**INTRODUCTION**

A key part of CPV’s technical support services for the Hiline range of pre-insulated district heating pipe systems is an advanced stress analysis service that ensures that a network’s design is optimised for the day-to-day thermal expansion that it encounters during many decades of operation.

**Thermal Expansion**

When designing and installing district heating pipe networks, stress analysis is a critical part process and one which should be carried out by default. To illustrate the importance of stress analysis, something as simple as adding in an unplanned branch connection can seriously impair a system’s ability to cope with the huge forces exerted on the pipe from thermal expansion.

To put this into context, a 200-metre length of buried DN250mm pre-insulated steel pipe, heated to an operating temperature of 120°C will expand by around 150mm – exerting stress of some 171MPa – the equivalent of 52 tonnes. This clearly needs to be dealt with in a way that does not impede the life expectancy of the network and ensure a long and trouble-free operation in delivering heating and hot water to consumers.

**sisKMR Stress Analysis Software**

CPV Ltd is a certified licensed holder for the sisKMR software package and our design team has several fully-trained engineers to carry out the calculations.

**We are able to offer expert advice in all aspects of stress analysis:**

By evaluating the proposed district heating network, comprising the pre-insulated pipe system and using a combination of their experience, rules of thumbs and the sisKMR software, pipe systems can be modelled and stresses calculated to the design principles and parameters according to standard *EN 13941, Design and installation of pre-insulated bonded pipe systems for district heating.*

**Pipe static calculation against proposed district heating network design and routing:**

The service covers the pipe initial static calculation for the entire district heating network including modelling the pipework geometry of buried pre-insulated pipework within sisKMR software and according to the proposed design/routing as provided by our client. CPV will model and undertake the analysis to be able to confirm the proposed design is acceptable. Where necessary, we will propose pipe arrangements, alternative pipe routing and other measures in mutual agreement with the client in order to establish an acceptable technical design solution. Having finalised the design and completed the analysis CPV Ltd provides a full stress analysis report together with supporting pipe route drawings.

**During Installation - Pipe Static calculation against variations:**

CPV can provide technical design support for the duration of the installation of a district heating network, making recommendations and providing subsequent qualification through stress analysis. Variations will be remodelled within the sisKMR software to demonstrate compliance. These services do not cover routing modifications that are not based on static requirements.
Pipe static calculation against ‘as-installed’ district heating network:

On completion of the installation of the pre-insulated district heating network, CPV can use the client’s ‘as-installed’ drawings in order to model the pipework geometry of buried pre-insulated pipework within the sisKMR software and complete a final stress analysis to qualify and demonstrate full compliance of the installed network. This produces a final stress analysis report together with supporting pipe route drawings.

Overview of sisKMR Software

sisKMR is a software programme designed for the static calculation of buried and above-ground pipe systems. It is able to calculate stresses imposed on heated buried pre-insulated bonded pipe systems as well as all kinds of open-air three-dimensional pipe systems for district heating applications, due to the loads imposed by thermal expansion.

The software is based on a beam-element programme with which the sections of three-dimensional pre-insulated bonded pipe systems with any number of branches can be calculated taking non-linear reactions of the soil and expansion cushions into consideration.

In addition, sisKMR contains standard modules for the fast calculation of common practical situations including:

- L-System
- Z-System
- U-System
- Deviation with expansion cushions
- Curved pipe
- Reduced Tee Branch
- Parallel Tee Branch

Alternatively, the stress analysis can be calculated according to the following standards:

- EN 13480
- EN 13941
- AGFW-Worksheet FW 401
- ASME : AD-S2
- ASME : AD2000-S2

The following modules are available for fast pre-dimensioning:

- Pipe bending (during excavation)
- One-time (start-up) compensator
- Strain reduction element (System 4)
- Maximum admissible laying length

With sisKMR the latest research results are included in the calculations:

- Cold installation
- Installation without expansion cushions
- Superimposed installation
- Pressure bends
- Mechanical pre-stressing of expansion cushions
- Subsequent burial of expansion cushions
- Horizontal branches

This technology is in line with the German Energy Efficiency Association for District Heating (AGFW) research programme, Innovative Heat Distribution.
Typical supports implemented in all types of open-air three-dimensional pipe system design and construction can be considered including:

- Fixed point (anchors)
- Axial holding point
- Three-way axial holding point
- Suspension or pendulum support
- Sliding bearing bracket
- Axial roller bearing support
- Roller bearing with separate roller tracks for u- and v-directions
- Single roller bearing
- Spring bearing effective in w-direction

For calculating admissible system limits using:

- Fixed points
- Free system limit with free axial displacement and rotation
- Free system limit with all displacement and rotation possibilities

Other possible considerations that can be taken into account include:

- Bearing tolerance
- End displacement
- Different friction values for axial and lateral displacement
- Local pre-stressing

In the calculation of load case histories, pre-displacements in the bedding and bearing points are taken into account so that friction and bedding reversal effects can be registered and included in the calculation of the load variation ranges, which are most important for the fatigue analysis of the system.

Complex three-dimensional systems, also with one-time compensators and strain reducers (bellows), can be calculated together as one entity.
sisKMR features comprehensive pre-installed material databases and nominal dimension tables which can be edited and extended by the user:

New databases for different pipe manufacturers and different pipe materials can be created to suit the user’s requirements.

The system features powerful graphics including:

- XY-XZ-YZ-View / 3D-View
- Contour mapping
- Crosshair cursor
- Scale for all axis directions
- Zoom function with mouse driven frame
- Display of the expanded system with different coloured loaded cases
- Either in steps or direct distortion of expansion cushion thickness and systems expansion
- System geometry can be displayed while entering data
- Clear output of calculation results with tables and graphics

The design parameters of most commonly used compensators can be calculated including:

- Axial compensator
- Angular compensator
- Lateral compensator
- Strain reduction element (axial compensator with a limit stop)

The calculation results are summarised in special bearing and compensator tables forming part of the final stress analysis report and is able to calculate:

- Point mass
- Single load
- Additional sectional loading in all directions (including wind and snow loads)
sisKMR at a glance

- Static calculation of pre-insulated pipe systems (above and below ground)
- A user-friendly interface
- A leading stress calculation software in the district heating industry
- Simple to use, quick data input and exact results
- Any bearing condition calculable
- Calculation capabilities of branched, topological piping system
- End point displacements and pre-stressing is feasible
- Comfortable calculation of loading case history
- Clear orientation by using a local co-ordinate system
- Visible graphic result while entering pipe geometry

Clear layout of results, either in simple or comprehensive reports:
<table>
<thead>
<tr>
<th>Size Range</th>
<th>Hiline Steel Metric</th>
<th>Hiline Steel Galvanised</th>
<th>Hiline Steel Flex</th>
<th>Hiline Steel Imperial</th>
<th>Hiline Copper</th>
<th>Hiline Aqua PP-R</th>
<th>Hiline Flex PE-Xa</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN 253, EN 448, EN 488, EN 489, EN 13941 &amp; EN 14419</td>
<td>EN 15632-4</td>
<td>Generally manufactured in accordance with EN 253 as no current standards exist for pre-insulated service pipes of these material types</td>
<td>EN 15632-1/2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Service Pipe Standards</th>
<th>Seamless EN 10216-2 &amp; 5 EN 10240, EN 1179 EN ISO 1461</th>
<th>Seamless EN 10305-1/2 &amp; 3</th>
<th>EN 10216-1/2 &amp; 5 EN 10216-2</th>
<th>EN 1057</th>
<th>DIN 8077</th>
<th>DIN 8078</th>
<th>EN 12318-2</th>
<th>DIN 16892</th>
<th>DIN 16893</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Service Pipe Material &amp; Grade</th>
<th>STEEL ST 37.0</th>
<th>STEEL ST 37.0</th>
<th>SEEMLESS R-35, P235 GH</th>
<th>STEEL ST 34.2</th>
<th>STEEL ST 37.0</th>
<th>COPPER</th>
<th>PP-R &amp; PP-RCT Multi-layer composite fibre reinforced</th>
<th>PE-Xa with EVOH Barrier</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Casing Pipe Material</th>
<th>HDPE &amp; METALLIC SPIRAL</th>
<th>HDPE &amp; METALLIC SPIRAL</th>
<th>HDPE</th>
<th>HDPE &amp; METALLIC SPIRAL</th>
<th>HDPE &amp; MDPE BARRIER</th>
<th>HDPE &amp; MDPE BARRIER</th>
<th>CORRUGATED LDPE</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Max Operating Pressure (bar)</th>
<th>25</th>
<th>25</th>
<th>25</th>
<th>25</th>
<th>10</th>
<th>10</th>
<th>6</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Max Cont Operating Temp (°C)</th>
<th>140</th>
<th>140</th>
<th>120</th>
<th>120</th>
<th>180</th>
<th>120</th>
<th>80</th>
<th>80</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Max Peak Operating Temp (°C)</th>
<th>152</th>
<th>152</th>
<th>140</th>
<th>140</th>
<th>N/A</th>
<th>130</th>
<th>95</th>
<th>95</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Insulation Material</th>
<th>PUR</th>
<th>PUR</th>
<th>PUR</th>
<th>PUR</th>
<th>PUR/MINERAL WOOL</th>
<th>PUR</th>
<th>PUR</th>
<th>PUR</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Insulation Value (w/mK)</th>
<th>0.0244</th>
<th>0.0244</th>
<th>0.023</th>
<th>0.024-0.029</th>
<th>0.0244 (PUR)</th>
<th>0.024-0.029</th>
<th>0.0216-0.026</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Delivered Lengths Electronic Surveillance</th>
<th>6m &amp; 12m</th>
<th>6m &amp; 12m</th>
<th>Up to 400m (coil)</th>
<th>6.5m &amp; 6m</th>
<th>6m &amp; 12m</th>
<th>6m</th>
<th>6m &amp; 12m</th>
<th>Up to 1000m (coil)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>APPLICATIONS</th>
<th>District Heating</th>
<th>District Cooling</th>
<th>Potable Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
</tbody>
</table>

* HDPE & *MDPE Casings can be supplied with oxygen diffusion barrier for diameters d75 - d400 (on request)
Project References

The Hiline system has been used on projects worldwide for a variety of applications. The list continues to grow, so please contact CPV for up-to-date project references. The list below illustrates a small selection of project types:

- City-wide district heating networks
- Hospitals
- Hotels, Sports and Leisure
- Manufacturing facilities
- Ministry of Defence
- Public buildings
- Research Facilities
- Residential (social and private)
- Schools
- Universities

About CPV Ltd

CPV operates in a wide array of sectors, with products satisfying many applications, most of which concern engineering pipe solutions for aggressive, corrosive, hot, chilled and potable liquids.

Its state-of-the-art production facility - based at the site of CPV’s headquarters near Romsey in Hampshire - is backed by a comprehensive selection of research, design, engineering, testing, quality, training and support services; ensuring the perfect marriage between its products and the applications in which they serve.

CPV is a member of the following organisations:

Product Solutions

Since the company’s inception in 1948, it has regularly led the way in the research and development of pipe systems, tanks and vessels. The current range encompasses:

- Pre-insulated pipe systems
- Chemical and hazardous drainage systems
- Pressure pipe systems
- Tanks and vessels
- Custom extrusions and fabrications
- Heat exchanger solar panels

CPV Ltd
Woodington Mill
Woodington Road
East Wellow
Romsey
Hampshire
SO51 6DQ
United Kingdom

Tel: +44 (0)1794 322 884
Fax: +44 (0)1794 322 885
Email: enquiries@cpv.co.uk

Follow us on Twitter: @CPVltd
Follow us on LinkedIn: /cpv-limited

Registered Office:
Station Road West, Ash Vale, Hampshire, GU12 5LZ
Registered in England and Wales No: 46847