1 Variable spring supports

1.1 Application

Rigid supporting structures are not capable to accommodate vertical displacement or large horizontal forced travels of piping. This nodes should be supported by spring hangers and spring supports. Variable spring supports are recommended for vertical displacements of piping up to 50–75 mm. Application of constant supports needs to be considered for higher values. Springs supports are designed for application in assemblies comprising hangers or piping supports according to the summary shown in pages B.5–B.7.

The MPS Gradior s.r.o. standard series of variable spring supports are designed for the load range between 0.2 kN to 108 kN. Higher loads require multi-spring supports with capacity up to 432 kN. Standard range of springs is designed in three nominal travel ranges of 50, 100 and 200 mm. Requirements for larger travel may be met by coupling several springs into a series to obtain the total nominal travel of 300 to 400 mm. The operating temperature range for springs is -40 °C to +80 °C or even up to +150 °C for short-term exposure. Any lower or higher temperature would result in change of spring force due to the change in shear modulus with the dispersion of +1.6 / -1.6 %. Change of spring force is proportional to the values above lower or higher temperature range. The spring service life for cyclic stress within the range of load change of 25 % higher than 1E5 full load amplitudes. The tolerance of spring rate is less than 5 % compared to the theoretical value.

Spring supports are covered to ensure operation safety, when the tube casing and plates prevent potential injuries on touch. However, the spring unit is not sealed off completely and is not secured against ingress and deposits of dust. That is why very dusty environments, i.e. ceilings of coal burning boilers, require cleaning of spring support interior using compressed air. Under such circumstances, the relevant purchase order shall include a literal specific requirement for cleaning options. The unit surface is galvanized as standard, outdoor applications in highly corrosive environment or primary circuits of nuclear power plants, where galvanized surfaces are not acceptable, can be treated by means of additional surface finishing using epoxy coating.

1.2 Design

The spring unit is designed with a pre-compressed springs inside a cylindrical casing, elements for indication of elevation (force) and turnbuckles for adjustment of spring force settings. Compensation of angular tolerances of spring and corrections of tolerances is enabled by the spherical bearing of in-built threaded rod, to ensure alignment of the rods without any additional bending. Spring units are delivered blocked to required set load. This blocking is ensured by means of shim device inserted into spring shell apertures and embraced with a safety tape. The device needs to be removed from the spring unit after piping pressure test, before the operation start up! The load capacity of spring unit lock during pressure test is double the nominal spring load.

1.3 Materials and Technologies

Helical coil springs for all variable spring supports are manufactured from SH grade materials acc. to EN 10270-1 for cold-coiled spring and grade 51CrV-4 compliant with EN 10089 for hot-coiled springs. Springs are quenched to the required level and pre-compressed to the block length prior to their insertion into units to achieve the spring presetting, when the creep yielding will be stabilized and pre-torsioning develops in the wire surface. Further loading will not cause any significant relaxation and the spring force will remain within the range under 2.5 % of the operating force. Springs have been designed using the non-linear elasto-plastic calculation model derived by the company MPS Gradior s.r.o.
1.4 Review of Spring Support Types

Specific type version of a spring unit is designated by the last character of the three digits specifying type number. To simplify identification, so that the second character does not have to cover all travel versions, the designation of type is written as simple as 1x2 (the second character is replaced with the "x" symbol).

Spring units are supplied as single-spring (types 1.1–1.4 and 1.6–1.7) or multi-spring (types 1.5 and 1.8). Particular design versions divided according to integration methods are described further below.

<table>
<thead>
<tr>
<th>Type 1x1</th>
<th>Range: 0.2–108 kN</th>
<th>Travel: 50, 100, 200 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1x2</td>
<td>Range: 0.2–108 kN</td>
<td>Travel: 50, 100, 200 mm</td>
</tr>
<tr>
<td>Type 1x3</td>
<td>Range: 0.2–108 kN</td>
<td>Travel: 50, 100, 200 mm</td>
</tr>
<tr>
<td>Type 1x4</td>
<td>Range: 0.2–63 kN</td>
<td>Travel: 50, 100, 200 mm</td>
</tr>
<tr>
<td>Type 1x5</td>
<td>Range: 48–432 kN</td>
<td>Travel: 50, 100 mm</td>
</tr>
<tr>
<td>Type 1x6</td>
<td>Range: 0.2–63 kN</td>
<td>Travel: 50, 100 mm</td>
</tr>
<tr>
<td>Type 1x7</td>
<td>Range: 0.2–108 kN</td>
<td>Travel: 50, 100, (200) mm</td>
</tr>
<tr>
<td>Type 1x8</td>
<td>Range: 48–432 kN</td>
<td>Travel: 50, 100 mm</td>
</tr>
</tbody>
</table>

Selection of spring size: required load under any piping operation and occasional conditions shall be within the range of selected spring operating characteristics. Further, the travel reserve is required to min. 5 mm or 20 % of the pipe displacement value. The selection of spring size shall also accommodate changes to the set load of spring by 10 %. Spring units also feature the so called "hidden travel allowances", i.e. 5 mm above the rated minimum or maximum. However, this allowance may not be relied upon during spring selection.

Caution: Displacement of the pipe above the lowest value of operating travel of spring support may impose the risk of complete spring alleviation!

Additional load is determined by the so called “dead forces” that are equal to the sum of loads on those parts of hanger or support assembly, which perform a displacement together with pipe. Those include mainly clamps, beams, supports and parts of rods below the spring support. It shall be added to the values of set load, obtained from piping flexibility analysis, when the dead forces exceed the approximate value of 0.01 to 0.02 multiple of calculation forces. The design load of spring is then determined by the formula \( F_{m} = F_{i} + \Sigma G \), where \( F_{m} \) refers to the force obtained through analysis of pipe for n-th load condition and \( \Sigma G \) is the sum of weights of moving assembly parts. The additional force is usually calculated with the accuracy to 0.002 multiple of the calculation force.

Selection of nominal travel is defined by the condition of load change between hot and cold condition respectively. The load change condition is determined using the following formula:

\[
\Delta F = \frac{(F_h - F_c)}{F_h} < 25 \%
\]

where \( F_c \) refers to hot load and \( F_h \) is the cold or set load respectively. Springs with lower travel show greater load changes due to higher stiffness, yet their application is more economical for their lower weight. Higher values of load change are acceptable if confirmed by the piping flexibility analysis.

Correction of design displacement is performed in case of the total displacement comprising the result of vertical and horizontal displacement exceeds 2.5 mm, or, if the travel reserve is below 10 mm. These values occur with approximately 4° deviation of rods exceeding 1 m per hanger length. The total design displacement of spring support is given by the formula \( s = u_1 + u_2 \cdot \tan(a/2) \), where \( u_2 \) refers to the vertical displacement obtained through pipe analysis, \( u_1 \) is the resultant horizontal displacement of pipe at the particular node, and \( a \) is the angular deviation of hanger rod. However, some software would calculate the combined displacement when the length of hanger rod is entered, such situation does not require any further correction.

1.5 Declination of Hanger Rod

Standards applicable to piping design require the assurance of the hanger rod declination to 4° from its vertical position in every direction. Spring units types 1x1–1x4 shall be therefore considered with respect to its characteristics described in the text below.
1 Variable spring supports
Design Instructions

a/ Spring Supports Type 1x1 and 1x2
These are used for assemblies SH1, SH2, SH4, SH5, SH8 and other. These are integrated into hanger rod between two joints. Horizontal displacement of pipe declines the full rod with spring unit, where the rod remains theoretically direct when passing through spring support. In this case, the angular deviation is limited only by parameters of swing joints in pipe clamps and attachment to structure, that is why spring cages do not require any check or specifications of special designs. The weight of spring support obviously results in slight “cranking” of link between both end points of the rod resulting in tilt inside the spring unit that is, however, balanced by the spherical pad on the interior spring plate.

b/ Spring Supports Type 1x3 and 1x5
These are used for assemblies SH3, SH6, SH10, SH13, SH21 and other. These are located on the auxiliary structure and the hanger rod is fitted in the joint cradle above spring support. The rod is passing through the inner diameter of spring as well as the space determined by planes of girders below the spring support. Horizontal displacement of pipe declines the rod passing through the spring; its deviation therefore requires consistent checking. That also depends on rated spring travel, as springs with high travel are long and the cathetus of the imaginary triangle developed is short. Springs with travel of 200 mm are applicable for rod declinations up to 2.5° only. Higher values require use of type 133A, see the relevant catalogue sheet for details. Another parameter to be checked is the collision of rod with girder webs under the spring support.

c/ Spring Supports Type 1x4
These are used for assemblies SH7 and SH15. They are fitted to the beam, when the hanger rod extends out of the spring support up to the top swing joint. Inside the spring, this rod is attached to the central unit plate via the spherical pad representing the second swing joint. Displacement of pipes results in declination of rod passing through the spring, its deviation therefore shall be checked. It depends on the nominal spring travel, as springs with high travel are long and the cathetus of imaginary triangle developed is short. Supports with travel of 200 mm are applicable for rod deviations of up to 2.5° only. Higher deviations require installation of type 134A, see the relevant catalogue sheet for details.

1.6 Displacement on Spring Supports
Standards applicable to piping design require assurance that the horizontal force developed by displacement of pipe does not exceed 0.07–0.3 multiple of the vertical load, depending on displacement. This condition can be met by suitable selection of elements in pipe support assembly. The assembly further requires verification of stability, as described further below.

a/ Spring Supports Type 1x7 and 1x8
Weld-on or clamped support is placed onto the flat head of spring unit with diameter D1, as specified in catalogue sheet. Horizontal displacement of pipe develops friction forces. The friction surface of metal-metal type may be used for horizontal displacement of up to 0.1 x nominal spring travel. The use of spring supports with PTFE slide plate in head is recommended for higher displacement levels. The support in pair requires polished slide surface made of stainless steel (design “T”). Further checks shall be focused on displacement allowances. Axial and lateral displacements require the allowance determined by distance between the spring support head and the edge of support base. Lateral displacement of clamp supports further require verification of assembly stability against spinning of clamps and pipe (cranking of support). That occurs approximately after lateral displacement of 0.4 × D1, where D1 refers to the diameter of spring support head. When higher displacement required, the clamp support shall be secured against spinning by means of attachment and shape joint.

b/ Spring Supports Type 1x6
These are equipped with rod ends that enable tilt by 6°. These are used in assemblies that require minimum resistance to horizontal movement. However, the analysis of piping flexibility requires verification, whether the node cannot develop any higher horizontal displacement of pipe, exceeding the anticipated level; that is due to various inaccuracies or very low flexibility of the piping or kinematic uncertainty of certain section. It is recommended to stabilise the piping using guides in adjacent nodes, i.e. to force nodal displacement of rigid strut at a single specific and possible direction required.
1 Variable spring supports

Design

1.7 Design of Particular Spring Unit Types

Eye – Rod Spring Unit
Type 1x1
Spring unit for attachment to the structure via welding eye and connection of rod to the turnbuckle. It is suitable for assembly with short assembly length. It may be also used in assemblies for seismic applications, when the spring in the rod centre is not secured against oscillation.

Rod – Rod Spring Unit
Type 1x2
Spring unit for the most common applications, attached into the threaded rod. The spring support may be located at any point on the rod; the only restriction is the option for adjustment of rod length by means of built-in turnbuckle. Its position on the rod shall be selected in such manner to prevent the spring support from collisions, spring unit shall be visible and accessible for adjustment purposes.

Beam top attachment
Spring Unit Type 1x3
Spring unit for installation on a pair of beams using a securing sheet featuring slots for bolting. The rod passes through the spring centre and it is attached to the top of spring support via a nut and lock nut set onto a spherical washer to enable tilting.

Beam to rod Spring Unit
Type 1x4
Spring unit for attachment to threaded rod and beam to set the support. Used for double-rod hangers of horizontal pipes. Attachment to the beam type 334 using bolts and pivot. The assembly is applied in restricted areas that require low construction height of hangers. Higher displacements of pipe need to be checked for compliance of rod declination values as specified in the relevant catalogue sheet.

Rod end Spring Unit
Type 1x6
Spring supports for attachment on structure and clamp support via rod ends. Suitable for assemblies with horizontal pipe displacement that require elimination of the effect of friction. The maximum deviation of support from its vertical axis shall be limited to 6°. The design of this support also enables additional height adjustment.

Spring Support Type 1x7
Spring support for attachments on structure using bolts and mounted to slide under pipe support. It is suitable for any regular assembly without the need for stabilisation. For horizontal displacement of pipe set on, exceeding 10 mm, the spring support of type 1x7T shall be used, fitted with a sliding head PTFE plate.
1.8 Marking

Spring supports are marked by two different means:

1. **Shortened labels** – used for code marking of assemblies only. This marking specifies the size and nominal travel of spring but it does not differentiate between various types.

   Number designating spring size as shown in Table 1.2, pg. 1.6.

   Number designating spring travel as shown in type number marking.

   Marking example: Designation of spring with load capacity of 12.000 N and nominal travel of 100 mm: the code No. **6.2**.

2. **Marking with type number** – is used for specification in purchase orders. Type number comprises the size and travel code, as well as specification of the spring support type.

<table>
<thead>
<tr>
<th>1 – variable spring support product group</th>
<th>1 – nominal travel of 50 mm</th>
<th>2 – nominal travel of 100 mm</th>
<th>3 – nominal travel of 200 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – spring unit for hangers, eye-rod attachment type</td>
<td>1 – spring unit for hangers, rod-rod attachment type</td>
<td>3 – spring unit for hangers, beam-rod attachment type</td>
<td>4 – spring unit for beam for double-rod hangers of horizontal pipe</td>
</tr>
<tr>
<td>5 – multi-spring unit, beam-rod attachment type</td>
<td>6 – spring support, attachment with two joint lugs</td>
<td>7 – spring support, slide surface – beam attachment type</td>
<td>8 – multi-spring support, slide surface – beam type</td>
</tr>
</tbody>
</table>

   Nominal load in (N), see table on pg. 1.6.

For marking examples see catalogue sheets for particular spring types.
1.9  **Spring Characteristics**

Single-spring units for hangers and supports are divided into twelve basic nominal load sizes ranging from 0.2 to 108 kN. Nominal load is defined by spring maximum operating load of spring in N and the operating travel. Size of spring marked with a number 1–12 corresponds with its nominal load. Characteristics of load-travel values for all spring sizes and spring rates relevant to particular nominal travel values are shown in the table below.

The table with spring characteristics relates to cage types 1, 2, 3, 4, 6 and 7.

Each of these cages is provided with a single spring only. For bearing capacity classes that determine the joining dimension of rod (see summary on pg. A.11) refer to the bottom line.

<table>
<thead>
<tr>
<th>Spring size</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal load FN (kN)</td>
<td>0.6</td>
<td>1.2</td>
<td>2.3</td>
<td>4</td>
<td>7</td>
<td>12</td>
<td>21</td>
<td>36</td>
<td>51</td>
<td>63</td>
<td>84</td>
<td>108</td>
</tr>
<tr>
<td>Load group</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

### Table 1.1 – Summary of Nominal Loads

<table>
<thead>
<tr>
<th>Operating travel (mm)</th>
<th>50</th>
<th>100</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring size</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Load (kN)</td>
<td>0</td>
<td>0.20</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Every spring is pre-set into the unit to the basic preload (with the label displacement value of 0 mm), which is equal to one half of the nominal travel. That means the default preload for nominal travel of 50 mm is 25 mm, the default pre-load for rated travel of 100 mm is 50 mm and the value for rated travel of 200 is 100 mm.
Multi-spring units for hangers and supports are divided into four nominal load sizes ranging from 48 and 432 kN. Spring sizes marked with number 13–16 corresponds with its nominal load. Characteristics of load-travel values for all spring sizes and spring rates relevant to particular nominal travel values are shown in the table below.

Table 1.3 – Summary of Spring Characteristics

<table>
<thead>
<tr>
<th>Spring size</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated load FN (kN)</td>
<td>144</td>
<td>204</td>
<td>336</td>
<td>432</td>
</tr>
<tr>
<td>Load group</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
</tr>
</tbody>
</table>

Multi-spring units are produced for nominal travel of 50 and 100 mm only. These springs are used for suspension of walls and boiler parts, supporting of duct systems, condensers, furnaces, cooling water supply pipes and various machinery or devices.

The multi spring units manufactured by MPS Gradior s.r.o. are equipped with locking mechanisms and sufficient load settings after installation.

Multi-spring units are usually used for balancing of small thermal displacements or installation inaccuracies, beam flexures, different setting-down of foundations, etc.

1.10 Design

Multi spring support comprise of four springs, these are arranged in circular pattern around the central tube. Springs are inserted onto dowels. When in the set position, the moving centre plate is blocked by means of thread bars that need to be removed prior to commissioning.

Spring supports type 1x8 shall be always provided with PTFE sliding surfaces for horizontal displacement of pipe exceeding 5 mm. The counterpart (base of support) shall be then provided with polished stainless surface. Supports are adjusted by loosening four heads of hexagonal shape to accommodate spanner designed with axial bearings to enable their easy loosening.

The table with spring characteristics relates to cage types 5 and 8 formed by multiple springs each. Bearing capacity classes to determine the joining dimension of rod (see the summary in introduction and data sheets for product group 800 – joining parts), see the bottom line.

Table 1.4 – Summary of Spring Characteristics

<table>
<thead>
<tr>
<th>Travel</th>
<th>Spring size</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>13</td>
</tr>
<tr>
<td>Load (kN)</td>
<td>48</td>
</tr>
<tr>
<td>0.5</td>
<td>5</td>
</tr>
<tr>
<td>1.0</td>
<td>10</td>
</tr>
<tr>
<td>1.5</td>
<td>15</td>
</tr>
<tr>
<td>2.0</td>
<td>20</td>
</tr>
<tr>
<td>2.5</td>
<td>25</td>
</tr>
<tr>
<td>3.0</td>
<td>30</td>
</tr>
<tr>
<td>3.5</td>
<td>35</td>
</tr>
<tr>
<td>4.0</td>
<td>40</td>
</tr>
<tr>
<td>4.5</td>
<td>45</td>
</tr>
<tr>
<td>5.0</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring rate (N/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>960</td>
</tr>
<tr>
<td>1,920</td>
</tr>
</tbody>
</table>
1 Variable spring supports
Installation Instructions

Installation of spring hangers is guided by assembly drawings supplied by the manufacturer. Spring hangers/supports are delivered blocked with preset cold set load as required. Hanger rods shall be shortened to the required length at suspension points prior to hanger installation.

1.11 Deblocking

Unlocking is always done after completion of pressure test and all works on piping, i.e. connecting of all equipment at the start and end of the route, branches and full erection. Locking devices are removed at any order, e.g. from the start of branch along the flow direction. However, it is essential that this process is performed without any excessive force: inability to remove the locking element is due to imbalance of load in spring and the pipe weight. The differential force is then transferred to the spring unit body via locking element. At first, the release of locking device shall be done by straining or releasing the rod using the turnbuckle on hanger or the adjustment nut on support. Further verification focuses on the subsequent hangers in branch, whether it transfers the load – properly strained rod or spring hanger; and whether the sliding supports sits tight on the base.

Spring supports type 1x2 and 1x4 are attached to rods using a turnbuckle integrated into the spring unit. The steel safety tape securing the locking devices shall be removed first. If the spring load is set-up properly, i.e. the pipe weight equals to the set spring load, locking device can be removed from spring shell slots freely. Potential modifications of settings are done by means of reducing the rod length (increasing the load) or extending the rod length (decreasing the load) by turning the turnbuckle. Once unlocked, the locking devices are secured to the hanger rod using a binding wire for future use.

Spring supports type 1x3 and 1x5 are set on a pair of beams. The hanger rod passes through spring unit to be secured with two nuts on the top bearing pad; these nuts are also used for additional adjustments. Horizontal displacement of hanger shall be prevented by means of contact plate.

Spring supports type 1x7 and 1x8 are inserted under sliding supports of piping. Supports shall be checked for correct position, so that the sliding support base always lies on the plate of spring support head. Additional load adjustments are performed by turning the centre bolt – moving support tube. The spring unit shall be secured against horizontal displacement using the bottom contact plate.

Spring setting check – unlocking of all springs will be followed by position check and processing of report with assessment of deviations from theoretical/installation position. Permissible deviations in vertical direction are:

- branch-intermediate hangers: +/-10 % of the nominal spring travel, max. 25 mm,
- branch-end hangers: +/-5 % of the nominal spring travel, max. 10 mm.

Checks shall be conducted to verify the actual travel reserves, which shall be within the following ranges:

- The reserve for constant supports in cold or hot condition to the end position shall be at least 10 % of the calculation displacement; however the minimum value is 25 mm.
- The reserve for variable springs in cold or hot condition to the end position shall be at least 10 % of to the calculation displacement; however the minimum value is 5 mm.
- Checks of travel allowance shall be done considering the assumed end position during operation as well! Unlocking of all hangers and the position check result shall be stated in report.

The depth for rod screwing into built-in turnbuckle should be equal to approximately 0.5 × rate spring travel. When the additional adjustment of load completed, the minimum length of screwing overlap shall be 0.5 × M (see figure below). For spring supports type 1x2 the top rod shall be screwed into the top plate to the depth M and secured by means of locking nut.

Springs adjustment corrections after deblocking are conducted progressively, from the node with greatest deviation from the installation position required to the node with lowest deviation. A deviation of position is defined as a drop or lift of pipe compared to the mark on spring support label or position defined in the design specification of springs (the piping cold position might differ from the set position). Negative deviation of position would raise the set load, whereas positive deviation will reduce it. Adjustment
of one node might result in spontaneous alignment of adjacent
hangers. Load on one node should be reset by the maximum of
5 % of the set value and if the position is not aligned to reach
the tolerance range required, the spring on adjacent hanger will
be reset. In case such unsatisfactory condition prevails, the proce-
dure will be repeated up to reset values of +/-10 % for particular
springs compared to initial settings. Higher re-adjustment values
shall be considered by the pipe design engineer, same as the
permissible value of deviation from the vertical position in mm
(permissible drop or lift). New values of spring load settings shall
be recorded and saved prior to commissioning. The check of cold
position is repeated after commissioning and first shutdown. Load
deviations in the newly established condition should not exceed
5 % compared to the previous settings.