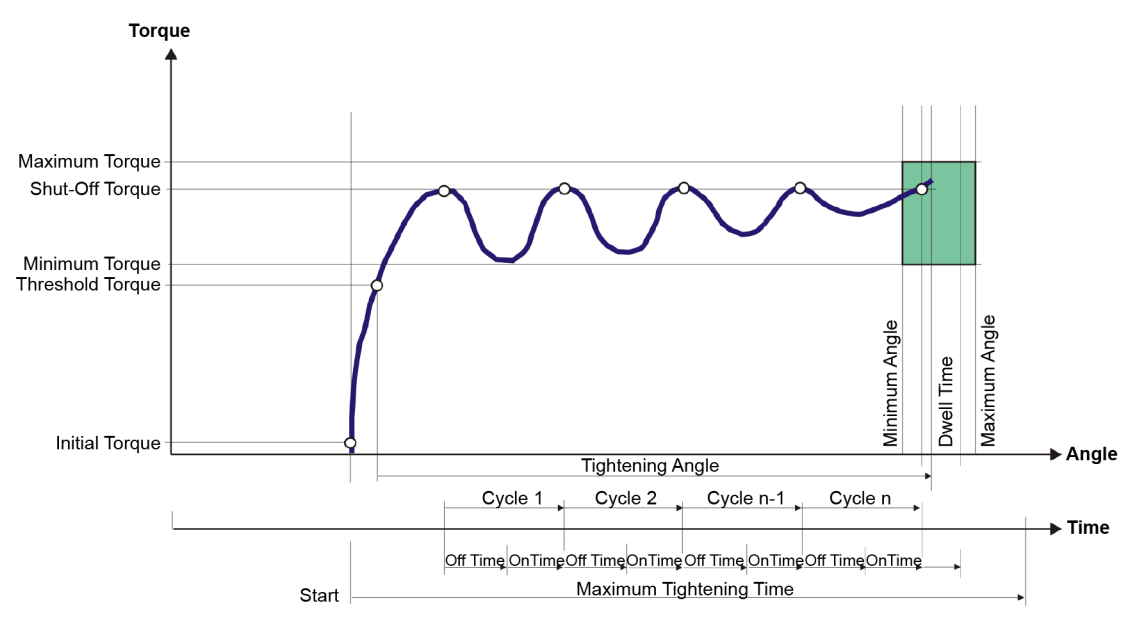

Fig. 5-3: Sequence 33

The torque occurring during the rundown operation as well as the angle are measured via the installed transducer and processed by the controller.

After the *Threshold Torque* is reached, the angle is counted. The tool is pulsed between rotary movement and maintaining the torque that has been attained.

When the *Shut-Off Torque* is reached, the tool is stopped and the attained shut-off torque is maintained, i.e., a mechanical release of the tool is prevented.

The relaxing of the joint can occur while the *PTR Off-Time* is elapsing.

After the *PTR Off-Time* elapses or when the programmed minimum torque is not reached, the tool restarts at the programmed speed.

After the *PTR On-Time* has lapsed, or when the shut-off torque is exceeded, the tool is stopped again and the shut-off torque is maintained. A cycle consists of an *PTR On-Time* and *PTR Off-Time*. The number of cycles that occur matches the number of repetitions that are programmed. However, the maximum time for this is restricted to 3000 milliseconds.

Then the dwell angle and the peak torque are recorded during the dwell time. During the programmed dwell time, an automatic, slow and controlled release of the tool occurs until the torque falls below the threshold torque.

The tightening values of the fastener, together with the result of the tightening, is fed to the controller.

When the *Trigger Torque* is reached, the torque trace is recorded and can be viewed via the trace function.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Shut-off Torque of the stage	0 … 1.2 × TQ calibration value[1]	TqP
Number of reruns	Number of repetitions of the *PTR On-Time* and *PTR Off-Time*	1 … 250	# Repetitions
PTR Off-Time	For the duration of this time, the tool remains in hold mode as long as the minimum torque is not exceeded	0 … 999	PTR Off (ms)
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
Speed	Speed preselection; in the range of maximum speed specified in the tool constants	± Maximum speed	n (rpm)
PTR On-Time	For the duration of this time, the tool remains on until the shut-off torque is reached	0 … 999	PTR On (ms)
Maximum Angle	High limit for angle reached and safety shut-off value	0 … 9 999	AngMax (deg)
Maximum Torque	High limit of torque reached	0 … 1.2 × TQ calibration value[1]	TqMax
Minimum Angle	Low limit of angle reached	0 … 9 999	AngMin (deg)
Minimum Gradient	Low limit of torque reached	0 … 1 × TQ calibration value[1]	TqMin
Threshold Torque	Beginning of angle counting	0 … 1.2 × TQ calibration value[1]	TqTh
Maximum Tightening Time	Safety Shut-off	The max fastening time applies for all tools of a tool group in this stage. 0 … 3 000 ms	
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ capacity	TqTr

5.6 Sequence 35: Clamping Force

Sequence 35 uses the clamp force for the tightening process. When the screw is tightened, a tensile force is created in the thread, which acts on the components to be joined in the direction of the screw axis and causes a slight deformation of the screw. The residual clamping force that arises holds the components together. The residual clamping force of the clamped components ensures that the connection does not come loose again.

There are two versions of sequence 35:

- Version 1: Customized software version (S168835)
- Version 2: Customized software version (S168813/MPSW300-B)

Version 1: Customized Software Version

Shut-Off angle and torque controlled fastening sequence with torque, angle and force control. In addition, there is a partially monitored torque control during fastening and a subsequent torque evaluation using the residual and clamp force method.

The rundown has to be within the monitoring range. This ensures that irregularities are detected when screwing in or on the screw and that the fastening processes always behave in the same way.

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

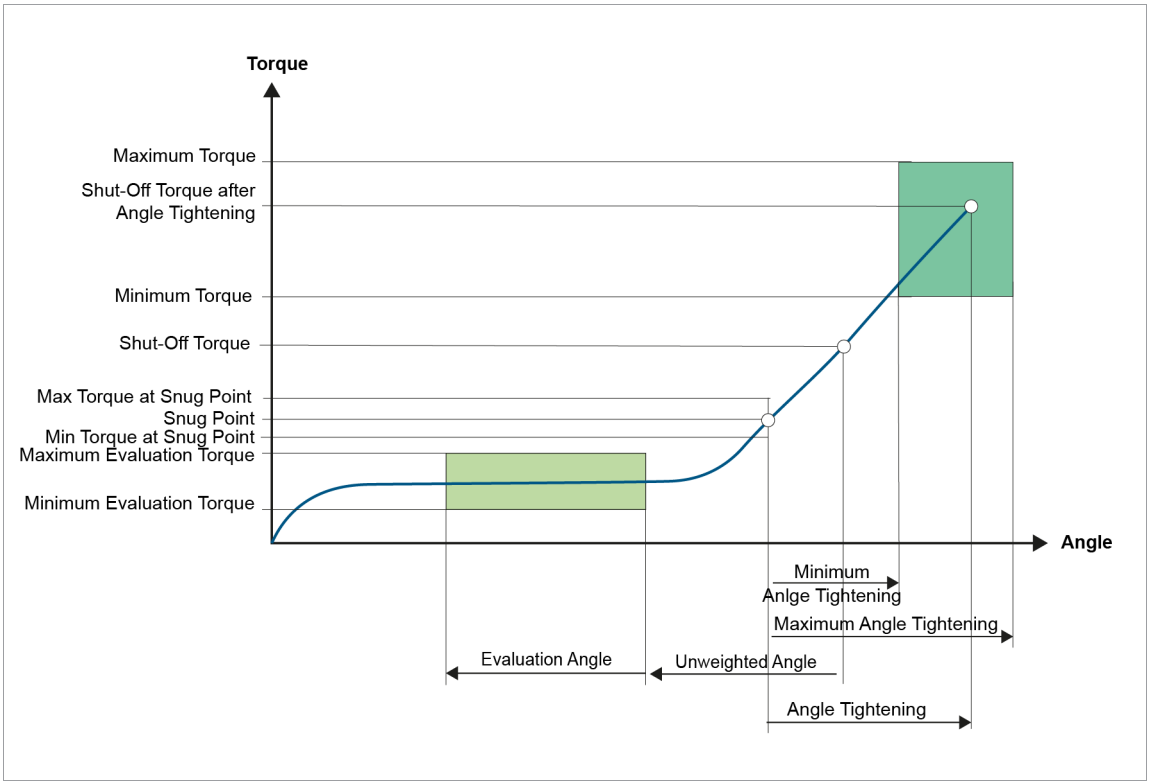

Fig. 5-4: Sequence 35 – Customized software version

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Torque at which the drive is stopped and the dwell time starts	0 … 1 × TQ capacity	TqP
Minimum Torque	Low limit of torque reached	0 … 1 × TQ calibration value[1]	TqMin
Maximum Torque	High limit of torque reached	0 … 1.2 × TQ capacity	TqMax
Torque Averaging Filter	Number of measured values used for filtering torque by averaging	1, 2, 4, 8, 16, 32	Ff
Min Torque at Snug Point	Lower limit of the torque achieved at the snug point	0.1 ... Max Torque at Snug Point	MdMin_FP
Max Torque at Snug Point	Upper limit of the torque achieved at the snug point	Min Torque at Snug Point ... Maximum Torque	MdMax_FP
AF for GD at Switchoff Point	Angle Averaging Filter for gradient at shut-off point Distance in angular degrees of the damped measured values used to calculate the gradient at the shut-off point	1 ... 30	AF_SOP (deg)
AF for Snug Point Detection	Angle averaging filter for the gradient at the snug point Distance in angular degrees of the damped measured values used to calculate the gradient at the snug point	1 ... 30	AF_APD (deg)
GD bevel für Snug Point Detection	Gradient flattening for snug point detection Percentage value for the gradient of the characteristic curve that is to be flattened at the snug point in order to find this point	0 ... 100	Bevel_APD

Parameter	Explanation	Range of values	Abbrev.
Calculation of factor	Used to determine the factors for the clamp force and residual clamping force method		-
Correction angle	Is required to determine the factor	0 ... 999	ANcorr (deg)
Clamping force sequence	Tightening according to the clamp force method with the *Clamping force factor (Tightening)*		-
Clamping force	Force at which the drive is stopped		FK (kN)
Clamping force factor (Tightening)	Factor is determined using a measurement method and entered here		EF (kN/deg)
Minimum clamping force	Lower limit of the clamp force		FKmin (kN)
Residual Clamping force factor (Tightening)	Factor is determined using a measurement method and entered here		EFR (kN/deg)
Maximum clamping force	Upper limit of the clamp force		FKmax (kN)
Residual clamping force sequence	Tightening according to the clamp force method with the *Residual Clamping force factor (Tightening)*		-
Back-off factor	Factor is determined using a measurement method and entered here		LF (kN/deg)
Residual clamping force	Force at which the drive is stopped		FRK (kN)
Minimum residual clamping force	Lower limit of the residual clamping force		FRKmin (kN)
Maximum residual clamping force	Upper limit of the residual clamping force		FRKmax (kN)
Factor statistics	Inserts the values determined in the factor calculation into the input fields		-
Speed	Range of the maximum speed specified in the tool constants	± Maximum speed	n (rpm)
Final Speed	Programmable maximum tool speed allowed for stage The final speed starts from the shut-off torque	± Maximum speed	n2 (rpm)
Evaluation Angle	Duration of the monitored range for determination of the press-in torque	0 … 9 999	AngE (deg)
Unweighted angle	Range between evaluation angle and shut-off torque. The safety angle starts retroactively at the shut-off torque	0 … 9 999	AngUnw (deg)
Minimum Evaluation Torque	Lower torque limit in the Evaluation Angle, below which the torque must not fall	0 … 1 × TQ calibration value[1]	TqEmin
Maximum Evaluation Torque	Upper torque limit in the Evaluation Angle, which must not be exceeded	0 … 1.2 × TQ calibration value[1]	TqEmax

The transducer records the torque and angle of rotation during the rundown. The tool stops when the shut-off torque is reached. The dwell angle and the peak torque are recorded during the dwell time.

The snug point is calculated retrospectively. The minimum and maximum torque at the snug point indicates the limits within the torque at the snug point should lie. The measuring card automatically calculates the necessary data for the subsequent angle tightening using the values for the (residual) clamp force. If an error is detected, the system stops with a corresponding error message. After the calculation, the angle

tightening is continued up to the calculated tightening angle (target angle). The torque continues to increase. Only then is the result transmitted to the main software.

The torque curve is recorded from the beginning of the rundown and can be displayed via the graphic function.

The maximum torque and the calculated tightening angle (actual angle) have to be within the specified limits of the (residual) clamp force so that the rundown can be evaluated as OK. If the maximum tightening angle is exceeded before the shut-off torque is reached, the process is stopped and evaluated as NOK.

The evaluation angle and evaluation torques define a monitoring range. In the range of the evaluation angle, the torque curve has to be within the limits of the minimum and maximum evaluation torque. If the values are exceeded or not reached, the fastening sequence is evaluated with NOK. To ensure that all fastening sequences behave in the same way, the minimum and maximum evaluation torques should be as close to each other as possible and the evaluation angle should be as large as possible.
The monitoring range can be deactivated by setting the evaluation torques and the evaluation angle to zero.
The safety angle begins after the evaluation angle. Looking back from the shut-off point, the safety angle determines when the evaluation angle begins. If the safety angle is too large and the evaluation angle is outside the torque graph, an error message with NOK evaluation is issued.

Version 2: Customized Software Version (S168813/S168300)

Shut-off torque controlled fastening process with torque and rotation angle control. The torque evaluation is carried out retrospectively by snug point detection and a monitoring range. The fastening process has to be within the monitoring range. This ensures that irregularities are detected when screwing in or on the screw and that the screw processes always behave in the same way.

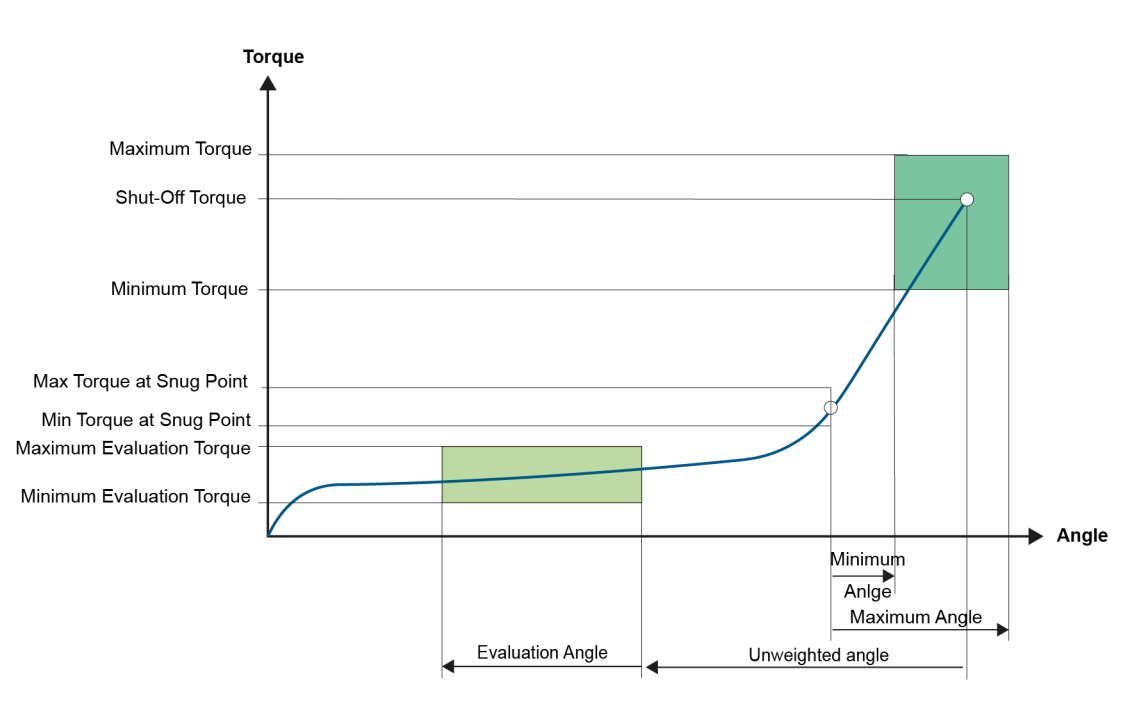

Fig. 5-5: Sequence 35 – S168813/S168300

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Torque at which the drive is stopped.	0 … 1 × TQ capacity	TqP
Minimum Torque	Low limit of torque reached	0 … 1 × TQ calibration value[1]	TqMin
Maximum Torque	High limit of torque reached	0 … 1.2 × TQ capacity	TqMax

Parameter	Explanation	Range of values	Abbrev.
Torque Averaging Filter	Number of torque measurement values used for averaging. This average value represents the torque averaging.	1, 2, 4, 8, 16, 32	Ff
Min Torque at Snug Point	Lower limit of the torque reached at the snug point	0.1 ... Max Torque at Snug Point	MdMin_FP
Max Torque at Snug Point	Upper limit of the torque reached at the snug point	Min Torque at Snug Point ... Maximum Torque	MdMax_FP
AF for GD at Switchoff Point	Angle averaging filter for the gradient at the shut-off point Distance in angular degrees of the attenuated measured values used for gradient calculation at the shut-off point	1 ... 30	AF_SOP (deg)
AF for Snug Point Detection	Angle Averaging Filter for gradient at snug point Distance in angular degrees of the attenuated measured values used for gradient calculation at the snug point	1 ... 30	AF_APD (deg)
GD bevel für Snug Point Detection	Gradient flattening for snug point detection Percentage value for the gradient of the characteristic curve to be flattened at the snug point in order to find this point	0 ... 100	Bevel_APD
Minimum Angle	Low limit of angle reached	0 … 9 999	AngMin (deg)
Maximum Angle	High limit for angle reached and safety shut-off value	0 … 9 999	AngMax (deg)
Speed	Programmable maximum tool speed allowed for stage	± Maximum speed	n (rpm)
Final Speed	Programmable maximum tool speed allowed or stage The final speed starts at 30 % of the shut-off torque	± Maximum speed	n2 (rpm)
Evaluation Angle	Duration of the monitored range for determination of the press-in torque	0 … 9 999	AngE (deg)
Unweighted angle	Range between evaluation angle and shut-off torque. The safety angle starts retroactively at the shut-off torque	0 … 9 999	AngUnw (deg)
Minimum Evaluation Torque	Lower torque limit in the Evaluation Angle, below which the torque must not fall	0 … 1 × TQ calibration value[1]	TqEmin
Maximum Evaluation Torque	Upper torque limit in the Evaluation Angle, which must not be exceeded	0 … 1.2 × TQ calibration value[1]	TqEmax

The tool stops when the shut-off torque is reached. The snug point is calculated retroactively. The minimum and maximum torque at the snug point indicates the limits within which the torque at the snug point should lie. Data is only transferred to the main software after the snug point has been determined. If an error is detected, a corresponding error message is issued.

The torque graph is recorded from the start of rundown and can be displayed using the graph function.

The maximum torque and the maximum angle have to be within the specified limits so that the rundown can be evaluated as OK. If the maximum angle is exceeded before the shut-off torque is reached, the process is stopped and evaluated as NOK.

The evaluation angle and evaluation torques define a monitoring range. In the range of the evaluation angle, the torque curve has to be within the limits of the minimum and maximum evaluation torque. If the values are exceeded or not reached, the fastening sequence is evaluated with NOK. To ensure that all

fastening sequences behave in the same way, the minimum and maximum evaluation torques should be as close to each other as possible and the evaluation angle should be as large as possible.
The monitoring range can be deactivated by setting the evaluation torques and the evaluation angle to zero.
The safety angle begins after the evaluation angle. Looking back from the shut-off point, the safety angle determines when the evaluation angle begins. If the safety angle is too large and the evaluation angle is outside the torque graph, an error message with NOK evaluation is issued.

5.7 Sequence 56: DTM, Drag Torque Measurement

Drag Torque Measurement with angle monitoring. The Drag Torque Measurement is initiated like a normal rundown cycle and completely performed by the controller. The Drag Torque Measurement is divided into four phases, that are consecutively activated. In the individual phases, the following functions are executed.

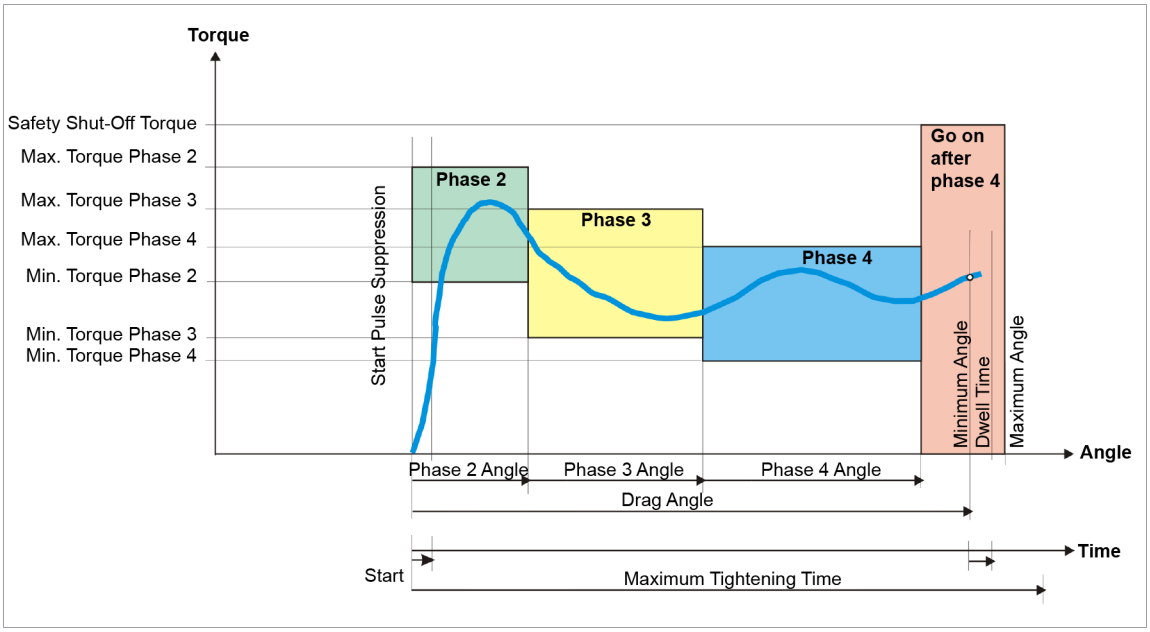

Fig. 5-6: Sequence 56

Phase 1: Engagement

This phase is not performed in the Drag Torque Measurement. An engagement stage is preferably simulated with Sequence 16 (set position). In this sequence, there is a reaction to the initiator (Engagement Initiator), which signals that the entrainment device (usually a socket) is engaged.

Phase 2: Breakaway Torque Measurement

Before the tool is started, the signal Workpiece out of position must be set. In this phase, the breakaway torque is checked. It must be within the limits *Minimum Torque Phase 2* and *Maximum Torque Phase 2*. If this applies, the sequence continuously transitions into Phase 3; otherwise, the tool is immediately stopped.
The torque occurring during the rundown cycle as well as the angle are measured via the installed transducer and processed by the controller.

Phase 3: Drag Torque Measurement

During the Drag Torque Measurement, the torque is checked to see if it exceeds or falls below *Minimum Torque Phase 3* and *Maximum Torque Phase 3*, respectively, and records the minimum and maximum frictional torque that occurs. After the Phase 3 angle is completed, there is a continuous transition into Phase 4.

Phase 4: Drag Torque Measurement

During the Drag Torque Measurement, the torque is checked to see if it exceeds or falls below *Minimum Torque Phase 4* and *Maximum Torque Phase 4*, respectively, and records the minimum and maximum

frictional torque that occurs. In this phase, the complete spin behavior is measured. After the Phase 4 angle is completed, the Drag Torque Measurement is finished, and there is a continuous transition into Phase 5.

Go on after phase 4: Engage top dead center (move to a defined end position)

During phase 5, the tool still continues to rotate until an external I/O signal reaches the *Total Angle* (TDC) position, signals it or the total angle is reached.

A maximum torque, which the measuring board itself calculates is used as a safety shut-off. Of all programmed maximum torque values from Phase 2 to Phase 4, the maximum torque is used, which is increased by 25 percent. However, this safety shut-off torque is valid over all phases.

The tool switches over to a second parametrized *Final Speed* if the parametrized switchover angle is reached during the rundown.

The total rundown angle is recorded from Phase 2 (breakaway torque measurement) up until the shutdown event. A programmable dwell time records the dwell angle and torque occurring during the dwell time. The overall evaluation of the measurement cycle is fed to the controller.

Throughout all of the angle-monitored Drag Torque Measurement, the torque curve is recorded from the very start and can be represented as an envelope curve in a graphic. As an option, a percentage value is programmed that permits an exceeding of the *Maximum Evaluation Torque* without the rundown being interrupted as NOK. If the parameter value Above Limit is assigned to a value greater than 0.00 %, the tool does not shut off after exceeding the Maximum Evaluation Torque in Phase 3 and Phase 4. At the end of the rundown, a reverse analysis of the torque values is performed. If the Maximum Evaluation Torque was exceeded at least once, then the error ZRF (Gear wheel faulty) is set. In subsequent processing, the percentage of the above limit instances that are above the Maximum Evaluation Torque are calculated. Depending on the overall angle of the rundown, the measuring board checks to see whether the percentage was exceeded. If this condition occurs, instead of the fault ZRF, the fault LFF (Bearing error) is recorded.

For the correct execution of this sequence, the input signals Engagement Initiator, Top dead center and Work-piece out of position must be programmed in the controller.

► Add or assign an input signal to the measuring board as a direct signal in the programming of the I/O map.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
Speed	Speed preselection; in the range of maximum speed specified in the tool constants	± Maximum speed	n (rpm)
Final Speed	Programmable secondary speed that occurs when switching angle is exceeded	± Maximum speed	n2 (rpm)
Total Angle	Shut-off Angle for the stage	0 … 9 999	AngTot (deg)
Maximum Torque Phase 2	Upper limit of the breakaway torque for evaluation in breakaway torque measurement	0 … 1.2 × TQ calibration value[1]	TqMaxP 2
Maximum Torque Phase 4	Up. Evaluation Torque during Drag Torque Measurement in phase 4	0 … 1.2 × TQ calibration value[1]	TqMaxP 4
Maximum Total Angle	Maximum angle, upper limit of total angle reached	0 … 9 999	AngMax (deg)
Maximum Torque Phase 3	Up. Evaluation Torque during Drag Torque Measurement in phase 3	0 … 1.2 × TQ calibration value[1]	TqMaxP 3

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

Parameter	Explanation	Range of values	Abbrev.
Minimum Torque Phase 2	Lower limit of the breakaway torque for evaluation in breakaway torque measurement	0 … 1.2 × TQ calibration value[1]	TqMinP2
Minimum Torque Phase 3	Lower Evaluation Torque during Drag Torque Measurement in phase 3	0 … 1.2 × TQ calibration value[1]	TqMinP3
Minimum Torque Phase 4	Lower Evaluation Torque during Drag Torque Measurement in phase 4	0 … 1.2 × TQ calibration value[1]	TqMinP4
Minimum Total Angle	Minimum angle, low limit of total angle reached	0 … 9 999	AngMin (deg)
P3 eval. (software-dependent)	Evaluation option of Phase 3, for a detected trop below the Max. Evaluation Torque for this phase		
Phase2 Winkel	Range evaluated in phase 2 for breakaway torque measurement	0 … 9 999	AngP2 (deg)
Phase3 Angle	Range evaluated in phase 3 for Drag Torque Measurement	0 … 9 999	AngP3 (deg)
Phase4 Angle	Range evaluated in phase 4 for Drag Torque Measurement	0 … 9 999	AngP4 (deg)
Maximum Tightening Time	Safety Shut-off	This applies for all tools of a tool group in this stage	
Above Limit	Portion of measurements tolerated that may be over the upper limit in phases 3 and 4	0 … 100.00	pAb (%)
Switching Angle	Specified angle for the speed changeover, starting when Final Speed is in effect	0 … 9 999	AngDs (deg)

Special option Phase 3 evaluation

As another special option, the evaluation of Phase 3 can be subjected to a special verification.

If this option is activated, then it is sufficient, if the currently measured torque is ever below the programmed maximum torque within phase 3. At the end of this phase, a check of this special option is performed. If this condition is met, the rundown proceeds continuously in the next phase (Phase 4). If the torque has not once fallen below the maximum torque, the sequence is terminated with a NOK event message (TQ>).

5.8 Sequence 94: Centering

Procedure with which the steering wheel of a passenger car can be installed correctly centered.

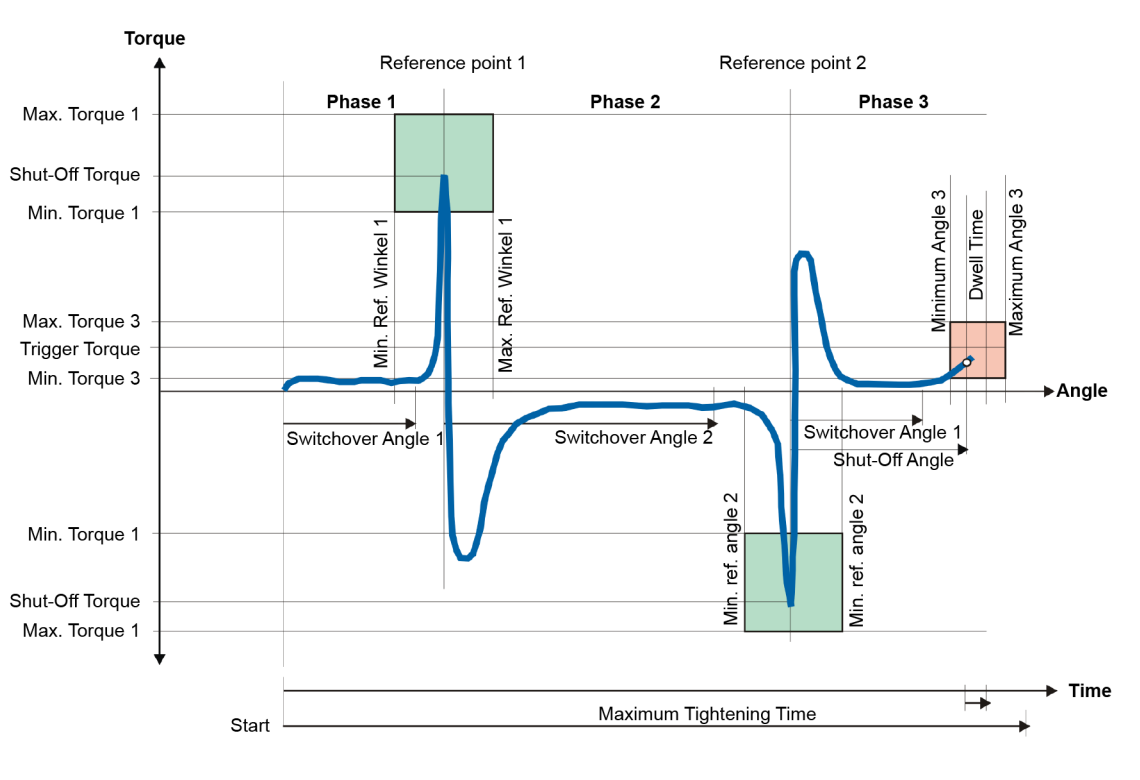

Fig. 5-7: Sequence 94

The torque occurring and the tightening angle occurring during the fastening sequence is measured by the installed transducers and processed in the controller. The angles are counted after the tool is started.

When the *Shut-Off Torque* is reached, the tool is placed in a defined Hold mode. At the holding point, the tool attempts independently to maintain and regulate for the Shut-Off Value - also called reference point 1 (Phase 1). Then the preselected direction of rotation is inverted and the tool is restarted.

When the *Shut-Off Torque* - also called reference point 2 - is reached, the tool is placed in a defined Hold mode (Phase 2). The search criterion shut-off angle is independently determined from the two reference points together with the compensation angle.

The direction of rotation is inverted again and the tool is started (Phase 3). When the *Shut-Off Angle* is reached, the tool is stopped.

The dwell angle and peak torque achieved during the dwell time are measured and the rundown results are processed in the controller together with the evaluation.

When the *Trigger Torque* is exceeded, a speed changeover is carried out in each phase.

The tool is stopped immediately when an error is measured in the individual phases and the tightening process is evaluated as NOK.

No threshold torque and no start pulse suppression time is to be programmed for this process. Both values are automatically set by the main software.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Shut-Off Torque	Shut-off Torque for phases 1 and 2	0 … 1.2 × TQ calibration value[1]	TqP

[1] Subsequent plausibility test related to the tool capacity (software-dependent)

Parameter	Explanation	Range of values	Abbrev.
Compensat. angle	Offset to the computed shut-off value	0 … 9 999	
Torque Averaging Filter	Number of measured values used for filtering torque by averaging. Eliminates noise spikes that may lead to unnecessary rejects	1, 2, 4, 8, 16, 32	Ff
dir. of rotation	Specified direction of rotation for start of rotation	1 … 2	1=re/ 2=li
Speed	Speed preselection; in the range of maximum speed specified in the tool constants	± Maximum speed	n (rpm)
Final Speed	Speed preselection; in the range of maximum speed specified in the tool constants	± Maximum speed	n2 (rpm)
Max. Torque 1	Upper limit of the torque reached in phases 1 and 2	0 … 1.2 × TQ calibration value[1]	TqMax
Max. Torque 3	Upper limit of the torque reached in phase 3	0 … 1 × TQ calibration value[1]	TqMaxP3
Max. Reference Angle 1	Upper limit of the angle reached in phase 1	0 … 9 999	RAnMax1
Max. Reference Angle 2	Upper limit of the angle reached in phase 2	0 … 9 999	RAnMax2
Max. Angle 3	Upper limit of the angle reached in phase 3	0 … 9 999	AngMax3
Min. Torque 1	Lower limit of the torque reached in phases 1 and 2	0 … 1 × TQ calibration value[1]	TqMin
Min. Torque 3	Lower limit of the torque reached in phase 3	0 … 1 × TQ calibration value[1]	TqMinP3
Min. Reference Angle 1	Lower limit of the angle reached in phase 1	0 … 9 999	RAnMin1 (grd)
Min. Reference Angle 2	Lower limit of the angle reached in phase 2	0 … 9 999	RAnMin2 (grd)
Min. Angle 3	Lower limit of the angle reached in phase 3	0 … 9 999	AngMin3 (grd)
Maximum Tightening Time	Safety Shut-off In addition, the maximum torque 1 is used for all phases.	This applies for all tools of a tool group in this stage	
Trigger Torque	Beginning of measurement recording for the trace display	0 … 1.2 × TQ calibration value[1]	TqTr (Nm)
Switching Angle 1	Specified angle for the speed changeover, from when Final Speed is implemented in phases 1 and 3	0 … 9 999	AnCo1 (grd)
Switching Angle 2	Specified angle for the speed changeover, from when Final Speed is implemented in phase 2	0 … 9 999	AnCo2 (grd)

The figure *Sequence 94* shows the illustration with correct measurement technology: the measured torque is represented as a negative value. The following figure shows the more interesting representation for the user: the pretensioning force of the steering wheel centering is equivalent to the tightening torque (positive).

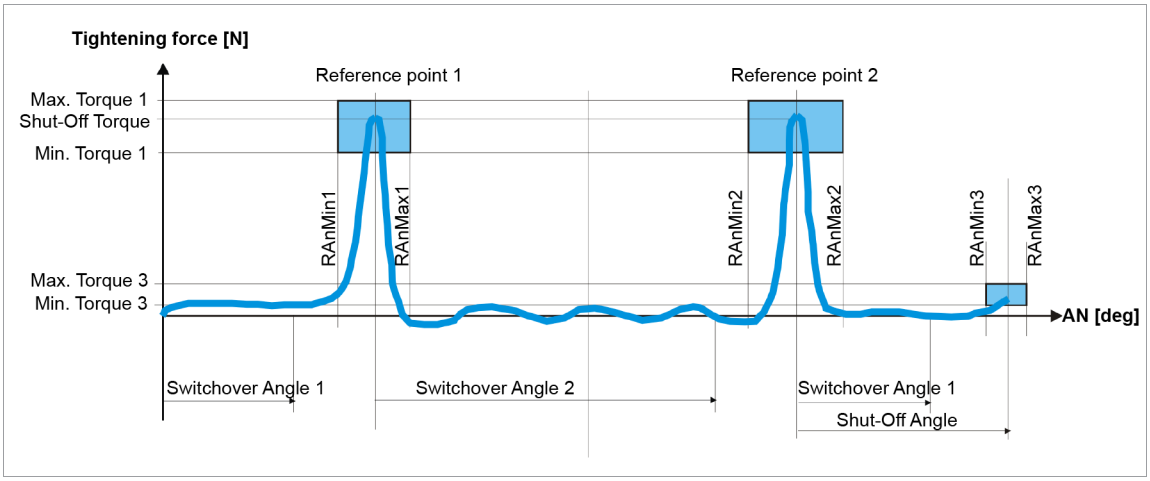

Fig. 5-8: Display angle / graphic recording

5.9 Sequence 97: Angle/Time Controlled with Clutch Monitoring

Angle or time controlled fastening sequence with clutch monitoring. This fastening sequence is only valid for tools of the CellClutch series.

The setting options differ between the pre-tightening stages, tightening stage and After Clutch Stage.

Pre-Tightening Stage 1 to 5

Stages 1 to 5 are used to pre-tighten the screw. They can be activated as required. If the clutch is already released in one of the pre-tightening stages, the rundown is aborted and evaluated with NOK.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Speed	Set speed for rotation.	± (Minimum speed[1] to maximum speed)	n (rpm)
Time	If the check box is activated, the time is monitored during rundown. If the check box is deactivated, the angle is monitored during rundown.		
Shut-Off Angle	High limit for angle reached. If the configured value is reached, the stage is finished and the next stage is started.	Angle: 0° – 65 535°	Ang (Deg)
Shut-Off Time	Set a value for the time. If the configured value is reached, the stage is finished and the next stage is started. The angle is not monitored. As result, the angle "0" is sent to the controller.	Duration: 0 ms – 32 000 ms	Time (ms)

[1] Minimum speed is 10% of maximum speed. For tools with a maximum torque of 2 Nm and 4 Nm, the minimum speed is automatically increased to 177 1/min.

Tightening Stage

The tightening stage monitors the clutch. Shut-off in the tightening stage takes place when the clutch is released. If the parameterized angle or time is reached before the clutch is released, the rundown is aborted and evaluated with NOK.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Speed	Set speed for rotation.	± (Minimum speed[1] to maximum speed)	n (rpm)
Time	If the check box is activated, the time is monitored during rundown. If the check box is deactivated, the angle is monitored during rundown.		
Maximum Angle	High limit for angle reached. If the clutch is not released within this value, the rundown is aborted.	Angle: 0° – 65 535°	AngMax (deg)
Max. tightening time Tmax (ms)	Set a value for the time. If the clutch is not released within this value, the rundown is aborted and evaluated with NOK.	Duration: 0 ms – 32 000 ms	Time (ms)

In the time-controlled fastening sequence, the angle is also monitored in the tightening stage. If the angle exceeds 65 535°, the rundown is aborted and evaluated with NOK. In this case, the parameterization must be split into two stages (pre-tightening and tightening stage).

After Clutch Stage

In the case that the tool is jammed, the *After Clutch Stage* option can be used to remove the tool from the screw. The stage is completed when the parameterized angle or time has been reached. If the start trigger is released or the clutch is released before the parameterized angle or time has reached, the rundown is aborted and evaluated with NOK.

The following parameters are entered into the controller:

Parameter	Explanation	Range of values	Abbrev.
Speed	Set speed for rotation.	± (Minimum speed[2] to maximum speed)	n (rpm)
Time	If the check box is activated, the time is monitored during rundown. If the check box is deactivated, the angle is monitored during rundown.		
Shut-Off Angle	High limit for angle reached. The stage is completed when the configured value is reached or the start trigger is released.	Angle: 0° – 65 535°	Ang (Deg)
Shut-Off Time	Set a value for the time. The stage is completed when the configured value is reached or the start trigger is released. The angle is not monitored. As result, the angle "0" is sent to the controller.	Duration: 0 ms – 32 000 ms	Time (ms)

[1] Minimum speed is 10% of maximum speed. For tools with a maximum torque of 2 Nm and 4 Nm, the minimum speed is automatically increased to 177 1/min.
[2] Minimum speed is 10% of maximum speed. For tools with a maximum torque of 2 Nm and 4 Nm, the minimum speed is automatically increased to 177 1/min.

6 Options

The following paths refer to the standard software S168813, customer-specific software may differ.

6.1 Redundancy

In Engineering, redundancy is generally referred to as the presence of functionally equivalent or comparable resources of a technical system, that are needed for flawless operation under normal circumstances. These additional resources increase the reliability, as well as functional and operational safety.

Distinctions are made between the following types of redundancy:

- None: Only one measurement circuit (transducer) is used. This supplies the necessary information for determining dynamic torque values.
- Transducer 2: An additional measurement circuit (transducer) is used. This supplies additional information about torque and tightening angle. The second measurement circuit is installed directly after the first measurement circuit.
- Resolver angle: Additional angle signals are generated from the resolver information in order to verify the angle information of the first angle encoder.
- Current/resolver: Equivalent torque information is produced from the motor current. In addition, the resolver supplies additional information. Both information sources are compared to the information of the first measurement circuit. If the deviation is too great, this generates an event message and possibly to a stoppage of the fastening sequence.
- Based on the dynamics of drive and control performance, the information from torque value and current value is not always prompt, so the current usually lags the torque. This causes an undesirable deviation and, thus, an unintended IRED fault.

Sequences supporting Redundancy:

Sequence	**10**	**11**	**13**	**15**	**16**	**20**	**21**	**30**	**31**	**32**	**33**	**35**	**41**	**46**	**48**	**50**	**51**	**56**	**63**	**73**	**75**	**78**	**80**	**94**	**97**
Transducer redundancy																									
…during the rundown		X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X		
… at the shut-off point	X	X	X	X		X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	
Current/resolver redundancy																									
…during the rundown		X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X		
… at the shut-off point			X	X		X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	
Resolver redundancy																									
…during the rundown			X		X			X	X	X			X	X	X	X	X		X	X	X	X	X	X	
… at the shut-off point			X		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Angle redundancy																									
…during the rundown			X		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
… at the shut-off point			X		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

► Select type of redundancy: *Navigator* > *Tool Setup* > *Tool Settings* > *Advanced*.

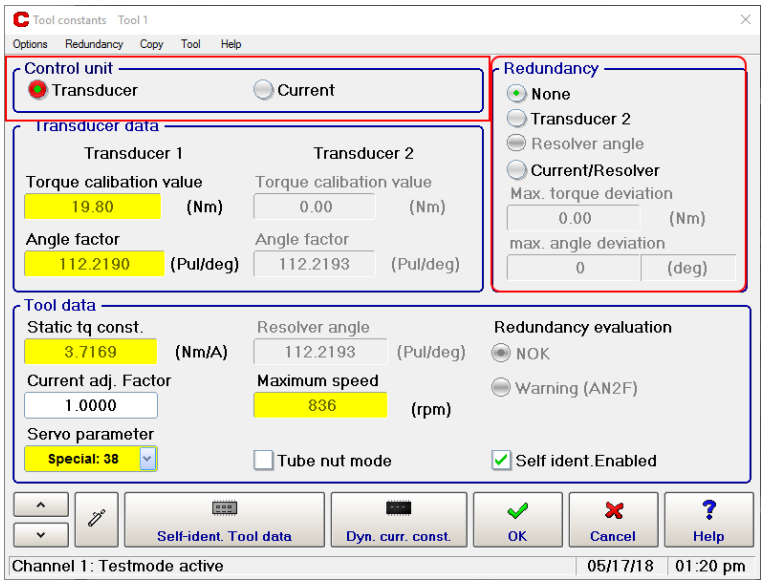

Fig. 6-1: Redundancy

When a redundancy is selected, additional parameters must also be entered.

6.1.1 Transducer Redundancy

With the transducer redundancy, a second transducer with torque and angle signals are used to generate redundancy values.

When the maximum torque deviation is entered in Tool constants, no restriction on a minimum value is checked. A graphic is displayed with the two torque sensor values.

A distinction is made between a redundancy evaluation during the rundown and a redundancy evaluation at the shut-off point.

Redundancy evaluation during the rundown

During the rundown, when transducer redundancy is activated, a continuous torque and angle redundancy is carried out. The value for the redundancy evaluation is ±8 percent of the transducer calibration value, measured until the tool stops. If a greater admissible max. torque deviation is programmed, this value is used.

With each redundancy evaluation, the current actual torque is checked for deviation. If deviation is too great, the fastening sequence is stopped and evaluated with MDRE error. After the tool is stopped (dwell time) a redundancy evaluation continues to be done until the dwell time lapses. This described redundancy value is applicable for all sequences, except sequences 10, 15, 41, 46 and 94.

Redundancy evaluation after the rundown at the shut-off point

If the Shut-Off Value is reached or the tool is stopped for other reasons, an evaluation of the deviation is done with the admissible deviation value programmed in Tool constants. The torque values are recorded in the dwell time in peak value memories for redundant evaluation.

In sequences 16, 41, 46 and 94, the torque is not evaluated. The torque redundancy evaluation is also not in effect in this context. Exceeding the programmed torque deviation displays and records a MDRE event message.

6.1.2 Current/Resolver Redundancy

With the current/resolver redundancy, the current value of the motor is converted into a torque value to be able to use it for the redundancy evaluation. Because of the current ripple, which is based on the control behavior of the servo component and other components, a greater tolerance band is necessary during the rundown.

If in the preceding document the name Current value is used, it means the equivalent torque value.

A distinction is made between a redundancy evaluation during the rundown and a redundancy evaluation at the shut-off point.

Redundancy evaluation during the rundown

During the rundown, with an active current/resolver redundancy, a continuous current redundancy evaluation is performed (see below). The value for the current redundancy evaluation is either ±20 percent of the transducer calibration value until the tool is stopped or the programmed deviation value (if it is greater than 20% of the transducer calibration value).

With each redundancy evaluation, the current actual torque is checked for deviation. After the tool is stopped (softstop, dwell time), there is no more recording and redundancy evaluation of the current value because torque and current react differently.

This applies for all sequences, except for sequences 10, 15, 41, 46, 56 and 94.

If the deviation is too great, the fastening sequence is stopped and evaluated with IRED fault. A sliding average of the transducer (*see chapter Torque Averaging Filter, page 82*) also is done for the current value.

In the following cases, the continuous current redundancy evaluation is suspended for a certain time:

- At the beginning of the stage for 25 ms (LiveWire: 70 ms)
- When there are speed changes for each change step for 15 ms (LiveWire: 70 ms)
- When a stick-slip edge occurs for 70 ms
- If a raising edge occurs (hard joint; basic conditions corresponding to the falling one in the case of the stick-slip) for 70 ms
- When a slip-off occurs for 200 ms
- With back-off sequences, the current redundancy is deactivated for the rest of the sequence after a stick-slip occurs

The times differ between cordless EC tools and corded hand tools/built-in nutrunners, because in this case the motor has a different characteristic.

Redundancy evaluation after the rundown at the shut-off point

If the shut-off point is reached or the tool is stopped for other reasons (see exceptions below), then an evaluation of the deviation is done with the admissible deviation value under Tool constants. In the event of a fault, the fastening sequence displays and records IRED event message.

The input value for the maximum torque deviation in Tool constants must be at least 10% of the transducer calibration value. At the Shut-Off Value, the redundancy evaluation is performed with at least 10% of the Shut-Off Value or with the programmed value of the maximum torque deviation, depending on which value is greater.

In the following cases, no evaluation is performed at the Shut-Off Value. No data of the redundancy are displayed in the Monitor tool:

- the torque at the shut-off point is less than 1/3 of the transducer calibration value (LiveWire: tool capacity)
- the shutdown occurred because the Start signal was deactivated away by a higher-level controller (PLC, controller) (SA-fault)
- the shutdown occurred, because an Emergency Stop situation has occurred (EMERGENCY STOP fault)
- the shut-off occurred because a different cancel condition was measured (CANCELLATION fault)
- the shut-off occurred because the maximum time monitoring has lapsed (TMAX fault)
- sequences 10, 15, 41, 46, 56 or 94 was run
- the shut-off torque is less than 40% of the tool capacity (with intelligent transducer).

If further angles of the transducer 1 occur during the dwell- time, the current value for the graph is tracked.

The current result values of the stage are displayed in tabular form in the Monitor tool. The current values are also represented graphically as a curve like the torque values of the transducer, *see chapter 6.1.5 Redundancy Graph, page 63*.

In sequence 48, in the first 90 degrees of the rundown, a speed reduction is implemented. The speed of the nutrunner is reduced to 10 rpm to minimize an undesired reaction of the current redundancy during the breakaway of the rundown. After these 90 degrees, the programmed speed is resumed.

Static/dynamic current redundancy

y default, the current redundancy evaluation is done statically, i.e. for the calculation of the equivalent torque value, the product from Static torque constant and Current adjustment is used, *see chapter 6.3.1 Activate Dynamic Current Calibration, page 67*.

- Static torque constant
  It represents a calculated theoretical value made up of motor, transmission and drive data and is defined in the unit "Nm/A". This constant is available either as a value in the table or for self-identification in the tool. The value is used as the starting point for further current/torque conversion calculations. If the required degree of precision is relatively low, the static torque constant can be directly used for current redundancy (e.g. for back-off-only operations).
- Current adjustment factor
  The motor of the tool can assume different values, therefore, this additional factor was added. Different motor properties that occur in the production of the motor balance out. The current adjustment is only valid in the range from 0.8000 to 1.3000. For higher precision that also considers the particularities of the joint, a dynamic current calibration can be performed, *see chapter 6.3 Dynamic Current Calibration, page 66*.

Current redundancy with Stick-Slip

Current redundancy with stick-slip *see chapter 6.7 Time Constants, page 73*.

Current Redundancy with Nut Slip-Off

A nut slip-off occurs if the socket inadvertently slips off the fastener head during the rundown (usually at the end of the rundown). In this case, the detected torque readings decrease toward zero and then suddenly rebounds as soon as the fastener head re-engages. During this condition, the detected current values typically lag behind the torque values, which then results with an IRED event message being displayed and recorded. A slip-off of the socket from the rundown causes a suppression of the current redundancy for 200 ms.

6.1.3 Resolver Redundancy

The motor of the tool that is used supplies resolver signals, which can be used for redundancy evaluation. The resolver pulses of the motor are continuously converted into angular values.

The resolver redundancy takes effect after the threshold torque is exceeded. In sequences without threshold torque, a backlash that occurs, which could have used a difference between the measured values of the two transducers, can go directly into the results at the Shut-Off Value. If the programmed max. angle deviation is greater than the fixed value (see below), the greater of the two is used.

A distinction is made between a redundancy evaluation during the rundown and a redundancy evaluation at the shut-off point.

Redundancy evaluation during the rundown

During the rundown, with the resolver redundancy activated, a continuous angle redundancy is implemented. The value for the redundancy evaluation, up until the tool stops, is ±15 degrees. If a greater value was programmed, it is valid. With each redundancy evaluation, the current actual torque values are checked for deviation. If the deviation is too great, the fastener sequence is stopped and evaluated with a WIRE fault. After the tool is stopped (dwell time) a redundancy evaluation is performed until the dwell time lapses. This redundancy value applies for all sequences, except sequences 10, 11, 15, 20, 21, 33 and 56.

Redundancy evaluation after the rundown at the shut-off point

If the Shut-Off Value is reached or the tool is stopped for other reasons, an evaluation of the deviation is done with the admissible deviation value programmed in Tool constants. If this value is exceeded, the fastening sequence is evaluated with a WIRE fault. In sequences 10, 11, 15, 20 and 21, there is no redundancy evaluation of the Shut-Off Value.

6.1.4 Angle Redundancy

An angle redundancy is performed with a torque and angle transducer.

The angle redundancy takes effect after the threshold torque is exceeded. In sequences without threshold torque, a backlash that occurs, which could have used a difference between the measured values of the two transducers, can go directly into the results at the Shut-Off Value. If the programmed max. angle deviation is greater than the fixed value (see below), the greater of the two is used.

The angle redundancy cannot be chosen individually and can only be used together with a torque redundancy.

A distinction is made between a redundancy evaluation during the rundown and a redundancy evaluation at the shut-off point.

Redundancy evaluation during the rundown

The value for the redundancy evaluation up until the tool stops is ±10 degrees. If a greater value was programmed, it is valid. With each redundancy evaluation, the comparison is performed with the current actual torque values for deviation. If the deviation is too great, the fastener sequence is stopped and evaluated with a WIRE fault. After the tool is stopped (dwell time) a redundancy evaluation is performed until the dwell time lapses. The aforementioned redundancy value of 10 degrees applies for all sequences, except sequence 10 10, 11, 15, 20, and 21.

Redundancy evaluation after the rundown at the shut-off point

If the Shut-Off Value is reached or the tool is stopped for other reasons, an evaluation of the deviation is performed with the admissible deviation value programmed in Tool constants.
When this value is exceeded, the fastening sequence is evaluated with a WIRE fault. In sequences 10, 11, 15, 20 and 21 no redundancy evaluation is performed in the Shut-Off Value.

Transducer redundancy with conductance

If there is a conversion from transducer to reference value Current only two redundancy types are available for selection:

a) without redundancy
b) with transducer redundancy

If no redundancy is selected, only the equivalent current value is converted into a torque value. As an indication that a converted torque value is represented, a "*" comes after the torque value in the rundown data table.

In the case of conductivity with selected transducer redundancy, it is assumed that a hand tool is used which is equipped with a torque verification transducer for torque verification.

6.1.5 Redundancy Graph

Redundancy values are addressed below. They can be:

- Redundant values of the current when the current/resolver redundancy is activated
- Redundant values of the second torque transducer when torque redundancy is activated.

► Select redundancy: *Navigator* > *Tool Setup* > *Tool Settings* > *Extended...* > *Redundancy*.

When current or torque redundancy is activated, it is possible to analyze the trace of the redundant values. For this purpose, the current values are converted into torque values and can be viewed in the trace display window on the controller screen. The trace data of the second torque transducer are also displayed with the redundancy type Transducer 2 activated.

The redundancy values are displayed in light blue or turquoise in the graphics window. By default the display of the redundancy graph is deactivated, that is, it is not displayed when you first open the trace display window on the controller.

► Display redundancy graph: *Navigator* > *Run Screen* > *Oscilloscope*. Option depends on the main software of the controller that is used.

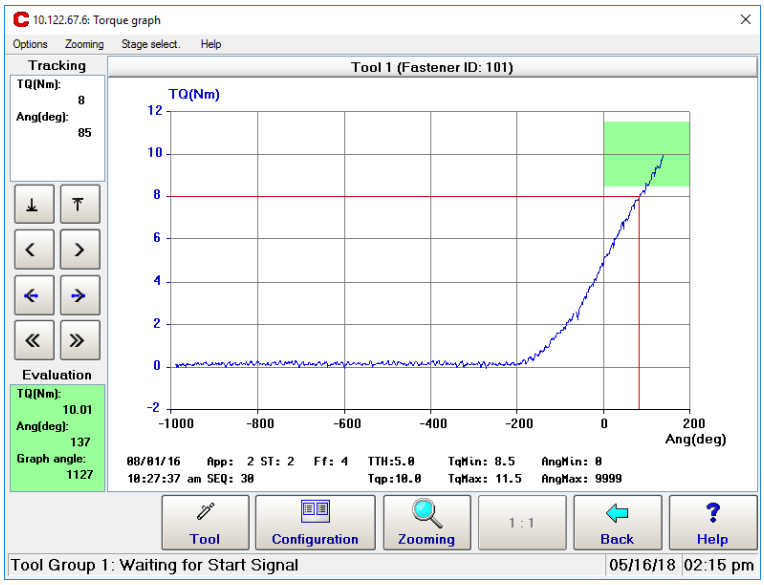

Fig. 6-2: Torque graph

All other functions, such as zooming, stage selection, etc. are designed exactly as if only the torque graph is represented.

The redundancy values are then stored in the archive if this was explicitly programmed. To do this, under *Navigator* > *Advanced* > *Controller* > *General* > *Trace Recording* select one of the modes *…with redundany graph* or *All Graphs*.

Saving the redundancy values in the archive is a function of the main software of the controller that is used.

The graphics memory comprises a total of 24575 graphics values. Exactly as many values are kept clear for the redundancy graph. The graphics values are saved simultaneously so that for each torque value of the first transducer a simultaneous redundancy value of the redundancy source is saved.

6.2 Static Current Calibration

The controller monitors the current required to achieve torque. If the current value and the torque measurement from the Transducer 1 are not within limits, then a TQRE or IRED error will be displayed. This can occur even though current redundancy is not activated. One reason may be that the Torque Constant for the tool is not correct.

This chapter describes the procedure for setting the torque constant. For this, the current measurement is converted into a torque value.

Step 1: Activate current monitoring

1. Select *Navigator* > *Tool Setup* > *Tool Settings* > *Extended...*.
   ➢ Screen *Tool Constants* opens.
2. Select in the frame *Redundancy* the option *Current/Resolver*.
   ➢ The input field *Maximum Torque Deviation* activated.
3. For *Maximum Torque Deviation* a value greater than 20% of Torque calibration value.
   Example: Torque calibration value = 168.00 Nm, then *Maximum Torque Deviation* should be greater than 33.6 Nm.
4. Accept settings and close screen.

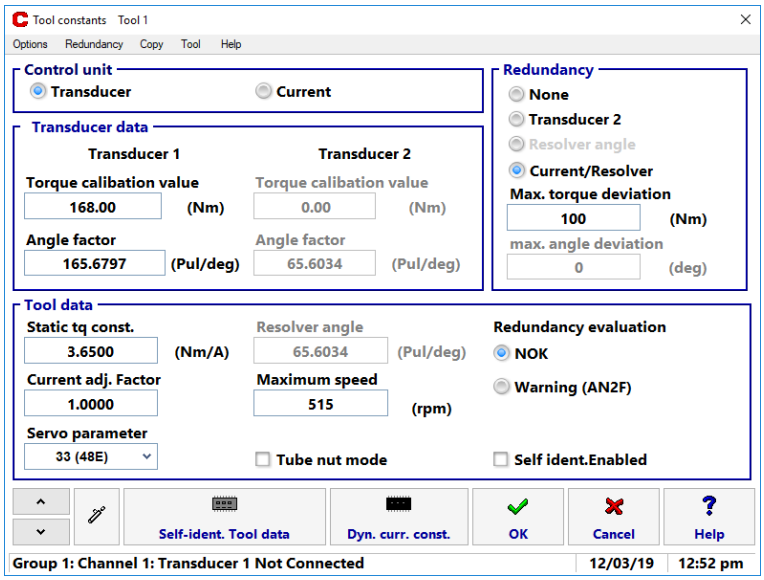

Fig. 6-3: Tool constants

Step 2: Do rundowns and note the current measurement

1. Do a rundown where torque is above 35% of Torque calibration value.
   Example: Torque calibration value = 168.00 Nm, then rundown should be above 58.8 Nm
2. Select *Navigator* > *Archive* > *Details*.
   ➢ Screen *Monitor Tool* opens.
3. In the second row of a stage result is the calculated torque (from current) displayed. For identification a star is added after the value.
4. Note both torque values of last stage.
   Example: final Torque value = 68.26 Nm, calculated torque value (based on current) = 76.94* Nm.

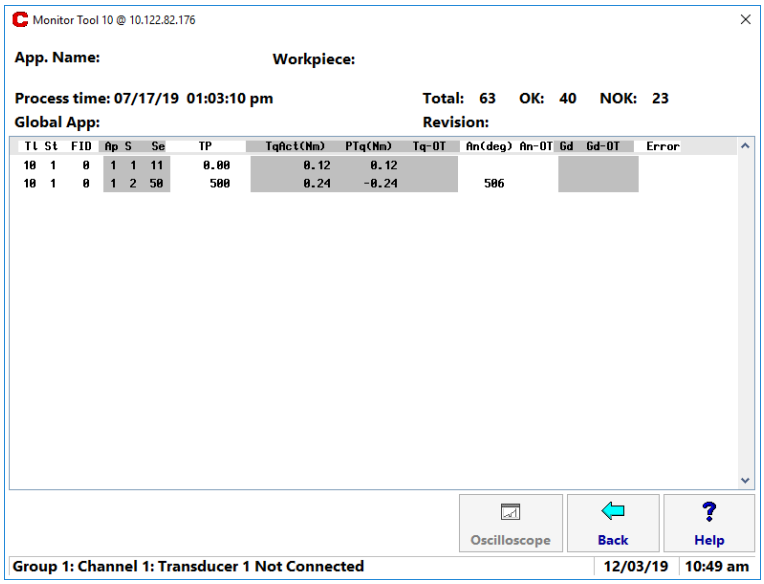

Fig. 6-4: Monitor Tool

Step 3: Calculate and set Torque constant

The Torque constant is defined as Nm/Ampere.

1. Select *Navigator* > *Tool Setup* > *Tool Settings* > *Extended...* > *Self-Identification Tool Data*.
   ➢ Screen *Transducer Data* opens.
2. Using the values from the previous figure, calculate the new Torque constant using this formula:

$$\text{New Torque constant} = \frac{\text{final Torque value}}{\text{calculated torque value (based on current)}} \times \text{old Torque constant}$$

Example:

$$\text{New Torque constant} = \frac{68.26\ \text{Nm}}{76.94\ \text{Nm}} \times 3.65\ \text{Nm} = 3.24\ \text{Nm}$$

3. In the screen *Transducer Data* use the arrows on right side to select the row *Torque Constant (Nm/A)*.
4. Click the button <Change> and enter the calculated new Torque constant.
5. Accept the entry and confirm all displayed messages.
   ➢ The new Torque constant is written to the Tool memory.

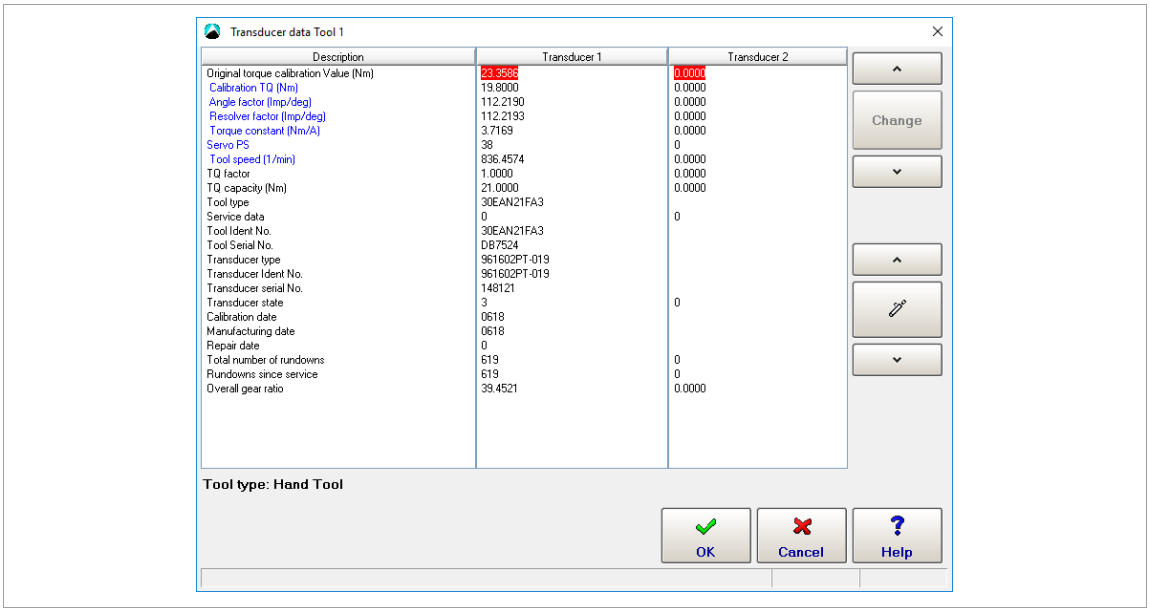

Fig. 6-5: Transducer Data

Step 4: Deactivate current monitoring

If current monitoring is not required for the application, then deactivate this option by:

1. Select *Navigator* > *Tool Setup* > *Tool Settings* > *Extended...*.
   ➢ Screen *Tool Constants* opens.
2. Select in frame *Redundancy* option *None*.

6.3 Dynamic Current Calibration

The servo current of a tool is generally transformed via a conversion factor into a torque value. Thus, the operator works exclusively with Nm measuring values in the torque range. This relationship is not linear. Via a Current calibration this non-linearity is to be compensated in a targeted manner. To do this, a calibration run is started for each tool and Application (App). This calculates a Dynamic current constant for each stage of the PG.

Calibration run

From a set number of OK rundowns, the average values are calculated and saved as Dynamic current constants. These dynamic current constants are valid until the basic conditions of the joint change. During the calibration run, the **Static current redundancy** is active.

6.3.1 Activate Dynamic Current Calibration

1. Activate *Dynamic Current Calibration* via *Navigator* > *Advanced* > *Controller* > *Advanced*.
   This is activated for all tools and all Applications.
2. In the adjacent input field, the number of cycles in the range from 5 to 99.
   This number determines the number of rundowns used to calculate the dynamic current factors. When exiting and confirming this menu, the dynamic calibration is automatically started.

Conditions per tool

A dynamic current calibration can be performed if the following conditions are met:

- Dynamic current calibration is activated, *see chapter 6.3.1 Activate Dynamic Current Calibration, page 67*
- Redundancy Transducer – Current/Resolver is activated, *see chapter 6.1 Redundancy, page 59*

Conditions per Application (App)

- The torque in the Shut-Off Value is greater than 35% of the transducer calibration value (the tool capacity with LiveWire).
- The calculation of the dynamic current calibration is done exclusively from the OK results. Results that are evaluated as NOK are thrown out in the calculation. Only after a complete successful calibration is performed, then the calculated dynamic calibration run results are used.
- For the dynamic current calibration - with the exception of Sequence 48 - only torque tightening sequences are provided. In all fastening sequences, the torque and current values measured at the Shut-Off Value are used. This is not possible in back-off strategy because they function with angle control and at the Shut-Off Value the torque or current values move toward zero. For this reason, in Sequence 48 the maximum torque that occurs is determined for the calculation of the dynamic value.

6.3.2 Display Dynamic Current Factors/Calibration Run

The current dynamic current factors are shown in a separate menu:

1. Select *Navigator* > *Diagnostics* > *Tool* > *Current Calibration*.
2. select the product group with <App> and the tool group with .
3. Check and analyze the desired values.

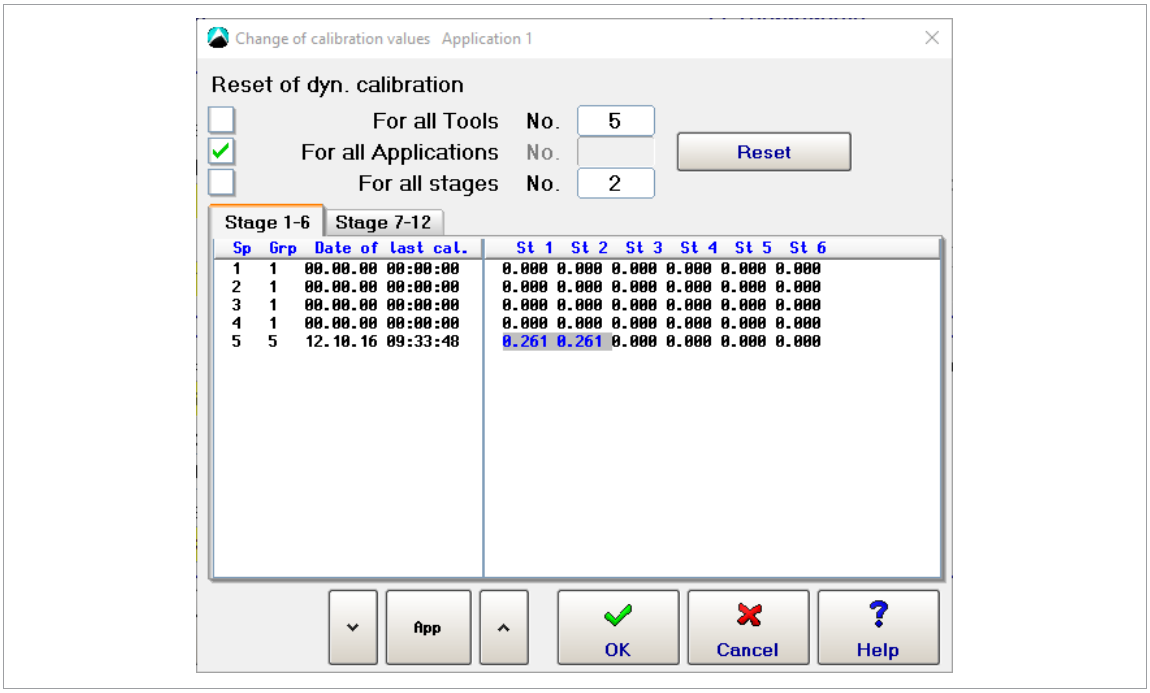

Fig. 6-6: Current Calibration

The screen is divided into two areas:

Left column: dynamic calibration values

Feature	Description
1.536 1.535	Completed calibration (Text blue, gray background)
1.542 1.532	Running calibration (Text black, yellow background)
St	Stage number (if available)
Sp	All connected tools
Grp	Associated tool groups
Date / last cal.	Date and time of the last dynamic calibration

The listed calibration values remain unchanged after a restart.

Right column: calibration information

Under *Calibration Info* a sequence analysis is displayed during the calibration run. After the calibration run is finished, the admissible and calculated deviations are output. The calculated torque is divided into three ranges: if it is in the top third of the calibration value, calculation is done with 20% admissible deviation, in the middle third with 25% and in the bottom third no more than 30%.

The listed values remain unchanged if a different Tool Group or Application is selected. After a restart or a new calibration run, they are deleted.

Recalculation of the current factors

If one of the quantities listed below changes, a new calibration run begins. The entire line is highlighted in yellow as an indication. Only changed stages are recalibrated.

- In the menu *Navigator* > *Standard* > *Stage* > *Stage n* > *Sequences*
  - Speed in sequence
  - Shut-off Torque in sequence
  - Torque Averaging Filter in the sequence
  - Sequence change
- In the menu *Navigator* > *Tool Setup* > *Tool Settings* > *Extended...* > *Self ident. Enabled* (Transducer data)
  - Tool change on intelligent transducers.
- In the menu *Navigator* > *Tool Setup* > *Tool Settings* > *Extended...* (Tool constants)
  - Maximum speed
  - Torque calibration value
  - Current adjustment factor
  - Static torque fact

6.3.3 Display Current Redundancy Values

► Select *Navigator* > *Archive* > *Details*.

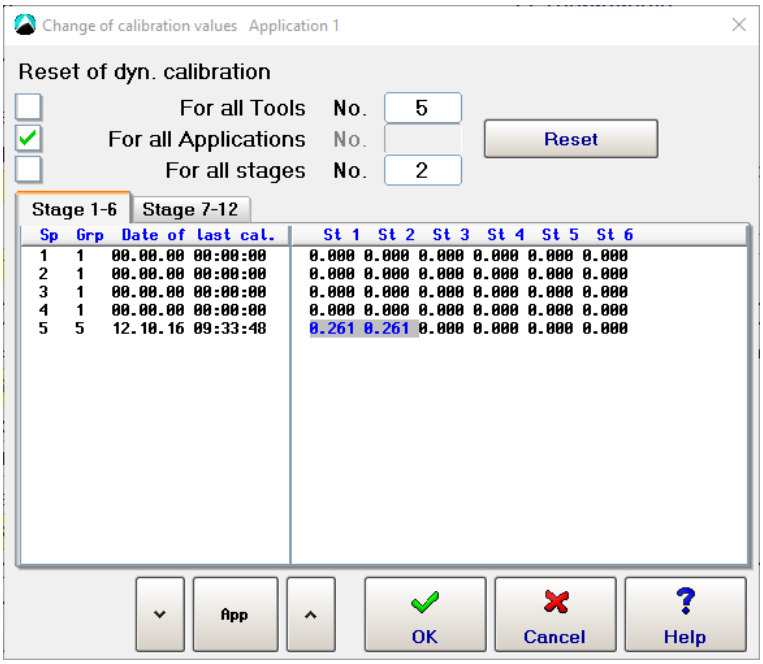

Fig. 6-7: Archive

If a calibration run has been initiated, the output of the redundant value for the current is suppressed. That is, in Monitor tool there is no display of the equivalent torque value. Only after the calculation of the dynamic current constants are the data of the redundancy displayed again in an additional line.

If no data of the redundancy are displayed, *see chapter 6.1.1 Transducer Redundancy, page 60*.

Button	Description
	Displays corresponding graphics of the redundancy values, *see chapter 6.1.5 Redundancy Graph, page 63*.

6.3.4 Reset Dynamic Current Calibration

A new calibration run can also be forced by a reset. All dynamic values of tools, Applications or stages are reset. The related stages are highlighted in yellow to indicate this.

1. Select *Navigator* > *Tool Setup* > *Tool Settings* > *Advanced* > *Dyn. curr. const.*
2. Press <Reset>.

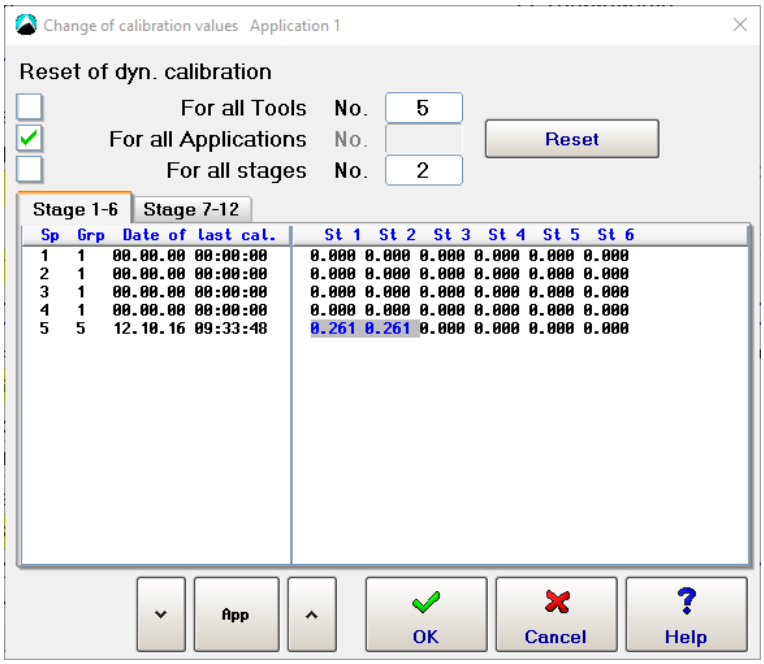

Fig. 6-8: Change of calibration values

6.4 PCR – Automatic Safety with Handheld Nutrunners

The PCR process (Permanent Current Redundancy) was introduced to increase the safety of the operator/worker in handling hand tools.

When a transducer fails during a rundown, an unexpected behavior of the tool may result in a risk of injury to the operator, which can be prevented with PCR. Internally, a latent current redundancy is activated without further parameter input. All required parameter values for this redundancy are independently assembled and/or calculated.

The redundancy evaluation occurs during the rundown and is only active with hand tools. For continuous redundancy checking during the rundown, a redundancy evaluation of ±35 % of the transducer calibration value is used. If this value is exceeded/fallen below, the hand tool shuts off immediately and a NOK evaluation with IRED (current redundancy fault) is given.

At the tool Shut-off Point, no redundancy evaluation is performed, because the evaluation took place already during the rundown. A display of the redundant data in the Rundown data table, Monitor tool or Measured value archive does not occur.

If a different type of redundancy (Transducer 2, Resolver angle or Current/Resolver) is used, the PCR is deactivated automatically to prevent conflicts with the programmed redundancy values.

6.5 Back-off without Application Preselection

Back-off of the fastening joint without Application preselection with torque monitor.

In this process, no rundown data and/or result evaluations (OK/NOK) are executed.

This process is employed mainly with handheld tools. The worker can back-off a tightened fastener as an independent subsequent operation using the direction switch on the tool for counterclockwise rotation.
In order to enable the back-off, the I/O levels input must first be configured, see programming manual.

Then enter the corresponding parameter values:

1. Select *Navigator* > *Standard* > *Tool Groups* > *Settings For Speed Left Rotation*.

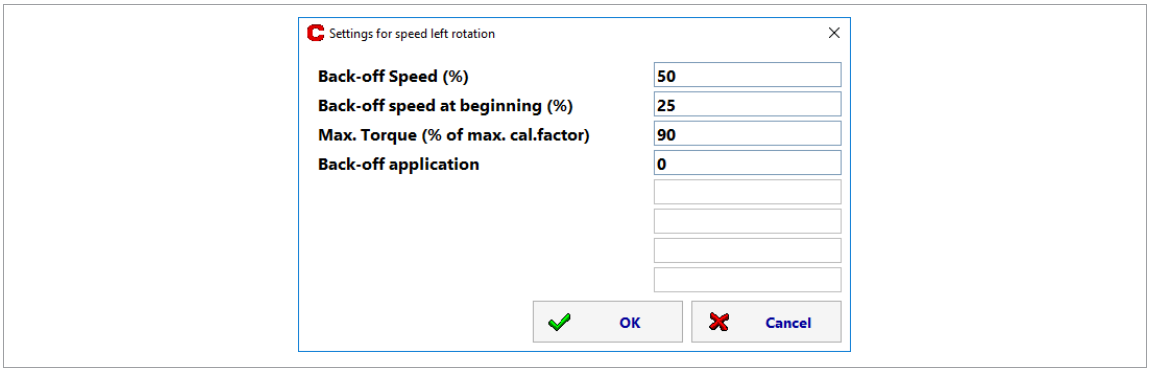

Fig. 6-9: Settings for speed left rotation

2. Enter all values in percent of their maximum values.

Back-Off Speed (%) and *Back-Off Speed at Beginning* must have identical signs preceeding the entered values. Otherwise, a correct processing of the back-off process is not guaranteed, and it can result in unforeseeable consequences.

3. Enter Back-off speed and Back-off speed at beginning in the range from -100% to +100%.
4. To change the direction of rotation possibly by placing a minus sign in front (-). If no minus sign is entered, the direction of rotation is "counterclockwise", which corresponds to a back-off.
5. Otherwise, the direction of rotation is "clockwise."
6. Enter the maximum torque only as a whole number (without a decimal). The area extends from 0 to 100% of the calibration value of the transducer.
7. Confirm parameters and thereby accept them.

The back-off without Application preselection is a cyclical process that is continuously executed by the controller. Each cycle has a duration of 500 ms. As long as the start switch is pressed, the main software of the measuring board gives the command for motor start on a cyclical basis. The measuring board on its part starts the motor with the prescribed parameter values (speed, direction of rotation, torque monitoring). The starting speed is active for 500 ms. After that, the switch is made to the programmed back-off speed. As soon as the tightening module determines that the programmed maximum torque has been exceeded, it interrupts the process for the sake of safety.

In order to be able to detect a communication interruption on the ArcNet line, a watchdog timer is started internally and is retriggered with each cycle. If this cyclical triggering stops, no more communication is possible and the measuring board stops the motor after no more than 1000 ms. As soon as communication is possible again, the motor is restarted.

6.6 System Information

6.6.1 Maintenance Information

This option depends on the main software of the controller that is used. The maintenance information is used to bring the tool into a regular maintenance or service rotation. In this maintenance/service, the standard wear parts are maintained or replaced. The function is for the parameterization of the maintenance intervals in order to be able to indicate a visual message that is output via email via TorqueNet.

1. Select *Navigator* > *Tool Setup* > *Tool Settings* > *System Bus*.
2. Mark corresponding nodes and open <System Information>.
   ➢ All important values of the maintenance counter appear under *6 Counter*.

All information is available only in English.

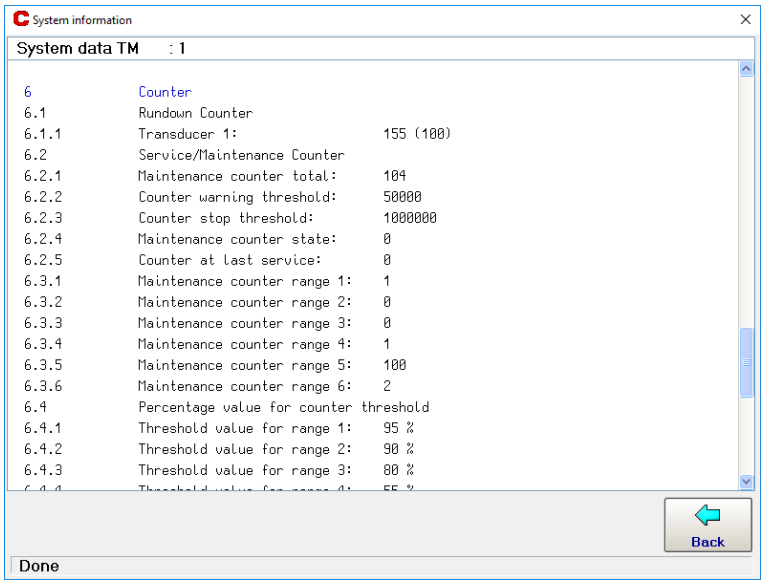

Fig. 6-10: System Information

The above view displays only a part of the information.

Dynamic Service Counter

1. Select *Navigator* > *Tool Setup* > *Tool Settings* > *System Bus*.
2. Mark corresponding nodes and open <System Information>.

The service counter has a dynamic element to enable it to take the differing loading of the tool into account. Depending on how great the loading on the tool is, the service counter will count with a higher or a lower value.

6.6.2 MCS Data (depends on software, tool)

In the course of a machine capability study (MCS), a study is made of how the machine performs with respect to the realization of prescribed quality evaluation. The capability indexes here are Cm (for machine controllability) and Cmk (for machine capability).

1. Select *Navigator* > *Tool Setup* > *Tool Settings* > *System Bus*.
2. Mark corresponding nodes and open <System Information>.
   ➢ All information from the last MCS that was run is shown under item *7 MCS data*.

All information is available only in English.

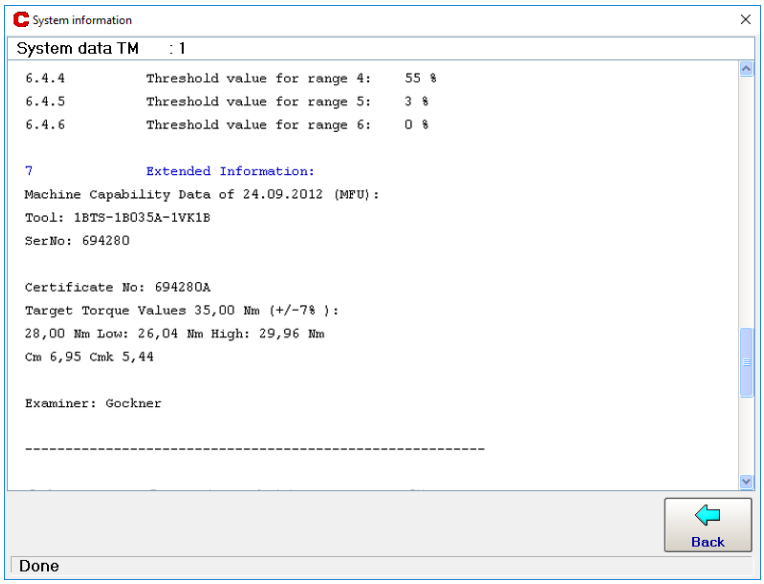

Fig. 6-11: System Information

The MCS data displayed only represent a small snapshot of the actual data that are supplied in writing with every tool on delivery and at repairs and maintenance. The data of the MCS are only written to the transducer when the maintenance, MCS etc. is run.

6.7 Time Constants

These parameters for time constants apply to all tools assigned to this application (tightening process). The following time constants must be entered:

Parameter	Description
Start Delay Time TV (ms)	(Only for setting without group fastening in synchronous sequence) The measuring card relays the start to the output electronics delayed by the time delay.
Start Pulse Suppression TA (ms)	Recording of torque values is suppressed during the start pulse suppression time so that the mass moment of inertia for the drive is not misinterpreted as being the tightening torque for the fastening joint during start-up.
Fastening Time Tmax (ms)	This is the maximum admissible rundown time of the corresponding stage. The maximum rundown time is effective for all tools of a tool group in a stage. After this time lapses, the stage is always interrupted with Stage NOK.
Dwell Time TN (ms)	The dwell time is a "wait" state used at the end of a rundown, between tool shutoff and the importing of the end tightening result values. This compensates for the effects of the tool's kinetic energy after shutdown, also referred to as "overshoot".
Marking Time TF (ms)	Duration of the output bit activation from the controller to an optional color marking system. Color marking systems can be used inconjunction with the controller, after an OK rundown, to physically mark a successful tightening process with a paint mark. The input of 0-7ms is evaluated as no color coding. Only the Marking time from the last parameter set of the application used (fastening sequence) is actually used.

7 Software-dependent Options

7.1 Stick-Slip

Stick Slip is an undesired effect in which a slipping and sticking occurs during the rundown due to friction under the head. It is typically recognized by an audible creaking (noisy joint) that occurs and the torque fluctuates very sharply. As a result an IRED event message can be triggered.

A stick-slip condition is then detected, if during the rundown, the current detected torque reading is more than 4% of the calibrated value below the peak value of the last 16 torque measurements. The detection of the stick-slip condition is activated independently of the threshold torque. In order to exclude undesired angle encoder errors, a switch is made to a different mode starting at 12.5% of the torque calibration value of the angle processor, independent of the stick-slip effect.

If stick-slip is measured, the following measures of the software are implemented:

- The current redundancy is not referenced for approx. 70 ms in tightening sequences.
- In back-off sequences, the current redundancy is deactivated for the rest of the fastening stage.
- The angle processor is placed in a mode determined by the preceding sign after the threshold torque is reached.
- The controller collects the stick-slip warnings and will generate a system warning. The generation of the system warning depends on, among other things, the software of the controller.

If the current detected torque reading is greater than 30% of the transducer calibration value and the parameter for the count of stick-slip condition is programmed to be greater than "0", then when running Sequence 31 and Sequence 51, and if stick-slip is detected, the speed is reduced to 4% of the maximum speed. This allows the stick-slip condition to end, and as a result, continue the rundown to completion. The stick-slip condition detection is deactivated in LiveWire at the start of a stage for 70 ms. This is to avoid the mechanical reaction of the tool to speed change.

7.2 Gradient Evaluation at the Shut-Off Value

This option depends on the main software of the controller that is used. Possible with Sequence 75.

With this option, the evaluation of the gradient can be influenced during the fastening sequence. Without activation of this option, all current gradient values that are calculated during the fastening sequence after the threshold torque is reached are checked to see if they exceed or fall below the gradient values. With activation of this option point, all gradient values are ignored and not evaluated.

An evaluation is first done at the end upon reaching the search criterion Shut off angle. Thus, the gradient value is evaluated on shut-off.
The Shut-Off Values reached are fed to the controller.

7.3 Hold Torque

This option depends on the main software of the controller that is used. Hold Torque function is available with sequence 20, 30 or 50 when using BTS(E) or fixtured tools.

This can be used to influence the fastening sequence after the normal sequence has reached shut-off.

All fastening sequences with this option activated, at first run in the typical method. When the search criterion *Shut-Off Torque* or *Shut-Off Angle* is reached, the fastening sequence is not stopped, but instead shifted into hold mode (speed 0 rpm).

The Shut-Off Values reached are evaluated and transmitted to data collection servers. This hold mode is maintained until either the controller terminates the cycle or the programmed maximum max fastening T_{max} has run down to the last second. The maximum torque that occurred in hold mode is used for evaluation of the rundown. As a safety shut-off, the maximum torque is used.

► Activate option in: *Navigator* > *Standard* > *Stage* > *Stage n* > *Sequences* > *Diagnostics* select Sequence, activate *Hold Torque*.

7.4 Fastener Breakage Detection

This option depends on the main software of the controller that is used. This function is available with Sequence 73 and 75.

► Activate option in: *Navigator* > *Standard* > *Stage* > *Stage n* > *Sequences*

Certain application of force of material fatigue can result in a breakage of the fastener head or the socket. With this option a fastener break is measured early, thereby protecting the worker/operator.

When there is a detected fastener break condition, it is assumed that, although the socket/fastener head of the tool turns continuously, the torque drops sharply within a few degrees. This fastener break causes the gradient to drop sharply (based on torque over angle measurements). When this occurs, the current calculated gradient value falls below the programmed minimum gradient limit value. This condition will cause the tool to shut off.

In order to also stop all other tools in this tool group, the measuring board that has measured the break transmits a status message to the controller. This in turn sends a stop command as quickly as possible.

As a safety shut-off, the maximum torque and the maximum angle are used.

7.5 Snug Point Detection

Two or more parts of a detachable connection come into contact at the snug point. The characteristic of such a system is a sharp increase in torque within a few tightening angles.

Depending on the fastening sequence, the snug point can be determined using a retrospective or predictive method. This is done by evaluating the recorded torque values and determining the torque increase gradient.

7.5.1 Snug Point Detection – Retroactive

Retroactive Snug Point Detection – Sequence 13

The snug point detection is possible with STM measuring cards of the S168025-3(...) series.

For the determination of an exact Snug Point Detection, the following requirements are necessary:

- At least 256 torque values must have been measured during prevailing torque monitoring.
- During Snug Point Detection it is obligatory to use a shut-off angle controlled fastening sequence with rotation angle and torque monitoring (final fastening stage with sequence 50).
- A marked torque increase must have taken place at the end of the prevailing torque monitoring. This means that the contact torque (shut-off torque) of the prevailing torque monitoring must be clearly above the rundown frictional torque.
- The threshold torque of the final fastening stage (sequence 50) must be programmed bellow the shut-off torque of the pretightening stage (sequence 13).
- The angle counting ends at the target of the pretightening stage (sequence 13) and is continued again only when the threshold torque of the final fastening stage (sequence 50) is reached (shut-off angle = jointing angle + residual angle). As a result, the dwell time of the pretightening stage (sequence 13), the start delay time between the stages and the start pulse suppression of the final fastening stage (sequence 50) must be programmed with "0".
- In the pretightening stage (sequence 13), the record-end torque is to be chosen such that the complete torque trace is located within the graphic recording. Only then can it be guaranteed that the pretensioning force remains reproducibly constant.

The angle from snug point to target of the pretightening stage, is called the snug angle. The snug angle determined from the pretightening stage reduces the shut-off angle of the final fastening stage (residual angle). Thus, the angle from the snug point of the pretightening stage to the stoppage of the tool in the final fastening stage is constant. This, in turn, causes the pretensioning force of the pretightening stage to also be considered in the final fastening stage to prevent exceeding the maximum pretensioning force of the final fastening stage.

Errors within the fastening sequence with Snug Point Detection are evaluated and are fed to the controller together with the fastener tightening values.

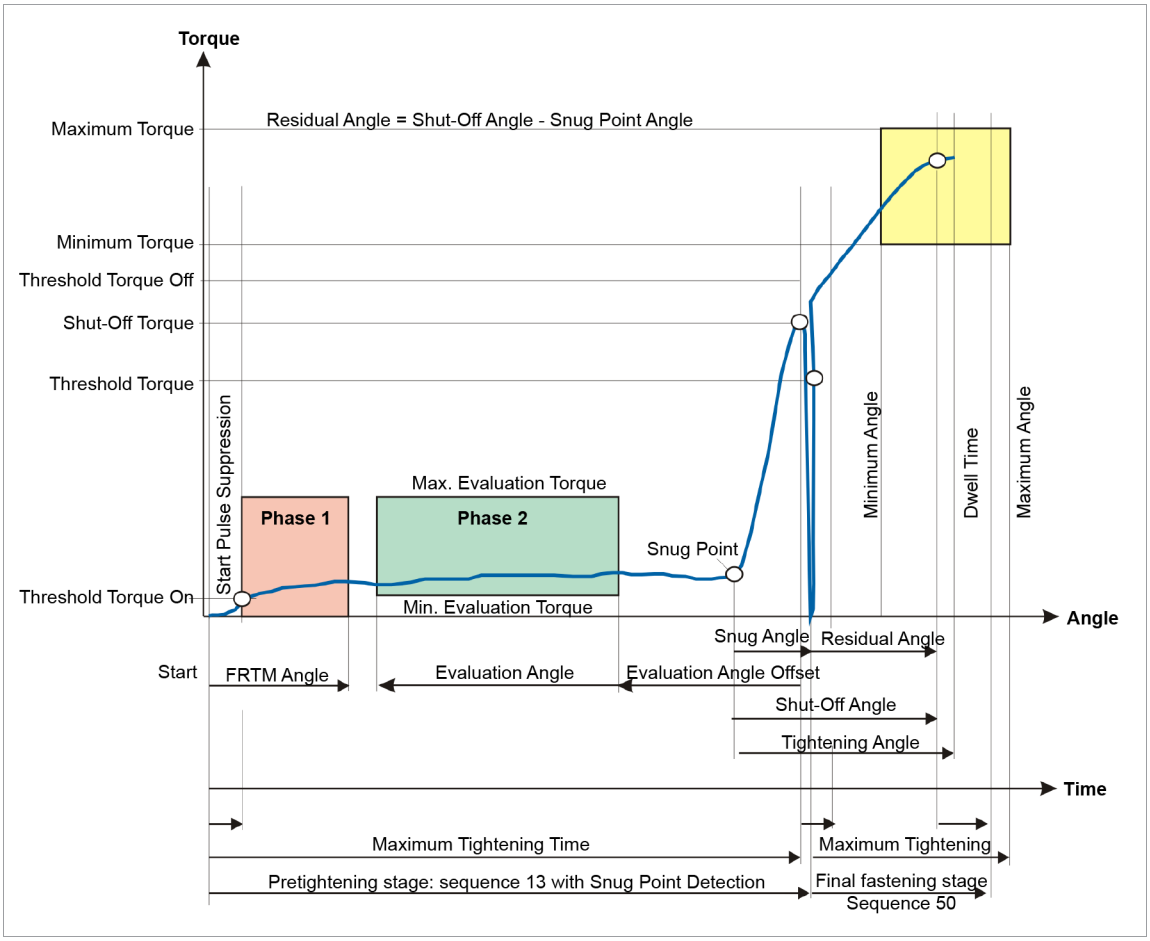

Fig. 7-1: Illustration of the complete tightening sequence

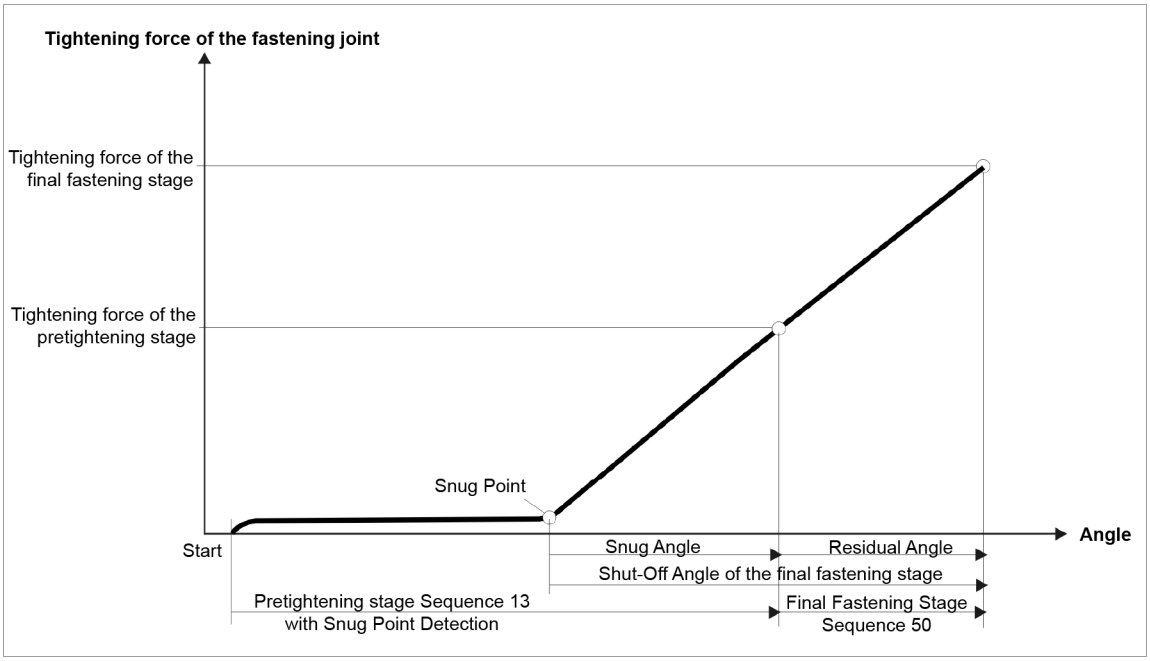

Fig. 7-2: Detailed representation: the tensioning force of the bolted joint, which is shown as being positive (equivalent to the tightening torque)

Retroactive Snug Point Detection – Sequence 35

The snug point is calculated retroactively after the shut-off torque has been reached.

AF for GD at Switchoff Point (AF_AP)

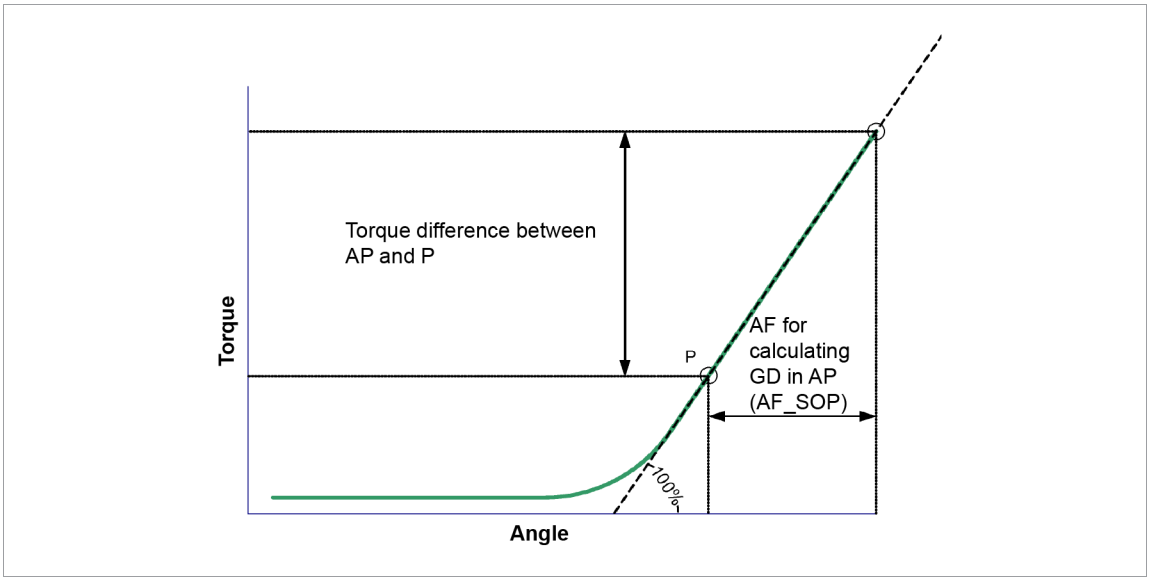

Fig. 7-3: AF for GD at Switchoff Point

The parameter *AF for GD at Switchoff Point* is used to calculate the gradient slope at the shut-off point. For this purpose, the angle over which the gradient triangle is to be calculated is parameterized
The point P is the point that lies before the shut-off point (AP) by this number of angles.

This gradient serves as a comparison gradient for the snug point search and represents the 100 % value for the gradient. It is calculated as follows:

$$\text{Gradient} = \frac{\text{Torque AP - Torque P}}{\text{AF\_SOP (deg)}}$$

the value will be chosen such that P is on the straight line, not in the curved area of the graph. In practice, a value of 20° – 40° should be sufficient, but in very hard joints could be, for example, 6°.

GD bevel für Snug Point Detection (Abfl_GD)

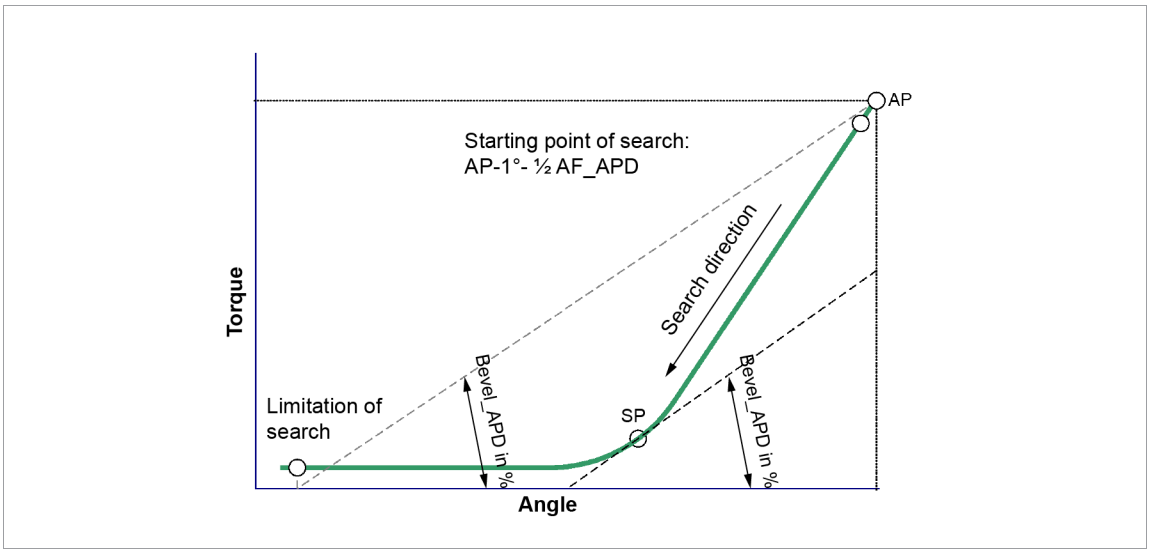

Fig. 7-4: GD bevel für Snug Point Detection

To recognize the snug point (SP), it is assumed that this is on the curved section of the graph between placement and tightening. The theoretical gradient at this point is between 0% (driving phase) and 100% (tightening).
The point that is searched for is the first point at which the gradient falls below the value defined by the parameter *Bevel_APD*. This is given in % (the gradient at the target turn off). The search starts from the point that is 1° and half of *AF_APD (deg)* away from the shut-off point.

Example: A value of 50%, for example, thus corresponds to half the gradient at the target turn off and the snug point is the point at which the gradient is less than 50%.

In practice, values between 40% and 80% are rational.

The search ends when a snug point is found.
If no snug point is found, the search will end at the angle value corresponding to the intersection of a straight line through the target turn off with the angle axis (see *Limitation of the search* in the figure). Here, the straight line has the same gradient as the flat area.

AF for Snug Point Detection (AF_FPE)

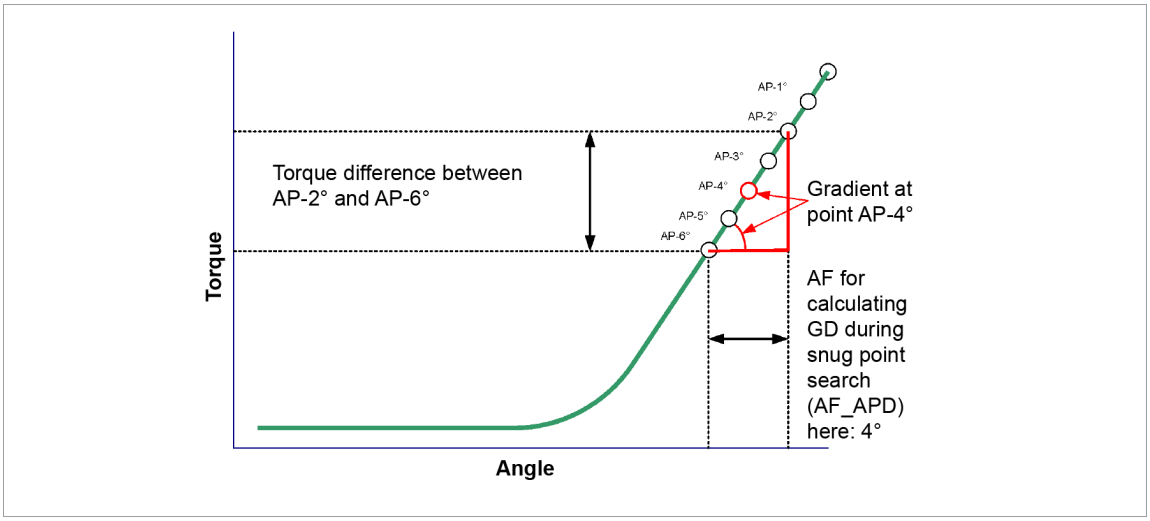

Fig. 7-5: AF for Snug Point Detection

During the search for a snug point, the gradient of each point between the target turn off and the end point of the search is determined. This is done using the parameter *AF_APD (deg)*. To determine the gradient a point of the graph, the torque difference between two auxiliary points is measured. These auxiliary points are at a distance equal to the angle value of *AF_APD (deg)*. The point for which the incline is to be calculated lies in the center between these auxiliary points:

$$\text{Gradient} = \frac{\text{Torque auxiliary point A - Torque auxiliary point B}}{\text{AF\_APD (deg)}}$$

The value should be as small as possible, but still large enough that the waviness of the graph is averaged out. For rough graphs, for example, a value of 20 is rational, while for smooth graphs a value of around 4 is sufficient.

7.5.2 Snug Point Detection – Predictive

Predictive snug point detection can be activated in fastening sequences 30, 31, 50 and 51. This function is only possible with STMD-H measuring cards from version S168025-633 or higher.

With this type of snug point detection, angle counting is not started at a defined torque, but at the calculated snug point. From this moment, the torque increases rapidly.
The rundown parameters are aligned with this value. The angle control is controlled via the snug point.

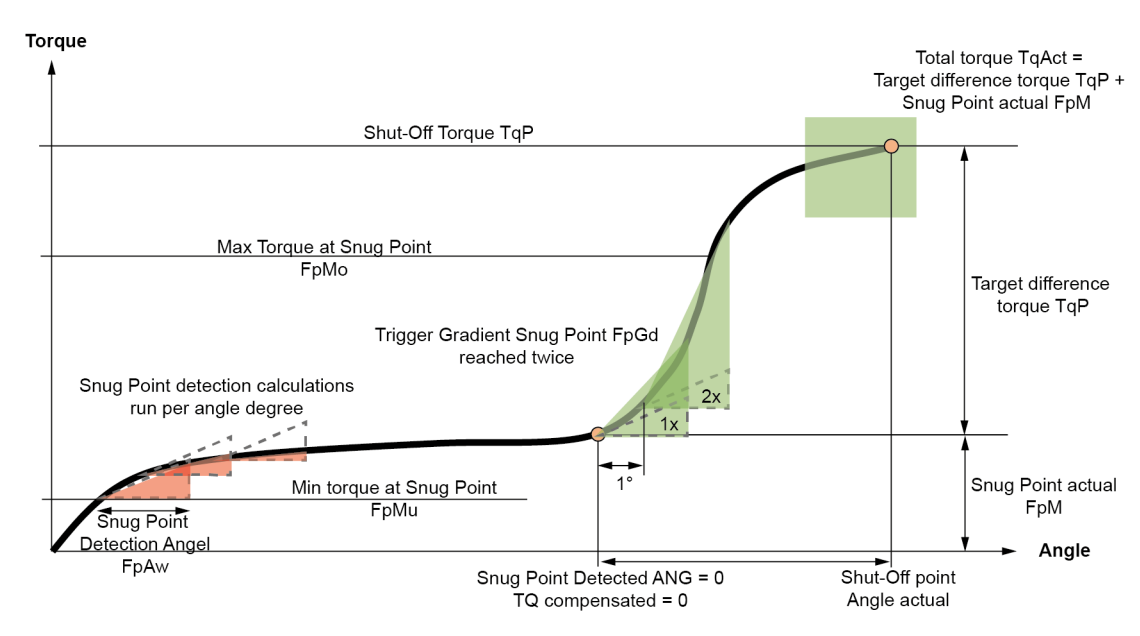

Fig. 7-6: Snug Point Detection

Parameter	Description	Range of values	Unit	Abbrev.
Snug Point Detection	If the checkbox is activated, angle counting starts as soon as the snug point is reached. If the check box is deactivated, angle counting and speed control (SEQ 31/SEQ 51) starts at the threshold torque.	active, inactive	Bit	
Snug Point Composation	The snug point compensation increases the regular shut-off torque by the measured torque at the snug point. Shut-Off Torque = Actual snug point torque + Target difference torque The setting applies to SEQ 30/SEQ 31.	active, inactive	Bit	
Min torque at Snug Point	Start of Snug Point Detection	> TqTr ... < FpMo	Nm	FpMu
Max torque at Snug Point	Maximum permitted upper torque of the snug point. If no snug point was detected before this torque is exceeded, the Snug Point Detection is aborted with the error *FPEF*.	SEQ 30/SEQ 31: > FpMo ... < TqP SEQ 50/SEQ 51: > FpMo ... < TqMax	Nm	FpMo
Snug Point Detection Angle	Number of degrees over which a gradient is calculated.	SEQ 30/SEQ 31: 3 ... < AngMax, max. 31 SEQ 50/SEQ 51: 3 ... < AP, max. 31	Deg	FpAw

Parameter	Description	Range of values	Unit	Abbrev.
Trigger Gradient Snug Point	A requirement for snug point detection is that this gradient is exceeded in two consecutive gradient triangles.	> 0,01 ... 9999	Nm/deg	FpGd

The snug point detection starts as soon as the parameter *Min torque at Snug Point* is exceeded. If the torque subsequently drops below this value again, the snug point detection will still continue. The snug point detection ends as soon as the parameter *Max torque at Snug Point* is exceeded or the snug point is detected.
If the potential snug point exceeds the *Max torque at Snug Point* parameter without a snug point is detected, the rundown aborts with the *FPEF* error (snug point detection error) and the *FPEF* error bit is set.
If the rundown is aborted with a general error (e.g. *MD>* or *TMAX*) and the snug point has not yet been found, only the *FPEF* error bit is set.

The number of stored angle degrees is the same as the number of angle degrees specified for the *Snug Point Detection Angle* parameter. Then, a gradient is calculated over this angle window and compared with the value *Trigger Gradient Snug Point*. value. If the calculated gradient is above the value *Trigger Gradient Snug Point*, he first condition for recognizing the snug point is given. To detect the snug point more reliably and without interference, the detection must be triggered in two successive gradient triangles. In this case, the snug point is set retroactively to the beginning of the first gradient triangle. Angle counting for the OK window starts from this point.

Since the snug point is defined as the beginning of the first gradient triangle and is not detected until the end of the second gradient triangle, a possible angle shut-off or speed change occurs at the end of the second gradient triangle at the earliest.
The distance between the snug point and the shut-off torque should be large enough so that the second gradient triangle does not exceed the shut-off torque. If this is the case, the rundown is aborted with an error message.

The gradient is calculated for each angle point. This procedure is repeated until the snug point is detected or the potential snug point exceeds the parameter *Max torque at Snug Point*. The first angle value of the gradient triangle is called the potential snug point.
Calculation of snug point: Length of 2 gradients + 1 angle degree

Snug Point Compensation

Snug point compensation can be activated in SEQ 30/SEQ 31. The snug point compensation determines the torque at the snug point. Then, it is added to the parameterized shut-off torque (target differential torque). This increases the shut-off torque to be achieved by the torque at the snug point. To prevent excessive torque being applied to the screw, all other tightening parameters are not affected by the compensation and remain unchanged (Maximum Torque, Torque Low Limit).
Example:
Snug point = 1 Nm
Parameterized shut-off torque = 10 Nm
➢ Compensated (actual) shut-off torque = 11 Nm

The torque in the shut-off torque and in the snug point (FP) is displayed in the archive.

The speed regulation for SEQ 31/SEQ 51 starts from the detection of the snug point (right side of the second gradient triangle). If the *Snug Point Detection* check box is active, the ramp is not adapted to the increased shut-off torque. If the compensated shut-off torque is above the OK window, the rundown is aborted immediately when the snug point is detected with the error message *TSP>* (snug point torque too high).

7.6 Speed Switching Torque

The speed reduction is available for sequence 31 or 51.

This function is used to reduce the speed n to the final speed n2. There is no hard switching between the speeds. The purpose of the reduction is to be able to work at a higher speed for longer.

Speed reduction SEQ 31

As soon as the threshold torque is reached, reduction to the final speed at the shut-off point begins. The progression of the reduction is opposite to the torque graph (inverse).

The function is active if the final speed 2 is parameterized (not equal to 0).

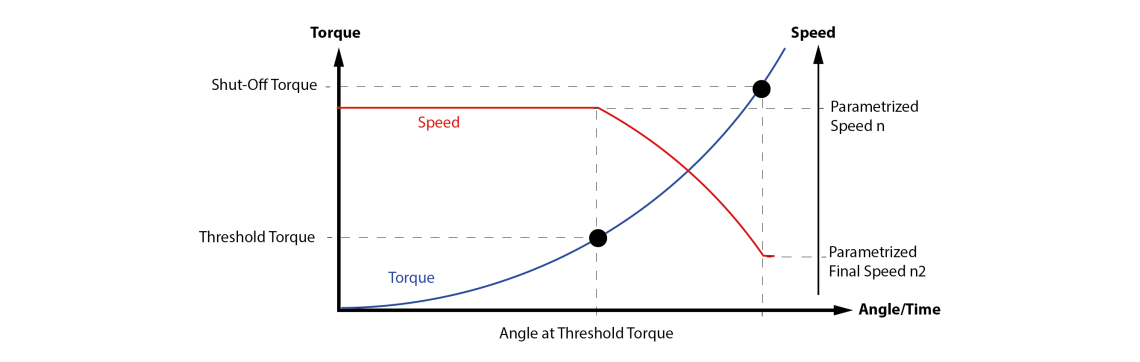

Fig. 7-7: Speed reduction SEQ 31

Speed reduction SEQ 51

As soon as the threshold torque is reached, deceleration to the final speed at maximum torque begins. The progression of the reduction is opposite to the torque graph (inverse). As the shut-off angle is within the maximum torque, the speed at the shut-off angle is slightly higher than the parameterized final speed n2.

The function is active if the final speed 2 is parameterized (not equal to 0).

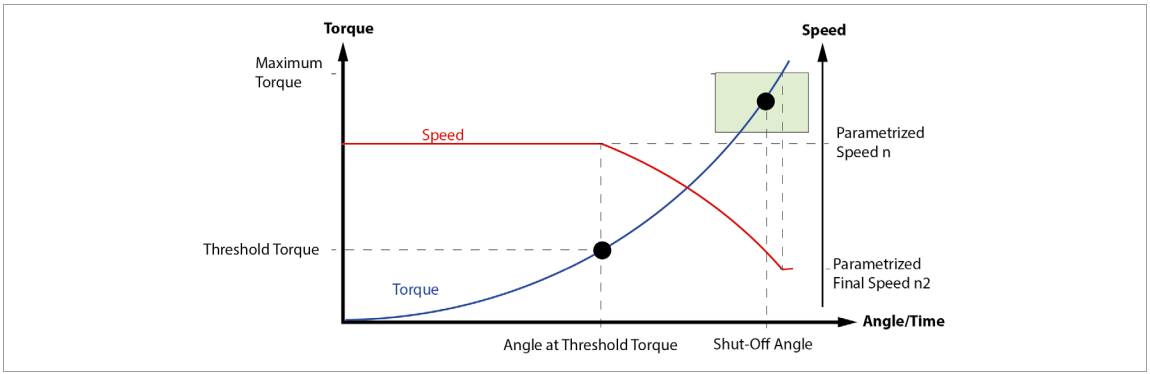

Fig. 7-8: Speed reduction SEQ 51

8 Special Parameter

Torque Averaging Filter

The filtering factor improves reproducibility of the tightening results.

The averaging of the measured torques eliminates noise spikes that would otherwise lead to unnecessary rejects and/or shut-off and therefore to tightening errors.

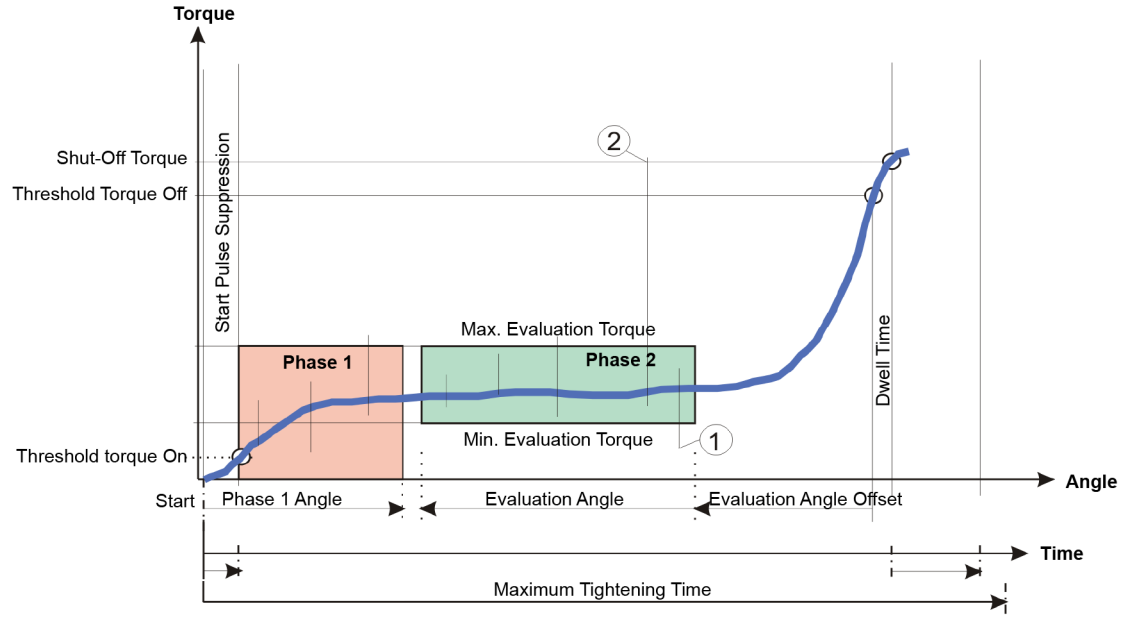

Fig. 8-1: Display Torque Averaging Filter

For instance:

- regarding 1: error in the evaluation by negative noise pulse (evaluation error)
- regarding 2: unnecessary shut-off by positive noise pulse

The filtering factor defines the number of measured values from the A/D converter to be used for averaging. The filtering increases with the filtering factor.

The values are measured in intervals of 300 µs (250 µs with LiveWire).

Setting to default of the filtering factor is 4. In order to prevent faulty shut-offs during faultless rundowns, the default setting should be used. The averaging affects the shut-off speed primarily with hard joints. Thus, the filtering should be set as low as possible.

Angle Averaging Filter

An angle averaging filter determines the angle samples for calculation of the gradients for sequences 6x and 7x, beginning with the threshold torque. The unit is degrees.

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