

**NATIONAL THERMAL POWER CORPORATION LTD.
1X500 MW NTPC VINDHYACHAL STPP STAGE-V (SG PKG)**

VOLUME-II B

**TECHNICAL SPECIFICATIONS
FOR
VIBRATION ISOLATION SYSTEM
FOR
ID FAN (2 NOS)
PA FAN (2 NOS)
FD FAN (2 NOS)**

SPECIFICATION NO. PE-TS-389-618-C001 (REV 0)



**BHARAT HEAVY ELECTRICALS LIMITED
Project Engineering Management
PPEI BUILDING, HRD & ESI COMPLEX
Plot No. 25, Sector 16A
NOIDA, U.P. – 201301
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FOR ID (2 NOS.) / PA (2 NOS.) / FD (2 NOS.)
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SECTION 'A'

SCOPE OF WORK

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Supply of Vibration Isolation System (VIS)

- i) Vibration Isolation System (VIS)
- ii) Tools and facilities required for erection and commissioning including seaworthy packing & transportation etc. complete.

Supervision of erection and commissioning of the VIS.

Vendor shall deploy experienced manpower for setting the VIS in position and final adjustments after machine installation. Vendor shall also confirm the readiness at site before deploying the manpower for supervision of erection. Vendor shall furnish proposed erection strategy of the entire system and procedure for replacement of VIS and downtime involved.

Design & Engineering for the Vibration Isolation System (Excluded in vendor's scope)

Design and engineering shall consist of the following:

- i) Selection of Vibration Isolation System (VIS).
- ii) Static and dynamic analysis and design of RCC deck slab (supporting arrangement for the equipment supported on VIS)
- iii) Calculation of loads on supporting structure along with their points of application and deflection limitations.
- iv) Calculation should establish that no dynamic loads are transferred to the structure supporting VIS and that the foundation system meets the amplitude/frequency requirements.
- v) Checking of stiffness for structure supporting VIS.

Documentation

Vendor shall furnish following documents:

- i) Bill of materials of various elements included in the supply along with detailed specifications of system and various items included in supply and standards local or international standards to which they conform.
- ii) General Arrangement (GA) drawing showing location and supporting details of VIS. (Excluded from vendor's scope).
- iii) GA and reinforced concrete details drawings for deck slab including bar bending schedule. (Excluded from vendor's scope).
- iv) Embedment drawings showing location of all embedment and their details pertaining to RCC deck slab (Excluded from vendor's scope).
- v) Design document. (Excluded from vendor's scope).
- vi) Methodology of providing the shuttering and its removal as well as concreting of deck slab, installation of VIS and sequence of above operation.



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- vii) Installation and maintenance manual indicating equipment, procedures, etc. necessary for installation/maintenance VIS.
- viii) List of power plants where such systems have been successfully installed for such applications.
- ix) Performance certificate from the end user/customer for at least two successfully executed contracts for such system.



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SECTION 'B'

PROJECT INFORMATION



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PROJECT INFORMATION

1.	Owner	NATIONAL THERMAL POWER CORPORATION LTD.
2.	Project	1X500 MW NTPC VINDHYACHAL STPP STAGE-V (SG PKG)
3.	No of Units	1
4.	Consultant	NATIONAL THERMAL POWER CORPORATION LTD.
5.	Location	The plant is located in Sidhi district of Madhya Pradesh, having a Latitude and Longitude of 24 6 N and 82 40 E respectively.
6.	District	Sidhi (Madhya Pradesh)
7.	Nearest Major Town	Renukoot, the nearest town, is about 50 kms. away from the project site.
8.	Nearest Railway station	The nearest rail head Shakti Nagar Railway Station, is approximately 2 km away from the project site
9.	Nearest Airport	The nearest airport is Varanasi located at a distance of approximately 220 km from the project site.



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SPECIFIC TECHNICAL REQUIREMENTS

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General Requirement

01. Bidder shall select no. and type of springs based on the input drawings as per Table-1 to satisfy the design requirement as per the relevant applicable codes refer annexure- I (section-c), and section –D.

Table-1

<u>Sl. No</u>	<u>TITLE</u>	<u>DRAWING NO.</u>
1	GENERAL ARRANGEMENT OF ID FAN NDZV 47 SIDOR	RP-DG-335-107-0204(R01)*
2	GENERAL ARRANGEMENT OF PA FAN PAF 19/10.6-2	RP-DG-335-106-0202(R03)*
3	GENERAL ARRANGEMENT OF FD FAN FAF 24.5/11.8-1	RP-DG-335-107-0211(R04)*

• INPUT DRG. OF ID/PA/FD FAN FOR VINDHYACHAL STPP STAGE-IV ARE VALID FOR VINDHYACHAL STAGE-V

1.02. Bidder shall also furnish the information about the entire range of spring units, damper units and spring cum damper units, manufactured by the vendor. The information to be furnished should include the load carrying capacity, stiffness (vertical & horizontal), damping resistance, dimension of spring and damper units as well as quality plan to enable customer to review the spring selection done by the bidder.

03. Customer may revise the requirement of springs (no. and type) based on the information furnished in 1.02 above by the bidder and the bidder shall be required to furnish revised price bid based on the requirement.


Seismic Loading:

Seismic loads shall be calculated adopting the site specific seismic information as specified in annexure-II (section-c)

Wind Loading :

The wind load shall be calculated in accordance with IS: 875 (Part 3). The various design parameters as defined in IS: 875 (Part 3) to be adopted for the project site shall be as follows:

- a. The basic wind speed “Vb” at ten metres above the mean ground level: 47 m/s.
- b. The risk coefficient “K1” : 1.07
- c. Category of terrain : Category 2

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Note: Notwithstanding the values of the above mentioned parameters, the design wind pressure so computed at any point shall not be taken less than 1500 N/sq.metre for all classes of structures, i.e. A,B & C, as defined in IS: 875 (Part-3).

Material (Design & Supply)


1. Steel helical springs and viscous dampers shall consist of:
 - a. Steel helical spring units and viscous dampers along with viscous liquid including associated auxiliaries for installation of the spring units and dampers like steel shims, adhesive pads, etc.
 - b. Frames for pre-stressing of spring elements.
 - c. Suitable hydraulic jack system including electric pumps, high pressure tubes etc. required for the erection, alignment etc. of the spring units. One set of extra hydraulic jacks, and hand operated pumps shall also be provided.
 - d. Any other items may be required for the pre-stressing, erection, release of pre-stress, alignment and commissioning of the steel helical springs.
2. The design of the supporting arrangement for the equipment supported on steel helical springs and viscous dampers shall be done by owner. The supporting arrangement shall consist of an RCC deck supported on steel helical spring units and viscous dampers which in turn shall be supported on RCC substructure. The RCC deck shall be provided by owner.
3. The spring units should have stiffness in both vertical and horizontal directions with the horizontal stiffness not less than 50% of vertical stiffness. The stiffness should be such that the vertical natural frequency of any spring unit at its rated load carrying capacity is not more than 3 Hz.
4. The damper units or spring cum damper units should be of viscous type offering velocity proportional damping. The damper units should be suitable for temperatures ranging from 0 to 50° c. The damping resistance of the individual damper units should be such that the designed damping can be provided using reasonable number of units. Damper units shall have damping resistance ranging from 40kNsec/m to 300 kNsec/m.
5. The sizes of the spring units, damper units, spring cum damper units should be such that groups of such units can be accommodated on column heads in case of elevated foundations and on pedestals/walls in case of foundations at ground level.
6. The steel helical springs and viscous dampers shall be designed for a minimum operating life of 30 years.

Manufacturing & Testing

1. Complete manufacturing and testing of the steel helical springs and viscous dampers shall be done at the manufacturing shop of the vendor. For this purpose the vendor shall submit the detailed programme for approval of customer and take up the

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<p>manufacturing / testing after approval of such programme. The programme shall include:</p> <ol style="list-style-type: none"> Manufacturing schedule and quality check exercised during manufacturing. Detail of test to be carried out at the manufacturing shop with its schedule. Special requirements, if any, regarding concreting of top deck. Complete step- by- step procedure covering the installation and commissioning of the spring system. Manuals for erection, commissioning, testing and maintenance of the steel helical springs and viscous dampers. A checklist for confirming the readiness of the civil fronts for erection of steel helical springs and viscous dampers. Checklist for equipment required at each stage of erection. Bill of materials (data sheet) of various elements such as spring units, viscous dampers, with their rating, stiffness etc. included in the supply. Bill of material (data sheet) for frames for pre stressing, hydraulic jack including electric pump, high pressure tubes, hand operated pump etc. with their rating and numbers. Any other details which may be necessary to facilitate design and construction of the foundations / structures. 	
<p>2. The springs shall conform to codes DIN 2089 and DIN 2096. The quality assurance and inspection procedure shall be finalised on the basis of the above codes and the quality plans be drawn accordingly.</p>	
<p>Transportation</p>	
<p>1. Steel helical springs and viscous dampers shall be suitably protected, coated, covered, boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection.</p>	
<p>2. The vendor shall be responsible for any loss or damage during transportation, handling.</p>	
<p>Erection and Commissioning</p>	
<p>1. Complete erection and commissioning of the steel helical springs and viscous dampers including pre-stressing of elements, placing of elements in position, checking clearances on the shuttering of the RCC top deck, releasing of pre-stress in spring elements, making final adjustments and alignments etc. all shall be supervised by a specialist supervisor.</p>	
<p>2. The scope of work shall be deemed to include all activities, which may not have been explicitly mentioned but are reasonably implied for the successful commissioning of steel helical springs and viscous dampers.</p>	
<p>3. The vendor shall guarantee the performance of the steel helical springs and viscous dampers for 24 months from the date of commissioning of each machine which shall be termed as "Guarantee Period".</p>	

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Supervision

The supervision of installation of steel helical springs and viscous dampers including pre-stressing, placing, releasing and alignment of spring units shall be done by a specialist supervisor of vendor, trained for this purpose.

Realignment of Spring System

If any realignment of the steel helical springs and viscous dampers is required to be done for aligning the shaft or for any other reasons during the first one year of operation from the date of commissioning of the machine, the same shall be done by the vendor.



TITLE:

**STANDARD TECHNICAL
SPECIFICATION FOR VIBRATION
ISOLATION SYSYTEM**

SPECIFICATION NO. PE-TS-999-600-C026

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SECTION - D

SUB-SECTION - D26

VIBRATION ISOLATION SYSTEM

SPECIFICATION NO. PE-TS-999-600-C026



Bharat Heavy Electricals Limited

Project Engineering Management



TITLE:

**STANDARD TECHNICAL
SPECIFICATION FOR VIBRATION
ISOLATION SYSYTEM**

SPECIFICATION NO. PE-TS-999-600-C026

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VIBRATION ISOLATION SYSTEM**1.00.00 SCOPE**

This section covers supply, supervision of erection/ commissioning & design engineering of the vibration isolation system (VIS) suitable for ID/PA/FD Fans/ TDBFP/MDBFP/TURBOGENERATORS/MILLS. The vibration isolation system shall be of proven make and should be in successful operation for similar machines.

2.00.00 Supply of VIS

VIS shall be supplied complete along with recommended spares if any. The selection of VIS shall be done by the vendor, in case not done by customer, so that the amplitude at bearing locations are within permissible limits as per machine supplier recommendation or ISO10816 whichever is governing and no dynamic loads are transferred to the structure supporting VIS. Minimum 90 % isolation shall be achieved and the system shall be capable of withstanding Seismic/Wind forces.

3.00.00 Supervision of Erection and Commissioning**3.01.00 Manual**

Vendor shall supply installation and maintenance manual indicating equipment, procedures etc. necessary for installation and replacement of VIS with downtime involved.

3.02.00 Tools and facilities

Vendor shall supply all tools and facilities as required for successful erection and commissioning of VIS. Vendor shall deploy experienced manpower to supervise successful installation of VIS

4.00.00 Design Engineering of Vibration Isolation System**4.01.00 Dynamic Analysis**

The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. Isolation efficiency of at least 90 % shall be obtained. The fundamental natural frequency shall be sufficiently above or below the



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frequency corresponding to operating speed. Vibration amplitude shall be calculated at all bearing locations and shall satisfy the permissible limits as per ISO 10816 or as specified by the machine supplier. Transient analysis shall be carried out for the short circuit /blade failure condition with an appropriate force function if required by the machine supplier. The forces for which substructure is to be designed shall be furnished.

4.02.00 Static Analysis

The static analysis shall include the

- a) Dead weights of machine stationary parts,
- b) Dead weights of machine rotary parts
- c) Loads due to machine power torque
- d) Loads due to maximum allowable unbalance
- e) Temperature loads
- f) Loads due to blade unbalance/short circuit
- g) Erections loads
- h) Seismic Loads
- i) Any other loads given by the supplier

Various load combinations must be investigated to obtain the most severe loads for foundation design purpose as per relevant IS codes or as per machine supplier recommendation whichever is more critical.

4.03.00 Check for Shaft Misalignment

Foundation deck must be adequately stiff to withstand all operating load combinations without excessively upsetting the rotor shaft alignment. The structural design must carefully be analysed for relative deflection for the members supporting machine shaft to satisfy the limits as given by machine supplier if any.

4.04.00 Design of RCC deck supported on VIS

Vendor shall provide General arrangement drawing of deck showing location and supporting detail of VIS, all embedment and their details as per the machine supplier drawing.

RCC design shall be done by working stress method for all machine foundations. Minimum reinforcement shall be governed by IS : 2974 as well as IS : 456.

All documents/drawings shall be supplied in 25 (twenty five) prints. All calculations shall be supplied in 6 (six) sets. Soft copy of the drawings in Auto Cad shall be supplied along with the soft copy of the documents supplied



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All documentation shall be in English language and all RCC/structural design shall be conforming to the relevant Indian Standard Code of practice.

5.00.00 Quality Plan and Test Certificate

Vendor shall furnish the quality plan and Test certificate for the hardware in their scope of supply. The quality plan shall be reviewed by BHEL/Consultant wherein the inspection and hold points shall be indicated. Vendor shall submit test certificate based on approved Quality Plan. Despatch of material by the vendor shall only take place after the receipt of Material Dispatch Clearance Certificate (MDCC) issued by BHEL/Consultant on the basis of test reports/test certificates submitted by the Vendor after manufacture.

6.00.00 Environmental Protection

VIS shall be suitably protected against environmental damages e.g. abrasion, discolouration, corrosion, oily water etc. to give a prolonged service matching the plant life.

ANNEXURE-I (section-c)

Codes and Standards

Some of the relevant applicable Indian standards and codes, etc. applicable to this section of the specification are listed below:

- DIN : 4024 Machine foundations; Flexible supporting structures for machine with rotating masses.
- DIN : 2089 Helical compression springs out of round wire and rod: calculation & design.
- DIN : 2096 Helical compression springs out of round wire and rod: quality requirements for hot formed compression springs.
- VDI : 2056 Criteria for assessing mechanical vibrations of machine.
- VDI : 2060 Criteria for assessing the state of balance of rotating rigid bodies.

ANNEXURE -II (Section-C)

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		ANNEXURE-EQ																	
	<p>CRITERIA FOR EARTHQUAKE RESISTANT DESIGN OF STRUCTURES AND EQUIPMENT</p> <p>All structures and equipment shall be designed for seismic forces adopting the site specific seismic information provided in this document and using the other provisions in accordance with IS:1893 (Part 1):2002 and IS:1893 (Part 4):2005. Pending finalisation of Parts 2, 3 and 5 of IS:1893, provisions of part 1 shall be read along with the relevant clauses of IS:1893:1984, for structures other than the buildings and industrial structures including stack-like structures.</p> <p>The peak ground horizontal acceleration for the project site, the site specific acceleration spectral coefficients (in units of gravity acceleration 'g') in the horizontal direction for the various damping values and the multiplying factor (to be used over the spectral coefficients) for evaluating the design acceleration spectra are as given at Annexure-I.</p> <p>Vertical acceleration spectral values shall be taken as 2/3rd of the corresponding horizontal values.</p> <p>The site specific design acceleration spectra shall be used in place of the response acceleration spectra, given at figure-2 in IS:1893 (Part 1) and Annex B of IS:1893 (Part 4). The site specific acceleration spectra along with multiplying factors specified in Annexure-I includes the effect of the seismic environment of the site, the importance factor related to the structures and the response reduction factor. Hence, the design spectra do not require any further consideration of the zone factor (Z), the importance factor (I) and response reduction factor (R) as used in the IS:1893 (Part 1 and Part 4).</p> <p>Damping in Structures</p> <p>The damping factor (as a percentage of critical damping) to be adopted shall not be more than as indicated below for:</p> <table><tr><td>a)</td><td>Steel structures</td><td>:</td><td>2%</td></tr><tr><td>b)</td><td>Reinforced Concrete structures</td><td>:</td><td>5%</td></tr><tr><td>c)</td><td>Reinforced Concrete Stacks</td><td>:</td><td>3%</td></tr><tr><td>d)</td><td>Steel stacks</td><td>:</td><td>2%</td></tr></table>			a)	Steel structures	:	2%	b)	Reinforced Concrete structures	:	5%	c)	Reinforced Concrete Stacks	:	3%	d)	Steel stacks	:	2%
a)	Steel structures	:	2%																
b)	Reinforced Concrete structures	:	5%																
c)	Reinforced Concrete Stacks	:	3%																
d)	Steel stacks	:	2%																
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	<p>Method of Analysis</p> <p>Since most structures in a power plant are irregular in shape and have irregular distribution of mass and stiffness, dynamic analysis for obtaining the design seismic forces shall be carried out using the response spectrum method. The number of vibration modes used in the analysis should be such that the sum total of modal masses of all modes considered is at least 90 percent of the total seismic mass and shall also meet requirements of IS:1893 (Part 1). Modal combination of the peak response quantities shall be performed as per Complete Quadratic Combination (CQC) method or by an acceptable alternative as per IS:1893 (Part 1).</p> <p>In general, seismic analysis shall be performed for the three orthogonal (two principal horizontal and one vertical) components of earthquake motion. The seismic response from the three components shall be combined as specified in IS:1893 (Part 1).</p> <p>For buildings, if the design base shear (V_B) obtained from modal combination is less than the base shear (\bar{V}_B) computed using the approximate fundamental period (T_a) given in IS:1893:Part 1 and using site specific acceleration spectra with appropriate multiplying factor, the response quantities (e.g. member forces, displacements, storey forces, storey shears and base reactions) shall be enhanced in the ratio of \bar{V}_B / V_B. However, no reduction is permitted if \bar{V}_B is less than V_B.</p> <p>For regular buildings less than 12m in height, design seismic base shear and its distribution to different floor levels along the height of the building may be carried out as specified under clause 7.5, 7.6 & 7.7 of IS:1893 (Part 1) and using site specific design acceleration spectra. The design horizontal acceleration spectrum value (A_h) shall be computed for the fundamental natural period as per clause 7.6 of IS:1893 (Part 1) using site specific spectral acceleration coefficients with appropriate multiplying factor given in Annexure-I.</p> <p>Further, the spectral acceleration coefficient shall get restricted to the peak spectral value if the fundamental natural period of the structure falls to the left of the peak in the spectral acceleration curve.</p> <p>Design/Detailing for Ductility for Structures</p> <p>The site specific design acceleration spectra is a reduced spectra and has an in-built allowance for ductility. Structures shall be engineered and detailed in accordance with relevant Indian/International standards to achieve ductility.</p>		
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ANNEXURE -I (Contd.)

SITE SPECIFIC SEISMIC PARAMETERS FOR DESIGN OF STRUCTURES AND EQUIPMENT

The various site specific seismic parameters for the project site shall be as follows:

- 1) Peak ground horizontal acceleration
(for design basis earthquake) : 0.212g
- 2) Multiplying factor to be applied to the site specific horizontal acceleration spectral coefficients to obtain the design acceleration spectra
 - a) for moment resisting steel frames designed and detailed as per IS:800 : 1.6
 - b) for braced steel frames designed and detailed as per IS:800 : 1.3
 - c) for moment resisting RC frames designed and detailed as per IS:456 and IS:13920 : 1.0
 - d) for design of structures not covered under 2 (a) to 2 (c) above and under 3 below : 1.6
- 3) Multiplying factor to be applied to the site specific horizontal acceleration spectral coefficients for design of equipment and structures where inelastic action is not relevant or not permitted : 2.646

Note: g = Acceleration due to gravity

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ANNEXURE – I (Contd.)

**HORIZONTAL SEISMIC ACCELERATION SPECTRAL COEFFICIENTS in units of 'g'
FOR VSTPP-IV**

Period (Sec)	Damping Factor (as a percentage of critical damping)						
	0.5%	1%	2%	3%	5%	7%	10%
.040	.08088	.08126	.08164	.08164	.08126	.08126	.08088
.042	.08504	.08429	.08353	.08315	.08277	.08240	.08202
.044	.08882	.08731	.08580	.08504	.08429	.08353	.08315
.046	.09260	.08996	.08807	.08693	.08580	.08504	.08429
.048	.09638	.09336	.08996	.08844	.08731	.08618	.08542
.050	.10016	.09600	.09222	.09033	.08882	.08769	.08693
.055	.10999	.10432	.09865	.09525	.09298	.09147	.08958
.060	.12019	.11263	.10507	.10092	.09751	.09525	.09298
.070	.14287	.13153	.11981	.11339	.10734	.10318	.09940
.075	.15497	.14136	.12775	.11981	.11226	.10734	.10243
.080	.16706	.15119	.13569	.12624	.11717	.11112	.10545
.085	.17678	.16101	.14325	.13267	.12208	.11490	.10810
.090	.19087	.17084	.15081	.13871	.12662	.11868	.11074
.095	.20183	.17991	.15837	.14476	.13078	.12208	.11301
.100	.21166	.18823	.16479	.15005	.13531	.12511	.11528
.110	.23056	.20372	.17727	.16026	.14287	.13115	.11944
.120	.24719	.21809	.18823	.16933	.14967	.13682	.12359
.130	.25966	.22829	.19730	.17689	.15572	.14174	.12737
.140	.27024	.23661	.20523	.18407	.16101	.14665	.13040
.150	.27856	.24530	.21166	.18974	.16593	.15043	.13342
.160	.28499	.25135	.21809	.19465	.16933	.15308	.13569
.170	.28914	.25777	.22224	.19843	.17235	.15534	.13720
.180	.29330	.26193	.22413	.20146	.17424	.15686	.13796
.190	.29746	.26420	.22829	.20372	.17575	.15761	.13833
.200	.29746	.26609	.23056	.20561	.17651	.15799	.13796
.220	.29464	.26380	.22665	.20361	.17352	.15419	.13413
.240	.28788	.25971	.22313	.19972	.16936	.14961	.12949
.260	.28197	.25385	.21779	.19507	.16442	.14423	.12440
.280	.27433	.24871	.21313	.18965	.15905	.13877	.11884
.300	.26498	.24143	.20664	.18380	.15358	.13354	.11457

CLAUSE NO.

CIVIL WORKS



ANNEXURE – I (Contd.)

HORIZONTAL SEISMIC ACCELERATION SPECTRAL COEFFICIENTS in units of 'g'
FOR VSTPP-IV

Period (Sec)	0.5%	Damping Factor (as a percentage of critical damping)						10%
		1%	2%	3%	5%	7%		
.320	.25602	.23309	.20044	.17821	.14833	.12853	.11012	
.340	.24947	.22679	.19415	.17250	.14329	.12370	.10584	
.360	.24148	.21869	.18774	.16700	.13809	.11904	.10169	
.380	.23342	.21288	.18189	.16134	.13338	.11520	.09835	
.400	.22561	.20525	.17622	.15619	.12882	.11114	.09478	
.420	.22000	.19982	.17071	.15119	.12472	.10752	.09197	
.440	.21293	.19455	.16568	.14665	.12073	.10433	.08924	
.460	.20765	.18780	.16046	.14191	.11685	.10090	.08658	
.480	.20058	.18249	.15568	.13792	.11337	.09819	.08430	
.500	.19559	.17731	.15134	.13371	.10998	.09523	.08176	
.550	.18187	.16485	.14058	.12419	.10244	.08920	.07659	
.600	.16850	.15299	.13064	.11575	.09558	.08378	.07230	
.650	.15631	.14224	.12174	.10798	.08963	.07892	.06821	
.700	.14519	.13221	.11319	.10112	.08452	.07456	.06490	
.750	.13475	.12283	.10584	.09481	.07960	.07066	.06141	
.800	.12525	.11464	.09902	.08900	.07544	.06690	.05835	
.850	.11660	.10698	.09299	.08366	.07113	.06355	.05568	
.900	.10906	.10041	.08742	.07906	.06780	.06059	.05309	
.950	.10230	.09430	.08229	.07486	.06429	.05743	.05029	
1.000	.09626	.08890	.07786	.07078	.06115	.05464	.04785	
1.100	.08628	.07988	.07042	.06401	.05539	.04982	.04342	
1.200	.07837	.07234	.06412	.05836	.05069	.04521	.03946	
1.300	.07158	.06644	.05888	.05348	.04619	.04106	.03592	
1.400	.06610	.06130	.05411	.04957	.04264	.03785	.03278	
1.500	.06107	.05686	.05028	.04581	.03949	.03501	.03001	
1.600	.05673	.05282	.04684	.04268	.03643	.03227	.02758	
1.700	.05302	.04942	.04376	.03990	.03423	.02986	.02569	
1.800	.04968	.04611	.04102	.03720	.03185	.02803	.02400	
1.900	.04643	.04340	.03835	.03507	.02977	.02624	.02238	
2.000	.04375	.04075	.03625	.03275	.02800	.02468	.02108	
2.200	.03925	.03675	.03250	.02975	.02525	.02233	.01912	

CLAUSE NO.	CIVIL WORKS							<div>एनडीपीसी NTPC</div>
	ANNEXURE - I (Contd.)							
	HORIZONTAL SEISMIC ACCELERATION SPECTRAL COEFFICIENTS in units of 'g' FOR VSTPP-IV							
	Period (Sec)	Damping Factor (as a percentage of critical damping)						
		0.5%	1%	2%	3%	5%	7%	10%
	2.400	.03550	.03325	.02975	.02700	.02315	.02038	.01748
	2.600	.03250	.03025	.02700	.02468	.02120	.01870	.01605
	2.800	.02975	.02775	.02468	.02260	.01940	.01718	.01482
	3.000	.02725	.02550	.02272	.02065	.01787	.01580	.01370