ЦКТИ–ВИБРОСЕЙСМ

ИНЖИНИРИНГ ПРОЧНОСТЬ ВИБРОЗАЩИТА И СЕЙСМОСТОЙКОСТЬ

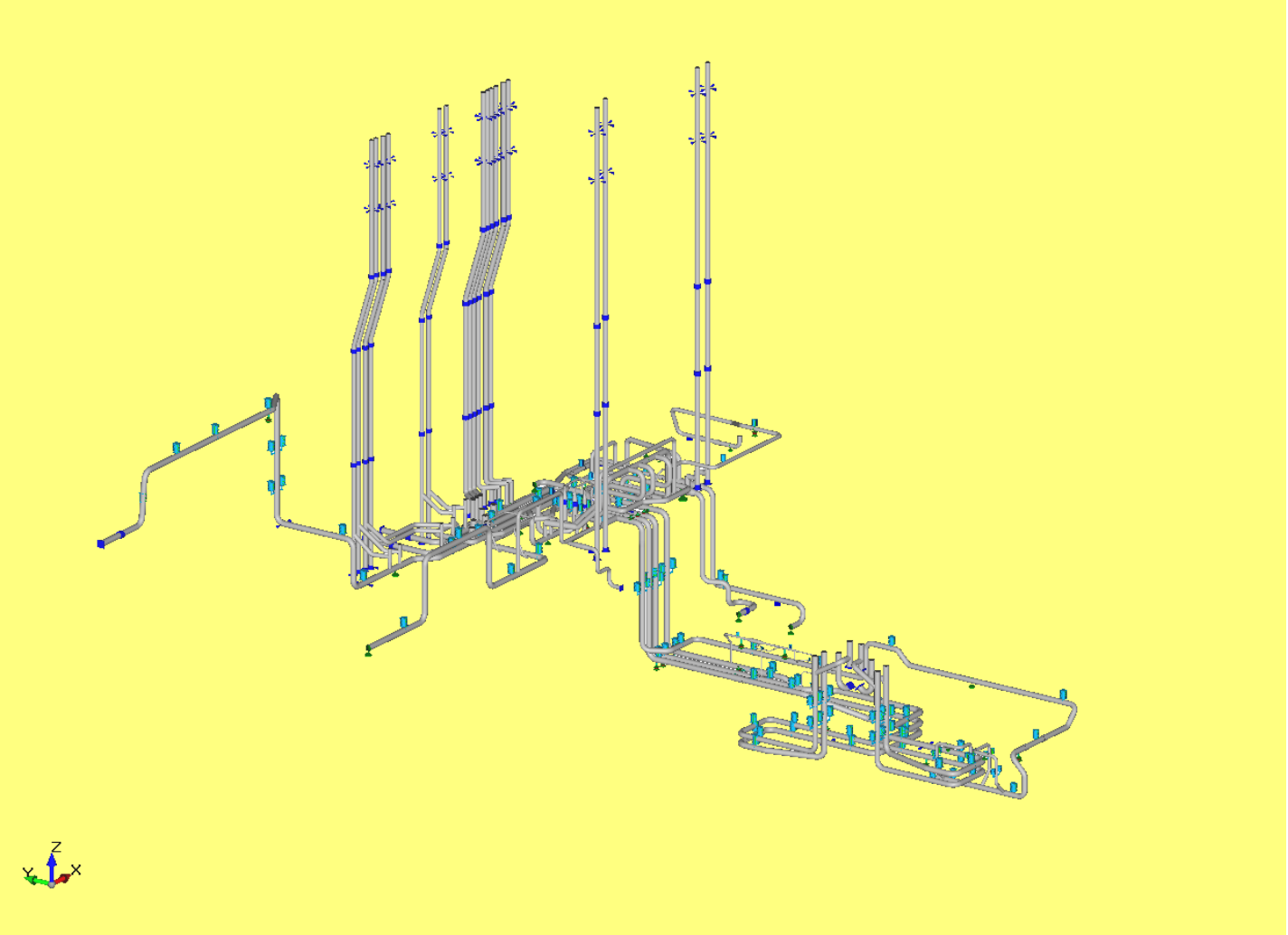
CKTI–VIBROSEISM

A STRUCTURAL–MECHANICAL CONSULTING ENGINEERING FIRM

dPIPE

Version 5.26

Calculation sample and recommended sequence for entering input data



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Piping Model

This sample calculation is based on the VVER-440 Main Steam Line extended from the Collector of Steam Generator (SG) up to the Containment's hermetic penetration. Figure 1 shows piping isometric sketch with main dimensions. Piping material is carbon steel ST20, operating temperature is 271°C, ambient temperature (cold state) is 20°C, working pressure is 4.5 MPa.

Table 1 shows thermal expansions of the SG collector nozzles:

Table 1. SG Nozzles. Thermal expansions:

Nozzle node	Thermal expansions, mm		
	X	Y	Z
P1	68	54	6
P2	63	57	6
P3	56	60	6
P4	49	64	6
P5	44	67	6

Locations of variable spring hangers are shown in Figure 1. Table 2 provides general data for spring hanger supports: number of rods and their lengths.

Table 2. Data for spring hanger supports

Spring hanger node	Rod number	Rod length
		mm
N1	2	2050
N2	1	1010
N3	2	2050
N4	1	830
N5	1	700
N6	1	670
N7	1	660

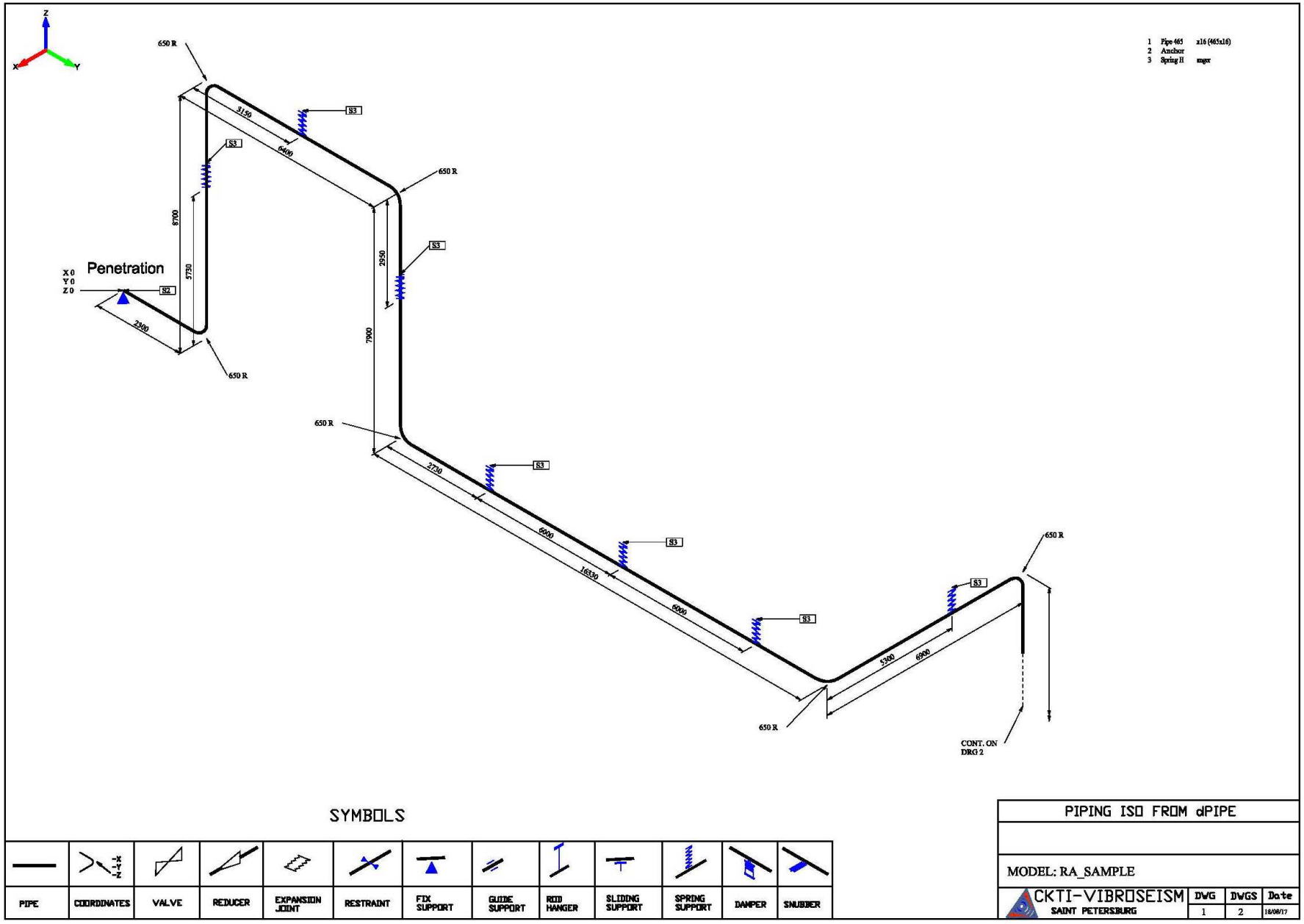


Figure 1. Piping Isometric Sketch

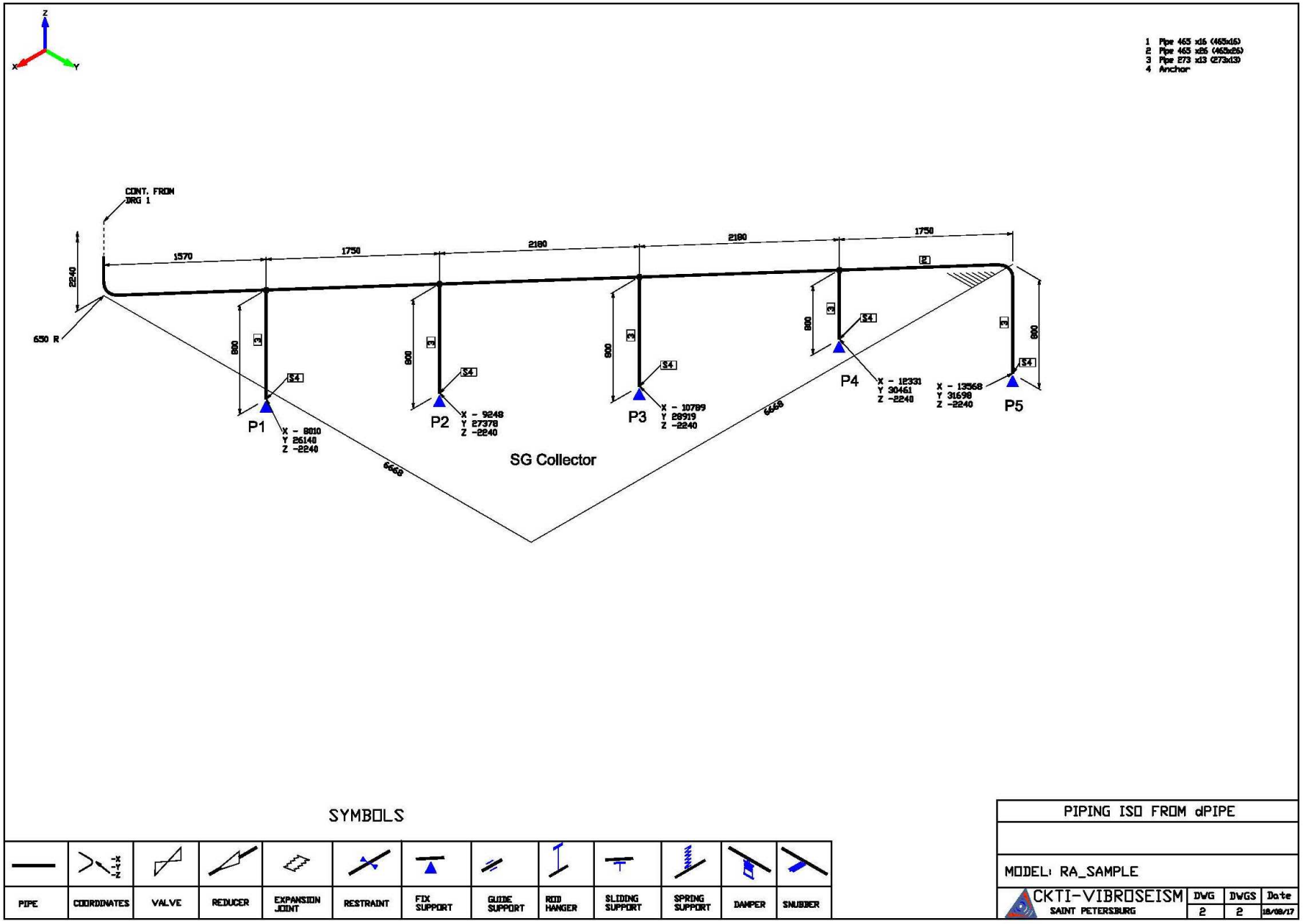


Figure 1. Piping Isometric Sketch (Cont'd)

Table 3. Piping cross-section data

DN	Outer Diameter D, mm	Wall thickness, s, mm	Weight per length, w, N/mm	R, mm
450	465	16	1.88	650
450	465	26	2.74	-
250	273	13	0.81	-

Seismic Input.

Seismic excitation is defined in terms of floor response spectra assigned to two different groups of piping supports: SG collector nozzles (group 'SG') and group 'RB', which includes all other piping supports fixed to the rigid structures of Containment. Table 4 provides data for response spectra used. Additional information for seismic anchor movements is available for the SG support group: seismic displacements along global axes are X -33mm, Y-34mm, Z-2mm. It is assumed that the group 'RB' supports have zero seismic displacements.

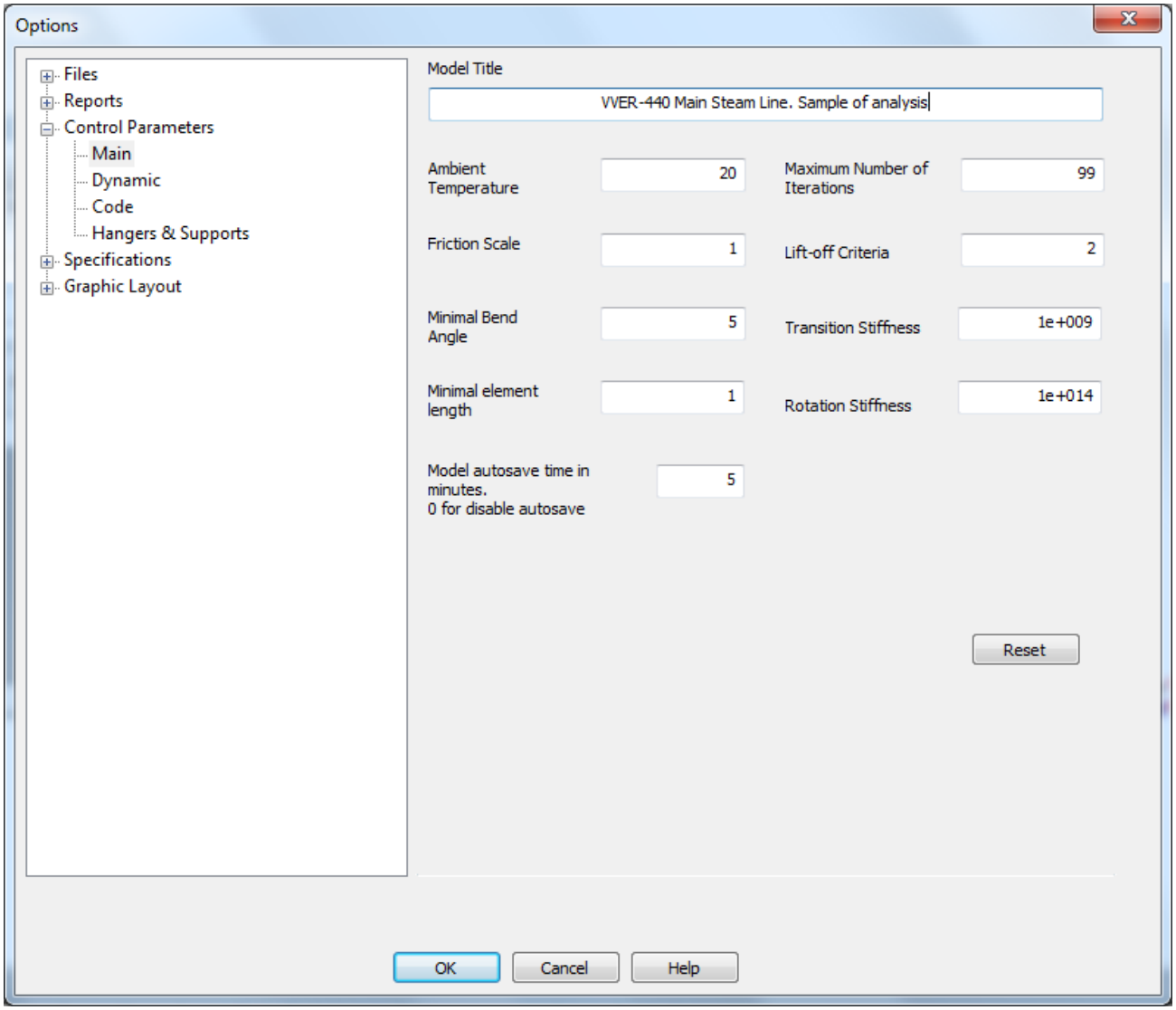
Table 4. 2% damped floor response spectra, SSE level

	X-Direction		Y-Direction		Z-Direction	
	Frequency, Hz	Acceleration, g	Frequency, Hz	Acceleration, g	Frequency, Hz	Acceleration, g
SG group	0.20	0.06	0.20	0.06	0.20	0.06
	2.00	1.00	2.56	1.37	2.50	0.88
	3.08	1.30	4.17	1.38	4.00	1.11
	4.60	2.50	6.22	2.57	8.00	1.10
	6.54	2.50	8.27	2.58	10.00	1.10
	11.67	1.00	11.67	1.21	12.00	1.13
	17.00	1.00	14.36	1.21	13.00	1.21
	27.00	0.68	28.72	0.61	28.00	0.46
	40.00	0.69	39.68	0.61	40.00	0.47
RB group	0.20	0.06	0.20	0.06	0.20	0.06
	2.00	1.40	2.00	1.40	2.50	0.92
	4.00	2.74	3.00	3.70	7.20	1.65
	4.20	4.00	5.40	3.70	10.50	2.25
	7.00	4.00	6.90	3.20	14.50	2.10
	12.00	1.60	9.00	3.20	17.80	1.80
	16.00	1.60	16.00	1.50	20.00	1.50
	23.00	1.00	23.00	1.00	28.00	0.78
	40.00	1.00	40.00	1.00	40.00	0.78

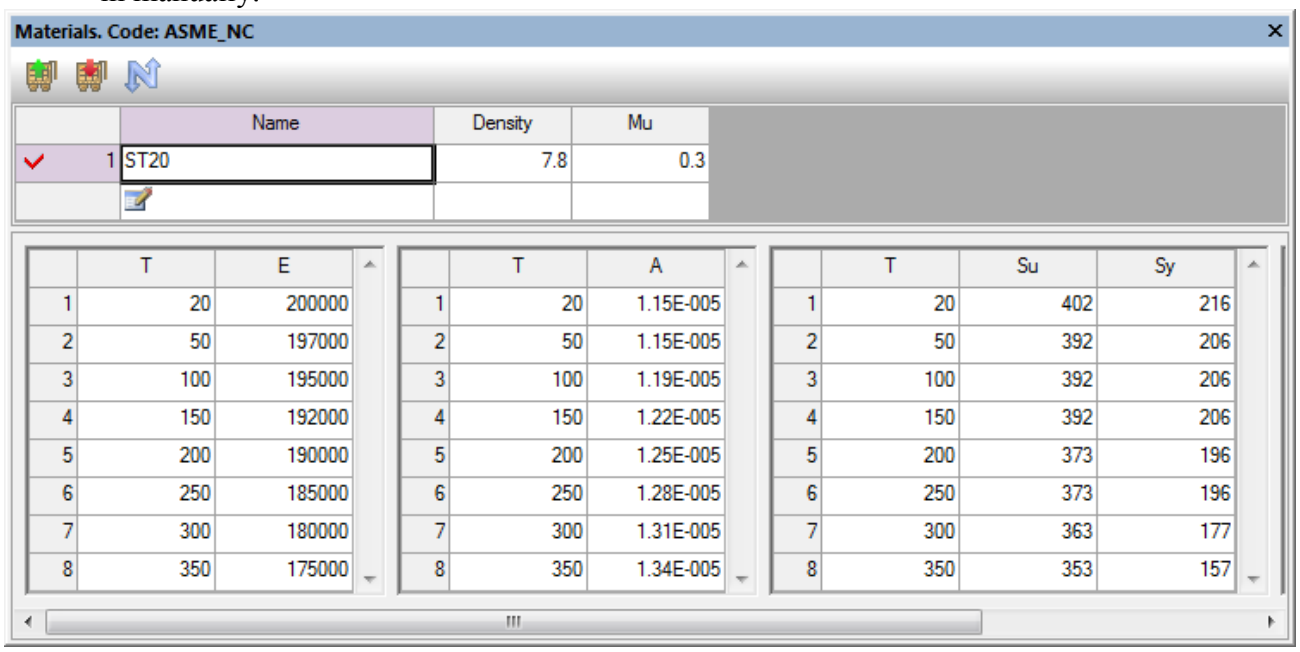
Recommended sequence for input data entering

1. Create a folder on your hard drive. Run the DDE program and save the empty model in the created folder with an appropriate name (for example, "RA_SAMPLE.DP5").

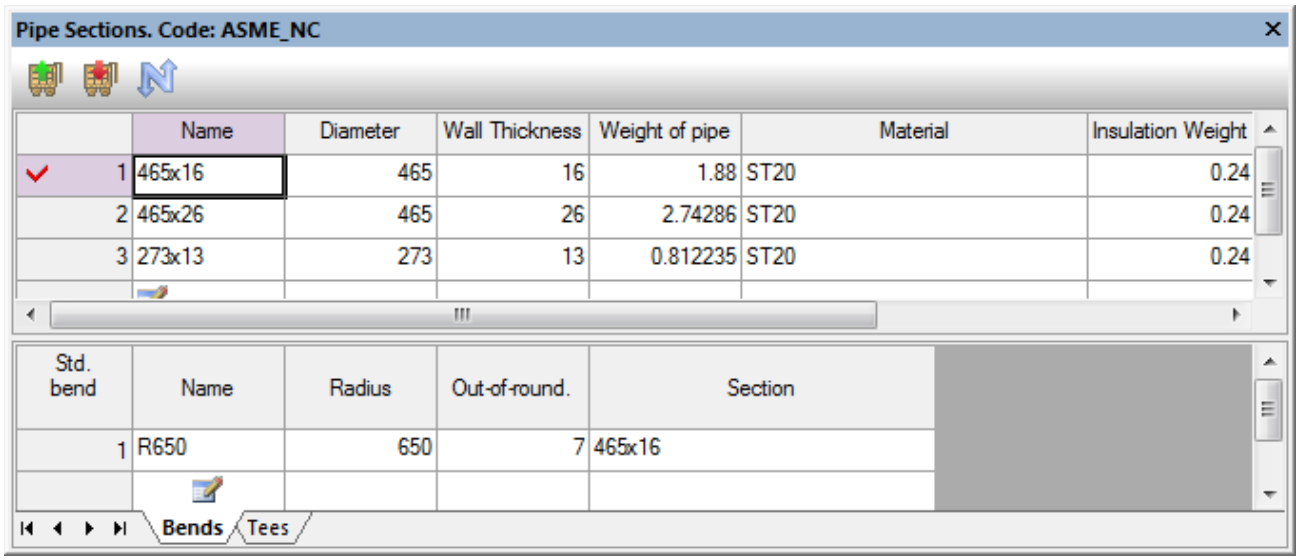
2. Enter the title for calculational model (menu “Tools-Options”). This text will be displayed in the headers of dPIPE printouts:



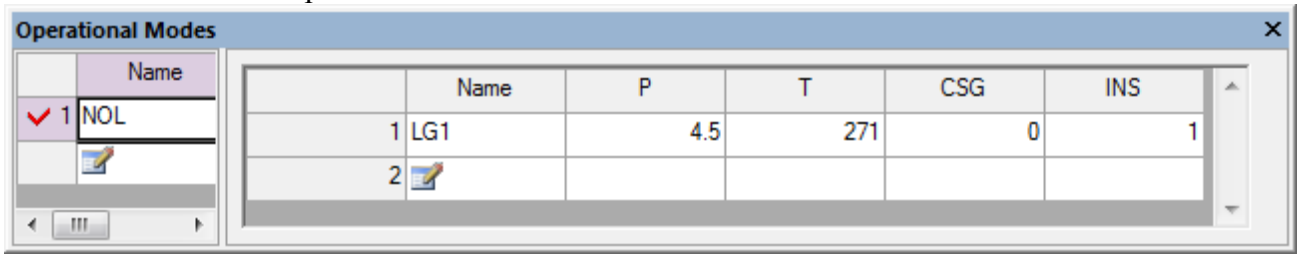
3. Define data for material: use button  and select from the database  or type the data in manually:



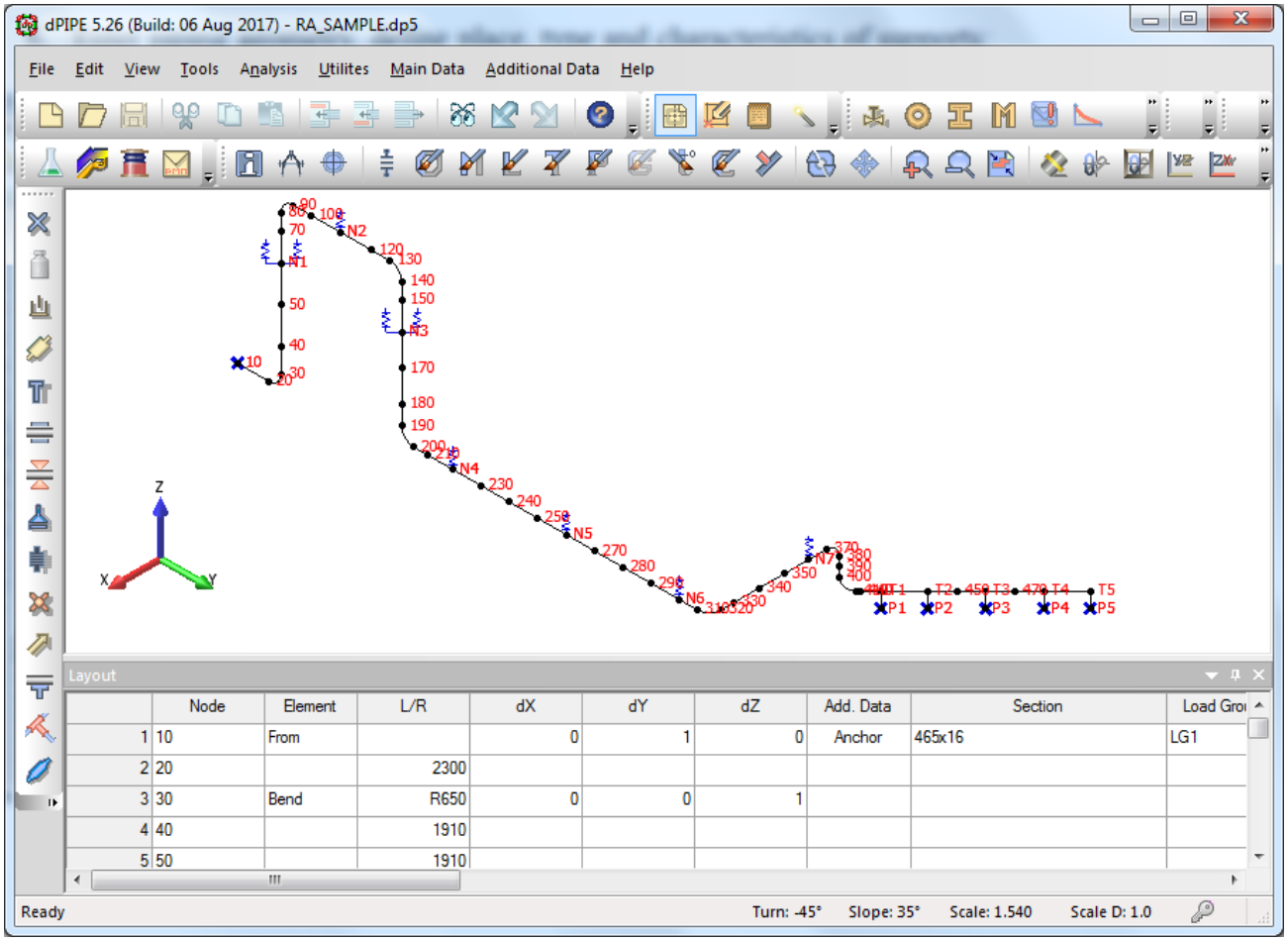
4. Define data for piping sections and fittings (bends, tees): use button  or menu “Main Data – Sections”:



5. Define data for working pressure, temperature and medium contents: use button  or menu “Main Data – Operational Modes”:

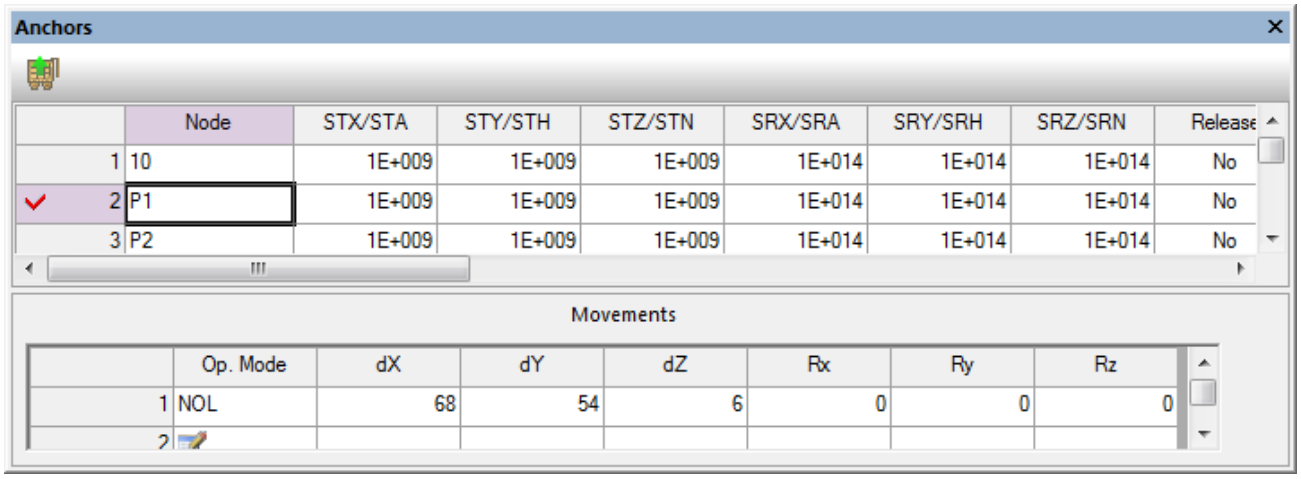


6. Enter piping geometry, define place, type and characteristics of supports:

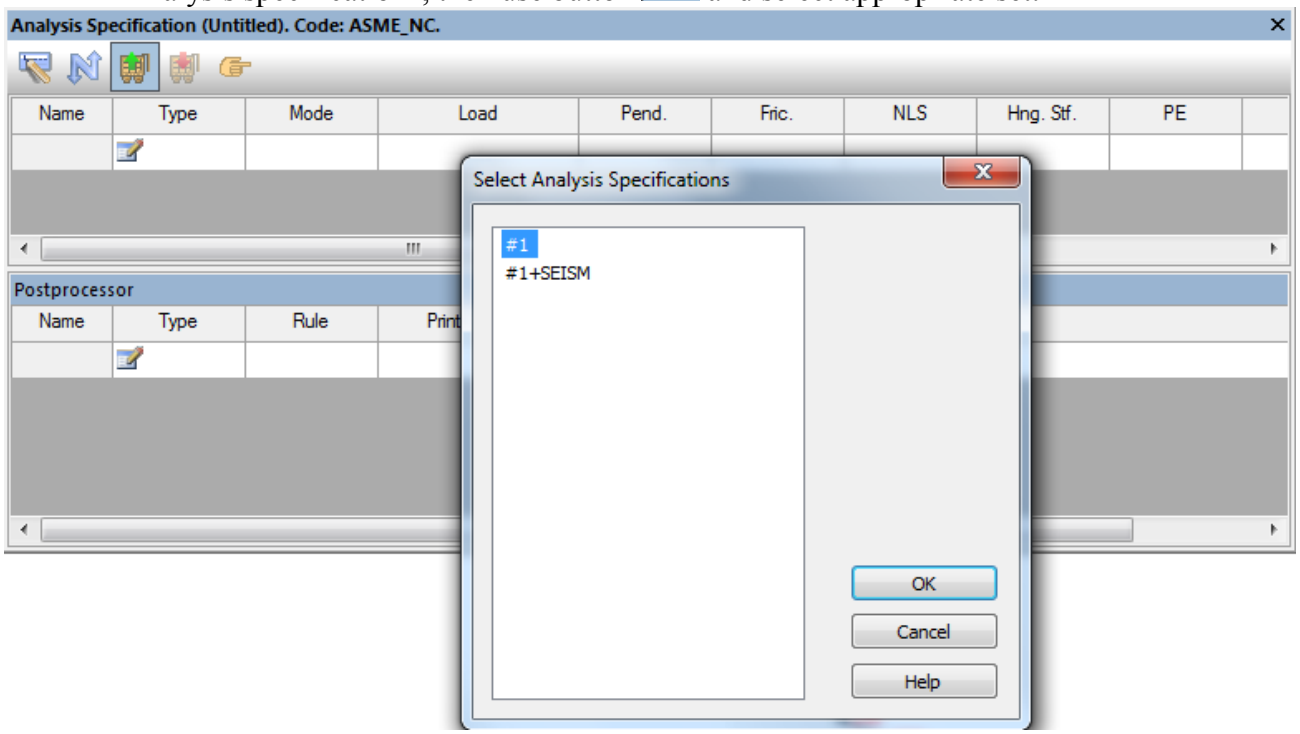


When entering data, it is recommended to save your progress regularly!

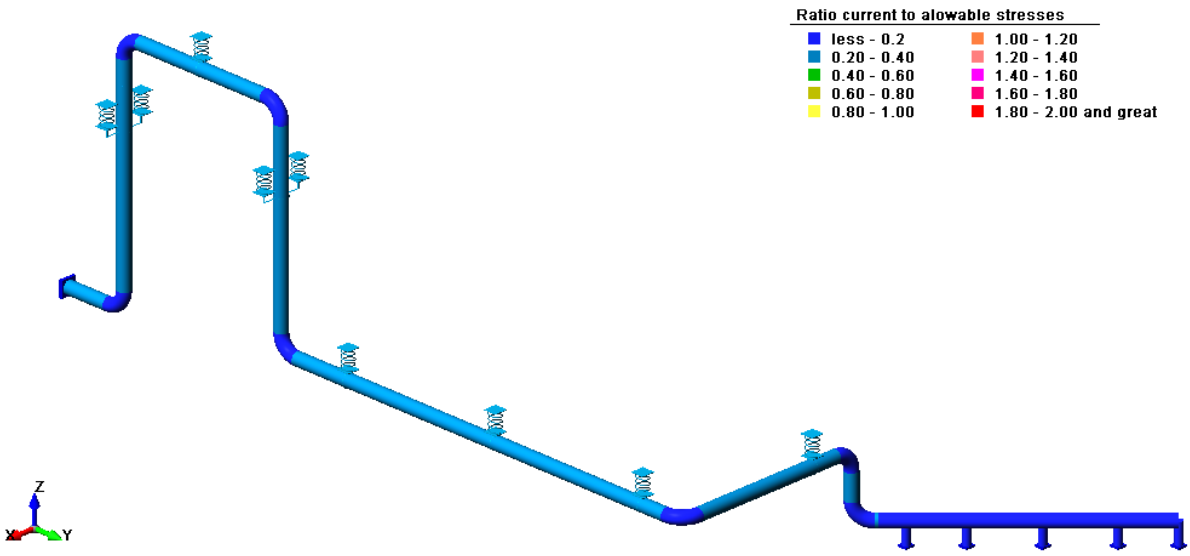
7. Enter predefined temperature movements for piping supports (data from Table 1). Menu "Additional Data - Anchors" or button  :



8. Define specifications for analysis and results post processing: use button  or “Main Data – Analysis specification”, then use button  and select appropriate set:



9. Run analysis (“Analysis – Batch mode” ). Subsequently, one can see results (Analysis – Pipe3DV ):



Equation 8 (Design Condition) stresses.

10. Check results for spring design (Analysis-View Support Loads, ):

Piping Flexibility and Stress Analysis, dPIPE

Version: 5. 2. 6 (Build: 06 Aug 2017)
Date: 18. 8.2017
Company: ООО "ЦКТИ-Вибросейсм"

R E S U L T S S U M M A R Y T A B L E S

Code: ASME NC (1992)

Model: VVER-440 Main Steam Line. Sample of analysis
Analysis: Spring Design. Stress Analysis (#1)

>>> Spring Hanger Design Data. Catalogue OCT 108.764.01-80

Sup N (node)	NC	Chain struct.	Springs Heights H_free	H_hot	H_cold	H_inst	Support's Loads P_hot	P_cold	P_seis	Movements DX	DY	DZ	ALPHA
N1	2	1*18	369	277	258	258	21.38	25.82		4	-1	19	0.1
N2	1	1*18	369	297	272	263	8.35	11.33		15	5	26	0.9
N3	2	1*06	201	160	150	133	19.22	24.02		26	8	10	0.7
N4	1	1*06	201	154	161	144	10.87	9.38		38	4	-6	2.6
N5	1	1*07	226	181	183	169	12.66	12.03		66	23	-2	5.7
N6	1	1*07	226	178	173	162	13.55	14.83		90	43	5	8.5
N7	1	1*19	414	319	305	302	13.34	15.30		78	51	14	8.1

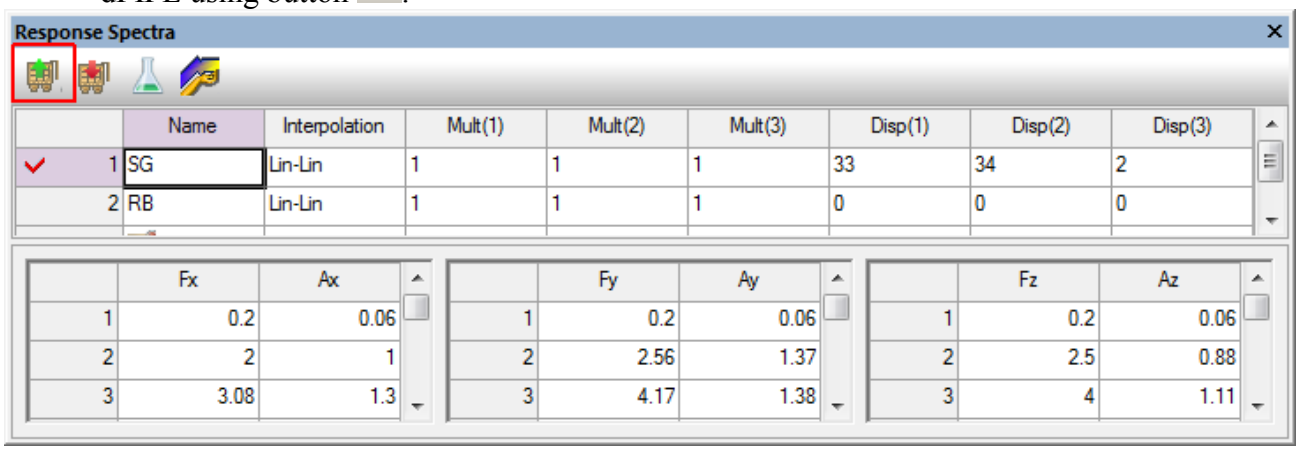
Notes:
NC - number of springs
H_free - unloaded spring height, mm
H_hot - spring height in hot state, mm
H_cold - spring height in cold state, mm
H_inst - spring height before installation, mm
P_hot - hot load, kN
P_cold - cold load, kN
P_seis - seismic load, kN
DX, DY, DZ - transient movements from cold to hot state,mm
ALPHA - angularity (swing from the vertical), deg

>>> Summary table for spring hangers loads

SUP N (node)	spring	P_des	P_oper	FS	var	DX	DY	DZ	ALPHA	load set
N1	06/Z2	21.42	21.38	1.5	0	3	-8	20	0.2	LS006
			25.82	1.3 !	21	-1	-6	1	0.2	LS007
N2	06/Z2	8.40	8.35	2.0	1	12	-6	34	0.7	LS006
			11.33	1.4	35	-3	-11	9	0.7	LS007
N3	06/Z1	19.32	19.22	1.7	0	23	2	27	0.6	LS006
			24.02	1.4	24	-2	-6	17	0.2	LS007
N4	06/Z1	10.84	10.87	1.5	0	38	4	10	2.7	LS006
			9.38	1.7	13	1	0	17	0.1	LS007
N5	07/Z1	12.64	12.66	1.6	0	65	23	12	5.6	LS006
			12.03	1.6	5	-1	0	15	0.1	LS007
N6	07/Z1	13.76	13.55	1.5	1	89	43	16	8.4	LS006
			14.83	1.3	8	-2	0	12	0.2	LS007
N7	07/Z2	13.40	13.34	1.5	0	76	51	17	8.0	LS006
			15.30	1.3 !	14	-2	0	3	0.2	LS007

Notes:
P_des - design load, kN
P_oper - operational load,kN
FS - load safety factor
var - variability, %
DX, DY, DZ - movements, mm
ALPHA - angularity (swing from the vertical), deg

11. If the results of analysis are satisfactory, one can move to seismic analysis. At the beginning, the Floor Response Spectra for different support groups should be entered: use button , or menu “Main Data – Spectra”. If spectra are in separate files, they can be imported in dPIPE using button :



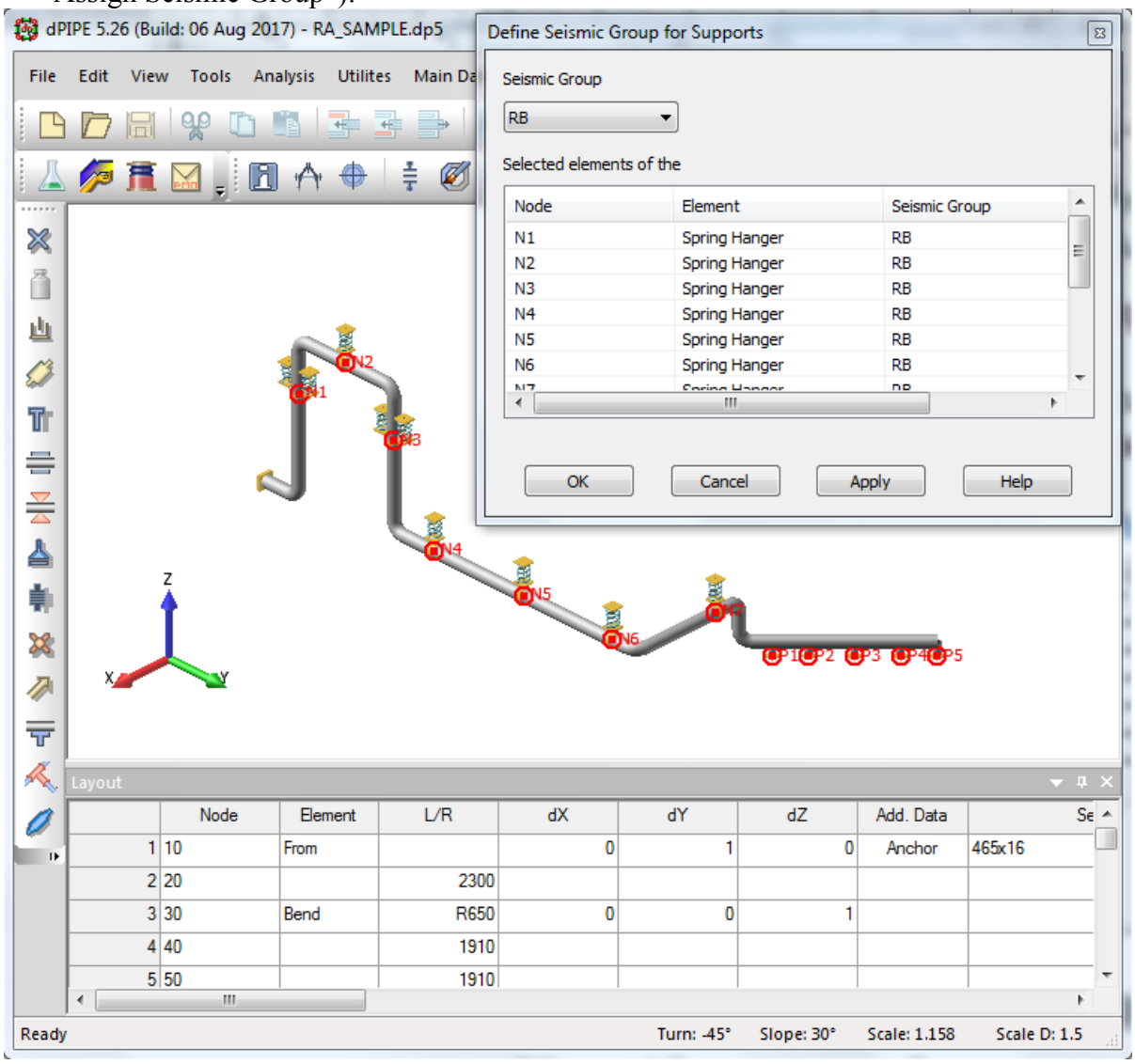
	Name	Interpolation	Mult(1)	Mult(2)	Mult(3)	Disp(1)	Disp(2)	Disp(3)
1	SG	Lin-Lin	1	1	1	33	34	2
2	RB	Lin-Lin	1	1	1	0	0	0

	Fx	Ax
1	0.2	0.06
2	2	1
3	3.08	1.3

	Fy	Ay
1	0.2	0.06
2	2.56	1.37
3	4.17	1.38

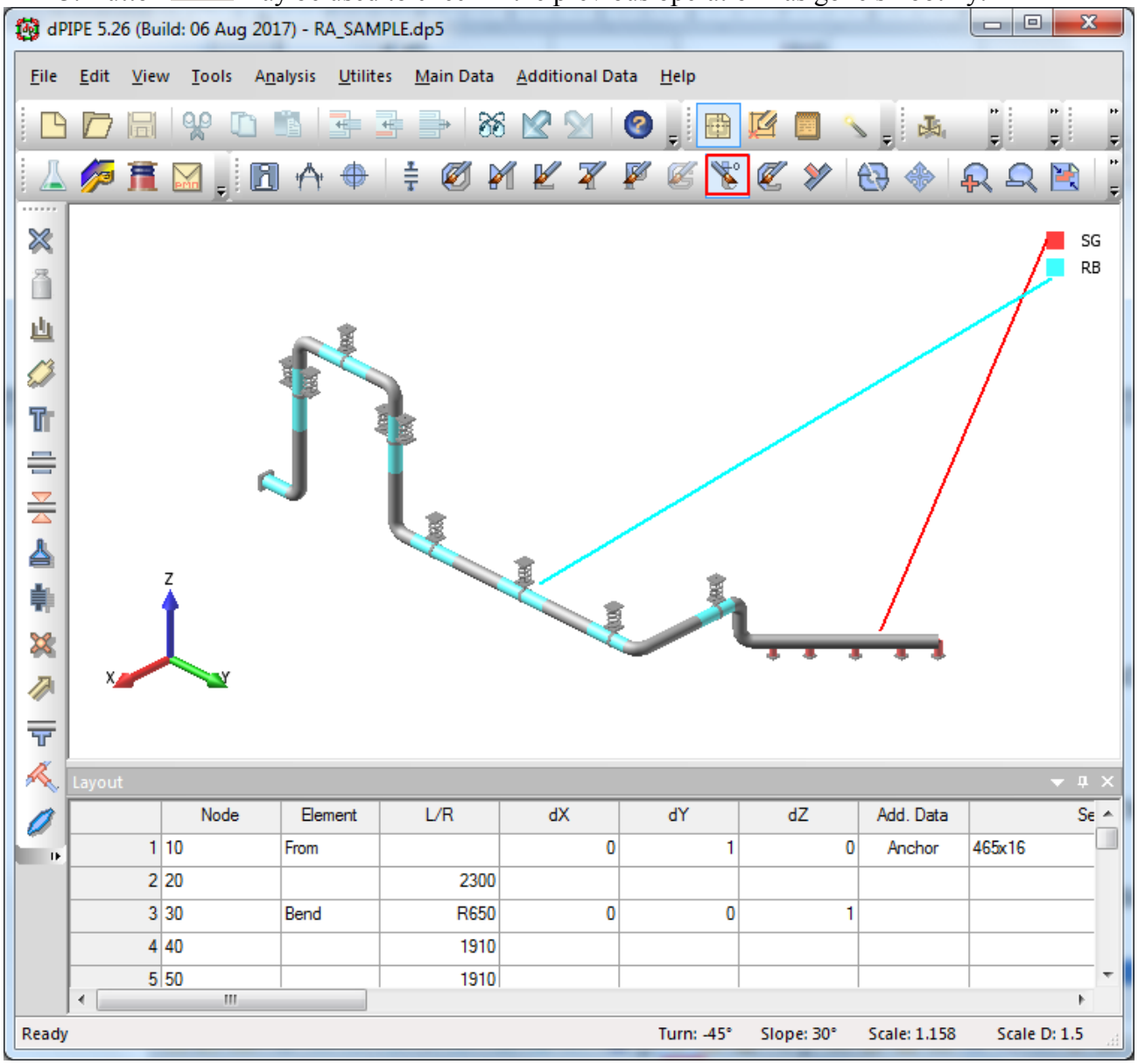
	Fz	Az
1	0.2	0.06
2	2.5	0.88
3	4	1.11

12. All piping supports should be assigned to their respective seismic support group. It can be done either through support summary tables (menu “Additional Data”), or (which is preferable) interactively with the use of button (or “Tools – Group operations with supports – Assign Seismic Group”):

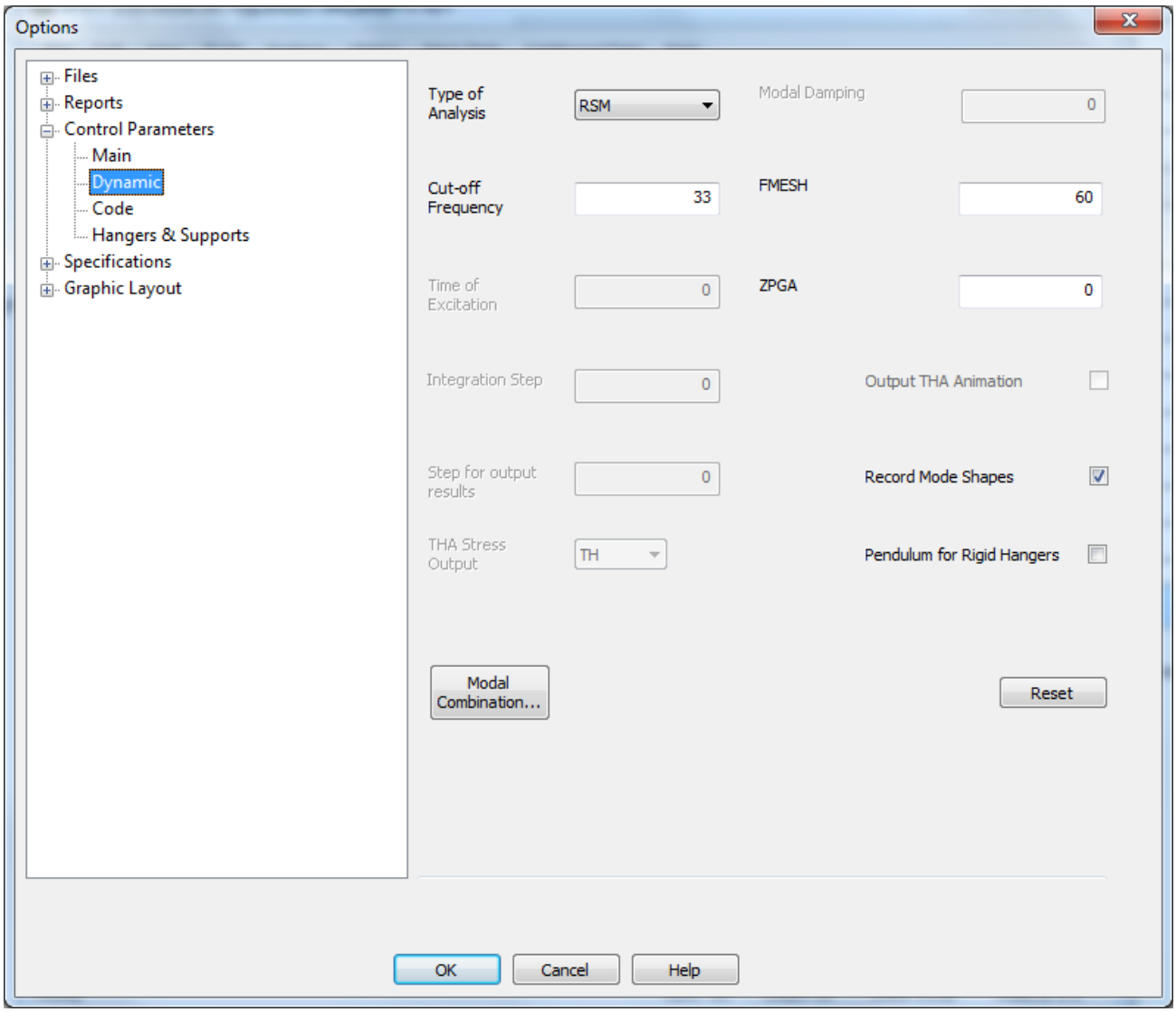


	Node	Element	L/R	dX	dY	dZ	Add. Data	Se
1	10	From		0	1	0	Anchor	465x16
2	20		2300					
3	30	Bend	R650	0	0	1		
4	40		1910					
5	50		1910					

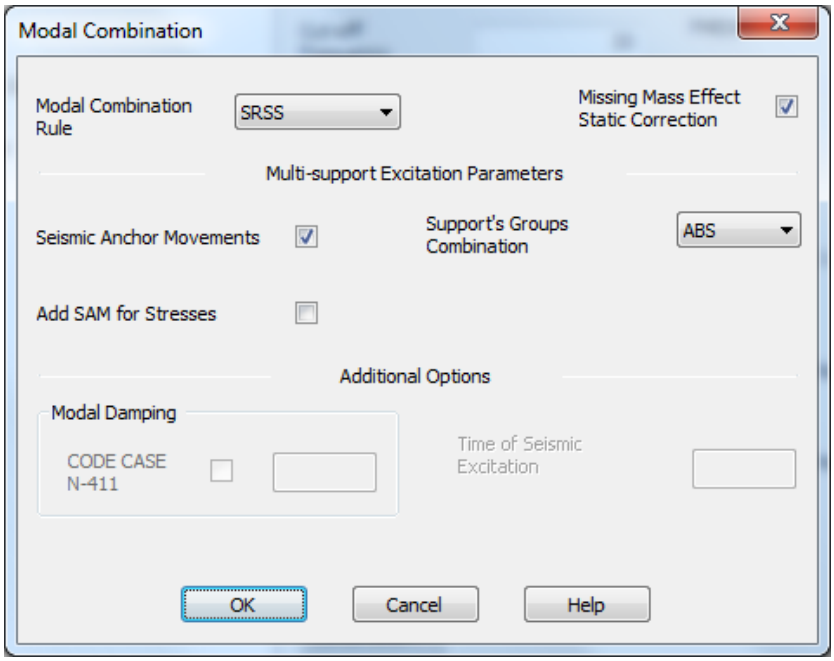
13. Button  may be used to check if the previous operation has gone smoothly:



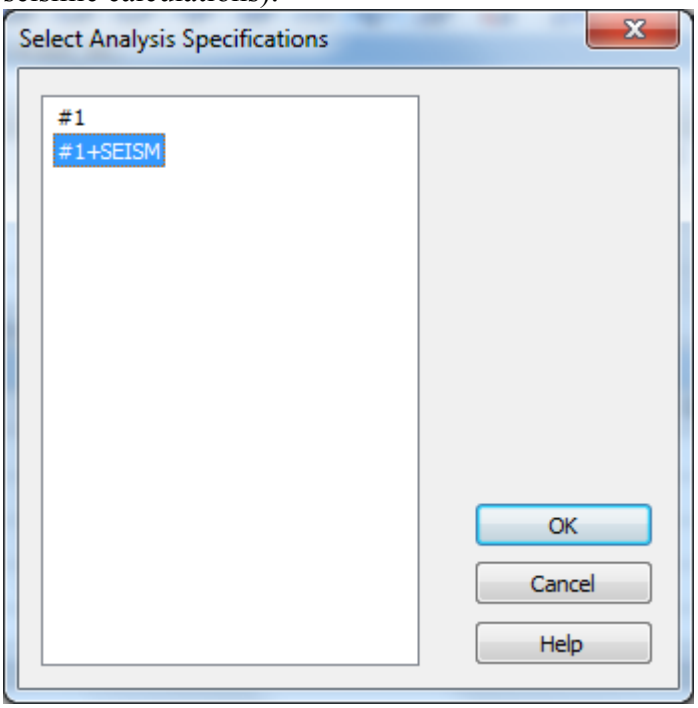
14. In options (Tools/Options, ) define parameters for dynamic analysis: Response Spectrum Method, Cutoff frequency FMAX = 33 Hz, Partial frequency for automatic meshing of the piping FE model, FMESH = 60 Hz:



15. In the TAB shown above, press button “Modal Combination” and in the appeared dialogue window check options “Missing mass effect Static Correction” and “Seismic Anchor Movement”:



16. Repeat item 8 (), but this time select #1+SEISM (specification for analysis that includes seismic calculations):



17. In order to perform analysis and view results, repeat steps 9 - 10.