

### Servo Press Kit YJKP - Advanced Force Mode

This Application Note describes the properties, operation and parameterization of the advanced force mode of the servo press kit YJKP.

YJKP

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## 1 components/software

Type/name	Software/firmware version	Date of manufacture
Servo Press Kit YJKP	General	--
Application software for YJKP (GSAY-A4-F0-Z4-1.3.3)	V1.3.3	--
Firmware for controller (CECC-X)	V3.4.6	--
Firmware for motor controller (CMMP-AS)	V4.0.1501.2.4	--

Table 1.1: components/software

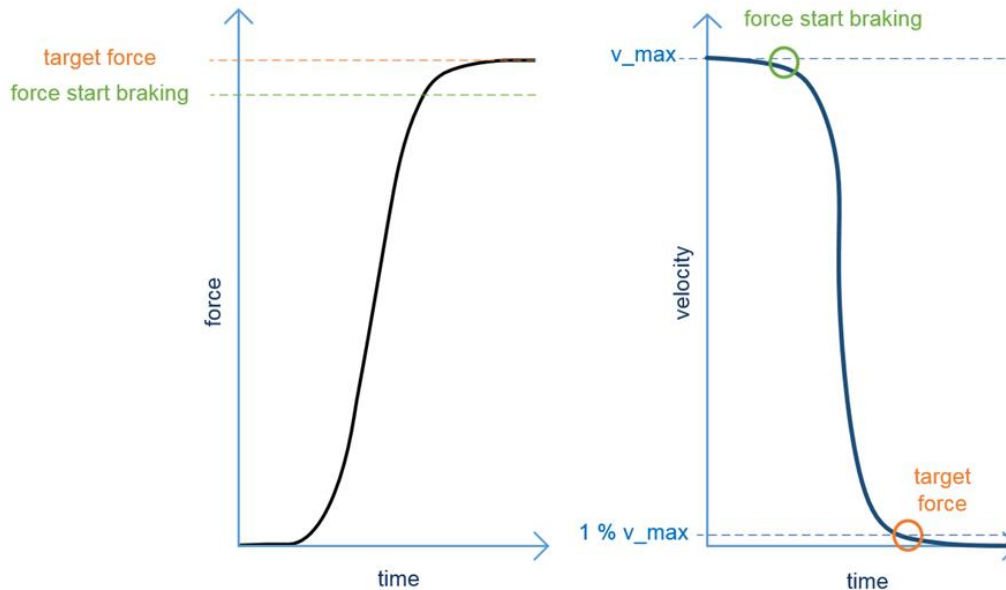
## 2 Overview

The intention of the advanced force mode function is to achieve a certain target force. As soon as this force has been reached without violating a limit value, the step will be fulfilled as successful.

In contrast with force mode, a parameterisable braking ramp is used. This reduces the pressing velocity ( $v_{\max}$ ) from 100% to 1%. As a result, the target force is achieved more precisely and faster.

The advanced force mode has the following properties:

- It is selected as a function in the sequencer.
- Both a force build-up and a force release are possible.
- The advanced force mode can be used several times in a program in the sequencer.



- The limits “Maximum position” and “Maximum force” are available, which can be monitored throughout the entire advanced force mode.
- Graphic displays for force/time [F/t] and force/displacement [F/s] are also provided for the analysis and evaluation of the process.
- Optionally, the advanced force mode includes the driving profile *velocity switch*. The process time can be optimised using this profile.
- The respective velocity limits of the sizes also apply during advanced force mode.
- The maximum duration of the advanced force mode is 50 s. After that, it is aborted.

### 3 Parameterization

#### 3.1 Influences

During the parameterization of the advanced force mode, different influences must be taken into consideration:

- **Velocity:** If the velocity is too high, the target force can be exceeded, and the pressing or servo press can be damaged.
- **Pressing/frame:** The *Force start braking* and *Velocity* parameters must be adapted depending on the rigidity of the pressing.
- **Target force:** The *Force start braking* and *Velocity* parameters must be adapted depending on the target force.

#### 3.2 Pressing parameters

- **Target force [N]:** The force to be pressed.
- **Force start braking[N]:** The force from which the reduction in velocity begins.
- **Velocity[mm/s]:** The maximum possible velocity during the pressing procedure.

**Edit program**

Step 1/4: Configure sequencer

No.	Function	Name
1	TARE	TARE
2	PM	POSITION_MODE
3	AFM	ADVANCED_FORCE_MODE
4	PM	POSITION_MODE
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Function: **Advanced force mode**

☒ Record

Velocity switch: **Limits**

Target force: 500.00 N

Force start braking: 200.00 N

Velocity: 4.00 mm/s

Buttons: Cancel, Save, Next

Commissioning | **Program** | Operation | Diagnosis

Ready

**FESTO**

Released

Actual force: 30.67 N

Actual position: 3.00 mm

Actual velocity: -0.02 mm/s

Tare: ☐ Tare

Offset: 0.00 N

Motion: ☐ Absolute, ☐ Relative, ☒ Jog

Velocity: 5.00 mm/s

Logout

#### 3.3 Limits

If one of the limits is exceeded, the set “failure reaction” is either executed or aborted. **Note:** The recommended “failure reaction” must be activated if this setting is possible in the application!

- **Max. position [mm]:** If the maximum position (absolute) is exceeded, the function is aborted.
- **Max. force [N]:** If the force is exceeded, the function is aborted.

Size	Up to 0.8 kN	Up to 1.5 kN	Up to 4 kN	Up to 7 kN	Up to 12 kN	Up to 17 kN
Limit of max. force [kN]	0.84	1.575	4.2	7.35	12.6	17.85

Function: **Advanced force mode**

☒ Record

**Limits**

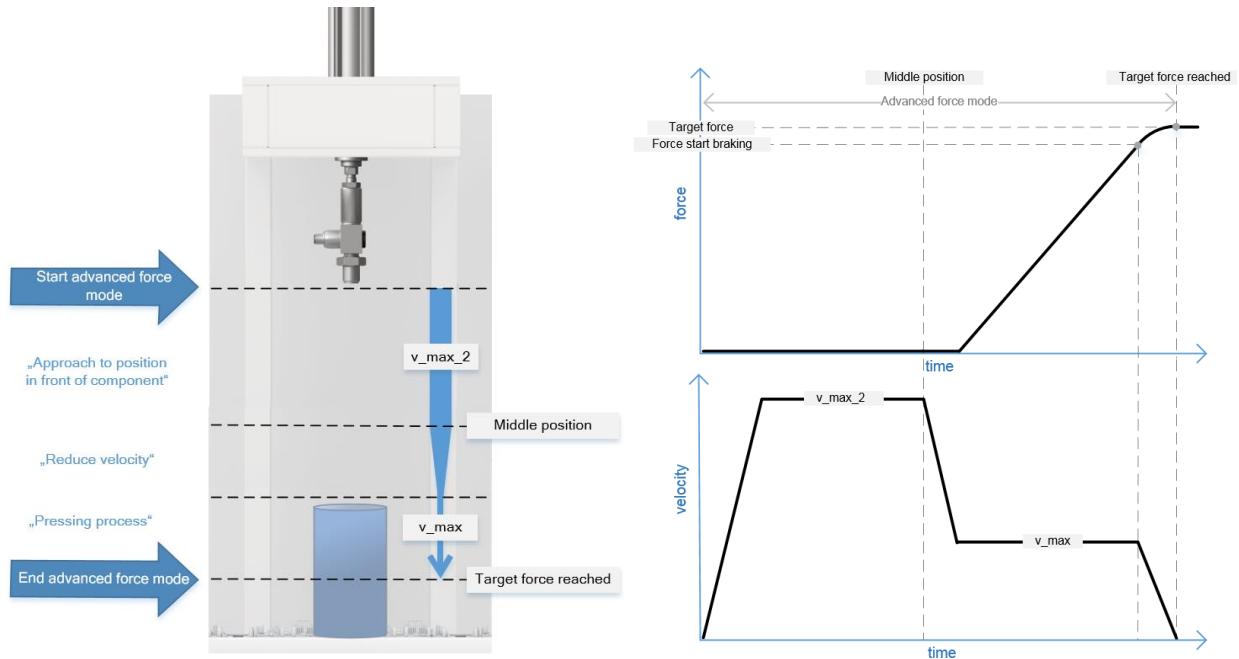
Max. position: 80.00 mm

Max. force: 800.00 N

Buttons: Close, Cancel, Save, Next

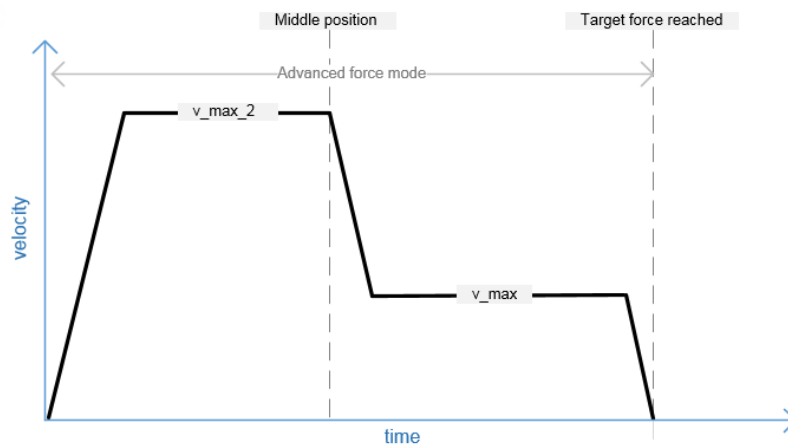
### 3.4 Velocity switch (optional)

Velocity switching can be activated optionally in advanced force mode. Using this function, an intermediate position (e.g., position shortly upstream of the pressing) can be approached at high velocity ( $v_{\max\_2}$ ). From there, the system brakes to the set velocity ( $v_{\max}$ ) without stopping.

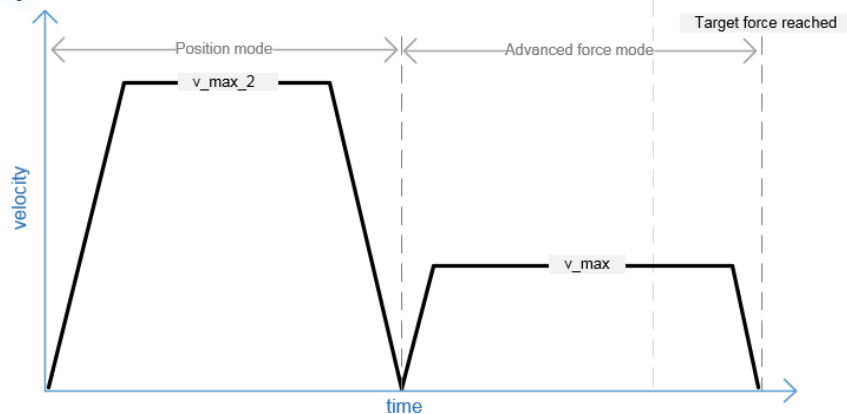


With this switching of the speed, the cycle time can be reduced in contrast with a separate positioning step. This is illustrated in the following diagrams:

**With approach velocity:**



**Without approach velocity:**



**Parameter**

- *Act:* Activation of velocity switch
- *Middle position*[mm]: At this position, the velocity starts to be reduced from  $v_{max\_2}$  to  $v_{max}$ .
- *Approach velocity*[mm/s]: Velocity from the start of force control up to the middle position ( $v_{max\_2}$ )

Velocity switch

Activate ☒

Middle position 16.00 mm

Approach velocity 30.00 mm/s

Close

Cancel Save Next

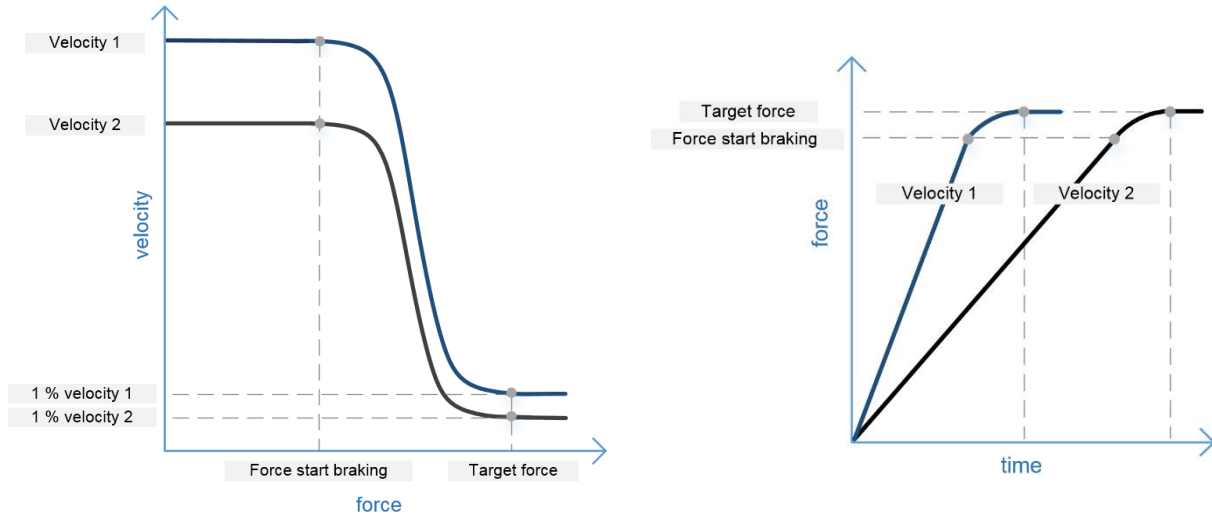
**Note:** The velocity is not reduced until the middle position is reached.

When determining the middle position, you must ensure that it is not too close to or on the pressing. Otherwise an excessive approach velocity ( $v_{max\_2}$ ) can lead to damage to the press and/or part.

### 3.5 Parameterisation procedure

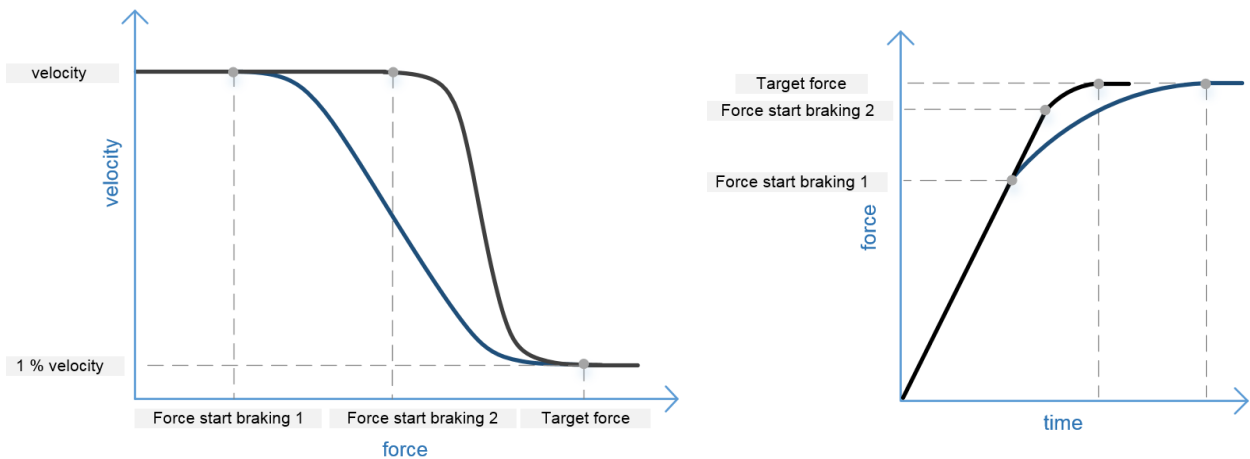
The *Velocity* and *Force start braking* parameters must be adapted depending on the influences from Chapter 3.1. These parameters depend on each other. At the beginning of parameterisation, a lower value should be selected for these parameters and then slowly increased. If the parameters are increased too much, the target force can no longer be reached reliably.

By changing the *Velocity* parameter whilst the *Force start braking* parameter remains the same, the pressing procedure responds as follows:



If the selected *Velocity* parameter is too high, braking can no longer be carried out quickly enough and the velocity is greater than 1% of the set *Velocity* parameter when the target force is reached.

By changing the *Force start braking* parameter whilst the *Velocity* parameter remains the same, the pressing procedure responds as follows:



If the selected *Force start braking* parameter is too high, braking can no longer be carried out quickly enough and the velocity is greater than 1% of the set *Velocity* parameter at target force.

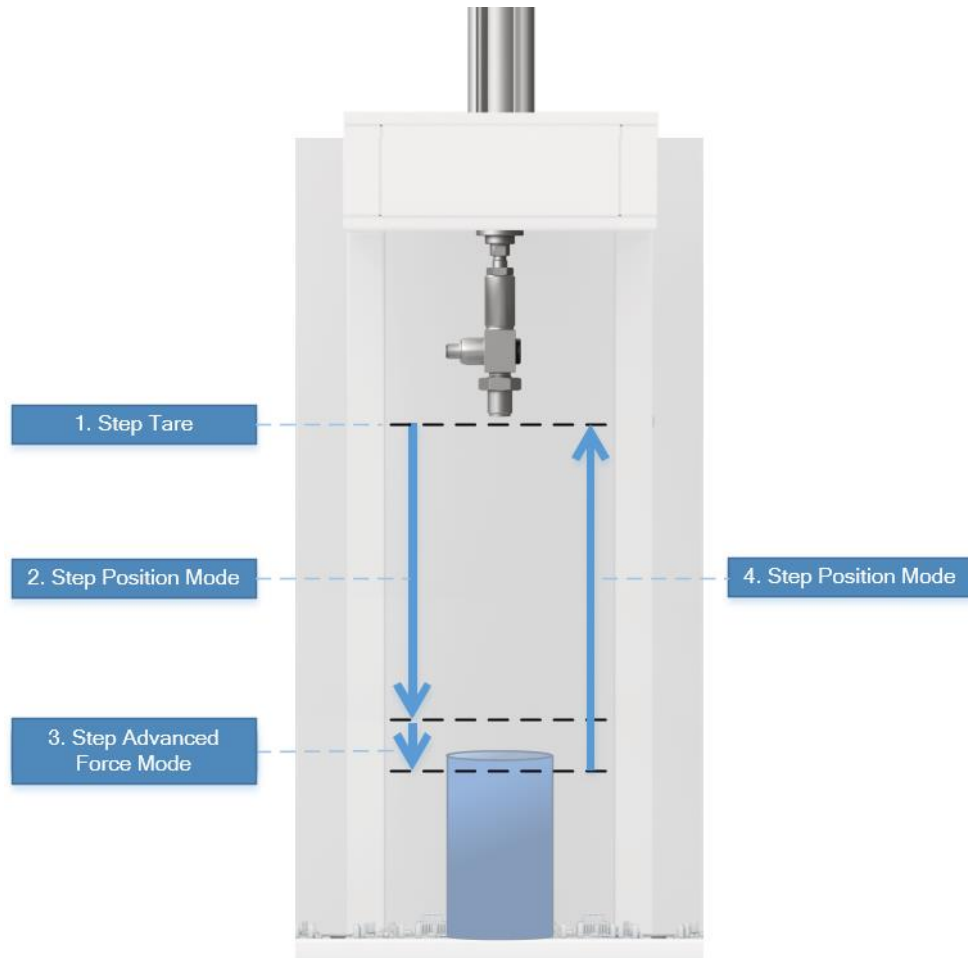
## 4 Application examples

### 4.1 Determination of the pressing parameters

#### 4.1.1 Sample application

The pressing procedure shall be carried out on a metal block using a servo press size up to 800 N. A force of 500 N shall be reached without overshooting.

To determine the parameters a simple 4-step program is created.



From the start position, the force sensor is first tared to an initial value. After that, the system is positioned upstream of the part and then pressed to the target force in advanced force mode. When the pressing procedure is complete, the system returns to the start position.

#### 4.1.2 Initial pressing parameters

In Step 1/4, the initial pressing parameters are set:

**Edit program**

**Step 1/4: Configure sequencer**

No.	Function	Name
1	TARE	TARE
2	PM	POSITION_MODE
3	AFM	ADV_FORCE_MODE
4	PM	POSITION_MODE
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Function: **Advanced force mode**

☒ Record

**Limits**

Target force: 500.00 N

Force start braking: 50.00 N

Velocity: 1.00 mm/s

Buttons: Insert step, Delete step, Copy step, Insert copied step, Configure failure reaction, Velocity switch, Limits, Cancel, Save, Next

Right Panel:

**Released**

Actual force: 29.96 N

Actual position: 3.00 mm

Actual velocity: -0.03 mm/s

Tare: ☐ Tare

Offset: 0.00 N

Motion: ☐ Absolute, ☐ Relative, ☒ Jog

Velocity: 0.00 mm/s

Bottom Bar: Commissioning, **Program**, Operation, Diagnosis

Status: ● Ready

Logout

- The recording of the advanced force mode step must be activated in order to assess and adapt the pressing parameters using the recorded curve.
- The target force of 500 N is set.
- We recommend that a low force is set under the *Force start braking* parameter and a slow velocity is set under the *Velocity* parameter. Both parameters are adapted later using the method from Chapter 3.5.

#### 4.1.3 Adapting limit values

Function: **Advanced force mode**

☒ Record

**Limits**

Max. position: 80.00 mm

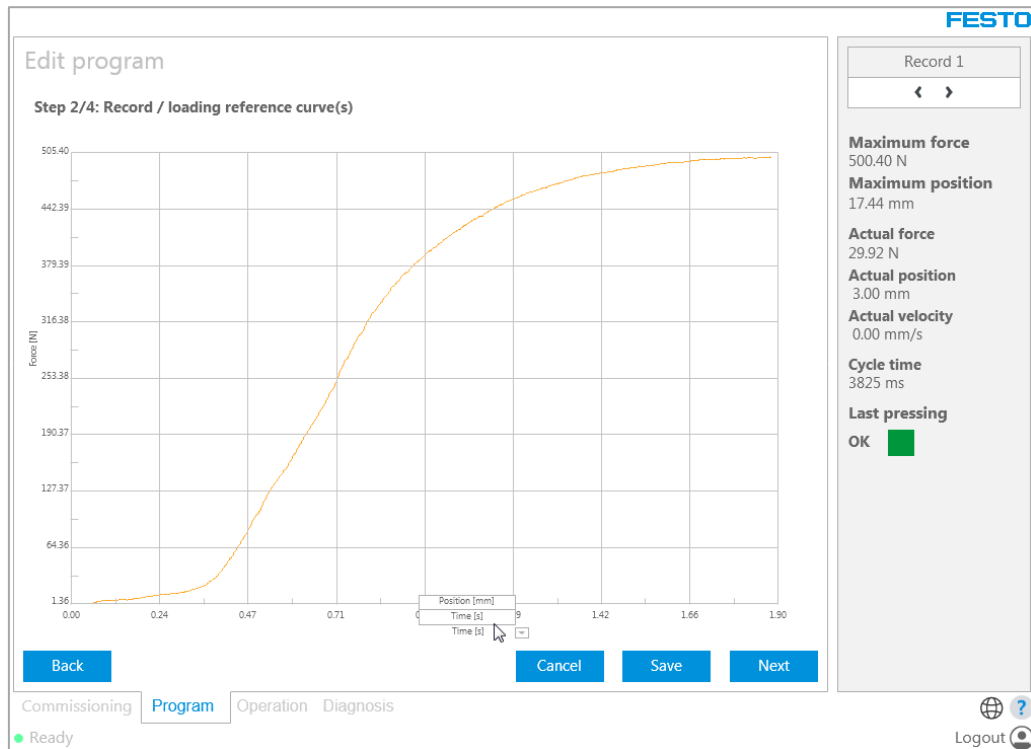
Max. force: 550.00 N

Buttons: Close, Cancel, Save, Next

- The limit values must be adapted depending on the mechanical structure and application.

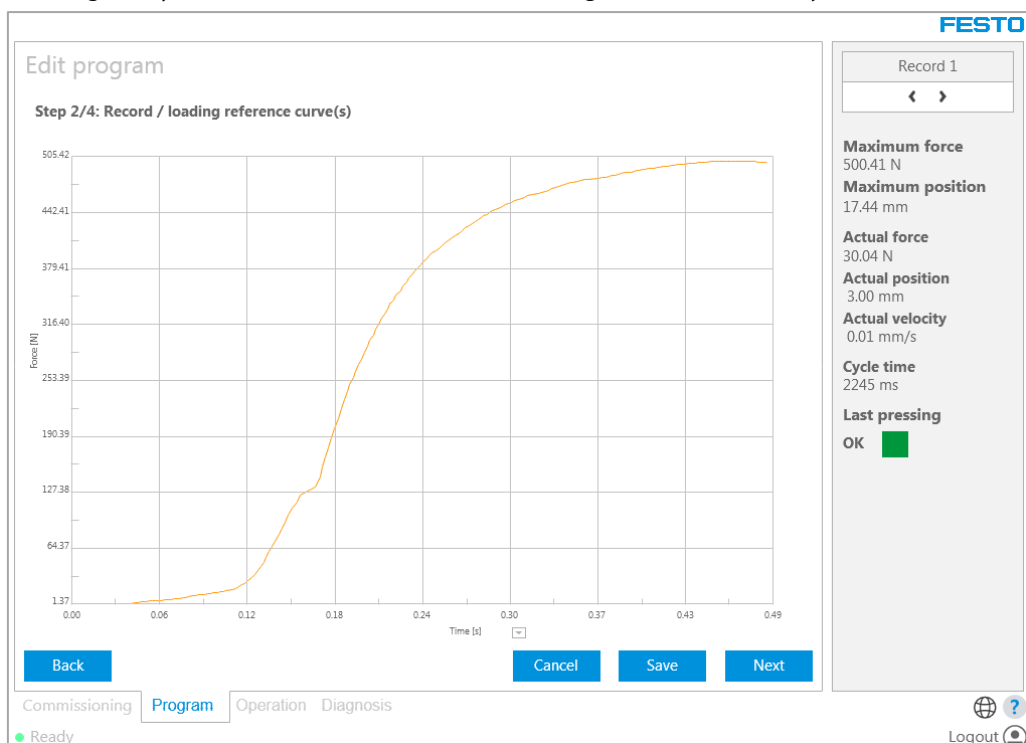
#### 4.1.4 Determining the optimum pressing parameters

- Switch to Step 2/4 using the “Next” button and record a reference curve using parameter values *Force start braking* = 50 N and *Velocity* = 1 mm/s. The force-time diagram is used for analysis:



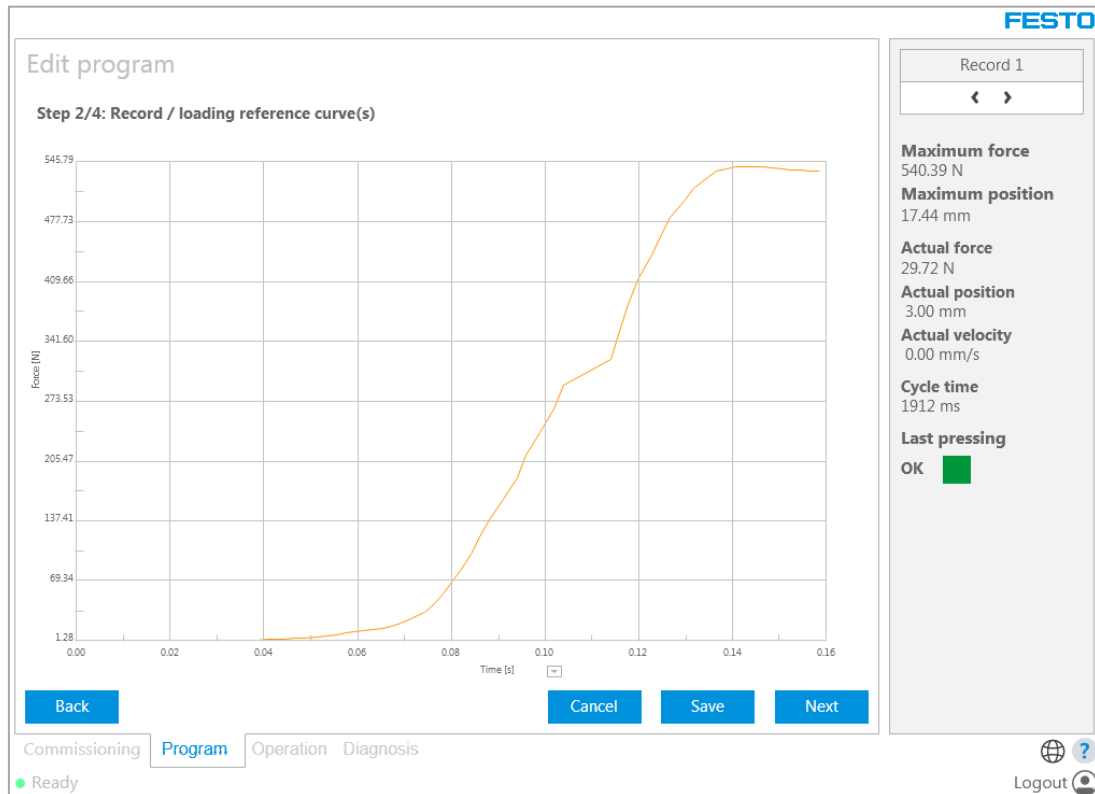
- The diagram shows that it takes too long for the target force to be reached. The time required for the step can generally be read from the time axis, about 1.880 s in this case. To improve the time, changes are made to both parameters *Force start braking* and *Velocity*. To do so, switch back to Step 1/4 with the "Back" button. There, the parameters are adapted, and a reference curve is recorded once again in Step 2/4:

- Recording with parameter values of *Force start braking* = 50 N and *Velocity* = 4 mm/s:



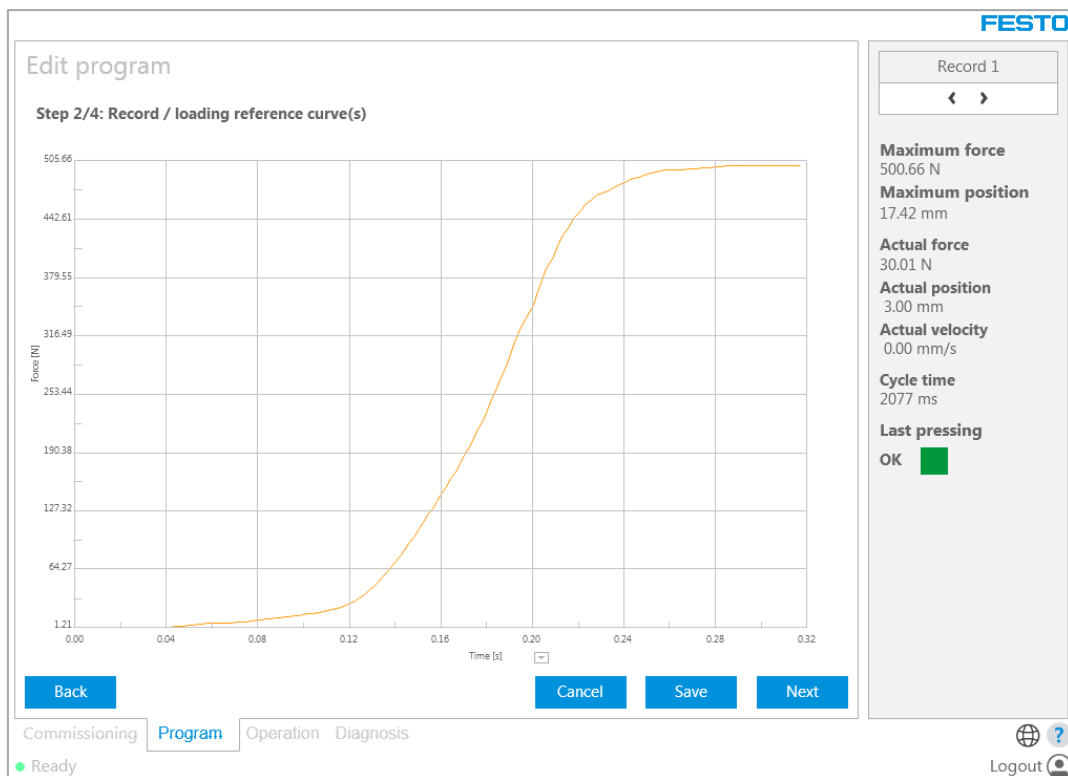
- The time reduces by about 0.480 s.

- Recording with parameter values of *Force start braking* = 50 N and *Velocity* = 10 mm/s:



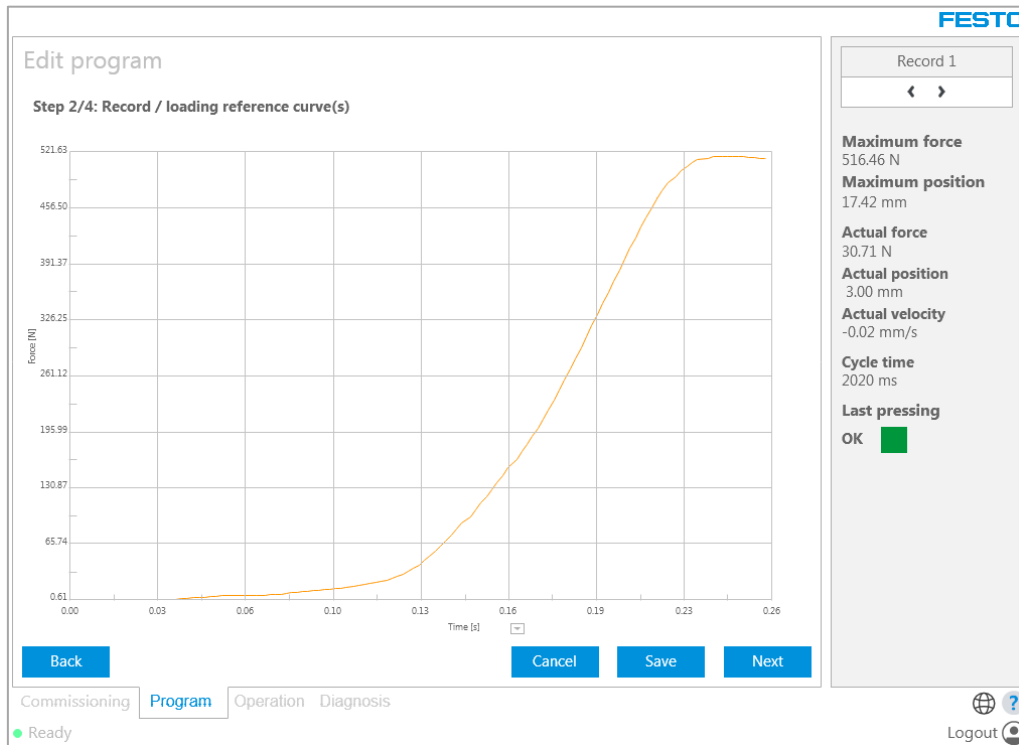
- The time reduces to about 0.158 s, but an overshooting of about 40 N occurs due to excessive velocity.
- A *Velocity* value of 4 mm/s is taken once again and the parameter value of *Force start braking* is increased:

- Recording with parameter values of *Force start braking* = 300 N and *Velocity* = 4 mm/s:



- Ideal for the application. The time reduces to about 0.318 s, and no overshooting occurs.

- Recording with parameter values of *Force start braking* = 400 N and *Velocity* = 4 mm/s:

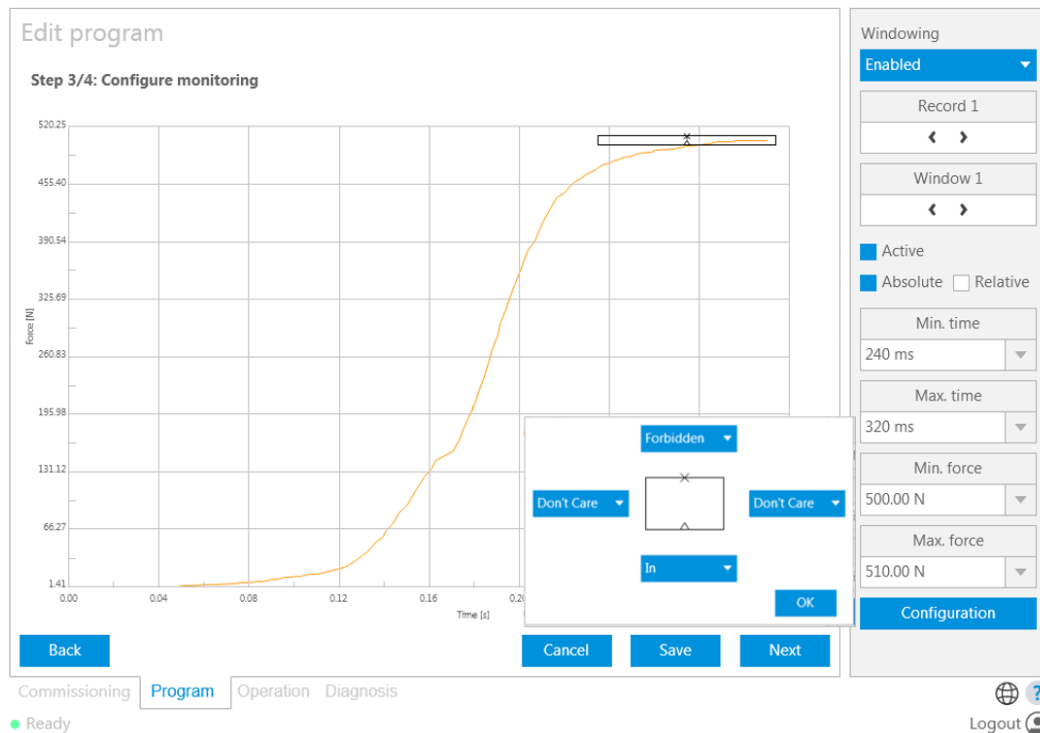


→ The time reduces to about 0.258 s. This is unsuitable as an overshooting of about 16 N occurs.

## 4.2 Creating an evaluation method

It is possible to use an evaluation method in the force-position diagram **or** in the force-time diagram.

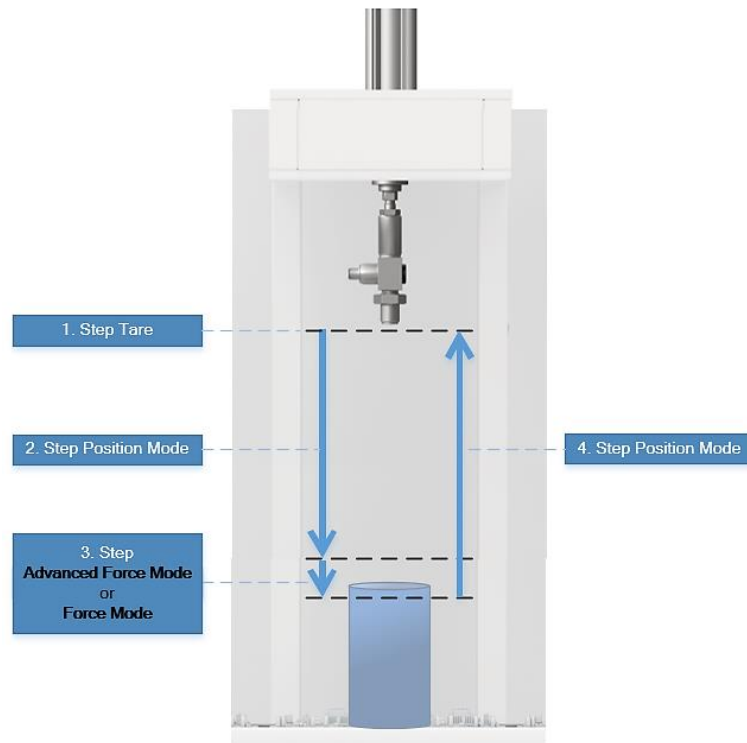
To monitor whether the target force has been reached, the following example takes the force-time diagram and applies the "Window" evaluation method:



- Using the window, it is possible to monitor whether 500 N are reached and whether an overshoot with a tolerance of 2% of the target force (= 510 N) is maintained.
- Additional evaluation methods can be added and, if necessary, the parameters can be optimised.

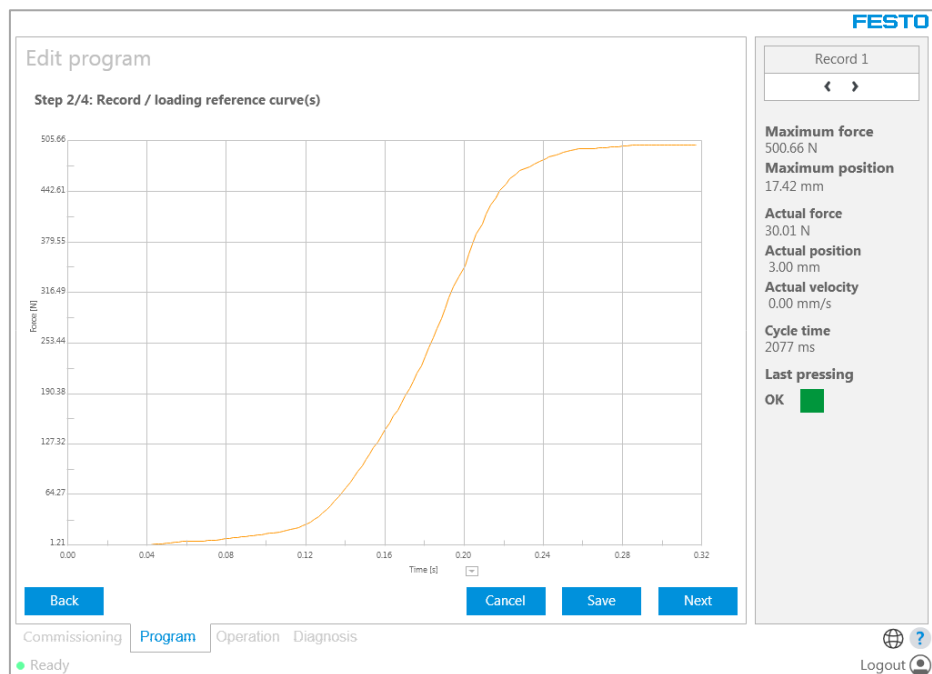
### 4.3 Comparison of the advanced force mode with the force mode

The same structure and requirements are used as in the previous Chapter 4.1.1.



#### Advanced force mode:

The determined optimum parameter values (*Force start braking* = 300 N, *Velocity* = 4 mm/s) from the previous Chapter 4.1.4 lead to the following curve:

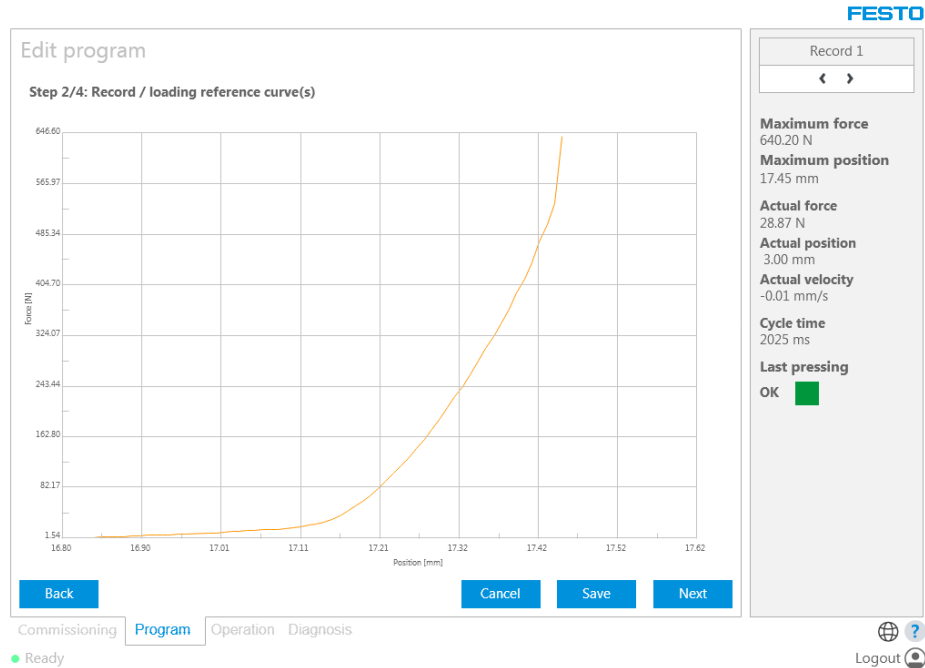


- ➔ The step time amounts to about 0.318 s, the cycle time amounts to about 2.077 s and no overshooting occurs.

**Force mode:**

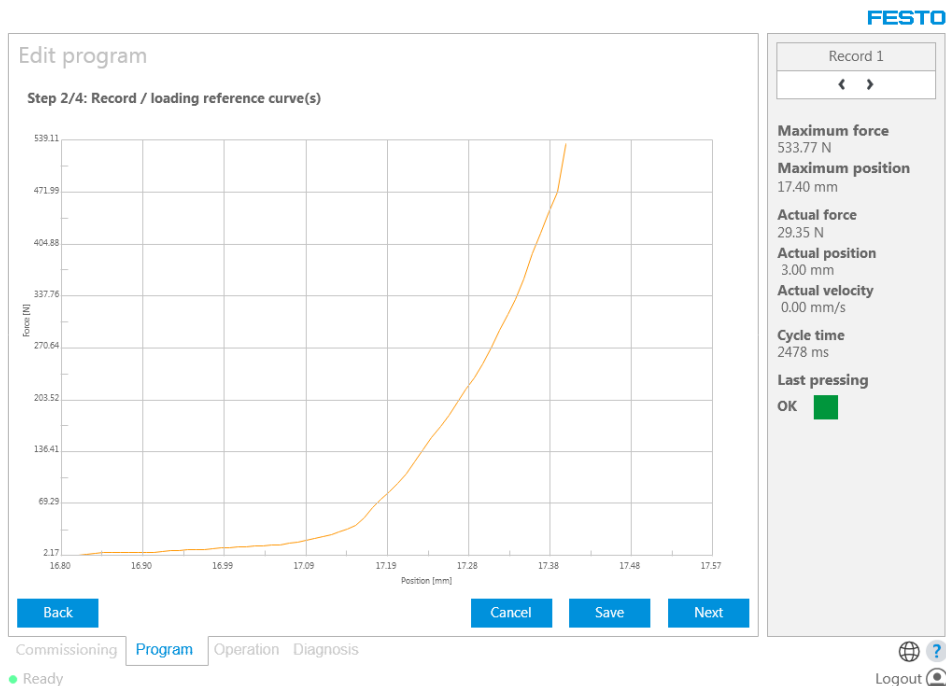
In the following, the parameters for force mode are determined. Here, only the velocity can be changed.

Recording with the same *Velocity* value (= 4 mm/s) as in advanced force mode:



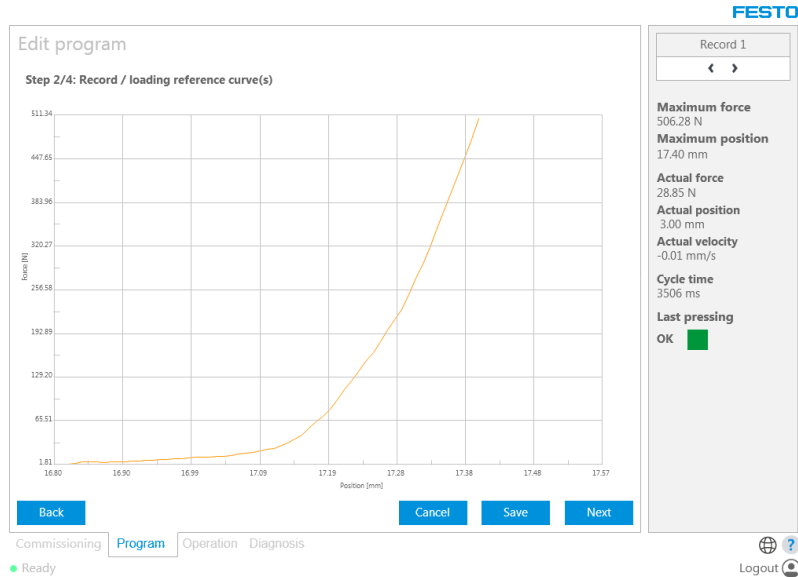
- ➔ A similar step time as for advanced force mode of about 300 ms is reached, but an overshooting of 140 N occurs.
- ➔ The overshooting must be strongly reduced.

Recording at a parameter value of *Velocity* = 1 mm/s:



- ➔ The step time is about 400 ms longer than in the case of advanced force mode is reached, and an overshooting of 33 N occurs.
- ➔ The overshooting must be reduced.

Recording at a parameter value of  $Velocity = 0.35 \text{ mm/s}$ :



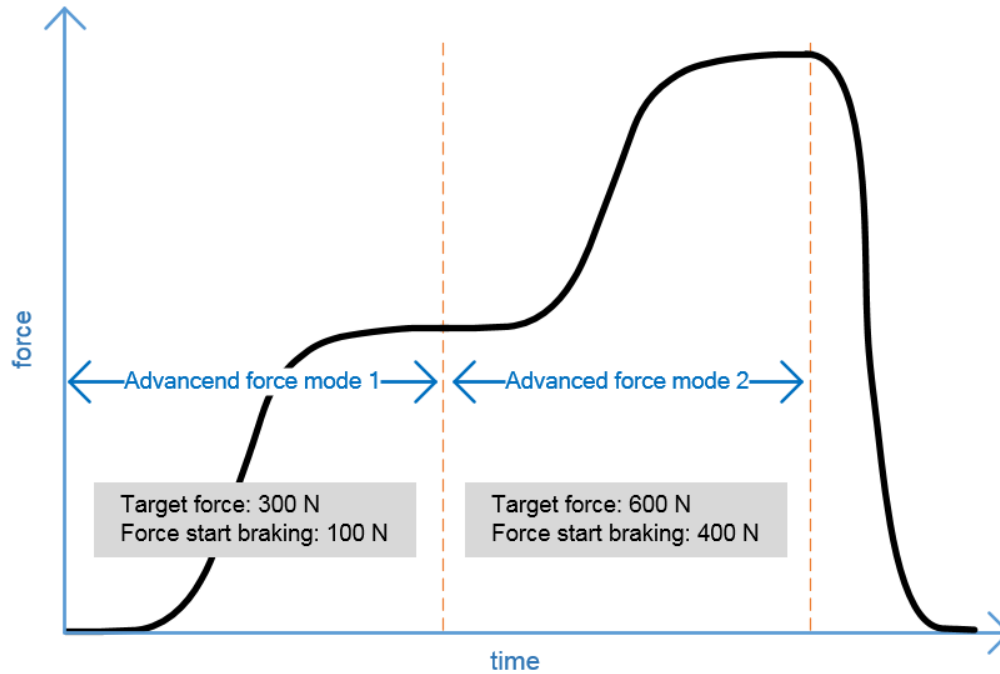
- ➔ The cycle time amounts to about 3.5 s, the stepping time amounts to about 1,800 ms and an overshooting of 6 N occurs. The target force reached therefore lies within the tolerance range of the application. This is the optimum setting for force mode.

In order for the same requirements on the precision of the joining procedure are reached, the force mode requires a step time of about 1,800 ms and the advanced force mode requires a step time of about 300 ms. The advanced force mode is therefore about 6 times faster than force mode.

With the velocity switching function of advanced force mode, the cycle time can be reduced even further.

#### 4.4 Step-by-step increasing and decreasing of force

If a step-by-step increase of the force is required, this increase can be implemented with a series of several steps of the advanced force mode. In the process, you must only ensure that the *Target force* parameter is not smaller than the *Force start braking* parameter:



If a step-by-step increase and then decrease of the force is required, this increase and decrease can be implemented with a series of several steps of the advanced force mode. A step-by-step reduction of the force is also possible in several steps. In case of a reduction, the *Target force* parameter must be smaller than the current force and the *Force at braking start* parameter:

