

Test report

no DBM-2025-0046-01-BMM dated 25.07.2025

SUBJECT	Gauge analysis of the digital automatic coupler installation on the frame of an SM42 series locomotive						
ORDER NUMBER	US/BMK/BMS/0033/2024						
CLIENT	<table><tr><th colspan="2">CLIENT</th></tr><tr><td>Name</td><td>Project DACTiVate</td></tr><tr><td>Address</td><td>XXXX</td></tr></table>	CLIENT		Name	Project DACTiVate	Address	XXXX
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SAMPLE/TESTED ELEMENT	<table><tr><th colspan="2">TEST OBJECT</th></tr><tr><td>Name:</td><td>Digital automatic coupler adapter</td></tr></table>	TEST OBJECT		Name:	Digital automatic coupler adapter		
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1 TEST SCOPE AND METHOD

The aim of this research is to analyze the gauge for a digital coupler installation on an SM42 series locomotive frame. The vehicle gauge outline was determined in accordance with the requirements of the PN-EN 15273-2 standard [1] for the G1 kinematic profile. The lower profile was selected for vehicles that can pass over humps and with rail brakes in the inactive position.

Using the guidelines contained in the standards, the outlines of the narrowed gauge were determined in characteristic cross-sections of the vehicle body.

2 TEST OBJECT AND PROCEDURE

2.1 Vehicle parameters

Table 2.1 presents the data for the gauge analysis adopted based on the available documentation and information provided by the Client.

Tab. 2.1. Parameters of the SM42 series vehicle

Name	Value	Unit	Symbol
Body base	7.5	[m]	a
Bogie base	2.6	[m]	p
Lateral displacement on the first-stage suspension	0.007	[m]	q
Radial wheel wear	0.040	[m]	U_{sr}
Vertical deflection of the first-stage suspension	0.025	[m]	Aff_I
Vertical deflection of the second-stage suspension	0.030	[m]	Aff_{II}
Vertical deflection amplitude of the vertical suspension	0.055	[m]	ΔAff
Lateral displacement on the body on a straight line	0.025	[m]	w
Lateral displacement on the body on the inside of a curve	0.025	[m]	$w_i(150)=w_i(250)$
Lateral displacement on the body on the outside of a curve	0.025	[m]	$w_a(150)=w_a(250)$
Height of the vehicle roll pole	0.980	[m]	h_c
Vehicle roll coefficient	0.35	-	s
Wheelset guide width	1.410	[m]	d
Half of the lateral spacing of the second-stage suspension	1.355	[m]	b_2
Difference in radial wheel wear	0.005	[m]	ΔU_{sr}
Maximum design asymmetry	1	[°]	η_0

2.2 DAC assembly model

Figure 2.1 shows a top view, and Figure 2.2 shows a bottom view of the coupler assembly model used for the gauge analysis. The model shows a section of the vehicle frame with buffers and a digital coupler model.

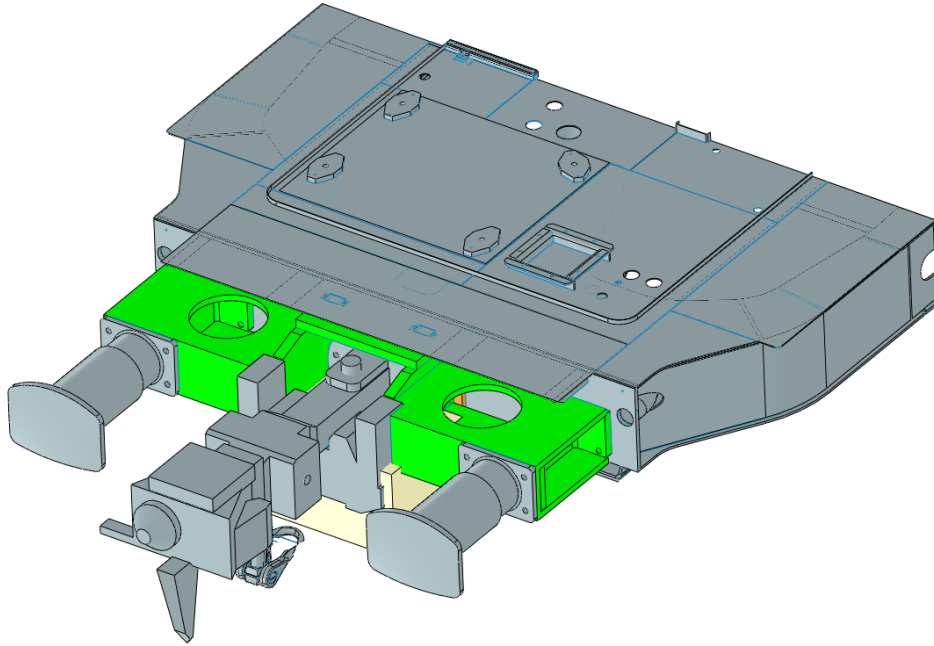


Fig. 2.1. Coupler assembly model in top view

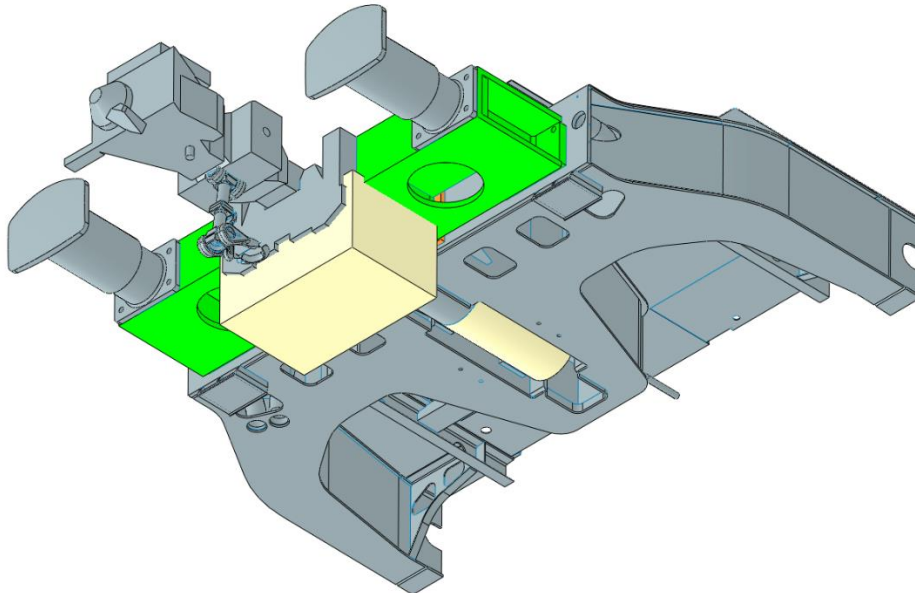


Fig. 2.2. Coupler assembly model in bottom view

2.3 Gauge and formulations

The reference outline applicable to the vehicle under consideration is shown in Fig. 2.3. The arrangement of the calculation cross-sections is shown in Fig. 2.4. Then, based on the procedures described below and contained in [1], the reduction values for the calculation cross-sections distributed along the body were determined.

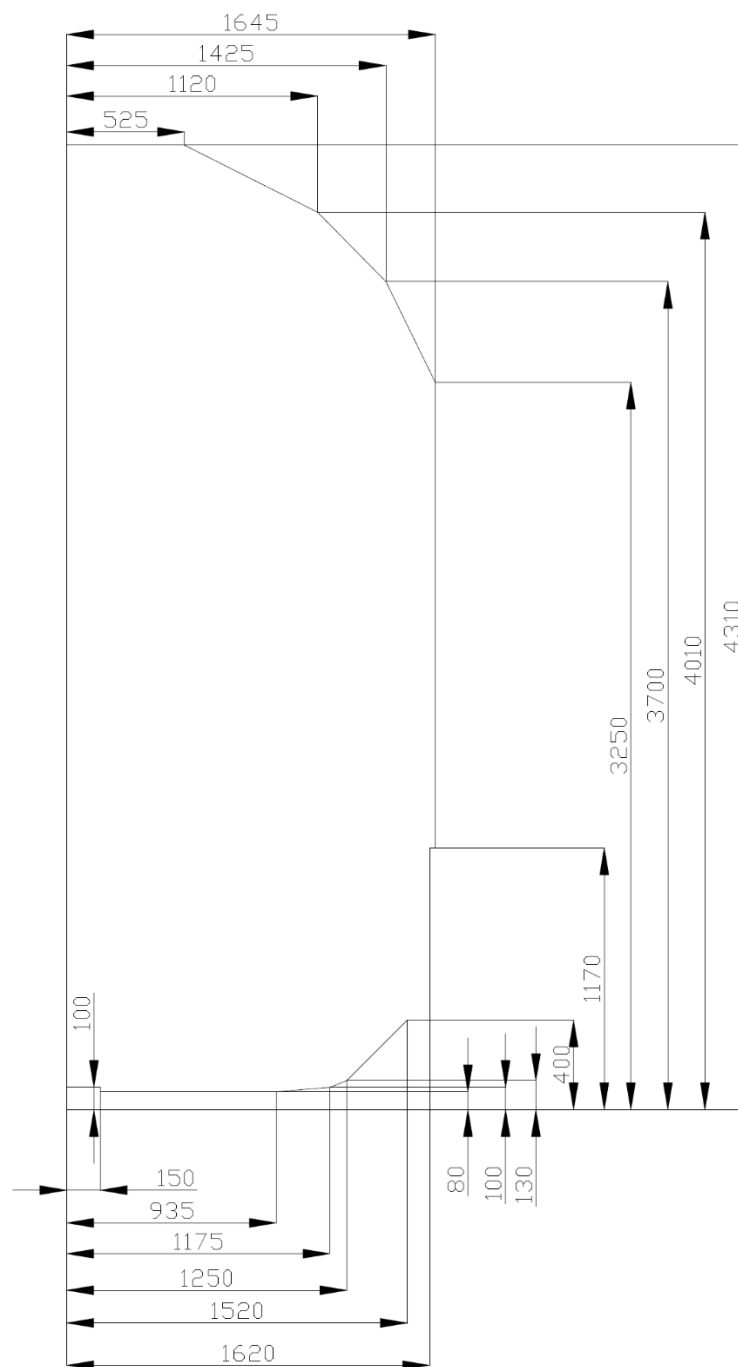


Fig. 2.3. Reference outline of the G1 kinematic gauge according to [1]

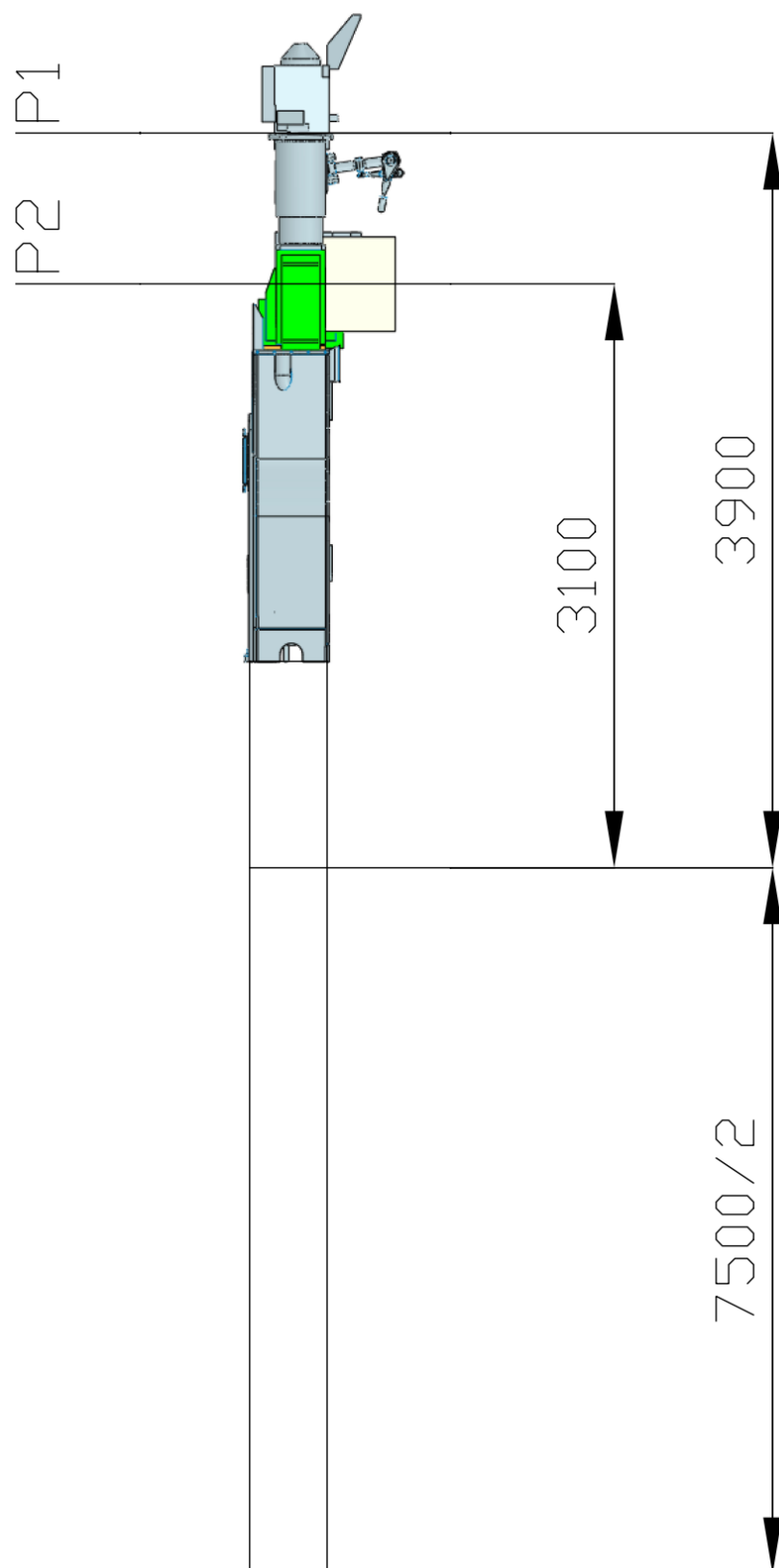


Fig. 2.4. Distribution of calculated cross-sections in which the narrowed gauge outline was analyzed

The vertical displacements of the vehicle according to [1] are considered as a increases in the lower part of the reference profile, and as a fall in the upper part of the profile.

In cross-sections located between the bogey pivots and between the body support points, the increases can be determined using the following relationship:

$$f_z = A_{ffl} + A_{ffl} + U_{sr} + \left[\frac{a \cdot n - n^2 + \frac{p^2}{4}}{1000} - 0,08 \text{ lub } 0,1 \right]_{>0} + e_{i1}$$

In cross-sections located between the bogey pivots and beyond the body support points, the increases can be determined from the following relationship:

$$f_z = U_{sr} + A_{ffl} + A_{ffl} + 0,1 \cdot s \cdot (b - b_2) + \left[\frac{a \cdot n - n^2 + \frac{p^2}{4}}{1000} - 0,08 \text{ lub } 0,1 \right]_{>0} + e_{i1}$$

In cross-sections located beyond the bogey pivots and between the body support points, the increases can be determined from the following relationship:

$$f_z = U_{sr} + \Delta U_{sr} \cdot \frac{n_a}{a} + A_{ffl} + A_{ffl} + \Delta A_{ff} \cdot \frac{n_a}{a} + \left[\frac{a \cdot n + n^2 - \frac{p^2}{4}}{1000} - 0,08 \text{ lub } 0,1 \right]_{>0} + e_a$$

In cross-sections located beyond the bogey pivots and beyond the body support points, the increases can be determined from the following relationship:

$$f_z = U_{sr} + \Delta U_{sr} \cdot \frac{n_a}{a} + \text{MAX} \left(A_{ffl} + A_{ffl} + \Delta A_{ff} \cdot \frac{n_a}{a}; A_{ffl} + A_{ffl} + 0,1 \cdot s \cdot (b - b_2) \right) + \left[\frac{a \cdot n + n^2 - \frac{p^2}{4}}{1000} - 0,08 \text{ lub } 0,1 \right]_{>0} + e_a$$

where:

$$e_{i1} = \frac{n_i}{a} \cdot \frac{(a - n_i - 3)^2}{500} \quad \text{when } a \leq 17,8 \quad \text{and} \quad n_i < \frac{a-3}{3}$$

or

$$e_{i1} = \frac{(a-3)^3}{3375 \cdot a} \quad \text{when } a \leq 17,8 \quad \text{and} \quad n_i \geq \frac{a-3}{3}$$

and

$$e_a = \frac{a \cdot n_i - n_a^2}{600}$$

The lowering of the reference profile results from dynamic upward movement on a vehicle that does not exhibit wheelset wear. This lowering at the highest point of the vehicle

profile should be assumed to be a lump sum of 10 mm for each suspension stage. The vehicle height should be lowered according to the following relationships:

a) height reduction for cross-sections located between bogie pivots:

$$e_i = 0,02 + \left[\frac{a \cdot n - n^2 + \frac{p^2}{4}}{1000} - 0,1 \right]_{>0}$$

b) height reduction for cross-sections located beyond the bogie pivots:

$$e_a = 0,02 + \left[\frac{a \cdot n + n^2 - \frac{p^2}{4}}{1000} - 0,1 \right]_{>0}$$

The narrowed gauge contours were determined based on the following relationships:

a) for cross-sections located between bogie pivots:

$$E_i = \frac{1,465 - d}{2} + q + w_\infty + z_{kin} - 0,015 ;$$

where:

$$a \cdot n_i - n_i^2 + \frac{p^2}{4} - 500 \cdot (w_\infty - w_{i(250)}) \leq |5^{(1)} \text{ lub } 7,5^{(2)}| ;$$

or:

$$E_i = \frac{a \cdot n_i - n_i^2 + \frac{p^2}{4}}{500} + \frac{1,465 - d}{2} + q + w_{i(250)} + z_{kin} + [x_i]_{>0} - |0,025^{(1)} \text{ lub } 0,030^{(2)}| ;$$

where:

$$a \cdot n_i - n_i^2 + \frac{p^2}{4} - 500 \cdot (w_\infty - w_{i(250)}) > |5^{(1)} \text{ lub } 7,5^{(2)}| ;$$

and:

$$x_i = \frac{1}{750} \cdot \left(a \cdot n_i - n_i^2 + \frac{p^2}{4} - 100 \right) + w_{i(150)} - w_{i(250)} .$$

⁽¹⁾ this value applies to vehicle parts up to a height of 0.4 m from the railhead and to those vehicle parts that, taking into account the raised profile, may be below this dimension,

⁽²⁾ this value applies to vehicle parts at a height above 0.4 m from the railhead, except for the parts listed in reference (1).

b) For cross-sections located beyond the bogie pivots:

$$E_a = \left(\frac{1,465 - d}{2} + q + w_\infty \right) \cdot \frac{2n_a + a}{a} + z_{kin} - 0,015 ;$$

where:

$$a \cdot n_a + n_a^2 - \frac{p^2}{4} - 500 \cdot \left[(w_\infty - w_{i(250)}) \cdot \frac{n_a}{a} + (w_\infty - w_{a(250)}) \cdot \frac{n_a + a}{a} \right] \leq |5^{(1)} \text{ lub } 7,5^{(2)}| ;$$

or:

$$E_a = \frac{a \cdot n_a + n_a^2 - \frac{p^2}{4}}{500} + \left(\frac{1,465 - d}{2} + q \right) \cdot \frac{2 \cdot n_a + a}{a} + w_{i(250)} \cdot \frac{n_a}{a} + w_{a(250)} \cdot \frac{n_a + a}{a} + z_{kin} + [x_a]_{>0} - |0,025^{(1)} \text{ lub } 0,030^{(2)}| ;$$

where:

$$a \cdot n_a + n_a^2 - \frac{p^2}{4} - 500 \cdot \left[(w_\infty - w_{i(250)}) \cdot \frac{n_a}{a} + (w_\infty - w_{a(250)}) \cdot \frac{n_a + a}{a} \right] > |5^{(1)} \text{ lub } 7,5^{(2)}| ;$$

and:

$$x_a = \frac{1}{750} \cdot \left(a \cdot n_a + n_a^2 - \frac{p^2}{4} - 120 \right) + (w_{i(150)} - w_{i(250)}) \cdot \frac{n_a}{a} + (w_{a(150)} - w_{a(250)}) \cdot \frac{n_a + a}{a} .$$

where:

n_i/n_a – distance of the cross-section under consideration from the nearest pivot,

a – vehicle base,

p – bogie base,

d – maximum distance between the outer edges of the worn rim flanges,

q – lateral displacement on suspension I° ,

w – lateral displacement on suspension II° (w_∞ – for a straight track, w_i – on the inner side of the curve, w_a – on the outer side of the curve),

z – quasi-static displacement:

$$z = \frac{s}{30} \cdot (h - h_c)_{>0+} + \tan(\eta_0 - 1^\circ)_{>0} \cdot |h - h_c| + \left[\frac{s}{10} \cdot (h - h_c)_{>0} - 0,04 \cdot (h - 0,5)_{>0} \right]_{>0}$$

3 TEST RESULTS

3.1 Narrowed gauge coordinates

The coordinates of the narrowed gauge outlines in characteristic cross-sections placed along the vehicle body are given in Table 3.1. The view of the continuous model of the narrowed gauge is shown in Figures 3.1 and 3.2.

Tab. 3.1. Coordinates of the narrowed outlines in [m] determined in accordance with the requirements of [1]

P1		P2	
X	Y	X	Y
0.000	0.300	0.000	0.275
0.332	0.300	0.296	0.275
0.332	0.280	0.296	0.255
0.753	0.280	0.789	0.255
0.993	0.300	1.029	0.275
1.068	0.330	1.104	0.305
1.338	0.600	1.374	0.575
1.438	0.600	1.474	0.575
1.441	1.370	1.477	1.345
1.466	1.370	1.502	1.345
1.442	3.230	1.477	3.230
1.216	3.680	1.252	3.680
0.908	3.990	0.944	3.990
0.309	4.290	0.345	4.290
0.000	4.290	0.000	4.290

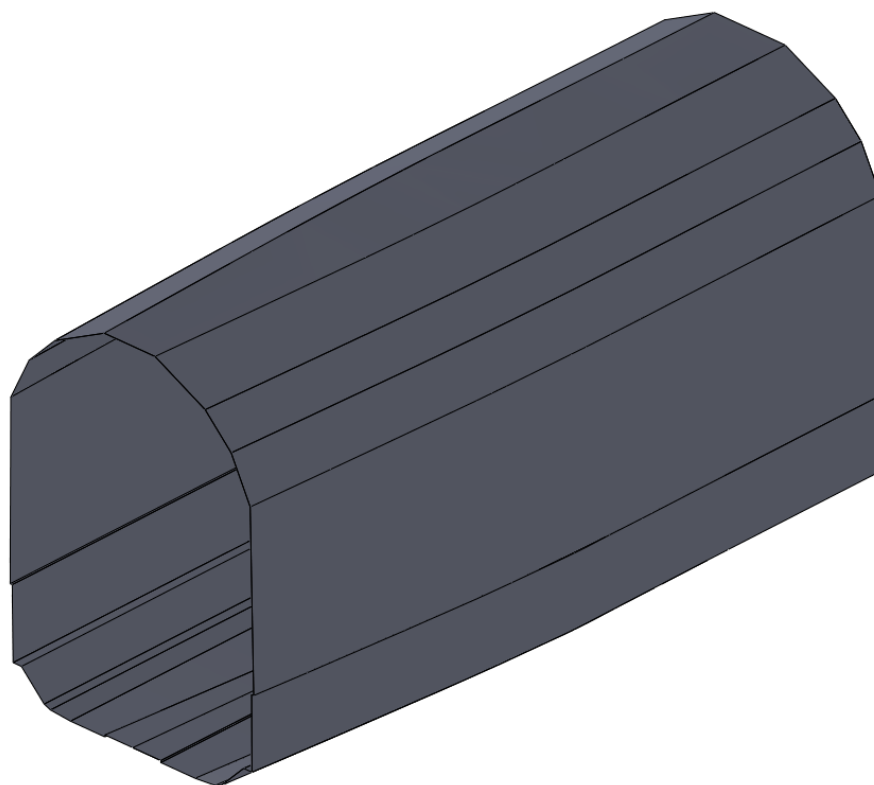


Fig. 3.1. View of the continuous narrowed gauge outline of the model body half from top

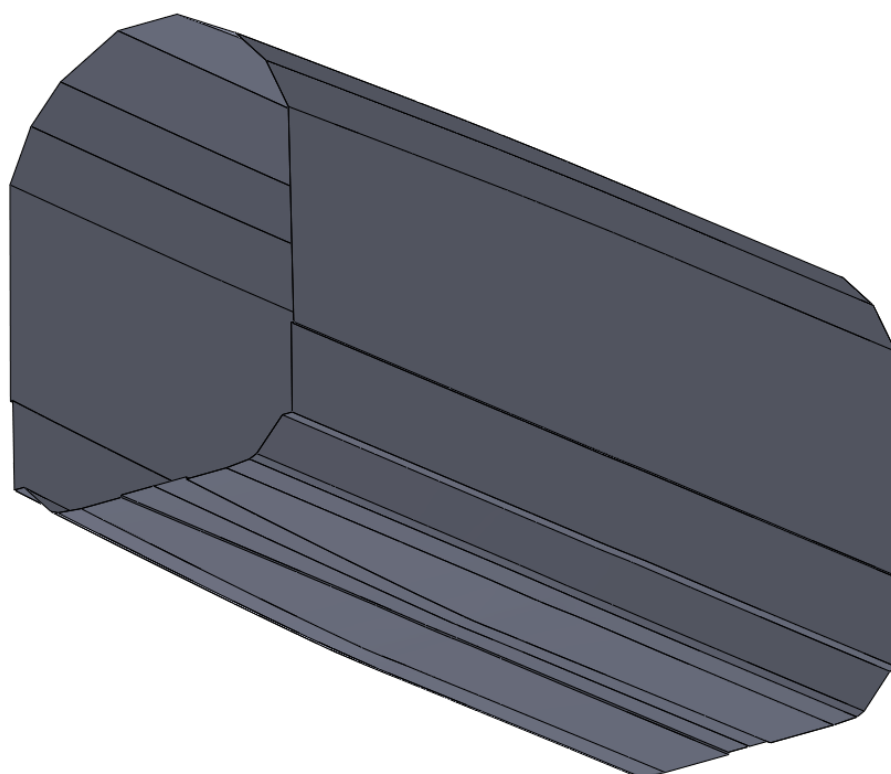


Fig. 3.2. View of the continuous narrowed gauge outline of the model body half from below

3.2 Test results compilation

Figures 3.3 and 3.4 present a comparison of the reduced profiles calculated in accordance with the requirements of the PN-EN 15273-2 standard [1] with the actual coupler installation profiles in the cross-sections under consideration. A comparison of the continuous gauge profile with the coupler installation model is presented in Figures 3.15 and 3.6.

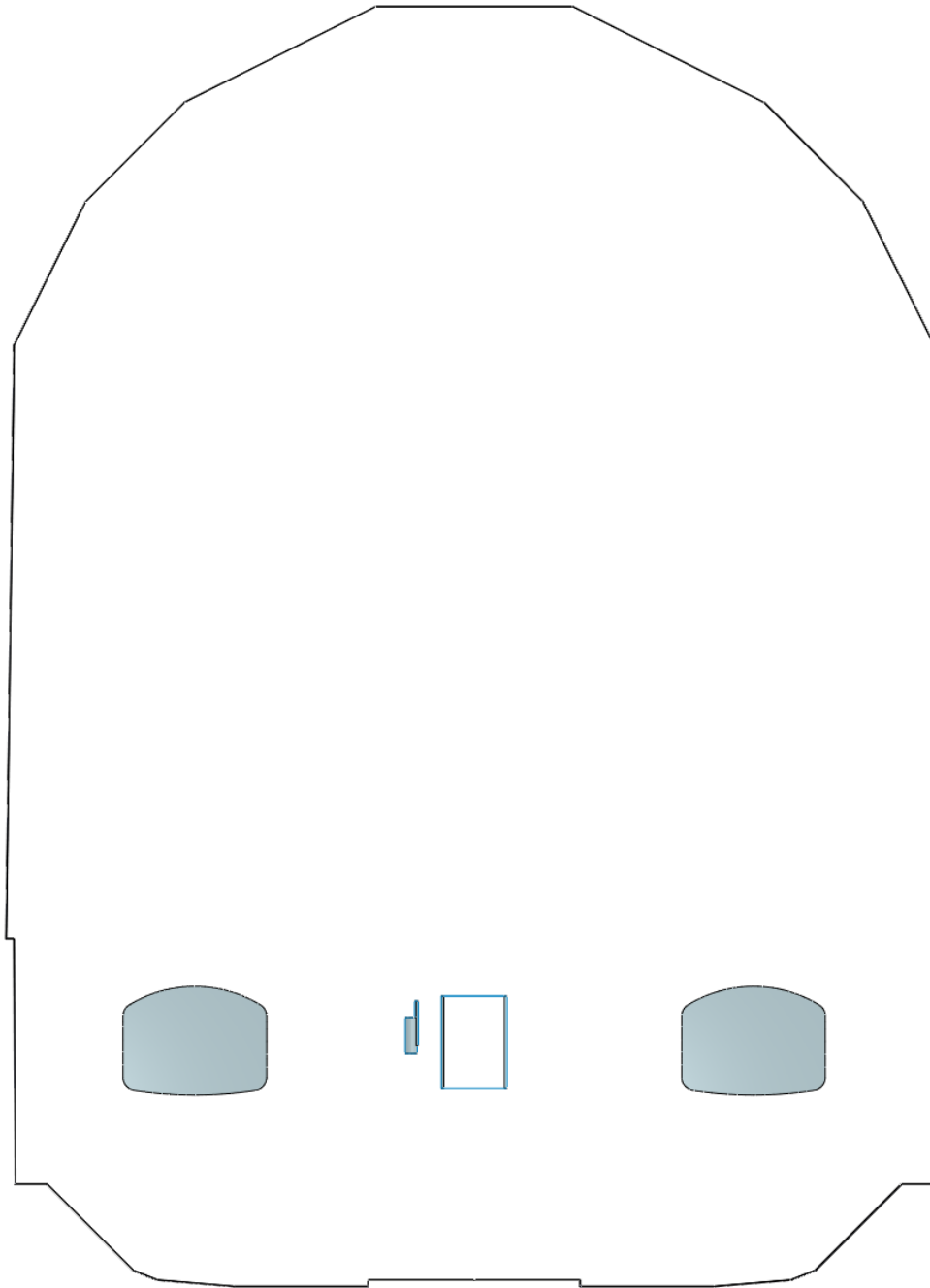


Fig. 3.3. Outline of the narrowed gauge in the P1 cross-section according to [1]

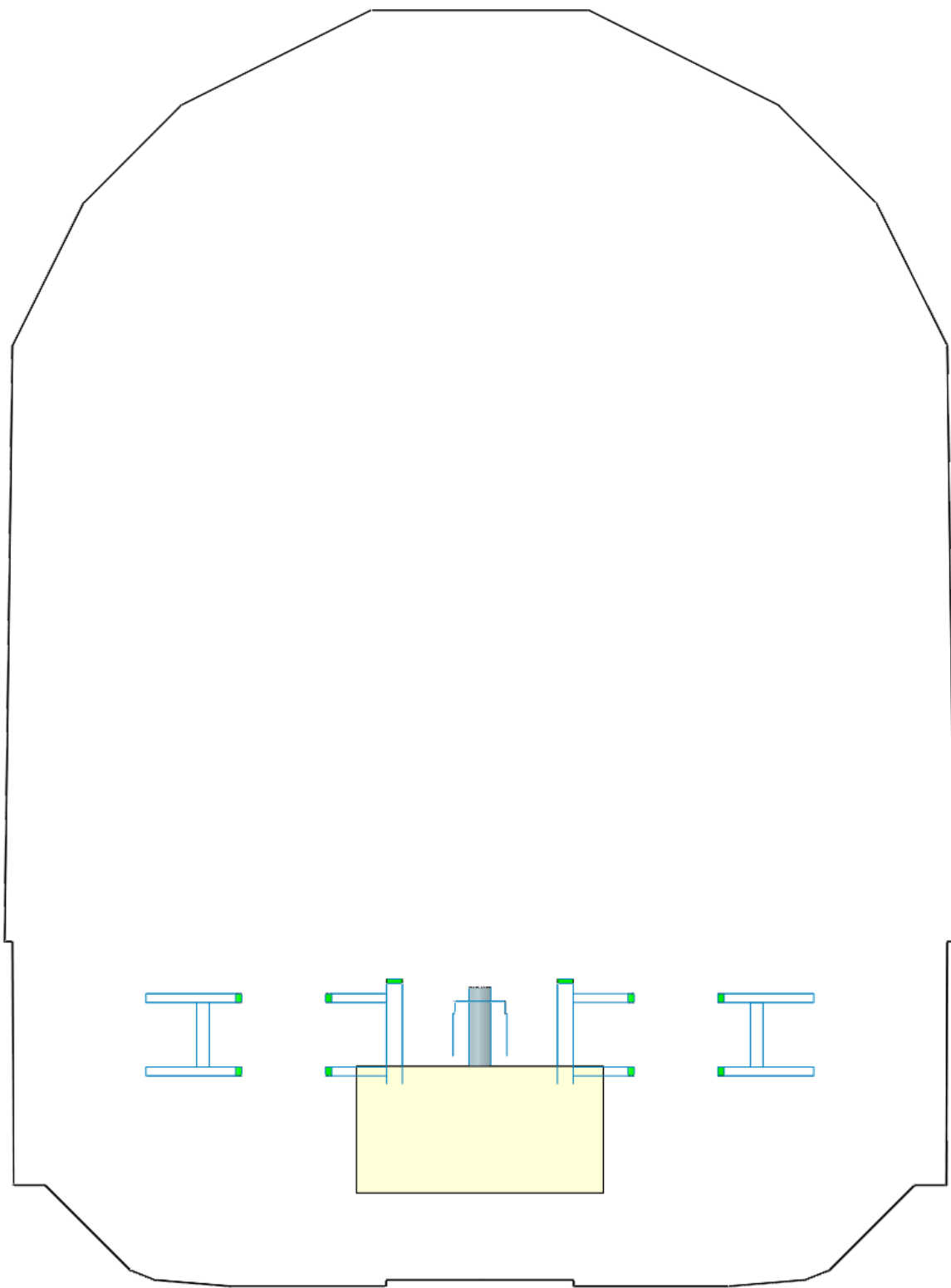


Fig. 3.4. Outline of the narrowed gauge in the P2 cross-section according to [1]

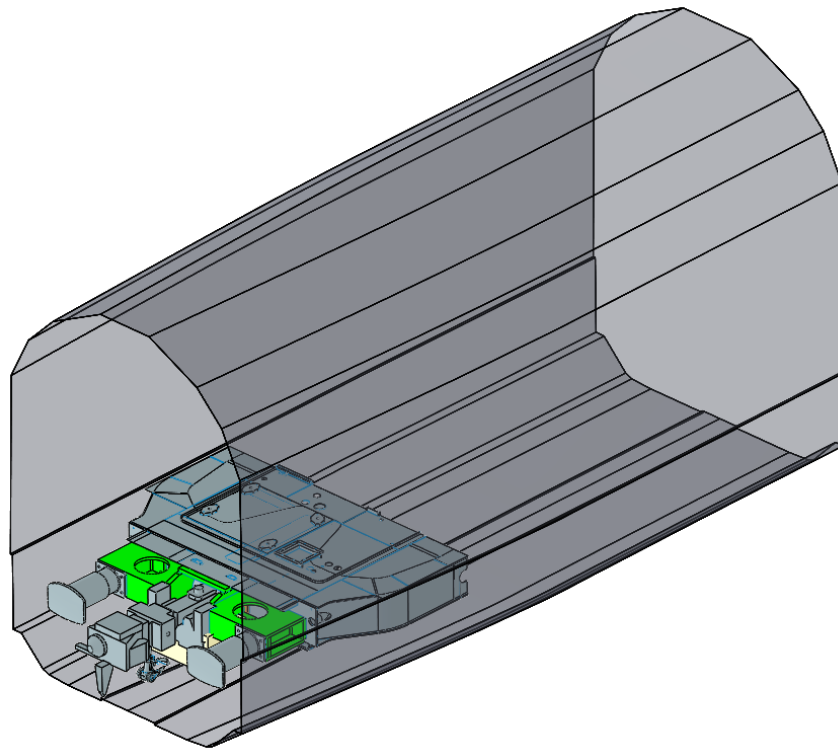


Fig. 3.5. Top view of the assembly model of the coupler and the outline of the continuous narrowed gauge

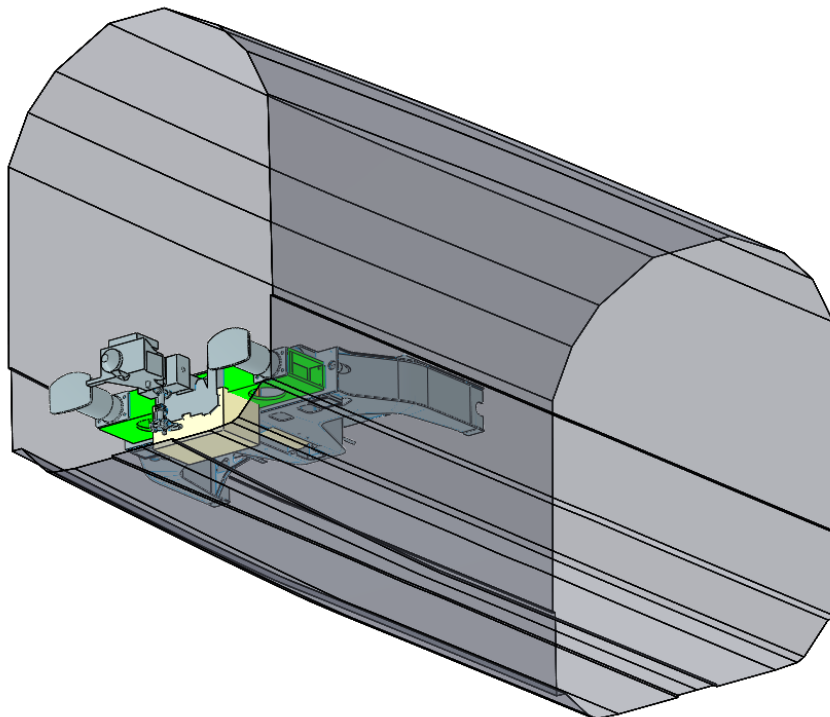


Fig. 3.6. View of the assembly model of the coupler and the outline of the continuous gauge narrowed from the bottom

4 CONCLUSIONS

Based on the parameters of the SM42 series locomotive, narrowed outlines were determined in accordance with the relationships resulting from the PN-EN 15273-2 standard [1] for the G1 kinematic gauge. The determined reference outlines were then compared with the actual dimensions of the vehicle in individual cross-sections. Based on this, it can be concluded that the actual outline of the digital coupler installation on the SM42 series locomotive frame does not exceed the restricted outlines determined according to [1].

5 ADDITIONAL INFORMATION

1. The test results refer exclusively to the tested samples/objects and the data/samples received for the test.
2. The test report may not be reproduced except in its entirety without the written consent of the Laboratory Director.

6 REFERENCE DOCUMENTS

- [1] PN-EN 15273-2+A1:2017-03 Kolejnictwo. Skrajnie. Część 2: Skrajnia pojazdów szynowych. Warszawa, 2017.

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