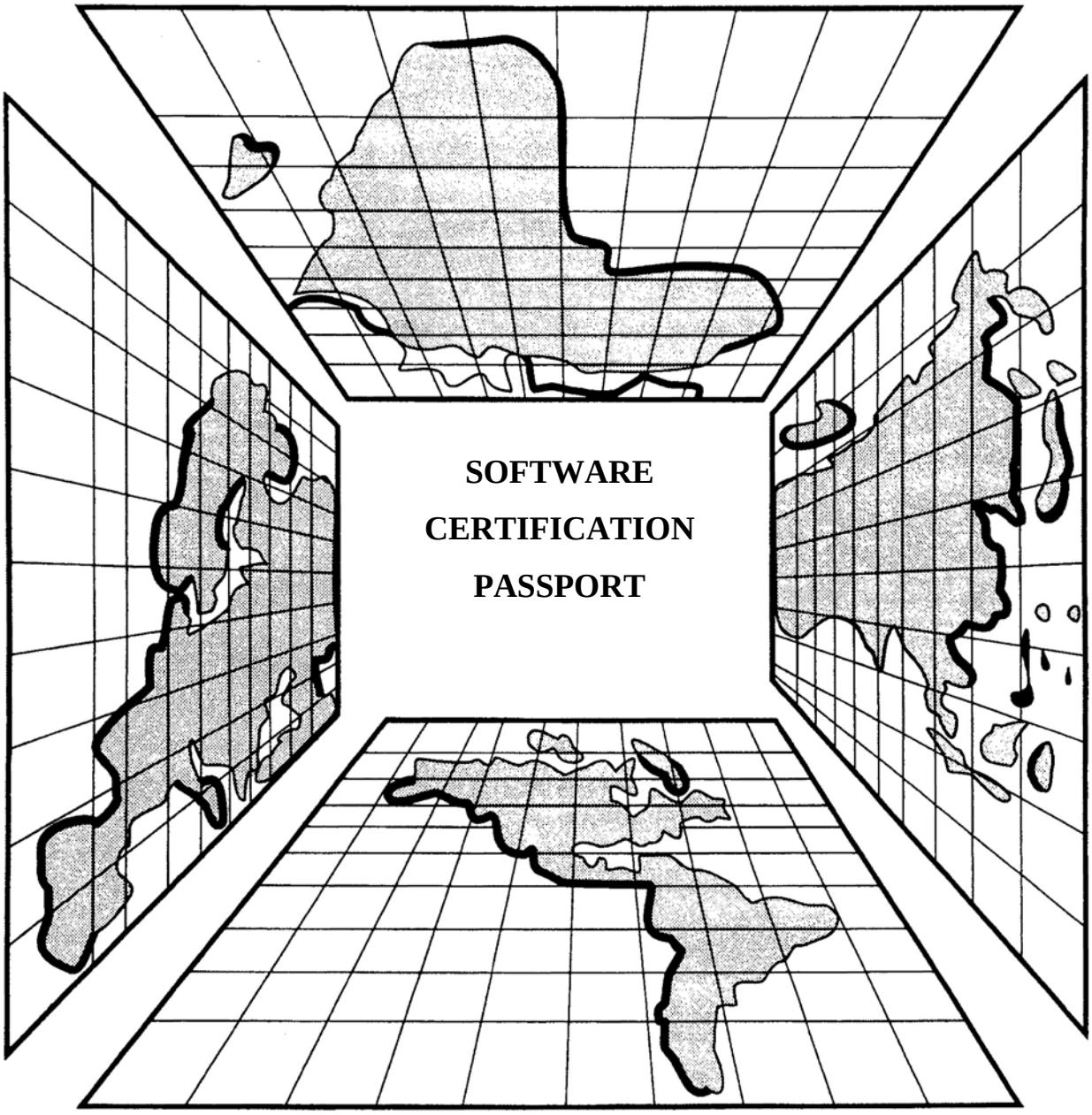
FEDERAL SERVICE FOR ENVIRONMENTAL, TECHNOLOGICAL AND NUCLEAR SUPERVISION

SCIENCE & TECHNOLOGY CENTER OF NUCLEAR AND RADIATION SAFETY



SOFTWARE CERTIFICATION PASSPORT

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SOFTWARE CERTIFICATION PASSPORT

Registration number of the deposited SS 638	**Registration number of SS certification passport** 265
Registration date 25.12.2008	**Date of issue** 23.09.2009

SS name, version: Software System dPIPE 5

Operating System: WIND0WS 2000/XP

Programming language(s): FORTRAN, C + +

Author(s): A.M. Berkovsky, P.S**.** Vasilyev, O.B. Kireyev, I.V. Popovich, G.I. Yudin

Developer: "CKTI-VIBROSEISM", LLC.

Applicant: "CKTI-VIBROSEISM", LLC.

Resolution of the Expert Council: Certify the software package dPIPE 5 for the period of 10 years

Annex: on 5 pages

Chairman of the Expert Council for certification of SS with Rostekhnadzor

(*signature)*
I.R. Ugoleva

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ANNEX TO CERTIFICATION PASSPORT NO. 265

Software system dPIPE 5

1. The list of registered software modules, registration numbers

dPIPE 5 does not contain any modules to be registered separately.

2. Purpose and scope of the SS

2.1. Purpose

dPIPE 5 software system (SS) is intended for calculation of stress-strain state (SSS) of pipelines of nuclear power plants (NPP) under the following loads and combinations thereof:

- internal pressure;
- concentrated and distributed weight load;
- compensation forces (loads from thermal expansion of pipelines and attached equipment);
- seismic loads given in the form of spectrum of response in terms of acceleration;
- seismic loads given in the form of accelerograms;
- dynamic loads given in the form of time-varying arbitrary direction forces concentrated at the nodes of the computational model.

SS allows to perform normative pipeline calculation (calculation of design stresses of categories $(\sigma)_2$ $(\sigma)_{RK}$, $(\sigma_{aF})_K$) for static loads and seismic forces in accordance with Annex 5 to Standards PNAE G-7-002-86. Comparison of design stresses with the allowable stresses (strength evaluation) is carried out accordance with sections 5.4 (static strength calculation), 5.9 (long-term static strength calculation), 5.6 (cyclic strength calculation), 5.11 (seismic effects calculation) of Standards PNAE G-7 -002-86.

When performing calculation for high-temperature pipelines, the SS allows to perform the procedure of accounting for release of thermal expansion compensation forces in accordance with the approaches adopted in RD 10-249-98 “Strength calculation standards for stationary boilers and steam and hot water piping.”

2.2. Type of a nuclear facility

AC pipelines falling within the scope of Standards PNAE G-7-002-86 (Section 1.1)

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2.3. Simulated modes

Static forces (weight, pressure, temperature, set offsets of reference nodes) under normal operating conditions (NUE) and in violation of normal operating conditions (NNUE).

Dynamic forces in violation of normal operation conditions, earthquake, plane crash, industrial explosions.

2.4. Restrictions on the use

Both static and dynamic analysis assumes the operation of the pipeline within the elastic region. Stress analysis in taps and tees is to be performed in accordance with paragraph 2.3.1 of Annex 5 to Standards PNAE G-7-002-86. Refined methods of paragraphs 2.8 and 2.9 of the same document are not implemented in the SS.

Minimum requirements for the computer:

- Operating system WINDOWS 2000/XP
- Disk space - at least 64 MB
- RAM - at least 128 MB

Restrictions on the dimension of solved tasks are determined by the amount of available memory and disk space. SS operating experience has demonstrated the successful solution of tasks with the following maximum dimensions:

- maximum number of items: 2,000
- maximum number of elastic suspensions: 300
- maximum number of anchor supports: 300
- maximum number of arbitrary poles: 300
- maximum number of concentrated weight loads: 300

SS not is designed to simulate wave propagation effects in shock processes.

2.5. Admissible parameter values

Parameter range - small movements in the elastic region.

Nonlinear work of elements of pipeline fastening is considered both for static effects (accounting of friction in sliding supports, one-way operation, deviation of suspensions from the vertical position), and as part of the dynamic analysis calculation method (DAM) for

dynamic effects (includes plugging connections, mechanical and hydraulic shock absorbers). For dynamic calculations the number of forms of natural oscillations of the system included in the analysis must be complete enough to correctly describe the motion of the system in the area of nonlinear unfastening elements.

The degree of sampling of the finite element model during static calculations reflects the basic geometry of the pipeline system, locations of cross-section changes, supports and lumped parameters. To determine the locations of maximum displacement and stresses it is recommended to assume the distance between the nodes of the computational model as at least five diameters of the current pipeline cross-section.

For dynamic calculations, the criterion of ensuring minimum partial frequency of the created model is added to the above requirements to determine the exact frequency within range of up to the maximum frequency (FMAX) considered in the analysis. It is recommended that the minimum partial frequency of the model is 2.5 - 3 times higher than FMAX frequency. With that purpose, the maximum length of the pipeline span shall be selected accordingly.

Integration step for dynamic calculation using DAM is set to be smaller or equal to one twentieth of the smallest period of natural oscillations of the system, which provides unconditional convergence of the solution.

2.6. Permissible error in the area of admissible parameter values

The accuracy of practical calculations is determined by the following:

- accuracy of solution of the problem under review for small deformations and displacements;
- accuracy of physical and mechanical properties of materials;
- accuracy of geometric dimensions, weight characteristics of the structure and load parameters;
- the value of integration step during the calculations using dynamic analysis method;
- the number of forms of natural oscillations taken into account during calculation using linear-spectral method or modal integration method;

The maximum error of the solution based on comparison of calculation results with theoretical and experimental data does not exceed 15% for stress-strain state parameters.

3. Information on the calculation methods used in the SS

The finite elements (FE) method is used in the calculation in the form of displacement. The main unknowns are the displacements of nodes of the finite element model.

The SS uses three basic types of finite elements: straight beam of circular cross section and arbitrary cross section, curved beam of circular cross section and elastic element. All the above elements have two-nodes and six degrees of freedom at each node.

For modeling and corresponding displaying of specific nodes and components of pipelines, dPIPE 5 SS uses a set of service elements, presentation of which within the calculation model is reduced to the above three major FE. With these service elements, straight pipe, elbow, reducer, rigid coupling, fittings (valve), compensator, resilient member, beam, mounting brace are modeled.

Accounting for non-linear support relationships in static analysis is carried out using an iterative procedure.

In order to determine the natural frequencies and oscillation modes of the pipeline Lanczos method is used.

Seismic forces calculation is performed using dynamic analysis method or linear spectral method.

During calculation using linear-spectral method the summation of response modal parameters for one spatial direction of the seismic action is possible according to the following rules: mean-square summation, ten percent summation, summation under CQC rule (perfect squares method). In case of a multiple-support effects the combination of impact on groups of supports is determined either by the mean-square rule, or by absolute summation. The summation of response parameters for spatial directions of the seismic action is carried out using the mean-square rule. Accounting for higher modes of oscillation is carried out by static correction.

As part of DAM a procedure of modal integration of the equations of pipeline system motion is implemented with account to damping supports (including taking into account disproportionate damping), mechanical and hydraulic shock absorbers, as well as support with plugged connections (stops with gaps). The total damping in the system is considered as a modal damping, common for all modes of vibration. The account for nonlinear properties of support links for unrelated system of modal equations is made using vector of nonlinear modal forces.

4. Databases (libraries of constants) used in the SS

The program does not use built-in databases (libraries of constants). All the initial

parameters required for the calculation are given in the preparation of the initial data.

5. The list of organizations that operate SS

- LLC “CKTI-VIBROSEISM”
- JSC “SPbAEP”
- JSC OKB “GIDROPRESS”
- JSC “Atomenergoproekt”
- JSC “Kaluga Turbine Works”
- JSC “Main Institute of “VNIPIET”
- Kalinin branch “Kalininatomtehenergo” of JSC “Atomtekhenergo”
- LLC “Resource”
- JSC “NPO CKTI”
- LLC “EnergoNefteHimProekt”
- JSC “Nizhny Novgorod Engineering Company “ATOMENERGOPROEKT”
- LLC “Scientific and Production Enterprise “Lifting structures”

6. Additional information

N/a.

7. Special conditions

The software tool is subject to re-certification in case of amendments to Sections 5.4, 5.6, 5.9, 5.11 and Annex 5 of PNAE G-7-002-86. In case of cancellation of PNAE G-7-002-86 the tool shall be re-certified as well.

8. Official experts

- V.S. Rubtsov, Candidate of Science (Engineering), head of the department of SEC NRS
- V.V. Tkachev, Candidate of Science (Engineering), senior researcher of INR RRC “Kurchatov Institute”
- A.M. Belostotsky, Doctor of Science (Engineering), CEO of R&D Center StaDiO

Chairman of the Expert Council

(signature) I.R. Ugoleva

Chairman of the Section No. 4 of the Expert Council

(signature) Y.I. Likhachev

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