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Type of document: **Inquiry**

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Name of document: **Technical requirements\_Couplers**

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Vehicle: 5-car bidirectional metro train

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Type: Metro Prague

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|                                      |  |

## CONTENTS

|  |           |
|--|-----------|
| Annotation .....   | 6         |
| Used Abbreviations .....   | 7         |
| <b>A. TERMINOLOGY STANDARDS AND TERM DEFINITIONS .....</b>                       | <b>8</b>  |
| A.1. List of Standards for draft, production and unit tests .....                | 8         |
| A.1.1 List of related documents, technical and legislation requirements .....    | 8         |
| A.2. Terminology and term definitions .....                                      | 8         |
| <b>B. INTRODUCTION .....</b>   | <b>9</b>  |
| B.1. General information .....   | 9         |
| <b>C. BASIC DESCRIPTION OF THE VEHICLE .....</b>                                 | <b>10</b> |
| C.1. Vehicle description .....   | 10        |
| C.1.1 Coupling .....   | 10        |
| C.1.1.1 Coupling planes .....  | 10        |
| C.1.1.2 Coupling of the metros into the train sets a compatibility .....         | 10        |
| C.1.1.3 Coupling of the coaches into the units .....                             | 11        |
| C.2. Active diagnostic system .....  | 11        |
| C.3. Nominal weights of train cars .....   | 11        |
| C.4. Trainset speed .....  | 11        |
| C.5. Track arrangement parameters .....  | 11        |
| C.6. Service life, service and maintenance .....                                 | 11        |
| <b>D. TECHNICAL SPECIFICATION OF THE SYSTEM / COMPONENT .....</b>                | <b>12</b> |
| D.1. Couplers for 5-car metro train .....  | 12        |
| D.1.1 Semi-automatic front coupler (SAFC) .....                                  | 12        |
| D.1.1.1 General .....  | 12        |
| D.1.1.2 Force and dimension parameters of the coupler .....                      | 12        |
| D.1.1.3 Requirements description for the particular design groups .....          | 13        |
| D.1.1.3.1 Semi-automatic coupler head .....                                      | 13        |
| D.1.1.3.2 Coupler shaft with reversible element .....                            | 14        |
| D.1.1.3.3 Coupler ring – rubber-metal coupler joint .....                        | 15        |
| D.1.1.3.4 Supporting and centring system of the coupler shaft .....              | 15        |
| D.1.1.3.5 Coupler basis .....  | 15        |
| D.1.1.3.6 Universal interface .....  | 17        |
| D.1.1.3.7 Deformation element .....  | 17        |
| D.1.1.4 Equipment of the coupler .....   | 18        |
| D.1.1.4.1 Pneumatic equipment .....  | 18        |
| D.1.1.4.2 Couplers labelling .....   | 19        |
| D.1.1.4.3 Earth connection .....   | 19        |
| D.1.2 Semi-permanent coupler (SPC) .....   | 20        |
| D.1.2.1 General .....  | 20        |
| D.1.2.2 Force and dimension parameters of the coupler .....                      | 20        |
| D.1.2.3 Requirements description for the particular design groups .....          | 20        |
| D.1.2.3.1 Coupler shaft with reversible element .....                            | 21        |
| D.1.2.3.2 Coupler ring – rubber-metal coupler joint .....                        | 22        |
| D.1.2.3.3 Supporting and centring system of the coupler shaft .....              | 22        |
| D.1.2.3.4 Coupler basis .....  | 22        |
| D.1.2.3.5 Universal interface .....  | 22        |
| D.1.2.3.6 Supporting system of the middle frame of the inter-coach gangway ..... | 22        |
| D.1.2.3.7 Deformation element .....  | 22        |
| D.1.2.4 Equipment of the coupler .....   | 23        |
| D.1.2.4.1 Electric connector interface .....                                     | 23        |
| D.1.2.4.2 Pneumatic equipment .....  | 24        |
| D.1.2.4.3 Couplers labelling .....   | 25        |
| D.1.2.4.4 Earth connection .....   | 25        |
| D.2. Technical part valid for all components .....                               | 26        |

|           |  |           |
|-----------|--|-----------|
| D.2.1     | Dynamic endurance of the design .....  | 26        |
| D.2.2     | Quality requirements .....   | 26        |
| D.2.3     | Quantities .....   | 26        |
| D.2.4     | Interchangeability .....   | 26        |
| D.2.5     | Approval .....   | 26        |
| D.2.6     | Uncoupling time .....  | 26        |
| <b>E.</b> | <b>SUPPLIERS'S RESPONSIBILITIES .....</b>  | <b>28</b> |
| E.1.      | General requirements .....   | 28        |
| E.1.1     | Service life .....   | 28        |
| E.1.1.1   | Service life of couplers .....   | 28        |
| E.1.2     | Patent infringement .....  | 28        |
| E.2.      | Environmental conditions .....   | 28        |
| E.2.1     | External climatic conditions .....   | 28        |
| E.2.2     | Corrosion aggressivity .....   | 28        |
| E.2.3     | Power supply system parameters of car .....  | 28        |
| E.2.4     | Nominal circuit voltage .....  | 28        |
| E.2.5     | Vibration and shocks .....   | 28        |
| E.2.6     | Working conditions .....   | 28        |
| E.3.      | Design requirements .....  | 28        |
| E.3.1     | Construction - priorities .....  | 28        |
| E.3.2     | Coordinate system of vehicle .....   | 29        |
| E.3.3     | Structural and crashworthiness requirements .....  | 29        |
| E.3.4     | Vehicle pressure loading .....   | 29        |
| E.3.5     | Materials .....  | 29        |
| E.3.5.1   | Health safety .....  | 29        |
| E.3.5.2   | Material standards .....   | 29        |
| E.3.5.3   | Paints and corrosion protection .....  | 29        |
| E.3.5.3.1 | Corrosion protection of the couplers .....   | 29        |
| E.3.5.3.2 | Colour scheme .....  | 29        |
| E.3.5.4   | Surface finish .....   | 30        |
| E.3.5.4.1 | Surface finish – inner area of leaves .....  | 30        |
| E.3.5.4.2 | Surface finish – outer area of leaves .....  | 30        |
| E.3.5.4.3 | Surface finish – other parts of the DLSD .....   | 30        |
| E.3.6     | Fire protection properties .....   | 30        |
| E.3.7     | Fire properties – Documentation of compliance of product with EN 45545 .....               | 30        |
| E.3.8     | Rivet and screw connections .....  | 30        |
| E.3.8.1   | Tightening torque of the tighten screw connection and its orientation on the vehicle ..... | 30        |
| E.3.9     | Welding .....  | 31        |
| E.3.10    | Adhesive bonding .....   | 31        |
| E.3.11    | Wiring and cabling .....   | 31        |
| E.3.12    | Noise .....  | 31        |
| E.3.13    | Weight .....   | 31        |
| E.3.13.1  | Weight limits .....  | 31        |
| E.3.14    | Identification and description .....   | 31        |
| E.3.15    | Degree of protection .....   | 31        |
| E.3.16    | Electromagnetic interference and compatibility .....                                       | 32        |
| E.3.17    | Testing voltage .....  | 32        |
| E.3.18    | Software, communication and diagnostics .....  | 32        |
| E.3.19    | Electronic equipment requirements .....  | 32        |
| E.3.20    | Further requirements .....   | 32        |
| E.3.21    | Triangular key .....   | 32        |
| E.4.      | RAM (Reliability, Availability, Maintainability) .....                                     | 32        |
| E.5.      | Safety .....   | 32        |
| E.5.1     | Safety relevant components .....   | 32        |
| E.5.2     | Requirements into safety integrity level .....   | 32        |
| E.6.      | Tests .....  | 36        |

|           |   |           |
|-----------|---|-----------|
| E.6.1     | Type test .....   | 36        |
| E.6.2     | System test .....   | 36        |
| E.6.3     | Routine test .....  | 36        |
| E.6.4     | Components tests .....  | 36        |
| E.6.4.1   | General.....  | 36        |
| E.6.4.2   | Semi-automatic front coupler (SAFC) .....   | 36        |
| E.6.4.2.1 | Semi-automatic coupler movement test .....  | 36        |
| E.6.4.2.2 | Semi-automatic coupler dynamic test.....  | 36        |
| E.6.4.2.3 | Strength test of couplers.....  | 37        |
| E.6.4.2.4 | Weight test of the components .....   | 37        |
| E.6.4.2.5 | Compatibility test.....   | 37        |
| E.6.4.3   | Semi-permanent coupler (SPC) .....  | 38        |
| E.6.4.3.1 | Movement test of couplers.....  | 38        |
| E.6.4.3.2 | Uncoupling test .....   | 38        |
| E.6.4.3.3 | Dynamic test of couplers .....  | 38        |
| E.6.4.3.4 | Strength test of couplers.....  | 38        |
| E.6.4.3.5 | Weight test of the components .....   | 39        |
| E.7.      | Spare parts .....   | 39        |
| E.8.      | Consumable supplies .....   | 39        |
| E.9.      | Guarantee, system fault, penalization for failure non-removal.....  | 39        |
| E.10.     | Maintenance .....   | 39        |
| <b>F.</b> | <b>BACK-UP TECHNICAL DOCUMENTATION.....</b>   | <b>40</b> |
| F.1.      | Requirements which are concerning with technical and operational documentation of metro cars and their components ..... | 40        |
| F.2.      | Documentation delivered with each piece.....  | 40        |
| F.3.      | Documentation delivered with first delivery .....   | 40        |
| F.4.      | Documentation delivered for project and design elaboration of vehicles.....   | 40        |
| F.5.      | Documentation delivered with offer .....  | 40        |
| F.6.      | Other documentation .....   | 40        |
| F.7.      | Selected documentation version .....  | 40        |
| F.8.      | Simulation and calculation reports .....  | 40        |
| F.8.1     | Simulation report of automatic coupler coupling.....  | 40        |
| F.8.2     | Strength analysis of the couplers.....  | 40        |
| F.8.3     | Strength analysis of screw connections.....   | 41        |
| <b>G.</b> | <b>OTHER REQUIREMENTS .....</b>   | <b>42</b> |
| G.1.      | Client's training .....   | 42        |
| G.2.      | Manufacturing requirements.....   | 42        |
| G.3.      | Preservation .....  | 42        |
| G.4.      | Packaging and protection.....   | 42        |
| G.5.      | Transportation .....  | 42        |
| G.6.      | Storage .....   | 42        |
| G.7.      | Installation .....  | 42        |
| G.8.      | Initial starting of component/system.....   | 42        |
| G.9.      | Obsolescence of items .....   | 42        |
| G.10.     | Recycling.....  | 42        |
| G.11.     | Supplier requirements .....   | 42        |
| G.12.     | List of key technical standards and regulations related to the vehicle .....  | 42        |
| G.13.     | Safety, hygiene and impact on the external environment .....  | 42        |
| <b>H.</b> | <b>OFFER PROCESSING.....</b>  | <b>43</b> |
| H.1.      | Documentation included in the offer.....  | 43        |
| <b>I.</b> | <b>ANNEXES .....</b>  | <b>44</b> |
| I.1.1     | CbC document .....  | 44        |

**Annotation**

Document sets out specific requirements for sub-suppliers of couplers in the five cars metro project.

### Used Abbreviations

According to the document TD080862 [1].

This inquiry document extends abbreviations used in TD080862 with following abbreviations that are mandatory.

| Used Abbreviations |   |
|--------------------|---|
| Abbreviation       | Description                                       |
| etc.               | Et cetera   |
| cca                | Approximately                                     |
| Nr.                | Number  |
| FZ                 | Functional test                                   |
| HS                 | Bodywork of vehicle                               |
| KZ                 | Single Test                                       |
| TOR                | Top of Rail (Starting Point for Height Measuring) |
| SAFC               | Semi-Automatic Front Coupler                      |
| SPC                | Semi-Permanent Coupler                            |
|                    |   |

**Table 1 – Used abbreviations**

## A. TERMINOLOGY STANDARDS AND TERM DEFINITIONS

### A.1. List of Standards for draft, production and unit tests

According to the document TD080862.

#### A.1.1 List of related documents, technical and legislation requirements

This inquiry document extends list of related documents, technical and legislation requirements, used in document TD080862, that are mandatory for supply of the component. Related documents are quoted as a whole or a part of them.

The list of base laws, standards and directives that shall be applied:

| Added standards         |  |
|-------------------------|--|
| Mark                    | Name   |
| EN 12663-1:2010+A1:2014 | Railway applications – Structural requirements of railway vehicle bodies – Part 1: Locomotives and passenger rolling stock   |
| EN 16019:2014           | Railway applications - Automatic coupler - Performance requirements, specific interface geometry and test method<br>Note: Valid as Auxiliary document for the identification, measurement, and testing of the coupler. |
| EN 15227:2021           | Railway applications – Crashworthiness requirements for rail vehicles  |
| EN 15663:2017+A1:2018   | Railway applications – Definition of vehicle reference masses  |

Table 2 – Added standards

### A.2. Terminology and term definitions

According to the document TD080862.



## **B. INTRODUCTION**

### **B.1. General information**

Requirements given in this document are specifications for the coupling equipment of metro cars.

## C. BASIC DESCRIPTION OF THE VEHICLE

According to the document TD080862.

### C.1. Vehicle description

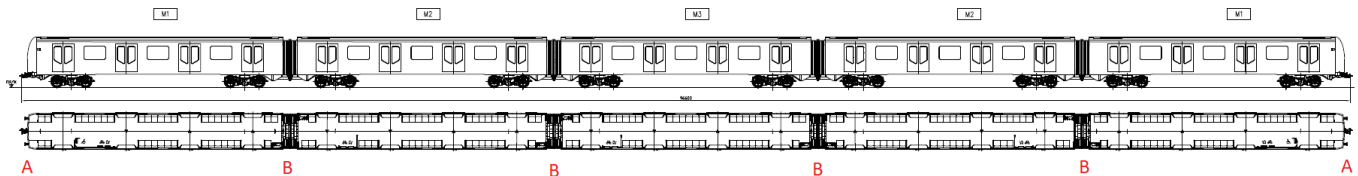
According to the document TD080862.

#### C.1.1 Coupling

##### C.1.1.1 Coupling planes

Coupling planes of the metro unit are shown in picture 1

**M1 + M2 + M3+ M2 + M1**



**Picture 1 – Schematic view of the train and its coupling planes**

The coaches are mutually coupled into the compact unit by means of couplers that are located beneath the gangway. The couplers transfer the traction and compressive forces generated during the run of the train, damp the longitudinal strokes generated during the dynamic run. In a case of a collision, the connection consisting of the flexible couplers are equipped with the deformation element, which absorbs the part of the energy generated during the impact. The coupler is equipped with anti-climb protection. The couplers are destined for the mechanical and pneumatic coupling of the coaches.

The metro coaches are equipped by means of following couplers:

- Semi-automatic front coupler (SAFC) coupling plane A,
- Semi-permanent coupler (SPC) coupling plane B,

| Position of couplers |        |     |        |     |        |     |        |     |        |      |
|----------------------|--------|-----|--------|-----|--------|-----|--------|-----|--------|------|
| Wagon:               | M1 (1) |     | M2 (2) |     | M3 (3) |     | M2 (4) |     | MC (6) |      |
| Type of coupler:     | SAFC   | SPC | SPC    | SPC | SPC    | SPC | SPC    | SPC | SPC    | SAFC |

**Table 3 – Position of couplers**

##### C.1.1.2 Coupling of the metros into the train sets a compatibility

This point is valid for the semi-automatic front coupler only (SAFC). The metros trains will be coupled together in the train sets by semi-automatic front couplers.

The nominal coupling speed  $v_{cc} = 2 \pm 1$  km/h will be considered. During the coupling sequence by a locomotive (depot or emergency manipulation), the maximum coupling speed  $v_{ccMAX} = 5$  km/h will be considered. This condition must be declared by simulation report by coupler supplier and must be a part of the offer, see Paragraph H.1.

Other requirements:

- The coupling sequence must be absolutely automatic, without other manual help of staff persons, controlled from the control board.
- The uncoupling of the automatic coupler will be done manually.
- Coupling compatibility with vehicles M1 ČKD Transportation systems (realization 1998-2011) is required!
- The smallest coupling radius is  $R = 60\text{m}$ , the automatic units coupling in the entrance of this radius to the straight line is required. Other track radiuses for coupling and uncoupling are defined in TD080862.
- The usage of hump yard is not considered.

#### **C.1.1.3 Coupling of the coaches into the units**

This point is valid for the intermediate couplers (SPC). Intermediate couplers provide connection of coaches into the unit.

The coaches will be coupled into the compact unit by means of shunting vehicle. The nominal coupling speed  $v_{cm} = 0,5 \pm 0,5 \text{ km/h}$ . The maximum coupling speed  $v_{cmMAX} = 1 \text{ km/h}$  will be considered.

The usage of hump yard is not considered.

#### **C.2. Active diagnostic system**

According to the document TD080862.

#### **C.3. Nominal weights of train cars**

According to the document TD080862.

#### **C.4. Trainset speed**

According to the document TD080862.

#### **C.5. Track arrangement parameters**

According to the document TD080862.

#### **C.6. Service life, service and maintenance**

According to the document TD080862.

## D. TECHNICAL SPECIFICATION OF THE SYSTEM / COMPONENT

### D.1. Couplers for 5-car metro train

#### D.1.1 Semi-automatic front coupler (SAFC)

##### D.1.1.1 General

The SAFC coupling must be fully compatible with the front couplings used on M1 vehicles from ČKD Transport Systems (implemented between 1998 and 2011) – it is mandatory. The coupling with M1 vehicles will serve as a rescue coupling and for passage between depots. In rescue conditions, coupling with loaded M1 vehicles is expected.

Based on past project experiences, a release system is required to unlock the horizontal centering system for coupling SAFC couplers when entering a 60 m radius curve. This means that the couplers must be manually released, and it must be possible to horizontally move the coupling shaft to easily adjust the coupling axis for the coupling operation.

##### D.1.1.2 Force and dimension parameters of the coupler

SAFC must be proposed to withstand the forces: compression force 800 kN and draw force 600 kN.

SAFC must withstand these draw and compression forces also in its maximum angular deflections including their superposition. All forcibly and dynamically stressed coupler's parts must be designed with the safety coefficient in accordance with EN 12663-1 par. 5.4.

SAFC must fulfil the requirements of fatigue strength in accordance with EN 12663-1 par. 5.6.

SAFC must be equipped with reversible element or elements (1st level – reversible element on the coupler shaft, 2nd level – rubber-metal joint) which must be dimensioned to absorb all energy loosen during the coupling sequence and to prevent coupler damage.

In the coupling moment the vehicles have the design mass in working order (definition in conformity with EN 15663; MVD + 1/2 of sitting passengers) where one of them is braked and the second one runs with coupling speed  $v_{ccMAX} = 5$  km/h, for more see Paragraph C.1.1.2. The mass in working order value will be cyclically actualized during the project's progress and will be submitted to the supplier upon its request. A Final re-calculation has to be done before the design freeze.

| Main parameters, dimensions of the coupler and its expected angular deflections |          |
|---|----------|
| Parameter   | Value    |
| Overall coupler length (coupling plane – basis mounting plane)                  | 1 685 mm |
| Overall coupler shaft length (coupling plane – coupler pin axis)                | 1 470 mm |
| Minimum angular rotation of the coupler shank in "xy" plane                     | ±30°     |
| Minimum angular rotation of the coupler shank in "xz" plane                     | ±6°      |
| Minimum torsional rotation of the coupler shank along the „x“ axis              | ±4°      |

Table 4 – Main dimension parameters of the automatic coupler

Note: in terms of the development work in metro project the values of horizontal and vertical coupler deflection can be changed. The purchaser reserves change of some of the presented parameters.

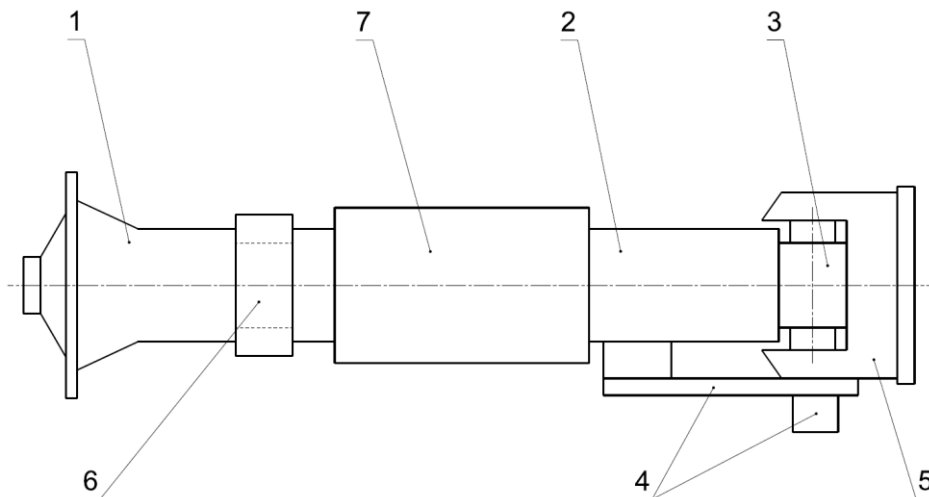
### D.1.1.3 Requirements description for the particular design groups

**The coupler design consists of the following sub-components:**

- Semi-automatic coupler head (pos. 1)
- Coupler shaft with reversible element (pos. 2)
- Coupler ring – rubber-metal coupler joint (pos. 3)
- Supporting and centring system of the coupler with manual release mechanism (pos. 4)
- Coupler basis (pos. 5)
- Universal interface (pos. 6)
- Deformation element (pos. 7)

**Sub-components outside of the main design:**

- Pneumatic equipment
- Couplers labelling
- Earth connection



Picture 2 – Schematic view of the coupler

#### D.1.1.3.1 Semi-automatic coupler head

SAFC must be equipped with the semi-automatic coupler head type 30 working on the “Scharfenberg” system (If it were not possible to ensure compatibility with M1 vehicles using this coupler head, the supplier must notify this fact.).

The head (its carrying structure) must be produced of cast steel. The sufficient check and maintenance openings to enable the accessing the mechanism inside for maintenance and reparations must be made in the coupler head design. The internal mechanism must be simply visually controllable. The sufficient number of drainage openings for rain water and other undesirable liquids drainage from the coupler head space must be provided. The bearings of the movable mechanisms inside of coupler head must be solved as self-lubricating ones or the system of lubrication canals to provide the sufficient lubrication must be provided. The service life of the bearing mechanisms together with the coupler centring mechanism must be not less than 8 years.

- The rubber elements located on the coupler head and the other design groups and coupler mechanisms, e.g. dusters, rubber-metal joints or spacing and sealing elements must be produced of such materials to ensure their error-free function in the whole temperature scope mentioned in the text of the enquiry and their service life was not less than 8 years.
- The error-less coupling and automatic locking of the mechanic and electric couplers must occur during the coupling sequence without any intervention of the vehicle attendance. The coupling test is required within the movement test.
- The coupling sequence must be absolutely automatic, without other manual help of staff persons, controlled from the control board.

- The uncoupling of the semi-automatic coupler will be manually.
- The force necessary for the manual uncoupling shall be 150 N and must not exceed 200 N.
- The uncoupling of the mechanism must work error-less and failure-free.
- The ability for coupling and uncoupling must be ensured also in winter operational conditions.
- The coupler head must be connected with the coupler shaft by means of universal interface (see D.1.1.3.6).

The coupler head must be in case of failure removable in a simple way and in terms of the interchangeability of all design groups changeable for a new one.

If the automatic coupler head or its associated systems are equipped with electric motors, pneumatic mechanisms, servomechanisms or other electric and pneumatic systems, these components must be solved to be protected before the condensate originating and water condensing (in case of electric sub-components especially in the internal function space).

#### D.1.1.3.2 Coupler shaft with reversible element

The reversible element is the 1st level of the longitudinal coupler suspension. The coupler shaft is one of the force elements of the coupler and must be able to transfer the forces mentioned in table 5. SAFC must withstand the mentioned draw and compressive forces also in its maximum angle deflections including their superposition.

All forcibly and dynamically stressed coupler's parts must be designed with safety coefficient in accordance with EN 12663-1, Paragraph 5.4.

The shaft must fulfil the requirements of fatigue strength in accordance with EN 12663-1, par. 5.6.

The required parameters (minimum absorbed energy, recommended reversible length in draw, recommended reversible length in compression etc.) are shown in table 5. The energetic dimensioning of the reversible element must fulfil the coupling conditions according to Paragraph C.1.1.2 with sufficient reserve.

The damage or angular rotation of the reversible element must be discoverable by means of simple verification to enable its simple registration during the periodic revisions of the component. This should be done when looking from the front or side of the vehicle.

| Required parameters of the reversible element of the SAFC |                   |            |   |  |   |
|---|-------------------|------------|---|--|---|
|   | Compression force | Draw force | Minimum deformation length of the reversible element for the stress | Minimum absorbed energy of the reversible element for the stress | Working temperature scope (the function of the element must be ensured in this scope) |
|   | [kN]              | [kN]       | [mm]  | [kJ]   | [°C]  |
| Compressive stress to the coupler shaft axis              | 800               | -          | 55  | 38   | - 35 ÷ 40   |
| Draw stress to the coupler shaft axis                     | -                 | 600        | 40  | 12   | - 35 ÷ 40   |

**Table 5 – Required parameters of the reversible element of the SAFC**

The earth conductors must be connected on the coupler shaft at least in two points. The seating faces for the cable shoes must be arranged in conformity with the valid European standards.

#### D.1.1.3.3 Coupler ring – rubber-metal coupler joint

The rubber-metal coupler joint is the second suspension level of the coupler and its function is to absorb the longitudinal draw and compression impacts caused by running of the compact train unit and to absorb a part of energy loosed during the coupling sequence.

The rubber-metal joint must enable by its design the horizontal and vertical turning of the coupler shaft and to enable the angular torsion turning of the coupler shaft around the vehicle “x” axis in the same time. Parameters of the joints torsion stiffness must be a part of the couplers technical description.

The rubber-metal coupler joint can be produced also from other material than rubber when the required material, energetic and thermal properties will be kept or improved.

The error-free function in the whole temperature scope presented in the enquiry text must be ensured and its service life must be not less than 8 years.

A coupler base type of "EFG" can be used.

#### D.1.1.3.4 Supporting and centring system of the coupler shaft

SAFC must be equipped with a system which will centre the non-coupled coupler raised into the working position and will keep it in the position when the coupler axis will be parallel with the vehicle “x” axis.

This system is in terms of this document divided into two mechanisms. The design of the centring system allows to merge both into one system.

##### **Centring mechanism – centring in “xy” plane**

The centring mechanism must centre the non-coupled coupler in the working position into the vehicle “x” axis except of the rescue coupling in all service vehicle regimes. If the non-coupled coupler deflects from the vehicle “x” axis the centring mechanism must respond and return the coupler into the original centred position.

The centring mechanism must be dimensioned to prevent the spontaneous deflections from the vehicle axis and to prevent injuries of persons or vehicle damage evoked by centrifugal force and transverse accelerations (see Paragraph D.2.1).

The centring mechanism must allow coupling and uncoupling in small radiuses in accordance to Paragraph D.1.1.1. This means that the couplers must be manually released, and it must be possible to horizontally move the coupling shaft to easily adjust the coupling axis for the coupling operation.

The service life of the rubber segments in this mechanism (if used) must be not less than 8 years and must work error-free in the whole temperature scope given by this enquiry.

The centring mechanism must enable the space adjustability (“xy” plane) by means of common accessible workshop tools.

##### **Supporting mechanism – centring in “xz” plane**

The supporting mechanism has to keep the non-coupled coupler in the working position in parallel position with the vehicle “x” axis in all operational regimes of the vehicle. If the non-coupled coupler deflects from the vehicle “x” axis the centring mechanism must respond and return the coupler into the original centred position.

The service life of the rubber segments in this mechanism (if used) must be not less than 8 years and must work error-free in the whole temperature scope given by this enquiry.

The supporting mechanism has to enable to rectify the coupler axis with the axis of the vehicle standing on the straight track by a simple intervention.

#### D.1.1.3.5 Coupler basis

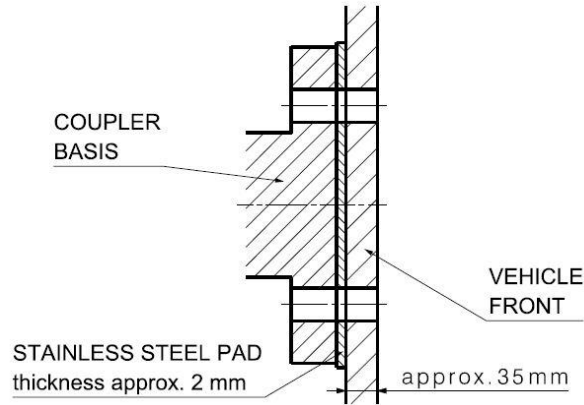
The coupler basis is a carrier of the whole coupler design. The coupler basis must be dimensioned for the whole loading force scope including full coupler deflections in both horizontal and vertical planes including their superposition. All forcibly and dynamically stressed parts of the coupler must be designed with safety coefficient in accordance with EN 12663-1, Paragraph 5.4.

The coupler basis must fulfil the requirements of fatigue strength in accordance with EN 12663-1, Paragraph. 5.6.

The connection between the coupler basis and coupler ring mustn't generate noise in any coupler regime and must enable the whole movement angular range given by this document.

The bearing surface of the coupler basis flange must be treated against the electro-chemical corrosion for the contact with the stainless steel pad mounted on the vehicle front, see picture 3. The material, used coating

and its parameters must be mentioned in the coating description which must be a part of the submitted documentation (see Paragraph H.1).

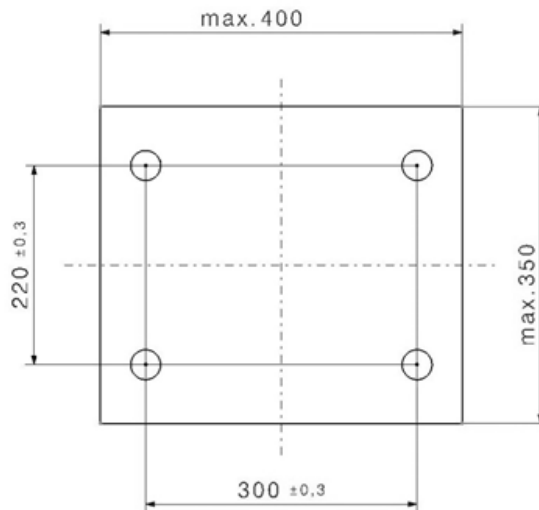


**Picture 3 – Arrangement of the coupler basis on the vehicle front**

The main producer label must be located on the visible place of the coupler basis in accordance to the document TD080862.

The earth conductors must be connected on the coupler basis at least in two points. The seating faces for the cable shoes must be arranged in conformity with the valid European standards.

The bases of all delivered couplers must have the following maximum dimensions, the following dimensions and spacing of screw openings for component mounting to the vehicle:



**Picture 4 – Coupler basis**

The basis and the vehicle body will be connected via certain number of screws. The screw connection has to ensure dynamic safety, fatigue safety and thermal safety. The basis must allow simple change of the coupler.

The SAFC basis must allow insertion of the coupler shaft to the universal interface level (see Chapter D.1.1.3.6) in case of crash. This point is valid only in case of SAFC. Other coupler types do not require this property.



#### D.1.1.3.6 Universal interface

Under universal interface (muff coupling) the connection, which will couple the stiff and flexible couplers, is thought.

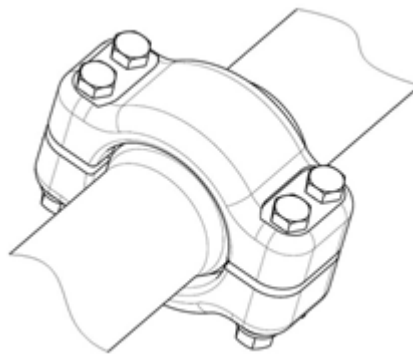
The universal interface design must be suitable dimensioned to warrant its function in all regimes of coupler stressing. The connection should be designed to prevent the penetration of dirties and liquids which can cause the corrosion of muff coupling elements and coupling interfaces of both coupler types.

The muff coupling must be centred in lateral and axial directions. The muff coupling design must fulfil all requirements of part interchangeability.

The supplier has to deliver the design documentation regarding all elements of the muff coupling, connecting material, tightening torques, lubricants, conservations and anti-corrosive preparations.

The force parameters of the muff coupling must be a part of the strength analysis of the couplers.

The muff coupling design mustn't be used as a carrier for pneumatic equipment. For indication of such see picture 5.



Picture 5 – Example of a universal interface

#### D.1.1.3.7 Deformation element

The stiff coupler must be equipped with deformation element which absorbs the energy in the moment of impact defined by scenarios according to vehicle category C-II according to EN 15227.

The deformation force and its tolerance field determined from its nominal value must be set in such way not to trigger the element in any coupler working regime; the triggering force (triggering peak) must be as low as possible but higher than the projected compression force 800 kN. Considered forces in the coupler contains table 6.

The required deformation length and necessary absorbed energy will be defined by purchaser in terms of crash simulations carried out by himself; they will be submitted to the supplier in terms of the design work development in terms of the project.

The part of the documentation must be the force-length deformation characteristics of the deformation element with the presented triggering force with defined tolerance and presented deformation force with presented tolerance. At the end of the deformation has to be secured, that all ASFC coupler will be sheared off from the coupler base and will be fully released out into the hole in the vehicle's car body. The shear off function has to be part of the dynamic test.

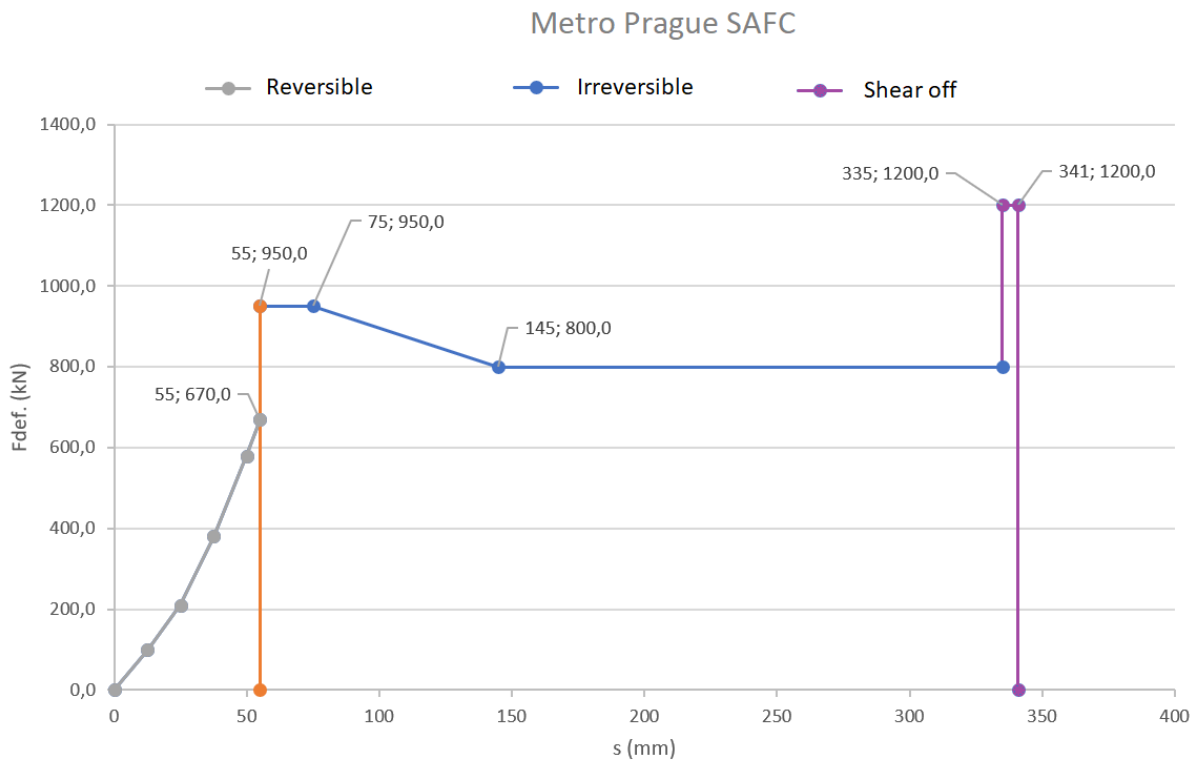
SAFC as whole must be physically dynamically tested in conformity with EN 15227 by independent testing authority (see Paragraph E.6.4.3.3). The test has to prove minimally the fulfilment of the values given by theoretical curve determined in terms of the project.

The purchaser reserves the right to require the parameter adjusting of the deformation element according to requirements of the particular crash scenarios and vehicle design.

The reflexion label must be located on the deformation element which informs the service during the visual checking that the deformation force was exceeded and the deformation element of the coupler was triggered. The required form of the label is an arrow whose tip shows the non-triggered (new) state of the deformation element and the insertion of the arrow the rate of the passed deformation.

| Basic parameters of the deformation element |                    |
|---|--------------------|
| Parameter                                   | Value              |
| Expected triggering force                   | 950 kN $\pm$ 7,5%  |
| Expected deformation force                  | 800 kN $\pm$ 7,5%  |
| Expected shear off force                    | 1200 kN $\pm$ 7,5% |
| Expected deformation length                 | 280 mm             |
| Expected shear off length                   | 6 mm               |

Table 6 – Basic parameters of the deformation element



Picture 6 – SAFC theoretical characteristic.

#### D.1.1.4 Equipment of the coupler

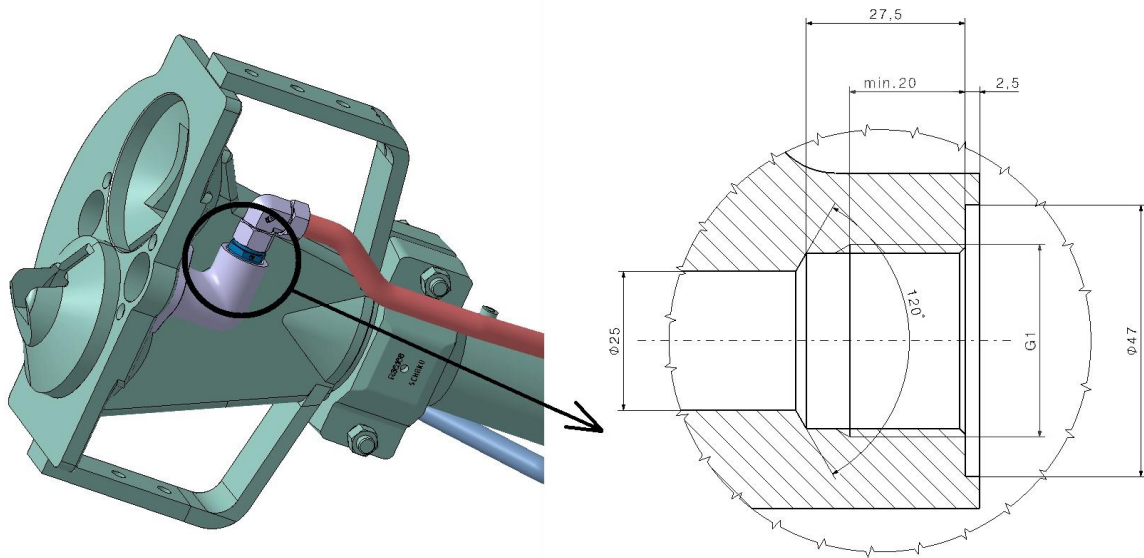
##### D.1.1.4.1 Pneumatic equipment

SAFC must be equipped with pneumatic interface. The interface must comply with current interface in metro Prague. The pneumatic equipment must not affect the coupling capability. These requirements will be validated via supplier within the coupling test in place of the operation.

The nominal diameter of the pipe is DN 25 mm. Connection thread on the couplers head is G1, minimum length 20 mm, nut type. The coupler head must be equipped with brake valve preventing lose of the air during the uncoupling. Operating pressure is 10 bar.

In case of breakdown of the couplers during their disruption the pneumatic system must lose its pressure-tightness which lead to activation of emergency braking of the train.

Flammable parts (hoses, sealings etc) must fulfil requirements of fire resistance in accordance to the main producer label must be located on the visible place of the coupler basis in accordance to the document TD080862.



Picture 7 – Pneumatic interface

#### D.1.1.4.2 Couplers labelling

The supplier equips each component (according to D.1.1.3) with non-removable sheet produced of stainless steel. The sheet must contain all information in accordance to the document TD080862.

#### D.1.1.4.3 Earth connection

The whole design including particular movable parts or fully separable parts during coupling sequence must be equipped with protecting earth connection which responds in its quality and performance to the actual valid electrical standards.

## D.1.2 Semi-permanent coupler (SPC)

### D.1.2.1 General

The semi-permanent coupler (thereinafter SPC or component only) is destined for the coupling of metro coaches together to the train set - see C.1.1.1. SPC must be designed with regards to interchangeability between the front parts of the coaches.

### D.1.2.2 Force and dimension parameters of the coupler

SPC must be proposed to withstand the forces: compression force 800 kN and draw force 600 kN.

SPC must withstand these draw and compression forces also in its maximum angular deflections including their superposition. All forcibly and dynamically stressed coupler parts must be designed with the safety coefficient in accordance with EN 12663-1, par. 5.4.

SPC must fulfil the requirements of fatigue strength in accordance with EN 12663-1, par. 5.6.

SPC must be equipped with one (EFG) or two reversible element levels (1st level – reversible element on the coupler shaft, 2nd level – rubber-metal joint) which must be dimensioned to absorb all energy loosen during the coupling sequence and to prevent the coupler damage.

Considered coupling velocities according to Paragraph C.1.1.3.

| Main parameters, dimensions of the coupler and its expected angular deflections |          |
|---|----------|
| Parameter   | Value    |
| Overall coupler length (coupling plane – basis mounting plane)                  | 1 355 mm |
| Overall coupler shaft length (coupling plane – coupler pin axis)                | 1 175 mm |
| Minimum angular rotation of the coupler shank in “xy” plane                     | ±30°     |
| Minimum angular rotation of the coupler shank in “xz” plane                     | ±8°      |
| Minimum torsional rotation of the coupler shank along the „x“ axis              | ±4°      |

**Table 7 – Main dimension parameters of the semi-permanent coupler**

Note: in terms of the development work in metro Prague project the values of horizontal and vertical coupler deflection can be changed. The purchaser reserves change of some of the presented parameters.

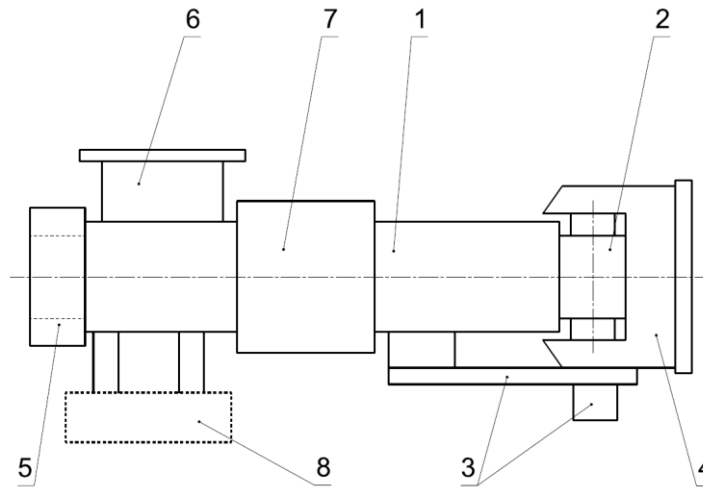
### D.1.2.3 Requirements description for the particular design groups

**The coupler design consists of the following sub-components:**

- Coupler shaft with reversible element (pos.1)
- Coupler ring – rubber-metal coupler joint (pos. 2)
- Supporting and centring system of the coupler (pos. 3)
- Coupler basis (pos. 4)
- Universal interface (pos. 5)
- Supporting system of the middle frame of the inter-coach gangway (pos. 6)
- Deformation element (pos. 7)

**Sub-components outside of the main design:**

- Electric connector interface (pos. 8)
- Pneumatic equipment
- Couplers labelling



Picture 8 – Schematic view of the coupler

#### D.1.2.3.1 Coupler shaft with reversible element

The reversible element is the 1st level of the longitudinal coupler suspension. The coupler shaft is one of the force elements of the coupler and must be able to transfer the forces mentioned in table 8. SPC must withstand the mentioned draw and compressive forces also in its maximum angle deflections including their superposition.

All forcibly and dynamically stressed parts of the coupler must be designed with safety coefficient in accordance with EN 12663-1, par. 5.4.

The shaft must fulfil the requirements of fatigue strength in accordance with EN 12663-1, par. 5.6.

The required parameters (minimum absorbed energy, recommended reversible length in draw, recommended reversible length in compression etc.) are shown in table 8. The energetic dimensioning of the reversible element must fulfil the coupling conditions according to Paragraph C.1.1.2 with sufficient reserve.

The damage or angular rotation of the reversible element must be discoverable by means of simple verification to enable its simple registration during the periodic revisions of the component. This should be done when looking from the front or side of the vehicle.

Required parameters of the reversible element of the SPC

|  | Compression force | Draw force | Minimum deformation length of the reversible element for the stress | Minimum absorbed energy of the reversible element for the stress | Working temperature scope (the function of the element must be ensured in this scope) |
|--|-------------------|------------|---|--|---|
|  | [kN]              | [kN]       | [mm]  | [kJ]   | [°C]  |
| Compressive stress to the coupler shaft axis | 800               | -          | 45  | 20   | - 35 ÷ 40   |
| Draw stress to the coupler shaft axis        | -                 | 600        | 40  | 12   | - 35 ÷ 40   |

Table 8 – Required parameters of the reversible element of the SPC

The earth conductors must be connected on the coupler shaft at least in two points. The seating faces for the cable shoes must be arranged in conformity with the valid European standards.

#### D.1.2.3.2 Coupler ring – rubber-metal coupler joint

See Paragraph D.1.1.3.3.

#### D.1.2.3.3 Supporting and centring system of the coupler shaft

Only vertical centring in “xz” plane is considered, see Paragraph D.1.1.3.4.

#### D.1.2.3.4 Coupler basis

See Paragraph D.1.1.3.5.

#### D.1.2.3.5 Universal interface

See Paragraph D.1.1.3.6.

#### D.1.2.3.6 Supporting system of the middle frame of the inter-coach gangway

The couplers will carry the middle frame of the inter-coach gangway. The couplers must be ready for the mounting of the supporting mechanism of the middle frame of the inter-coach gangway. The system must be designed to carry at least half of the gangways weight and one service person with tools.

| Couplers load                           |         |
|---|---------|
| Parameter                               | Value   |
| Estimated weight of the whole gangway   | 130 kg  |
| Maximum load from standing passengers   | 1064 kg |
| Weight of the service person with tools | 500 kg  |

**Table 9 – Couplers load**

The supporting mechanism mustn't impede or complicate the coupling and uncoupling of the couplers or restrain their operation deflections.

The particular dimensions of the sliding plate for the supporting mechanism for the middle frame of the inter-coach gangway will be determined during the development stage of the project.

The final design must be bilaterally approved between the supplier and purchaser.

#### D.1.2.3.7 Deformation element

SPC must be equipped with deformation element which absorbs the energy in the moment of impact defined by scenarios according to vehicle category C-II according to EN 15227.

The deformation force and its tolerance field determined from its nominal value must be set in such way not to trigger the element in any coupler working regime; the triggering force (triggering peak) must be as low as possible but higher than the projected compression force 800 kN. Considered forces in the coupler contains Tab. 7.

The required deformation length and necessary absorbed energy will be defined by purchaser in terms of crash simulations carried out by himself; they will be submitted to the supplier in terms of the design work development in terms of the project.

The part of the documentation must be the force-length deformation characteristics of the deformation element with the presented triggering force with defined tolerance and presented deformation force with presented tolerance.

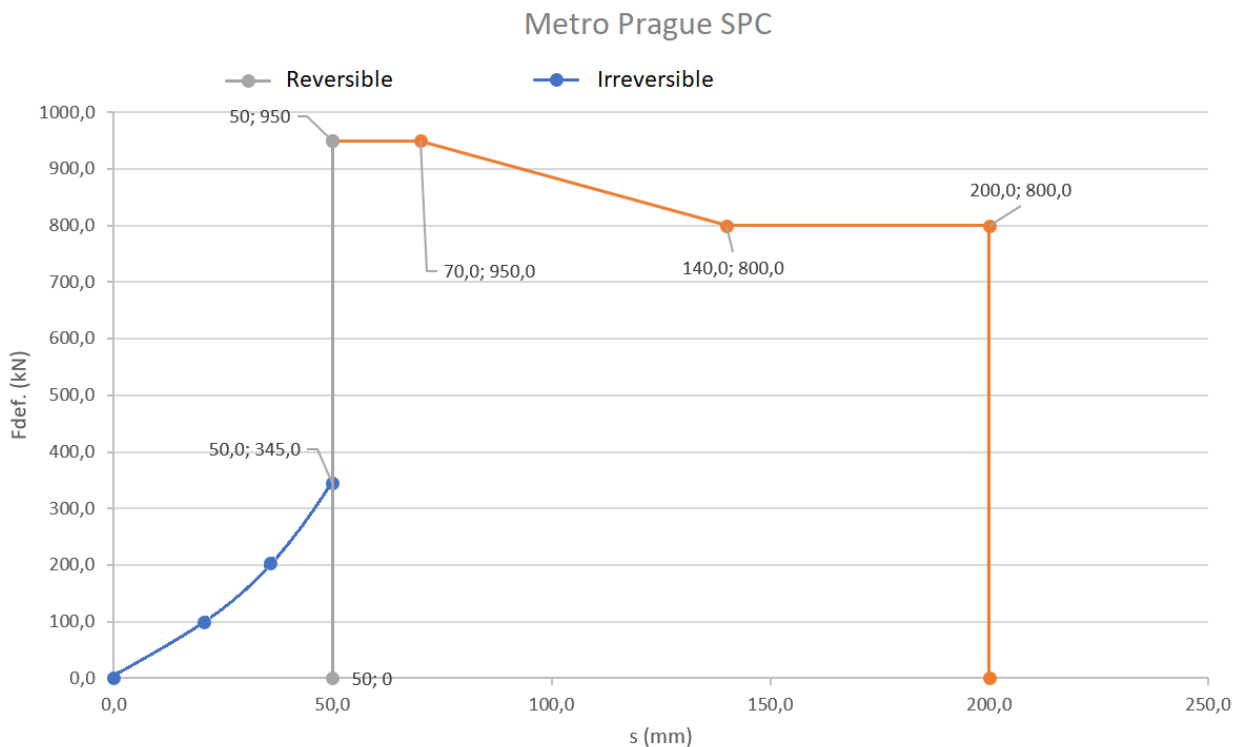
SPC as whole must be physically tested in conformity with EN 15227 by independent testing authority (see Paragraph E.6.4.3.3). The test has to prove minimally the fulfilment of the values given by theoretical curve determined in terms of the project.

The purchaser reserves the right to require the parameter adjusting of the deformation element according to requirements of the particular crash scenarios and vehicle design.

The reflexion label must be located on the deformation element which informs the service during the visual checking that the deformation force was exceeded and the deformation element of the coupler was triggered. The required form of the label is an arrow whose tip shows the non-triggered (new) state of the deformation element and the insertion of the arrow the rate of the passed deformation.

| Basic parameters of the deformation element |                  |
|---|------------------|
| Parameter                                   | Value            |
| Expected triggering force                   | 950 kN $\pm$ 10% |
| Expected deformation force                  | 800 kN $\pm$ 5%  |
| Expected deformation length                 | 150 mm           |

Table 10 – Basic parameters of the deformation element



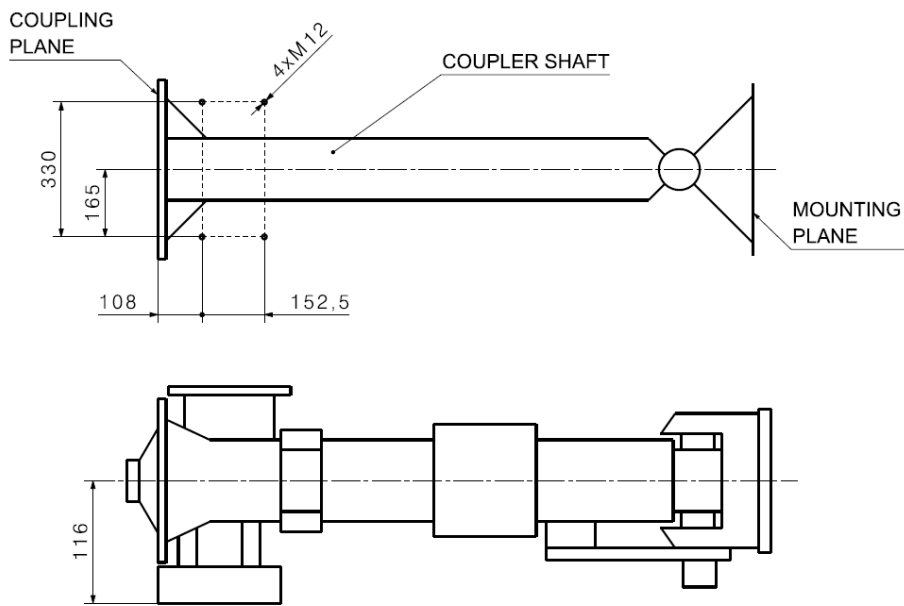
Picture 9 – SPC theoretical characteristic.

#### D.1.2.4 Equipment of the coupler

##### D.1.2.4.1 Electric connector interface

Bottom of the coupler will be equipped with 4 mounting points made via thread holes with dimension M12. These points will serve as an interface for electrical connector mounting.

The design of the connector interface must be unified for all intercoach coupler types. The design and dimensions of the interface are in picture 10.



Picture 10 - Position of electric interface

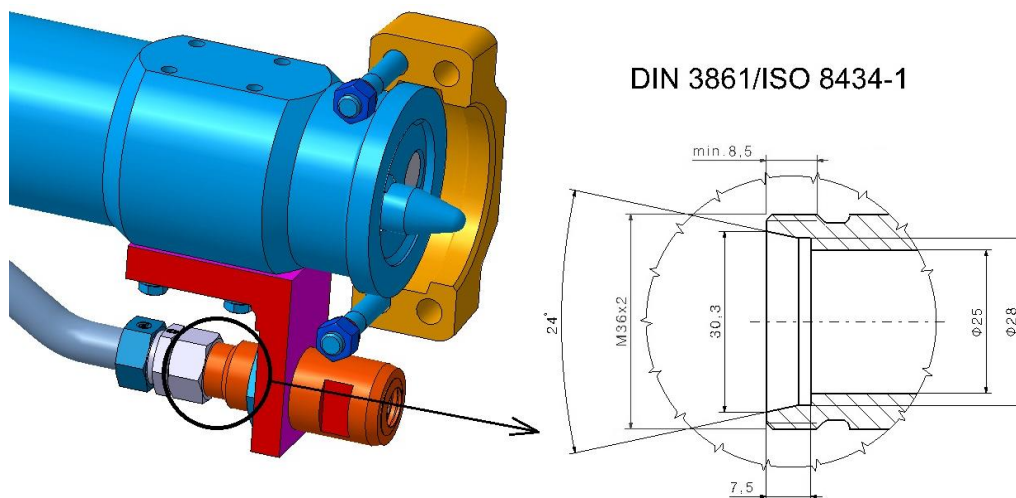
#### D.1.2.4.2 Pneumatic equipment

SPC must be equipped with pneumatic interface allowing montage of the pneumatic equipment. The interface should allow the placement of the cantilever on the bottom side of the coupler.

The pneumatic interface will have one-pipe design. The nominal diameter of the pipe is DN 25 mm. Thread design in accordance to ISO 8434-1, connection thread M36x2 – minimum length 8,5 mm, screw type. Operating pressure is 10 bar.

The pneumatic equipment must not affect the coupling capability. in case of breakdown of the couplers during their disruption the emergency braking of the train must be activated.

Flammable parts (hoses, sealings etc) must fulfil requirements of fire resistance in accordance to the main producer label must be located on the visible place of the coupler basis in accordance to the document TD080862.



Picture 11 – Pneumatic interface



D.1.2.4.3 Couplers labelling

See Paragraph D.1.1.4.2.

D.1.2.4.4 Earth connection

See Paragraph D.1.1.4.3.

## D.2. Technical part valid for all components

### D.2.1 Dynamic endurance of the design

The train in whole and its particular components including couplers must be dimensioned in such way to withstand the loads actuated by vibrations and acceleration (deceleration) in conformity with EN 12663-1, tables 13, 14, 15, 16, 17, 18 for the vehicle category P-III.

The component or its parts must not be spontaneously detached and drop on the track during the operation.

### D.2.2 Quality requirements

The product and materials quality and properties (especially from the point of view of fire reaction and health protection) are to be documented with the relevant certificates and protocols from accredited testing laboratories.

The materials used mustn't generate any bad or unusual smell.

### D.2.3 Quantities

| Quantities                          |          |   |
|-------------------------------------|----------|---|
| Coupler                             | Quantity | Note  |
| Semi-automatic front coupler – SAFC | 2 pcs.   | Coupler located on every end of the unit  |
| Semi-permanent coupler – SPC        | 4 sets   | The couplers coupled by the muff coupling create the coupling between other couches to the train set. |

Table 11 - Quantities

### D.2.4 Interchangeability

The component and the particular sub-components of the identical type must be completely 100 % interchangeable in all their parameters and dimensions. Each deviation must be discussed with the purchaser.

### D.2.5 Approval

The components, connecting material, calculation reports and documentation can be considered for approved (bilaterally approved) after client's approval only!

### D.2.6 Uncoupling time

The coupling and uncoupling of the coaches is not desired during their operation. The uncoupling time limits of coupling planes via skilled workers in depot conditions contains table 12. The design of components and sub-components must be carried out with regards to keep the time limit.

| Uncoupling times                              |            |                   |
|---|------------|-------------------|
| Coupling plane                                | Time (min) | Number of workers |
| Plane A (semi-automatic front coupler – SAFC) | 1          | 1                 |
| Plane B (semi-permanent coupler – SPC)        | 5          | 2                 |

Table 12 – Uncoupling times

The supplier of the component will also deliver the necessary tools, which will be used during the uncoupling sequence. The supplier must provide the description which is required for the uncoupling of the component into the technical description of the coupler.

The statement of the requirement on uncoupling times must be part of the offer documentation.

Verification of the uncoupling times will be a part of movement tests, see Paragraphs E.6.4.2.1, E.6.4.3.1.

## **E. SUPPLIERS'S RESPONSIBILITIES**

### **E.1. General requirements**

According to the document TD080862.

#### **E.1.1 Service life**

According to the document TD080862. The service life of the rubber segments must be not less than 8 years and must work error-free in the whole temperature scope given by this enquiry.

##### **E.1.1.1 Service life of couplers**

The service life of the component must correspond to the maintenance cycle of the vehicle. The service life and the guarantee must be documented in the direction to the purchaser of the component and the final client.

The service life of metal parts that are not subject to regular replacement must correspond to service life of the vehicle.

#### **E.1.2 Patent infringement**

According to the document TD080862.

### **E.2. Environmental conditions**

According to the document TD080862.

#### **E.2.1 External climatic conditions**

According to the document TD080862.

#### **E.2.2 Corrosion aggressivity**

According to the document TD080862.

#### **E.2.3 Power supply system parameters of car**

According to the document TD080862.

#### **E.2.4 Nominal circuit voltage**

According to the document TD080862.

#### **E.2.5 Vibration and shocks**

According to the document TD080862.

#### **E.2.6 Working conditions**

According to the document TD080862.

### **E.3. Design requirements**

#### **E.3.1 Construction - priorities**

According to the document TD080862.

### **E.3.2 Coordinate system of vehicle**

According to the document TD080862.

### **E.3.3 Structural and crashworthiness requirements**

According to the document TD080862.

### **E.3.4 Vehicle pressure loading**

According to the document TD080862.

### **E.3.5 Materials**

According to the document TD080862.

#### **E.3.5.1 Health safety**

According to the document TD080862.

#### **E.3.5.2 Material standards**

According to the document TD080862.

#### **E.3.5.3 Paints and corrosion protection**

According to the document TD080862.

##### **E.3.5.3.1 Corrosion protection of the couplers**

###### **The non-protected surfaces of corrosive materials are not allowed.**

The couplers are under the walking surface of the inter-coach gangway; the cleaning substances, water contaminated with thawing salt from the shoes in winter period and other chemical substances used for vehicle maintenance can drop away to them. It is necessary to take this fact into account during the designing and respect it during the proposal and using of chemical substances, lubrication greases and other substances which create the protection of the coupler design.

The contact surfaces, the precisely machined muff coupling surfaces and other surfaces without possibility of applying of sufficient protection coating layer are necessary to be protected by conservation greases of sufficient quality and thickness. The contact surfaces where it is necessary to reduce the friction value as most as possible, e. g. the contact surfaces of coupler bases, must be protected by the producer by such chemical substances which protect them against contact and atmospheric corrosion without any influence to the functionality of the screw connection or other functional and technical standpoints. It is necessary to pay attention especially to the contact surfaces bases.

The design must withstand the common cleaning substances, machine pressure washing and thawing salt as mentioned in Paragraph E.10.

##### **E.3.5.3.2 Colour scheme**

Surface finish of the couplers meets the requirements of the specification of surface finish F000004 in accordance to [4]. The specification/s is/are part of attachment of this demand. Final required shade is RAL 7022. in case that Supplier proposes in any range different surface finish - Supplier must give reasons for this decision, Supplier must respect corrosive aggression of environment, required lifetime and submit in its full extent technical and safety data sheets of used components in surface finish.

If any parts of component have no requirements on surface finish from Customer (usually inner hidden parts of component etc.), Supplier proposes the whole surface finish considering the placing of component, required lifetime and corrosive aggression of environment. Supplier will submit the whole overview of surface finishes of demanded component for Customer's assessment.

#### **E.3.5.4 Surface finish**

This point is valid in interaction with the document TD080862.

Only the materials of the relevant kind, quality and processing which are prescribed by relevant valid production documentation will be used for the production of all parts of the component. The producer will discuss any deviations from the valid documentation which can improve the product parameters in written form. Any other deviations aren't permitted.

**All materials must fulfil the requirements given by these technical requirements.**

**All materials must be able for ecological liquidation after the termination of their service life.**

The quality of materials, semi-finished products and parts is verified by check-out of the producer in conformity with the relevant valid production documentation and these technical requirements. The material sub-suppliers will document the conformity of the materials for the production to the component producer by the relevant certificate.

The certificates of all materials will be delivered always with the first supply. The producer commits himself that all certificates are valid in the time of product delivery.

The purchaser is allowed to carry out inspections in the supplier's production plant without any influence to law prescriptions regarding failure responsibility.

##### **E.3.5.4.1 Surface finish – inner area of leaves**

According to the document TD080862.

##### **E.3.5.4.2 Surface finish – outer area of leaves**

According to the document TD080862.

##### **E.3.5.4.3 Surface finish – other parts of the DLSD**

According to the document TD080862.

#### **E.3.6 Fire protection properties**

According to the document TD080862.

#### **E.3.7 Fire properties – Documentation of compliance of product with EN 45545**

According to the document TD080862.

#### **E.3.8 Rivet and screw connections**

According to the document TD080862.

The main screw connection of the component mounting to the vehicle must be oriented to enable the visual checking of the nut during the view to the front part of the vehicle. The nut must be always directed to the coupling plane.

Required risk classes of screw connections are given in TD080862. The supplier presents the list of screw connections classification in the strength analysis of the screw connections. The supplier submits his reference (technical recommendation) for the possibility to reuse the connection material after dismantling in case of risk class H.

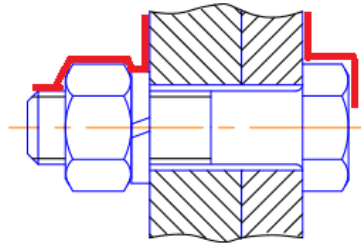
The connection material which will be hydrogenized during its technological working must be dehydrogenized to eliminate the possibility of hydrogen numbness.

##### **E.3.8.1 Tightening torque of the tighten screw connection and its orientation on the vehicle**

All screw connections on the component tightened for defined torque must be marked in the submitted documentation.

Each torque-tightened screw connection must be completed with the torque value including tolerance and marking of chemical substances and lubricants used for the screw connection treatment in the drawing.

These screw connections must be marked with the reflective paint stripe which will cover the whole component until the connected parts. This marking indicates that the connection was tightened for the defined torque during the production and wasn't loosened during the operation. For the example see picture 12.



Picture 12 – Example for torque-tightened screw connection marking.

### E.3.9 Welding

According to the document TD080862.

### E.3.10 Adhesive bonding

According to the document TD080862.

### E.3.11 Wiring and cabling

According to the document TD080862.

### E.3.12 Noise

According to the document TD080862.

### E.3.13 Weight

According to the document TD080862.

#### E.3.13.1 Weight limits

| Weight limits                              |        |
|--|--------|
| Parameter                                  | Value  |
| Semi-automatic front coupler (SAFC)        | 300 kg |
| Semi-permanent coupler (SPC)               | 275 kg |
| Semi-automatic intermediate coupler (SAIC) | 360 kg |

Table 13 – Weight limits

The mass and keeping of the mass limits must be declared by a weighting test protocol of the component, see Paragraphs E.6.4.2.3, E.6.4.3.4.

### E.3.14 Identification and description

According to the document TD080862.

### E.3.15 Degree of protection

According to the document TD080862.

**E.3.16 Electromagnetic interference and compatibility**

According to the document TD080862.

**E.3.17 Testing voltage**

According to the document TD080862.

**E.3.18 Software, communication and diagnostics**

According to the document TD080862.

**E.3.19 Electronic equipment requirements**

According to the document TD080862.

**E.3.20 Further requirements**

According to the document TD080862.

**E.3.21 Triangular key**

According to the document TD080862.

**E.4. RAM (Reliability, Availability, Maintainability)**

According to the document TD080862

**E.5. Safety**

According to the document TD080862.

**E.5.1 Safety relevant components**

According to the document TD080862.

**E.5.2 Requirements into safety integrity level**



## ROLE LIST

| Number  | Vehicle function |  | Safety requirements  | Threat occurs when ...   | Examples   | Danger - description  | Classification |                 | Risk acceptance principle | Note   |
|---------|------------------|--|--|--|--|---|----------------|-----------------|---------------------------|--|
|         | Function         | Vehicle Function (ČSN EN15380-4)   | Safe securing of what ...  |  | Type themes / elements   |   | SAS            | THR             |                           |  |
| BE-5a-1 | BE               | Transport and protect passengers, train crew and cargo - Protect from fire | Isolation and prevention of spreading of fire, limitation of generation of fumes | If there is a fire and its subsequent spread and spread of fumes | Selection of interior and exterior material according to valid standards, isolation of potential sources of fire | burst into flame, fire, spreading of smoke - Fire hazard due to smoke spreading | 2              | min 1E-6 - 1E-7 | Code of correct practice  | Material analysis in terms of fire resistance<br><br>HL3 according to ČSN EN 45545 |

|           |     |  |   |  |  |   |   |      |                          |   |
|-----------|-----|--|---|--|--|---|---|------|--------------------------|---|
| CEG-10d-1 | CEG | Provide appropriate conditions for passengers, train operators and cargo<br>Provide a comfortable / reasonable climate -<br>Protect against pressure waves | Hearing protection (Passengers and Driver) and keeping attention (Driver) | At high noise levels, person may be disoriented, passengers may lose balance, unfocused / tired driver | vehicle noise analysis, compliance with set limits           | Sufficient conditions for staying in the vehicle (driver's cab, passenger compartment) cannot be guaranteed -<br><br>Danger due to high noise level | 0 | 1E-5 | Code of correct practice | Noise level recording                                       |
| DB-12c-1  | DB  | Provide access and loading -<br>Provide external access  | Emergency services access in case of extraordinary event                  | If the emergency services cannot secure and transport injured persons in time                          | Evacuation windows, access plan for local emergency services | Failure to handle extraordinary events -<br><br>Insufficient access in case of emergency (eg door opening from outside)                             |   |      | ---                      | The risk is not further regulated beyond existing measures. |

|          |    |  |   |   |  |   |   |                 |                          |   |
|----------|----|--|---|---|--|---|---|-----------------|--------------------------|---|
| DB-4a-1  | DB | Provide access and loading -<br>Provide external access      | Ensuring safe boarding and getting off passengers in stations | Loss of balance by catching the door mechanism, catching and crushing the limb, unexpected gap or step during getting off | Standard mechanism covering, absence of sharp corners on possible contact points during passage  | Danger during boarding or getting off - Danger for passengers in entrance or exit areas   | 0 | 1E-5            | Code of correct practice | Meet Standards for entrance / exit areas        |
| DC-12a-1 | DC | Provide access and loading -<br>Provide internal door access | Evacuation of passengers from standing train                  | Passengers are exposed to the effect of combustion products for a longer period during slow evacuation.                   | Sufficient number of doors, evacuation windows, walk-through train and evacuation doors on the fronts of the train, operating rules for evacuation | Failure to handle extraordinary events -<br><br>Evacuation of persons is not possible in case of emergency. Escape exits are not sufficient (eg driver's door, emergency exits) | 1 | min 1E-5 - 1E-6 | Code of correct practice | Compliance with standards and local regulations |

## **E.6. Tests**

### **E.6.1 Type test**

According to the document TD080862.

### **E.6.2 System test**

According to the document TD080862.

### **E.6.3 Routine test**

According to the document TD080862.

## **E.6.4 Components tests**

### **E.6.4.1 General**

This point is valid in interaction with the document TD080862.

The test methodology must be bilaterally approved at the latest one week before the test performance if not provided in other way for the particular test (see furthermore).

The component tests must be carried out under presence of purchaser. If the purchaser cannot be present and also in case of the tests when it is explicitly required (see furthermore) the HD video and photographic record must be acquired. These records will be submitted to the purchaser at the latest one week after the test termination.

The relevant protocols which document the fulfilment of determined conditions must be acquired from all tests. The input conditions can be after the bilateral agreement of the supplier with the purchaser completed and modified on the base of project development and knowledge stage during the component development.

### **E.6.4.2 Semi-automatic front coupler (SAFC)**

The automatic coupler must be tested in conformity with the test requirements – see par. 5 of EN 16019. The requirements should be edited corresponding the head type.

- Type tests (EN 16019, par. 5.1)
- Routine tests (EN 16019, par. 5.2)
- Functionality test of the pneumatic connection is required

#### **E.6.4.2.1 Semi-automatic coupler movement test**

The movement test will be carried out on the supplier's or independent testing laboratory test bench. The coupler function and the fulfilment of the declared coupler deflections in all three axes x, y, z must be demonstrated.

The test of coupling and uncoupling must be carried out during the movement test.

The component will be sufficient in that case only, if no permanent deformations and damages will occur. The noise emission generated by the component, run smoothness, damage etc. will be followed.

The parameters and boundary conditions of the test must be discussed with the purchaser and bilaterally approved at the latest one week before the test.

The test will be considered for successful only in the case when the test verifies the theoretical proposed coupler parameters.

#### **E.6.4.2.2 Semi-automatic coupler dynamic test**

The functionality of the deformation element must be proved by successfully terminated dynamic test of the complete coupler – “crash test”. The test will be considered for successful only in the case when the test verifies the theoretical proposed coupler and deformation element parameters. The test must be carried out by accredited independent testing laboratory.

The coupler supplier proves by this test that the coupler proposed by him and the calculations and simulations carried out by him are fulfilled.

The test parameters and test speeds must be in conformity with EN 15227 including axial offset in vertical direction in minimally 40 mm.

The obtained dependencies deformation force – length will be used for the crash simulation model validation.

The purchaser reserves the right to require also the function test of the reversible stroke in case of necessity.

The parameters, boundary conditions and test methodology must be discussed with the purchaser and bilaterally approved at the latest two weeks before the test.

The test executor elaborates the evaluation report which will contain among others also the measured characteristics of coupler deformation in all selected test scenarios. The video and picture documentation must be provided and submitted at the latest with the final test report.

#### E.6.4.2.3 Strength test of couplers

The SAFC shall be subjected to strength test by both tensile and compressive force at maximum designed level, to demonstrate compliance with strength calculations as well as the full functionality and safety of components for operation.

The test must demonstrate that:

- The components can withstand the forces that are required and the properties required by this document are met.
- The force must be applied gradually up to the maximum tensile or compressive load and remain in this mode for at least 5 minutes.
- There must not be any permanent deformation on the component.
- Uncoupling or burst of couplers / coupler neither buckling of the coupler must not occur.

After the test must be performed:

- Uncoupling test of the component.
- Movement test.

Checking of the dimensions of the component (length of the coupler).

The test must be performed by an independent certified laboratory. Among the test results shall be a chart displaying achieved loading forces.

The test results must be documented and summarized in a report.

The complete conditions and test specification are mutually agreed between the purchaser and the supplier, no later than 10 working days before testing. The test must be made no later than during the first article inspection (FAI).

The test can be regarded as successful, if all the above requirements are met and full functionality and readiness of the component to the next function has been demonstrated.

Compression forces will increase until destruction of the coupler – activation of shear-off element. Buckling of the coupler cannot occur during the test.

#### E.6.4.2.4 Weight test of the components

The weight test of the components and tools will be carried out on the calibrated scale with valid calibration sheet. The weight of the components and tools must be recorded and confronted with the maximum mass determined in the drawing documentation.

The test will be considered for successful only in the case when the measured weight doesn't exceed the values presented in the documentation.

The parameters and boundary conditions of the test must be discussed with the purchaser and bilaterally approved at the latest one week before the test.

#### E.6.4.2.5 Compatibility test

Test of compatibility shall be performed with SAFC head and other heads used in Metro Prague. Purpose of this test is to check compatibility and correct function when coupling with other vehicles. The test shall be performed with every single vehicle type (ČKD M1 vehicle).

Test shall simulate following operation sequence:

- automatic coupling,
- running of two coupled vehicles (manipulation, especially towing),
- manual uncoupling.

The test is successfully evaluated in the case that all coupler heads are correctly coupled and uncoupled. Failures and any signs of malfunctioning are forbidden during the test. Both coupler heads (Škoda Train and other trains) should be checked for damage like scratches and cracks after the test.

### **E.6.4.3 Semi-permanent coupler (SPC)**

#### **E.6.4.3.1 Movement test of couplers**

The movement test will be carried out on the supplier's or independent testing laboratory test bench. The coupler function and the fulfilment of the declared coupler deflections in all three axes x, y, z must be demonstrated.

The test of coupling and uncoupling must be carried out during the movement test.

The component will be sufficient in that case only, if no permanent deformations and damages will occur. The noise emission generated by the component, run smoothness, damage etc. will be followed.

The boundary conditions of the test must be discussed with the purchaser and bilaterally approved at the latest one week before the test.

The test will be considered for successful only in the case when the test verifies the theoretical proposed coupler parameters.

#### **E.6.4.3.2 Uncoupling test**

The uncoupling test will be carried out by the supplier. The requirement of uncoupling time must be approved see table 12.

#### **E.6.4.3.3 Dynamic test of couplers**

The functionality of the deformation element must be proved by successfully terminated dynamic test of the complete coupler – "crash test". The test will be considered for successful only in the case when the test verifies the theoretical proposed coupler and deformation element parameters. The test must be carried out by accredited independent testing laboratory.

The coupler supplier proves by this test that the coupler proposed by him and the calculations and simulations carried out by him are fulfilled.

The test parameters and test speeds must be in conformity with EN 15227 including axial offset in vertical direction in minimally 40 mm.

The obtained dependencies deformation force – length will be used for the crash simulation model validation.

The purchaser reserves the right to require also the function test of the reversible stroke in case of necessity.

The parameters, boundary conditions and test methodology must be discussed with the purchaser and bilaterally approved at the latest two weeks before the test.

The test executor elaborates the evaluation report which will contain among others also the measured characteristics of coupler deformation in all selected test scenarios. The video and picture documentation must be provided and submitted at the latest with the final test report.

#### **E.6.4.3.4 Strength test of couplers**

The SAFC shall be subjected to strength test by both tensile and compressive force at maximum designed level, to demonstrate compliance with strength calculations as well as the full functionality and safety of components for operation.

The test must demonstrate that:

- The components can withstand the forces that are required and the properties required by this document are met.
- The force must be applied gradually up to the maximum tensile or compressive load and remain in this mode for at least 5 minutes.

- There must not be any permanent deformation on the component.
- Uncoupling or burst of couplers / coupler neither buckling of the coupler must not occur.

After the test must be performed:

- Uncoupling test of the component.
- Movement test.
- Checking of the dimensions of the component (length of the coupler).

The test must be performed by an independent certified laboratory. Among the test results shall be a chart displaying achieved loading forces.

The test results must be documented and summarized in a report.

The complete conditions and test specification are mutually agreed between the purchaser and the supplier, no later than 10 working days before testing. The test must be made no later than during the first article inspection (FAI).

The test can be regarded as successful, if all the above requirements are met and full functionality and readiness of the component to the next function has been demonstrated.

#### E.6.4.3.5 Weight test of the components

The weight test of the components and tools will be carried out on the calibrated scale with valid calibration sheet. The weight of the components and tools must be recorded and confronted with the maximum mass determined in the drawing documentation.

The test will be considered for successful only in the case when the measured weight doesn't exceed the values presented in the documentation.

**The parameters and boundary conditions of the test must be discussed with the purchaser and bilaterally approved at the latest one week before the test.**

#### E.7. Spare parts

According to the document TD080862.

#### E.8. Consumable supplies

According to the document TD080862.

#### E.9. Guarantee, system fault, penalization for failure non-removal

According to the document TD080862.

#### E.10. Maintenance

According to the document TD080862.

## **F. BACK-UP TECHNICAL DOCUMENTATION**

### **F.1. Requirements which are concerning with technical and operational documentation of metro cars and their components**

According to the document TD080862

### **F.2. Documentation delivered with each piece**

According to the document TD080862.

### **F.3. Documentation delivered with first delivery**

According to the document TD080862.

### **F.4. Documentation delivered for project and design elaboration of vehicles**

According to the document TD080862.

### **F.5. Documentation delivered with offer**

According to the document TD080862.

### **F.6. Other documentation**

According to the document TD080862.

### **F.7. Selected documentation version**

According to the document TD080862.

### **F.8. Simulation and calculation reports**

#### **F.8.1 Simulation report of automatic coupler coupling**

The supplier creates the simulation report which will document the sufficient dimensioning of the automatic coupler reversible element. The automatic coupler must be dimensioned to absorb safely the energy loosen during the coupling of two identical units with operational mass at the speed of 5 km/h without any damage of couplers and vehicles.

This condition must be documented by simulation report by coupler supplier. The preliminary simulation report must be part of the offer documentation, see Paragraph H.1.

The boundary conditions of the report must be discussed with the purchaser and bilaterally approved.

The simulation report must be bilaterally approved by the supplier and purchaser.

#### **F.8.2 Strength analysis of the couplers**

The supplier creates the strength analysis of:

- Semi-automatic front coupler,
- Semi-permanent flexible coupler,
- Semi-automatic intermediate coupler with electrical head,

which will document the ability to safely transfer the forces declared to the component in full scope of deflections and with inclusion of the safety coefficients in accordance with EN 12663-1, Paragraph 5.4.

The strength analysis must include calculation of static as well as fatigue strength in accordance to EN 12663-1, Paragraph 5.6. The strength analysis must prove that the components fulfil requirements specified by TSI legislation and EN standards.

Welds must be assumed in accordance to EN 12663-1 and the fatigue must be evaluated in accordance to DVS 1612.

During the homologation process of the vehicle a requirement can occur to the component supplier to carry out a static test proving fulfilment of legislative requirements on draw/compression loads including



check of flexible stroke characteristics for selected components. This requirement is at the moment an option only.

**Part of the calculation shall be buckling calculation considering the same load conditions as defined in paragraphs E.6.4.2.3, E.6.4.3.4 of this document.**

All design groups stressed during the component function including muff coupling, coupling interface and automatic coupler head must be reflected in the report.

The boundary conditions of the report must be discussed with the purchaser and bilaterally approved.

The simulation report must be bilaterally approved by the supplier and purchaser.

### **F.8.3 Strength analysis of screw connections**

The supplier creates the strength analysis of all screw connections between the components and vehicle structure; further of all other functional screw connections on which depends the right components function and documents the ability of screw connection to transfer safely the forces which are declared on the component.

The supplier carries out mandatory the strength analysis of the screw connections used on the universal interface including torques determination and proposal of chemical substances destined for lubrication.

The worst component load during the superposition of full horizontal and full vertical deflection in both draw and compression regime of the coupler must be considered as one of the calculation scenarios.

The minimum safety coefficient  $k = 1.25$  must be considered.

The strength analysis must be crowned by the commenting report of the calculation results.

All design groups of the component which are stressed during the component function must be regarded in the report.

**Among others, the following must be the report result:**

- Definition of boundary conditions,
- Strength analysis of screw connections for fixation of the component to the vehicle structure,
- Strength analysis of the other functional screw connections on which depends the right component function,
- Determining of friction coefficients (in the thread, under the screw head),
- Tightening torques calculation and determined assembly tolerance ( $\pm$  value %),
- Proposal of lubricants and chemical substances for treatment of particular connections.

The torque box end spanner will be used for the assembly of the component to the vehicle structure. The tightening factor value in the range of  $\alpha_A = 1.2 \div 1.6$  must be selected.

The boundary conditions of the report must be discussed with the purchaser and bilaterally approved.

The simulation report must be bilaterally approved by the supplier and purchaser.

## **G. OTHER REQUIREMENTS**

### **G.1. Client's training**

According to the document TD080862.

### **G.2. Manufacturing requirements**

According to the document TD080862.

### **G.3. Preservation**

According to the document TD080862.

### **G.4. Packaging and protection**

According to the document TD080862.

### **G.5. Transportation**

According to the document TD080862.

### **G.6. Storage**

According to the document TD080862.

### **G.7. Installation**

According to the document TD080862.

### **G.8. Initial starting of component/system**

According to the document TD080862.

### **G.9. Obsolescence of items**

According to the document TD080862.

### **G.10. Recycling**

According to the document TD080862.

### **G.11. Supplier requirements**

According to the document TD080862.

### **G.12. List of key technical standards and regulations related to the vehicle**

According to the document TD080862.

### **G.13. Safety, hygiene and impact on the external environment**

According to the document TD080862.

The design of all coupler elements must be designed in such a way that the possibility of injury to passengers or maintenance personnel is avoided during operation. Particular emphasis is placed on protruding parts outside the vehicle and the edges of the coupler surface that may in any way come into contact with the vehicle operator or passengers. All parts that are in contact with the operator and service personnel must have rounded edges with a minimum radius  $R_{Pmin} = 3\text{mm}$ .

## H. OFFER PROCESSING

According to the document TD080862.

### H.1. Documentation included in the offer

**Required documentation handed over with the offer:**

- Assembly drawings of the couplers including the main dimensions. These dimensions must describe the main sizes of the components. The drawing must contain the design of electric connector interface; the centre of gravity (COG) position of the component must be presented in the drawing.
- 3D model of the offered components in STEP format or IGS, volume model required.
- The supplier shall provide quotation of the components mentioned in this inquiry.
- The supplier shall provide estimated time schedule of works on the components planned for the development, production and test.
- The information about the torsional stiffness of the couplers [Nm/deg] must be a part of the documentation.

## I. ANNEXES

| List of related documents |   |                             |
|---------------------------|---|-----------------------------|
| No                        | Title   | Number and type of document |
| 1                         | GENERAL TECHNICAL REQUIREMENTS FOR PRAGUE METRO PROJECT'S SUBDELIVERIES | TD080862                    |
| 2                         | COUPLING SYSTEMS CbC TABLE  | TD082990_CBC                |
| 3                         |   |                             |
| 4                         |   |                             |

Table 14 – List of related documents

### I.1.1 CbC document

The CbC document (Clause by Clause) is made for the bilateral obligatory approval of the delivered components parameters. The document is compiled as a set of tables which describe the general part of the technical specification TD080862 and the technical part which describes the properties of inquired components and requirements to the supplier which are described in this document. The tables are compiled of particular points and chapters which are presented in both inquiry documents.

**The supplier is obliged to express himself to each point and to write down if fulfils or doesn't fulfil the particular point.**

The CbC document is made for the evaluation of the possibilities of the particular inquired suppliers and will be approved and locked after the termination of the design contest with the winning supplier.

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