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Recommended applications of pneumatic clamps

- Basic Vario series -

Issued: May 2015

Efficient dimensioning of clamps

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The document presented shall assist with selecting the suitable clamp for the clamping task to be done. Selecting the right clamp provides for a persistent and reproducible clamping process, which also provides the precondition for safe a production process , e.g. by spot-welding. If the clamps are too small dimensioned, failures in quality and process will be pre-programmed. If the dimensions are too great, this does not only cause higher costs but high energy consumption as well.

Therefore, before starting the detailed construction, we recommend a pre-selection for which we provide the guidelines as follows:

The preselection starts with the estimation of the clamping forces

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Each preselection of the suitable pneumatic clamp starts with the estimation of the clamping forces required. However, how high are the clamping forces?

In practice, it is assumed that the components that come from the moulding tool have a certain tolerance range. One task of the clamping tools is it to eliminate these deviations before the joining process. Even though these differences are only a few millimetres, forming forces are required from the clamping tool via this pathway that increase with the sheet thickness.

A small test arrangement has been used (see Annex) to determine these forming forces exemplarily and simplified formulas have been derived from these results.

Clamping force (N) ⇨ $F = 48 \times s^3$

Analysis of result: The clamping force increases exponentially with the increasing sheet thickness

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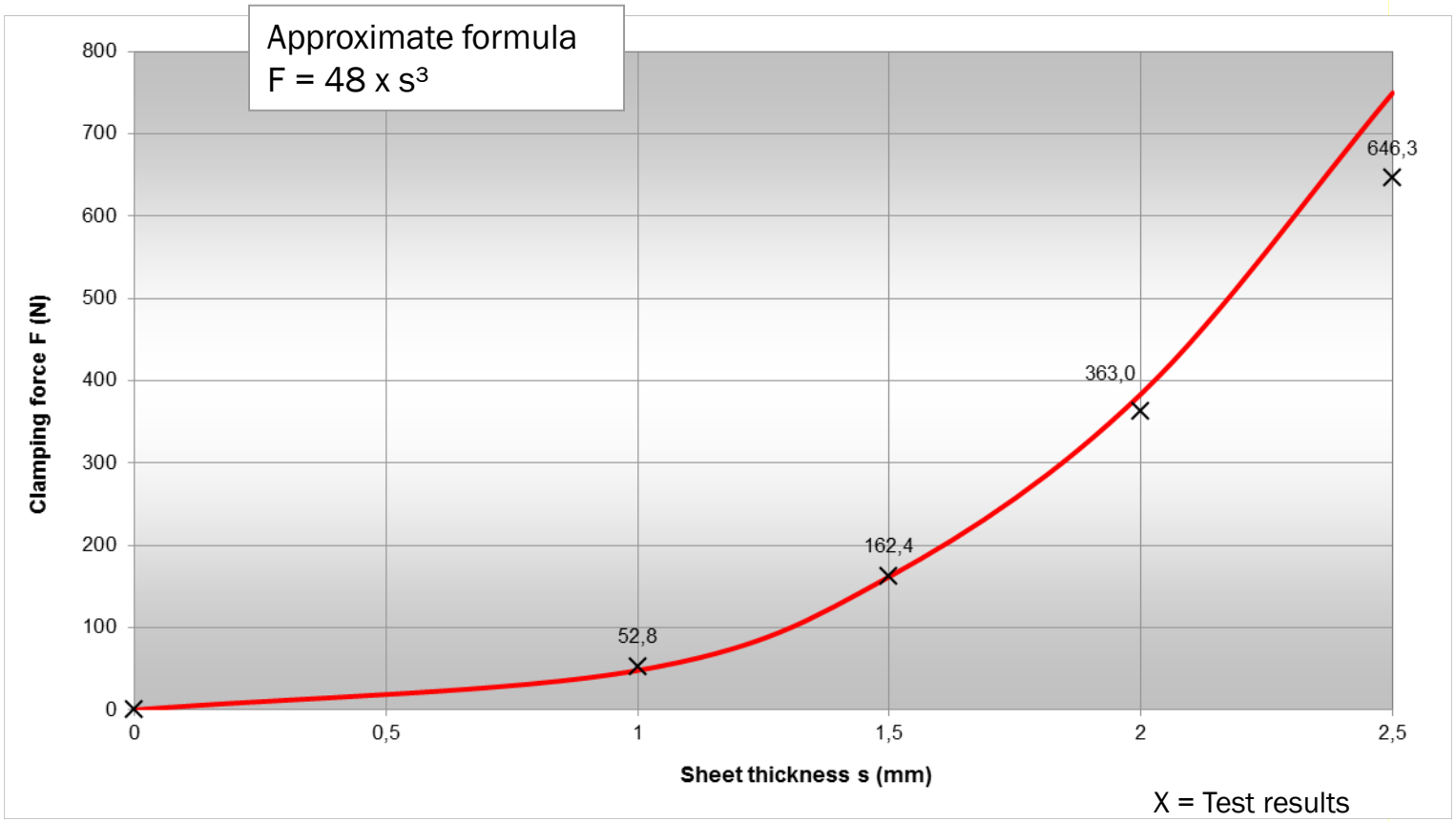
Base: Metal sheet in ST quality, clamping stroke 4 mm



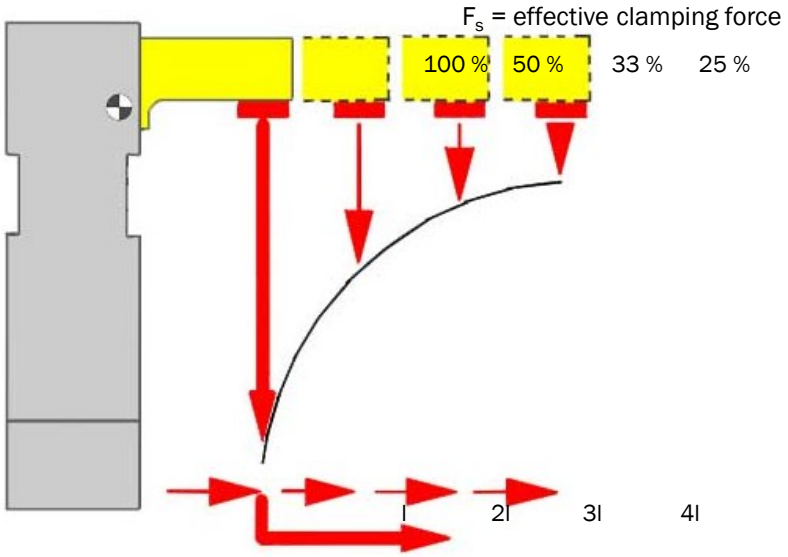
=> The formula $F = 48 \times s^3$ approximately describes the relation between the required clamping force for a forming stroke of 4 mm depending on the sheet thickness.

The available clamping force depends on the clamping arm length

All clamps with pivoted clamping arm generate a defined torque (M) on the driving axle.

Due to the relation $M = F_s \times l$ ⇨ $F_s = \frac{M_{max}}{l}$ the clamping force which actually acts in the clamping point decreases depending on the length of the clamping arm.

⇨ Double arm length = half of the clamping force!



Outreach

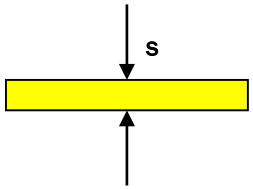
Clamping force as per data sheet

General procedure for selecting the clamp

A. Determination of the clamping force required on the component

⇨ Sheet thickness (s)

⇨ Quality of metal sheet (e.g. ST quality)

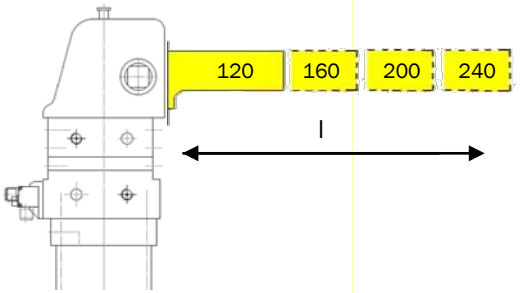


$F_s = 48 \times s^3$ = Force in Newton

B. Determination of the clamping torque required "M_s"

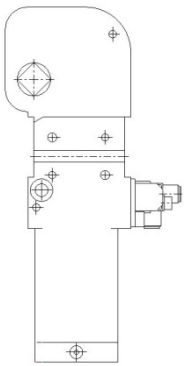
⇨ Outreach component / clamping arm length "l"

$M_s = F_s \times l$



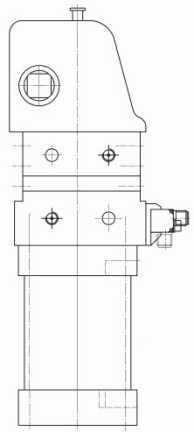
C. Selection of clamping tool that generates this clamping torque with an assumed reliability of 30 %.

Range of standard products



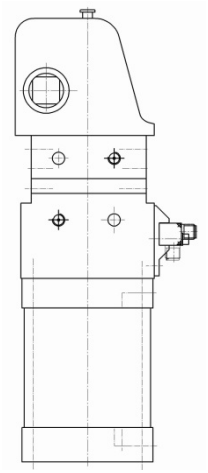
V 40

- Clamp with spanner toggle lever mechanism
  Cylinder Ø 40 mm
- Clamping torque 120 Nm
- Dimensions 235 x 54 x 83 mm
- Weight 2.0 kg
- Air consumption 145 cm³



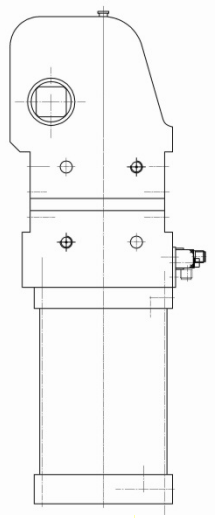
V 50.1

- Clamp with spanner toggle lever mechanism
  Cylinder Ø 50 mm
- Clamping torque 160 Nm
- Dimensions 321 x 68 x 92 mm
- Weight 4.3 kg
- Air consumption 290 cm³



V 63.1

- Clamp with spanner toggle lever mechanism
  Cylinder Ø 63 mm
- Clamping torque 380 Nm
- Dimensions 361 x 78 x 107 mm
- Weight 5.7 kg
- Air consumption 500 cm³



V 80.1

- Clamp with spanner toggle lever mechanism
  Cylinder Ø 80 mm
- Clamping torque 800 Nm
- Dimensions 486 x 108 x 140 mm
- Weight 17 kg
- Air consumption 880 cm³

Clamping force depending on outreach

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Outreach (mm)							
Model	120	160	200	240	280	320	360
V40	1,000 N	750 N	600 N	---	---	---	---
U40							
V50.1	1,334 N	1,000 N	800 N	666 N	---	---	---
U50							
V63.1	3,166 N	2,376 N	1,900 N	1,584 N	1,356 N	1,188 N	---
U63							
V80.1	6,666 N	5,000 N	4,000 N	3,334 N	2,856 N	2,500 N	2,222 N
U80							

Selection of clamp on the basis of outreach and sheet thickness

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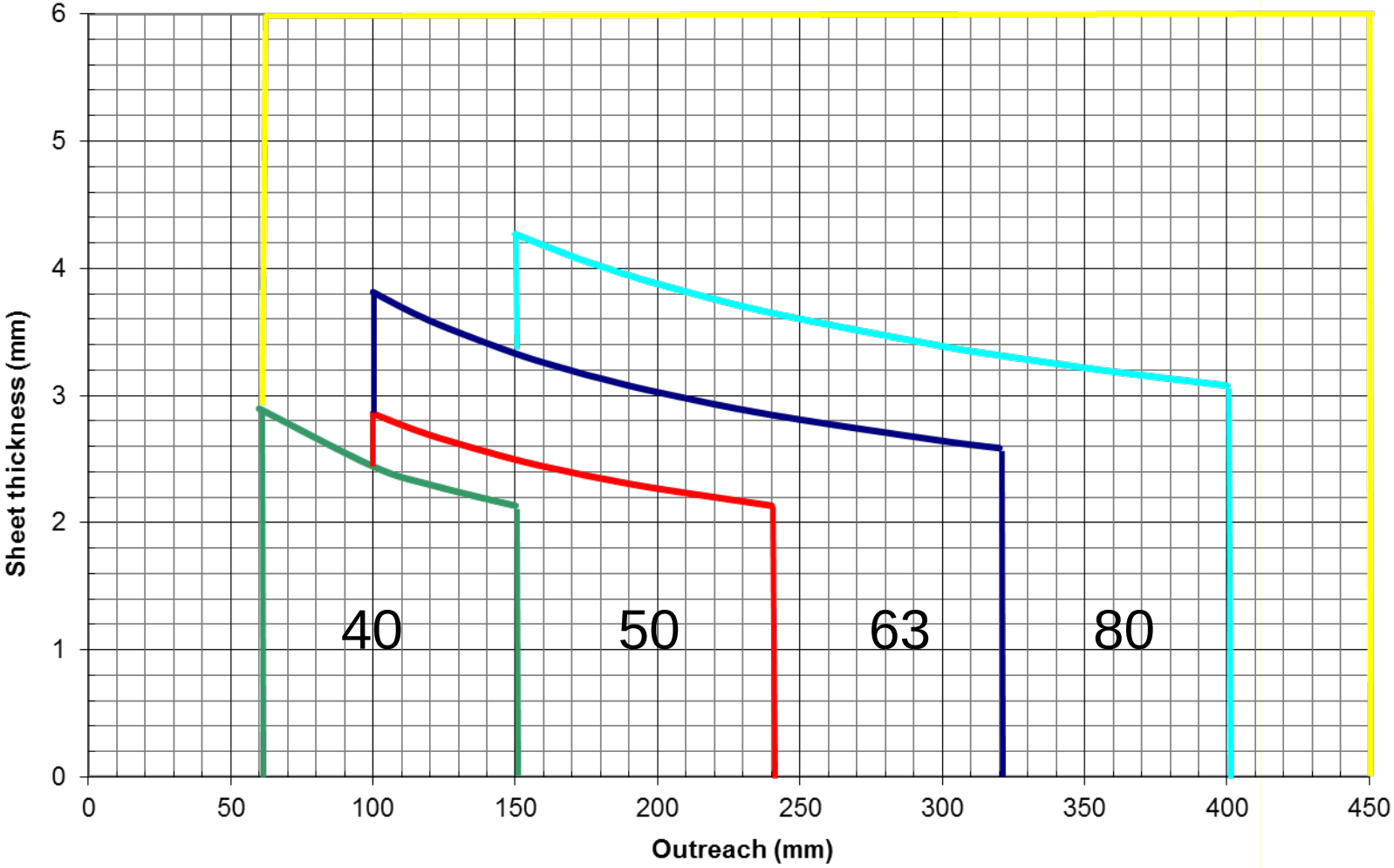

*) Force reserve 30 %

Decision matrix
Clamp weight and length

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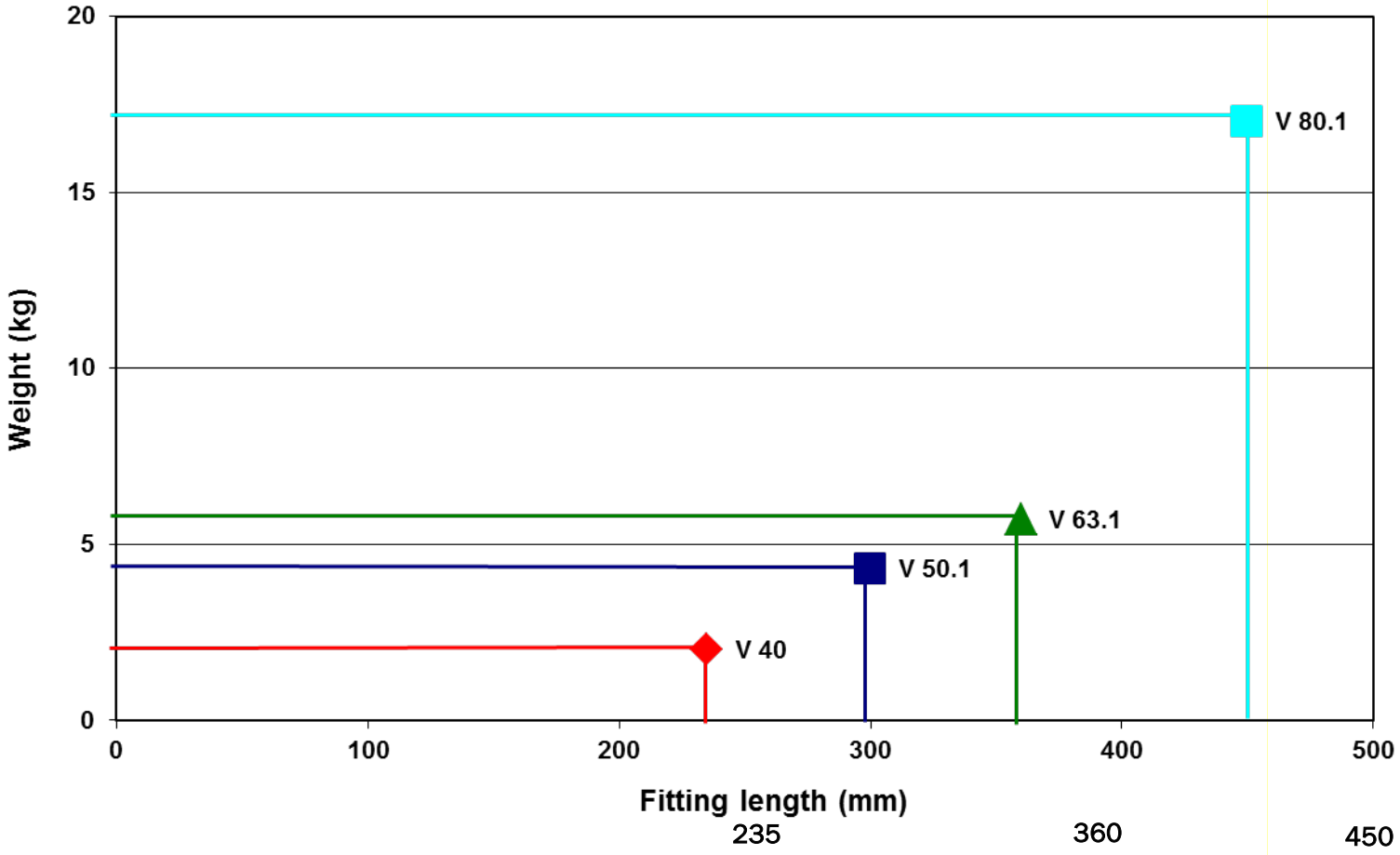
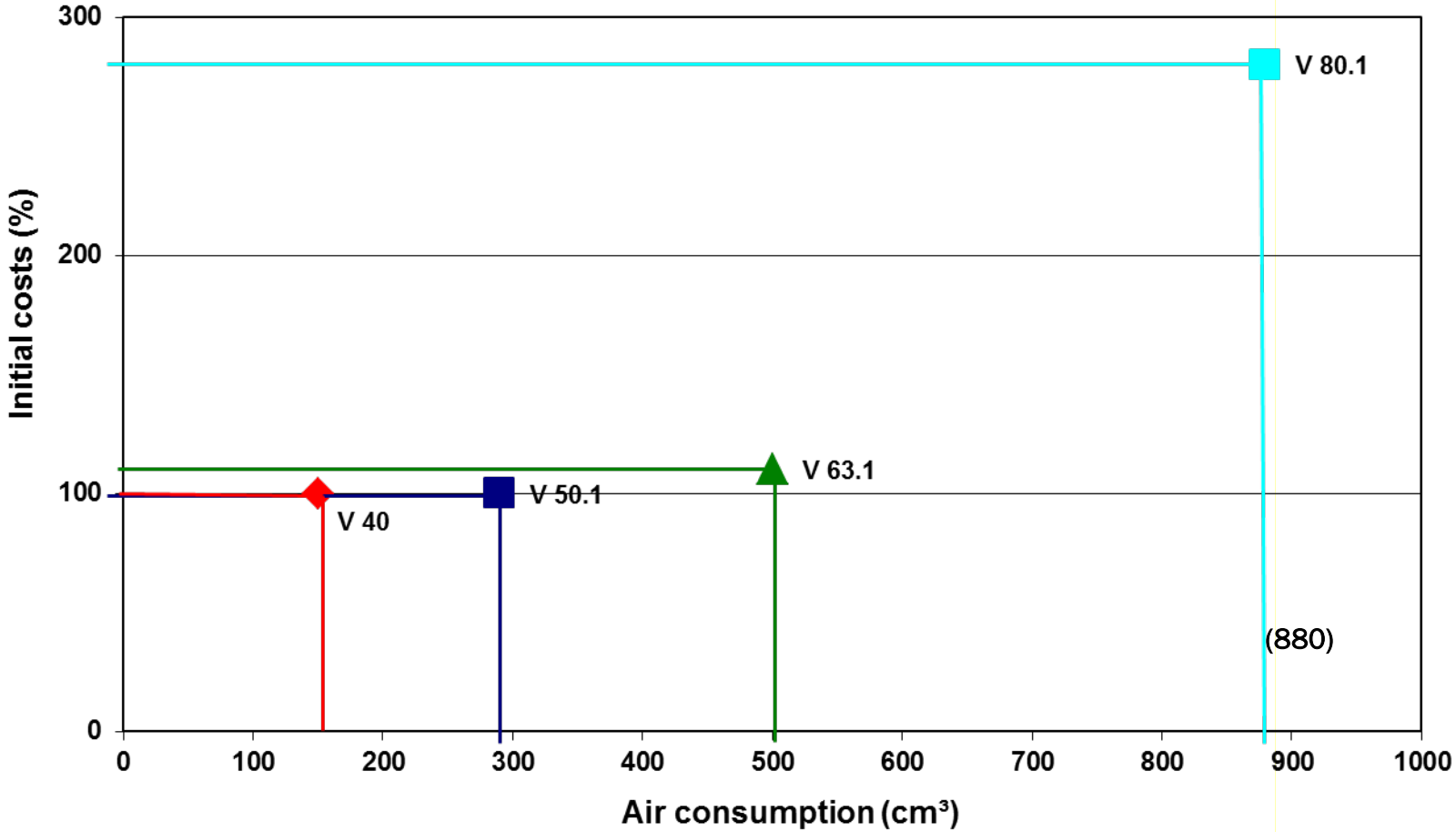
In case of robot grippers, clamp weight is a decisive application criterion.



In case of fixtures, the total height of the tool depends on the clamp length .

Economic criteria for clamp selection



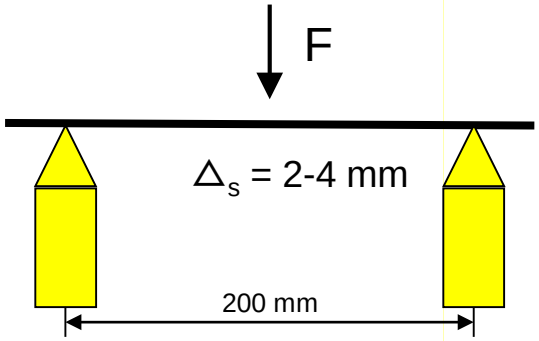
Test procedure
for determination of clamping force

Simplified test procedure for determination of required clamping force

The car body parts used in vehicle construction are very different and so the occurring clamping situations will be. Therefore, no generally applicable guidelines can be defined for these process forces.

If focused on the most common clamping tasks in the flange area for the case analysis, the following simplification can be used:

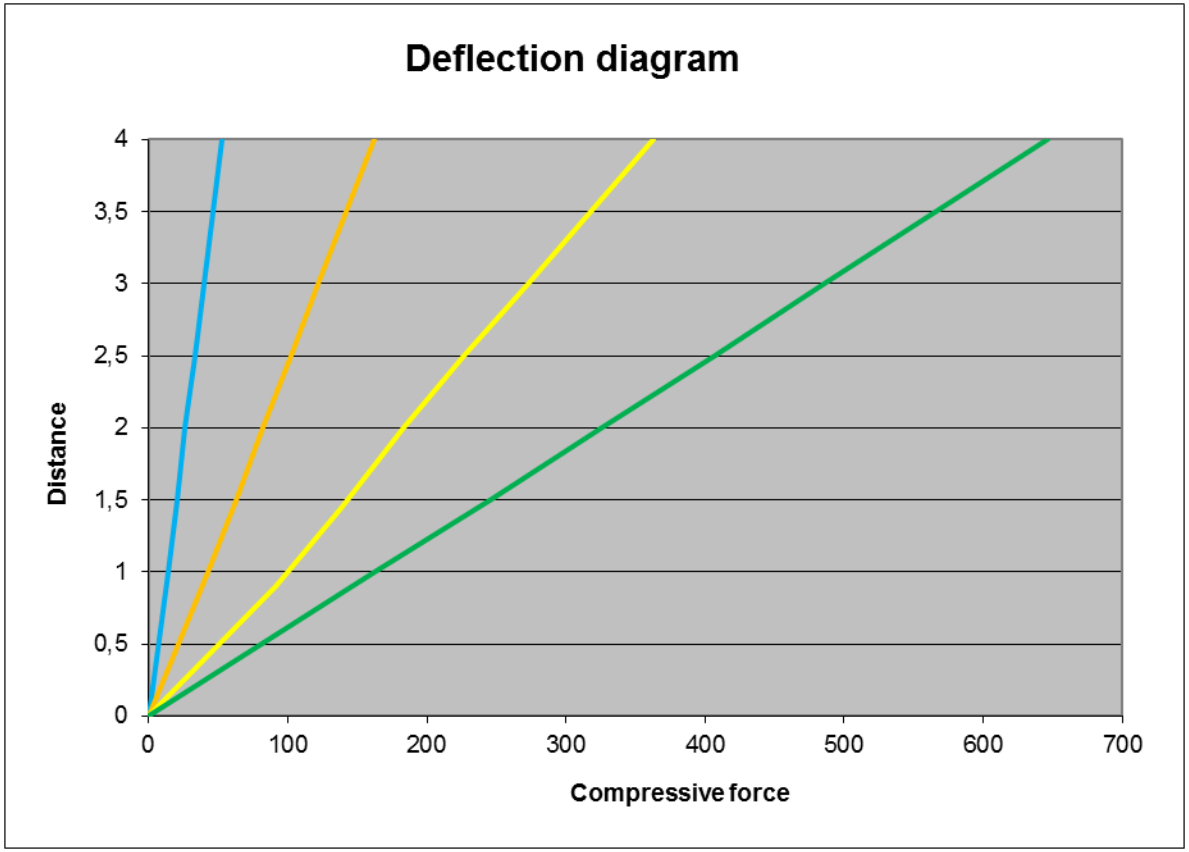
- Projection of the component by a sheet with flange area 40 mm
- Distance of clamping positions approx. 200 mm
- Maximum forming of the component in the required process position = clamping position by approx. 2 – 4 mm



Test arrangement

Results of test procedure

A test arrangement under the conditions described provides the following results for standard car body sheets in ST quality for the different sheet thicknesses:



	Row 1 1.0 mm sheet	Row 2 1.5 mm sheet
1.00 mm	14 N	43.0 N
1.50 mm	20.5 N	62.5 N
2.00 mm	26.5 N	82.0 N
2.50 mm	33.0 N	102.5 N
3.00 mm	39.5 N	122.0 N
4.00 mm	52.8 N	162.4 N
	Row 3 2.0 mm sheet	Row 4 2.5 mm sheet
1.00 mm	91.0 N	162.5 N
1.50 mm	138.5 N	245.0 N
2.00 mm	183.0 N	326.0 N
2.50 mm	226.5 N	407.0 N
3.00 mm	272.5 N	485.0 N
4.00 mm	363.0 N	646.3 N

=> Force/Distance curve is linear ≈ constant spring rate

Approximate formula for determination of clamping force

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Assuming that the clamping process acts in the elastic range of the material, the result can derived from the test series saying that

- the clamping force linearly increases with bending “b” of the sheet.
- The clamping force in the third degree increases with the sheet thickness “s”.

Approximate formula

$$Fs = 12 \times b \times s^3$$

For sheet forming b = 4mm

$$\Rightarrow Fs = 48 \times s^3$$

Analysis of result: The clamping force increases exponentially with the increasing sheet thickness

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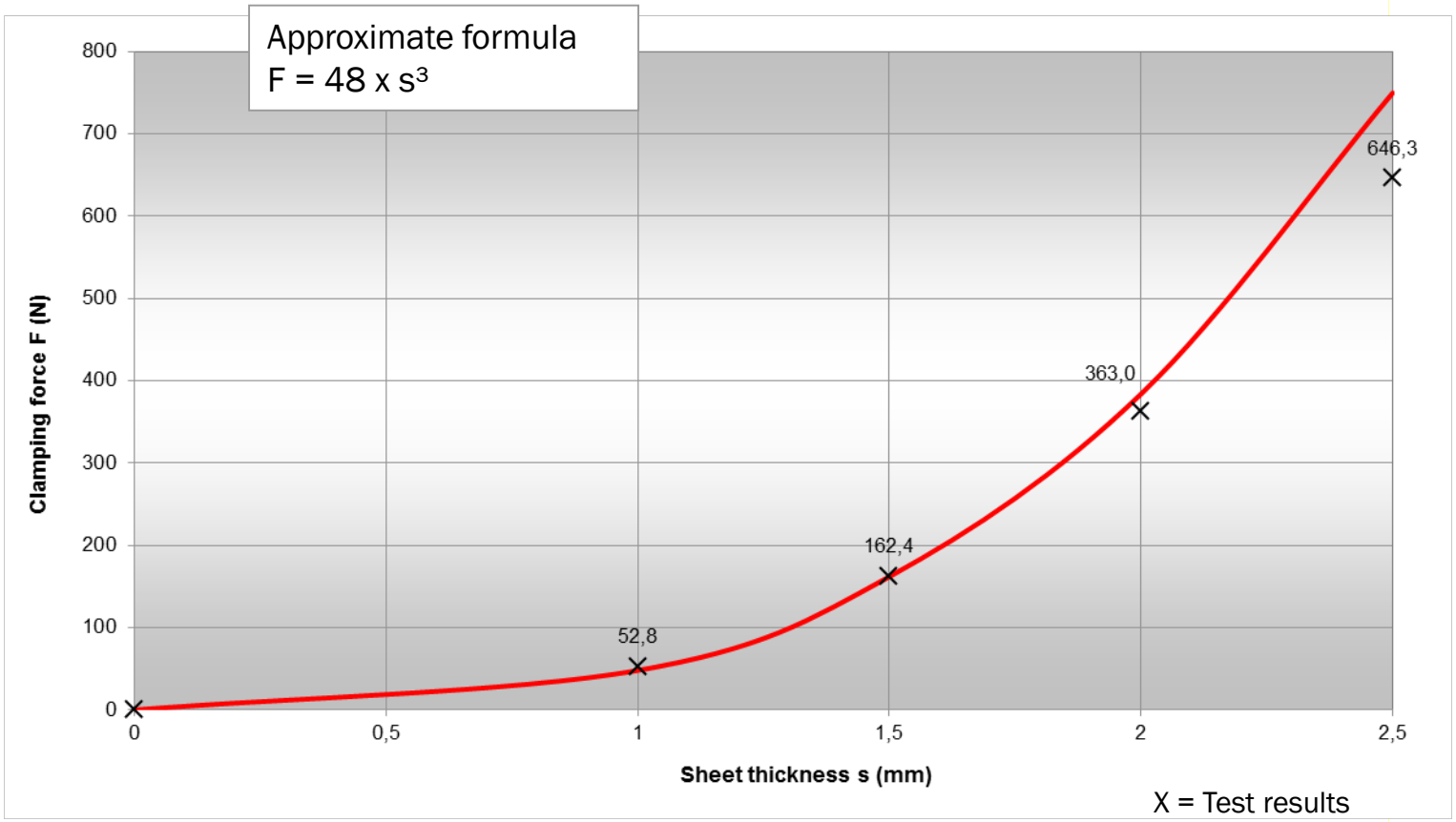
Base: Metal sheet in ST quality, clamping stroke 4 mm



=> The formula $F = 48 \times s^3$ approximately describes the relation between the required clamping force for a forming stroke of 4 mm depending on the sheet thickness.

Are there any other questions about the topic of pneumatic clamps?

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