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The Flexibility Analysis of the Transfer Pipeline between the Tubular Furnace and the Vacuum Column from the Vacuum Distillation Plant

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Abstract

This paper originally presents the flexibility analysis of the partially vaporized transfer naphtha pipe DN600-DN1200 between the tubular fired heater H3 and the vacuum column C5 from the vacuum distillation plant in order to reduce the mechanical tensions generated by the net weight of the fluid pipe, by the internal pressure and temperature. This analysis is carried out using the CAESAR II program, version 5.30.

Key words: *flexibility pipe under pressure, net weight, temperature.*

Generalities

The systems of pipelines are made of a set of elements which separate a closed space from the environment, set up on a precisely determined route, that are used for the transporting and distributing in terms of technical security of hydrocarbons.

General Modeling Conditions

The main constituent of the pipeline is the system of pipes which hermetically delimits the closed space through which the partially vaporized naphtha is circulated. The pipe subject to this analysis is part of the vacuum distillation plant. The diameter of the pipe between DN600 and DN1200 has been determined according to the flow rate of the circulated fluid.

This pipeline analysis (fig. 1) implies the following operation conditions required by the technological process:

- temperature, in °C:
  - maximum operating conditions 390 °C,
  - design conditions 425 °C;
- pressure, in bars:
  - maximum operating conditions 0.5 bars,
  - design conditions 1 bar;

- the pipe, DN600-DN1200 (OD x WT : 609,6 x 9,52; 762 x 9,52; 1219 x 9,52);
- pipe material: ASTM A335 Gr. P5 whose equivalent is X11CrMo5 according to SR EN 10216-2:2008;
- the fluid: partially vaporized naphtha.

The general modeling conditions are the following:

- the coefficient of friction was considered 0.1;
- the loads in connections were considered in terms of maximum operating (dilatations from 288K (15°C) to the maximum temperature);
- it has not been considered the effect of wind loading, earthquakes or transient flow phases;
- on the route of the pipeline were enumerated all the nodes with the interest sections.

The flexibility analysis of this pipeline is made by taking into consideration two loading variants which were considered separately, using the CAESAR II program, version 5.30.

The analysis of this pipeline implies the following operation conditions required by the technological process.

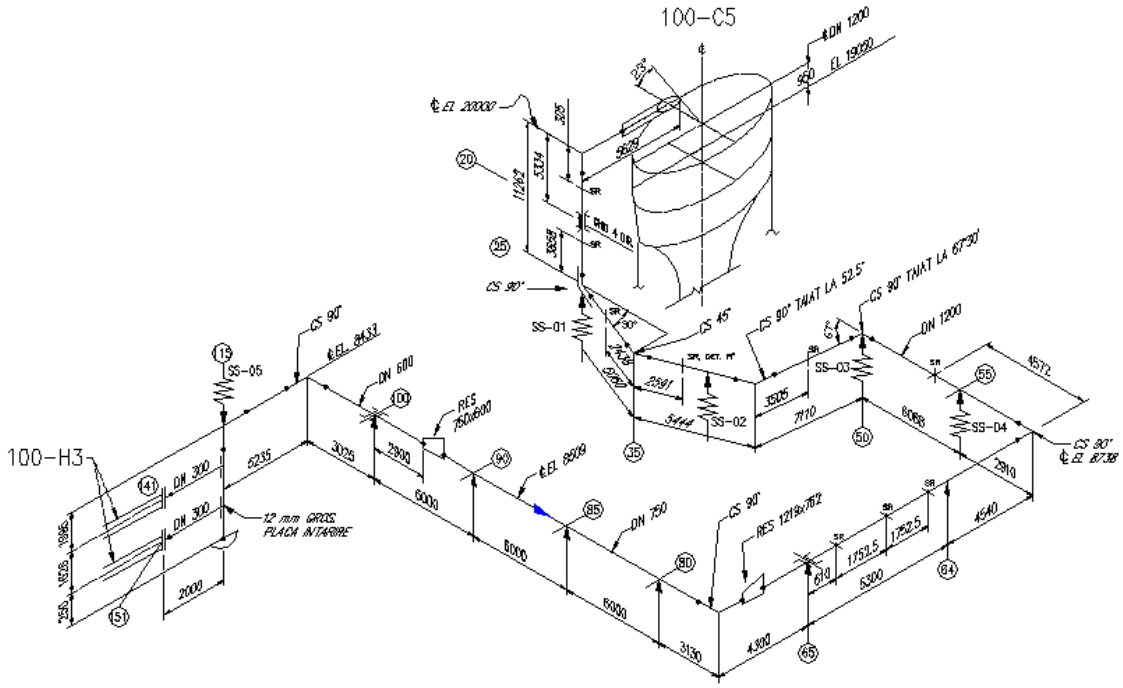

Fig. 1. The isometric scheme of the transfer pipeline

The following variants have been analyzed:

- the loading variant 1 (W+T1+P1+H) takes into account the pipeline loaded with product at the temperature of 390°C and the internal pressure of p = 0.5 bars (the accidental loadings were not considered – seismic, eolian, snow);
- the loading variant 2 (W+T2+P2+H) takes into account the pipeline loaded with product at the temperature of 425°C and the internal pressure of p = 1 bar (the accidental loadings were not considered – seismic, eolian, snow).

Table 1. The coordinates of nodes in which the calculations were performed

NODE	X mm.	Y mm.	Z mm.	NODE	X mm.	Y mm.	Z mm.
10	.000	20000.000	.000	**70**	14189.000	8509.400	-20486.000
15	4629.000	20000.000	.000	**80**	14189.000	8509.400	-17356.000
20	4629.000	14666.000	.000	**85**	14189.000	8509.400	-11356.000
22	4629.000	8738.000	.000	**90**	14189.000	8509.400	-5356.000
25	4629.00	8738.00	.00	**100**	14189.000	8443.200	644.000
30	7159.00	8738.00	-4382.00	**105**	14189.000	8443.200	3669.000
35	7159.000	8738.000	-7657.000	**115**	19424.000	8443.200	3669.000
40	7159.000	8738.000	-9826.000	**125**	19424.000	6438.200	3669.000
53	49.000	8738.000	-9826.000	**130**	19424.000	4812.200	3669.000
55	49.000	8738.000	-15914.000	**136**	19424.000	4241.200	3669.000
60	49.000	8738.000	-20486.000	**141**	21324.000	4812.200	3669.000
64	4589.000	8738.000	-20486.000	**151**	21324.000	4812.200	3669.000
65	9889.000	8738.000	-20486.000	**10025**	-1003.058	20000.00	-5.565

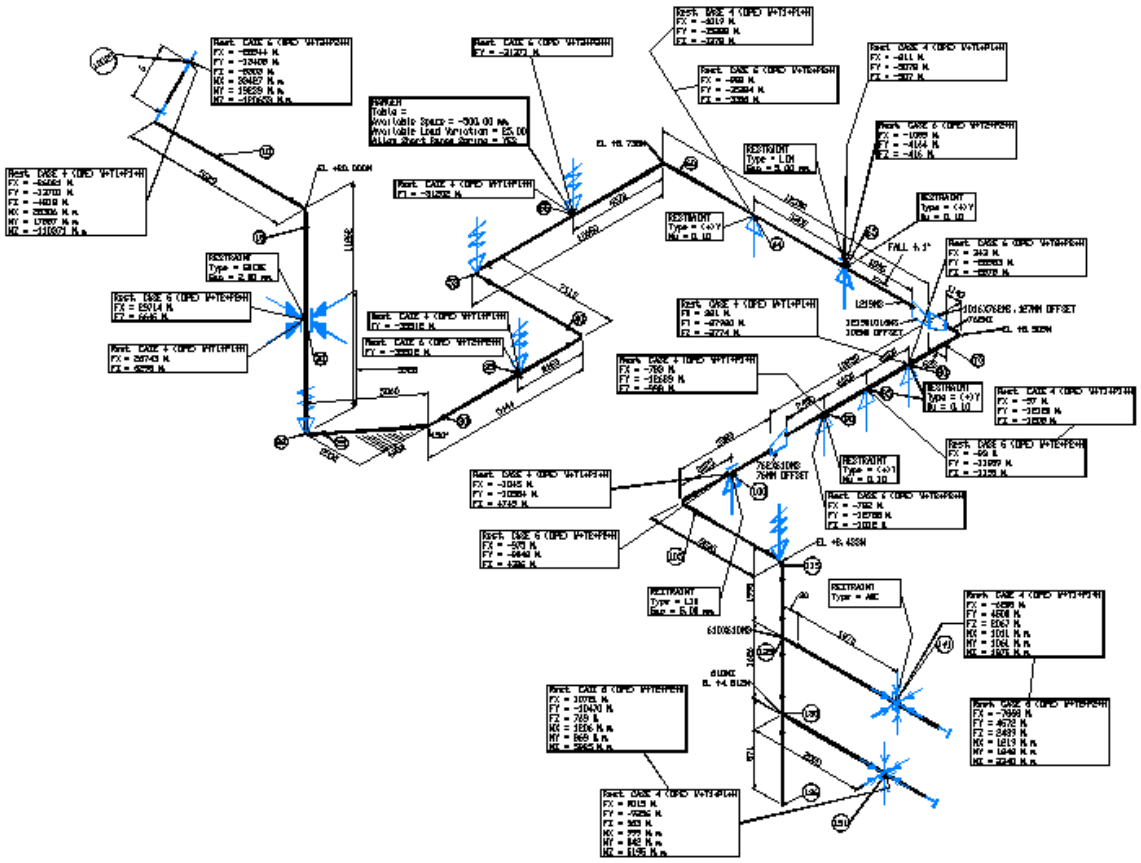

Fig. 2. The marking of nodes and the results of the simulation on pipeline sections

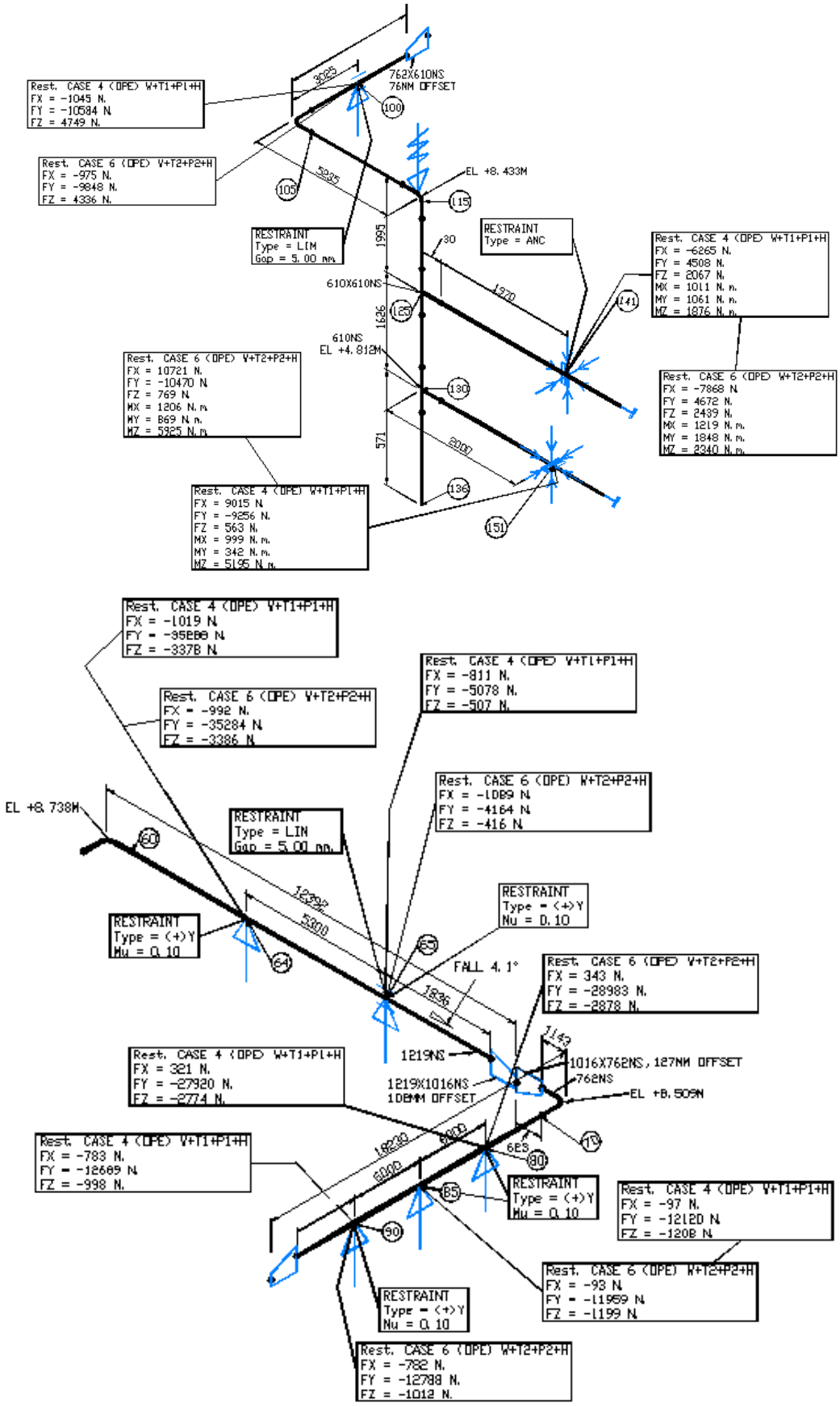

Fig. 3. The marking of nodes and the results of the simulation on pipeline sections

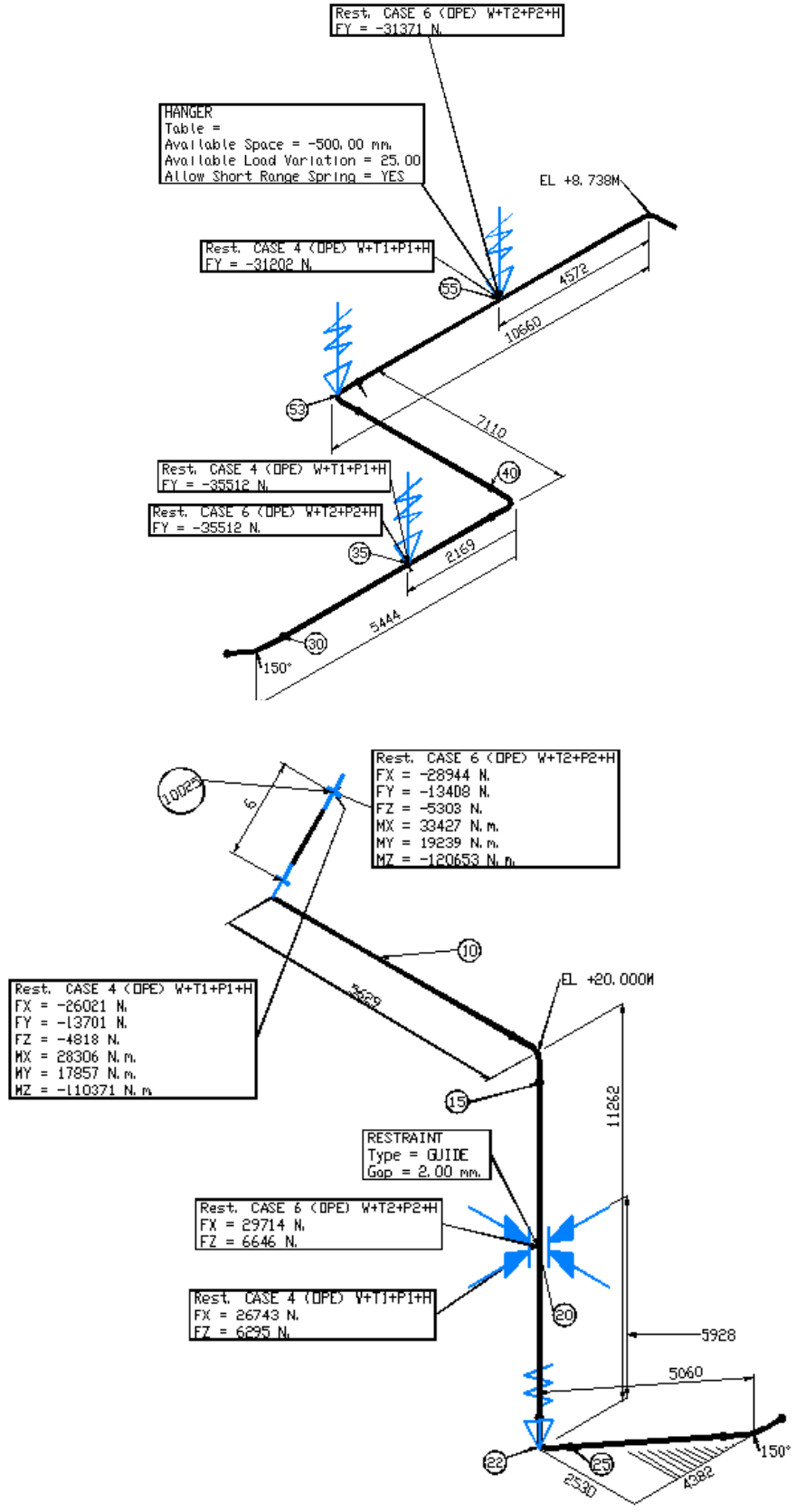

Fig. 4. The marking of nodes and the results of the simulation on pipeline sections

Table 2. Presentation of the simulation results

VARIANT 1									
Node	**Forces, N**			**Torques, Nm**			**Movements, mm**		
	F_x	**F_y**	**F_z**	**M_x**	**M_y**	**M_z**	**D_x**	**D_y**	**D_z**
20	26743	0	6295	0	0	0	2.000	-25.478	2.000
22	0	-57599	0	0	0	0	-34.301	-52.443	-4.625
35	0	-35512	0	0	0	0	-22.327	-42.329	-40.581
53	0	-15085	0	0	0	0	-55.131	-15.317	-50.545
55	0	-31202	0	0	0	0	-52.166	-5.400	-78.257
64	-1019	-35288	-3378	0	0	0	-29.126	-0.000	-96.573
65	-811	-5078	-507	0	0	0	-5.000	-0.000	-93.748
80	321	-27920	-2774	0	0	0	8.894	-0.000	-76.916
85	-97	-12120	-1208	0	0	0	-3.987	-0.000	-49.610
90	-783	-12689	-998	0	0	0	-17.510	-0.000	-22.306
100	-1045	-10584	4749	0	0	0	-30.803	-0.000	5.000
115	0	-18598	0	0	0	0	-11.460	15.030	17.676
141	-6265	4508	2067	1011	1061	1876	-2.418	4.504	13.878
151	9015	-9256	563	999	342	5195	-2.415	-0.335	13.705
10025	-26021	-13701	-4818	28306	17857	-110371	5.581	4.734	10.160
VARIANT 2									
Node	**Forces, N**			**Torques, Nm**			**Movements, mm**		
	F_x	**F_y**	**F_z**		**F_x**	**F_y**	**F_z**		**F_x**
20	29714	0	6646	0	0	0	2.000	-28.341	2.000
22	0	-57599	0	0	0	0	-38.644	-58.300	-5.864
35	0	-35512	0	0	0	0	-25.247	-46.896	-45.833
53	0	-15231	0	0	0	0	-61.528	-16.408	-57.666
55	0	-31371	0	0	0	0	-57.744	-5.718	-88.452
64	-992	-35284	-3386	0	0	0	-31.802	-0.000	-108.507
65	-1089	-4164	-416	0	0	0	-5.000	-0.000	-105.012
80	343	-28983	-2878	0	0	0	10.248	-0.000	-86.006
85	-93	-11959	-1192	0	0	0	-4.364	-0.000	-55.670
90	-782	-12788	-1012	0	0	0	-19.581	-0.000	-25.336
100	-975	-9848	4336	0	0	0	-34.367	-0.000	5.000
115	0	-18178	0	0	0	0	-12.754	16.604	18.296
141	-7868	4672	2439	1219	1848	2340	-2.687	5.000	13.962
151	10721	-10470	769	1206	869	5925	-2.683	-0.394	13.756
10025	-28944	-13408	-5303	33427	19239	-120653	6.220	5.276	11.324

Conclusions

On the basis of the presented analysis and by applying the CAESAR II program, the following issues can be emphasized and underlined:

- any pipeline section can be determined and verified, in such a way that the tension levels, the forces, torques, movements (generated in maximum operation conditions) are in the admissible limits;
- the supports were well located and correctly chosen on the pipeline section in order to prevent the appearance of dangerous mechanical tensions.

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Analiza flexibilităţii conductei de transfer dintre cuptorul tubular şi coloana de vid din instalaţia de distilare în vid

Rezumat

În această lucrare se prezintă, în mod original , analiza flexibilității conductei de transfer de păcură parțial vaporizată DN600-DN1200 dintre cuptorul tubular H3 şi coloana de vid C de la instalația de distilare în vid cu scopul reducerii tensiunilor mecanice generate de greutatea proprie a conductei cu fluid, presiunea interioară şi temperatură. Această analiză se realizează prin intermediul programului CAESAR II, versiunea 5.30.