

## Special Provision Language for **Vibration Control and Monitoring**

Vibration producing activities (such as blasting, pile driving, vibratory compaction, pavement breaking or operation of heavy construction equipment) are common in construction projects. Four levels of vibration control can be provided on a project, depending on things such as structure susceptibility to damage, proximity to vibration producing activities, local concerns, or district policy. The "levels" can briefly be defined as follows:

- Level 1 -** No specific mention in contract of possible problems or controls. On a statewide basis, this is most common for minor or small quantities of pavement breaking or pile driving, when they are not in proximity to occupied structures or sensitive receptors.
- Level 2 -** Alert contractor to possible problems by brief description in the special provisions. Vibration levels and monitoring are at the discretion of the contractor, and the contractor is responsible for all damage caused by his activities.
- Level 3 -** Detail concerns and require the contractor to do a prescribed condition survey and to employ a qualified vibration specialist to establish a safe vibration level and monitor the vibrations. As an alternative, a vibration level may be set by the Department, such as the "OSM Alternative Blasting Level Criteria". It may also be appropriate to use experienced based vibration criteria, such as established District 1 during construction of the Duluth Freeway Tunnels. The contractor is still responsible for any problems.
- Level 4 -** State takes lead role and has consultant(s) do a damage susceptibility study to establish vibration control limits, and a preconstruction condition survey for each structure. The State also takes responsibility for vibration monitoring during construction to insure compliance with vibration control limits. At this level, the State assumes some responsibility for damage to structures if the established vibration limits are not exceeded by the contractor. The degree of responsibility depends on the vibration specification - most vibration specifications are aimed at avoiding structural damage, leaving the contractor responsible for any cosmetic damage (e.g. plaster cracks, broken windows, etc.) and keeping residents/occupants informed and "happy".

Examples of Level 2 through Level 4 specifications are given below. Each of these was produced for a specific project and need to be personalized or fine-tuned for other projects. There may be levels between those shown, but care must be taken to keep the specifications consistent, for example, it would be inconsistent to expect the contractor to take total responsibility for vibrations and then put a vibration specification in the contract.

### **Level 2**

#### **S- CONSTRUCTION VIBRATIONS**

Vibration producing activities (such as blasting, pile driving, vibratory compaction, pavement breaking or operation of heavy construction equipment) may be required for construction of this project. The Contractor is advised that structures are located close to the proposed work and that construction activities shall be conducted so as to preclude damage to these structures and undue annoyance to occupants. The contractor shall be responsible for all damage caused by his activities.

### Level 3

#### S- CONSTRUCTION CONTROLS AND MONITORING

Vibration producing activities (such as blasting, pile driving, vibratory compaction, pavement breaking or operation of heavy construction equipment may be required for construction of this project. The Contractor is advised that structures are located close to the proposed work and that construction activities shall be conducted so as to preclude damage to same. The Contractor shall be responsible for any damage caused by his activities.

At least 30 days prior to start of such work, the Contractor shall provide a \_\_\_\_\_ plan (blasting, pile driving, etc.) plan to the Engineer, which shall include, but not be limited to the following: proposed construction method(s), vibration monitoring plans (including the format for reporting the vibration readings), anticipated vibration levels at the closest building(s), condition survey format, and public relations activities. A copy of all reports shall be provided to the Engineer.

#### S- .1 Condition Survey

A preconstruction building Condition Survey shall be conducted by the Contractor on the \_\_\_\_\_ building(s), prior to the commencement of any vibration producing activity. (In lieu of naming the buildings, a radius of 400 ft from the vibration producing activity can be used – this distance can be adjusted based on the type of activity and the sensitivity of the receptors.)

The survey will include documentation of interior sub-grade and above grade accessible walls, ceilings, floors, roof and visible exterior as viewed from the grade level. It will detail (by engineering sketches, video tape, photographs, and/or notes) any existing structural, cosmetic, plumbing or electrical damage. The survey will be conducted by a Professional Engineer, registered in the State of Minnesota.

A report shall be issued that will summarize the pre-construction condition of the building(s) and will identify areas of concern, including potential personnel hazards (falling debris) and structural elements that may require support or repair.

Crack displacement monitoring gages will be installed as appropriate across any significant existing cracks to help verify any additional building distress if it should develop. The appropriate location, number, and type of gages will be established by the Contractor and/or the Project Engineer. The gages will be read prior to vibration producing activities, as well as during these activities. Data shall be obtained on a weekly basis for as long as vibration-producing activities are being conducted. A report shall be submitted which summarizes the data. The Engineer shall be alerted if any significant movement is detected by the monitoring gages.

#### S- .2 Vibration Controls

(Sound level limits should also be included for blasting projects)

The Contractor shall employ a qualified vibration specialist to establish a safe vibration level for the \_\_\_\_\_ building(s). This specialist shall also supervise the Contractors vibration-monitoring program. During all vibration producing activities, the Contractor shall monitor vibration levels at \_\_\_\_\_ building(s), and shall not exceed the safe level established to preclude damage to this structure(s).

The vibration monitoring equipment shall be capable of continuously recording the peak particle

velocity and providing a permanent record of the entire vibration event. Copies of all vibration records and associated construction activity (blasting, pile driving, pavement breaking, etc.) data shall be provided to the Engineer in a format approved by the Engineer.

S- .3 Public Relations

The Contractor shall maintain a complaint log and make this available to the Engineer on request. Occupants/owners of adjacent buildings shall be notified by the Contractor at least 2 weeks prior to commencement of any vibration producing activity that might affect the structure or inhabitants.

**Level 4**

S- VIBRATION MONITORING AND CONTROL

The following provisions do not relieve the Contractor of any responsibility for damage caused by his operations, nor do they relieve the Contractor from compliance with all applicable federal, state, county and city codes relative to the use and storage of explosives. In the event that a conflict occurs between this specification and other codes, it shall be resolved by the Engineer.

S- .1 Susceptibility Study

A detailed document titled \_\_\_\_\_, has been prepared for Mn/DOT by (Name of consulting firm), and a copy of this report is available for inspection at the District \_\_\_ Headquarters, (address & contact). This report includes an evaluation of buildings and structures in proximity to the project and an evaluation of their susceptibility to construction vibration damage. The vibration criteria for this project is based on this study.

S- .2 Condition Survey

A condition survey will be (or has been) performed for buildings in proximity to the project. This survey will document the existing exterior and interior conditions of these buildings.

The survey will include documentation of interior sub-grade and above grade accessible walls, ceilings, floors, roof, and visible exterior as viewed from the grade level. It will detail (by engineering sketches, video tape, photographs, and/or notes) the existing structural, cosmetic, plumbing and electrical damage, but will not necessarily be limited to areas in buildings showing existing damage.

Crack displacement monitoring gages will be installed as appropriate across any significant existing cracks to help verify any additional building distress, should it develop. The gages will be read prior to commencement of vibration producing activities, as well as during these activities. Results of this monitoring will be made available to the Contractor.

S- .3 Ground Vibration Controls

The following vibration control limits are applicable for all construction work, including but not limited to blasting, pile driving, compaction, ripping, and hauling activities.

The Contractor is advised that the ground vibration control limits defined herein may restrict his construction practices, and that he should consider these limitations in preparing his bid.

If the Contractor exceeds 80% of the ground vibration limit as given below, for any construction activity, he shall cease that activity and submit a report. The report shall give the construction parameter data and

include a proposal for corrective action necessary to ensure that the specified limit is not exceeded for future activities. This report shall be submitted to the Engineer, and his permission must be obtained prior to the continuation, or beginning of any future vibration producing construction activities.

If the Contractor exceeds the ground vibration limit for any construction activity, the Engineer will direct that all activities related to those causing the vibration be stopped. The Contractor shall submit to the Engineer a report giving the construction parameter data and include the proposed corrective action for future construction events. In order to proceed with any further vibration producing activities, written permission must be obtained from the Engineer.

#### A. Definitions

The following definitions shall apply to the vibration controls:

Peak particle displacement - the peak particle displacement is the maximum movement induced by the vibration. The displacement amplitudes are in units of mils (0.001 inch) zero to peak amplitude.

Peak particle velocity - The peak particle velocity is the maximum rate of change with respect to time of the particle displacement. The velocity amplitudes are in units of inches per second (ips), zero to peak amplitude.

Frequency - The frequency of the vibration is the number of oscillations which occur in one second. The frequency units are given in Hertz (Hz) where one Hz equals one cycle per second.

#### B. Ground vibration control limit

(Sound level limits should also be included for blasting projects)

The ground vibration controls are applicable to external locations adjacent to affected buildings or structures. The maximum single component peak particle velocity resulting from construction activity shall not exceed \_\_\_\_\_.

#### S- .4 Instrumentation

The Contractor shall furnish, maintain and operate three vibration monitors (amplitude and frequency sensitive) during any vibration producing activities that could, in the judgment of the Engineer, produce measurable ground vibrations. In the event that the Contractor chooses to have concurrent vibration producing activities at more than one location on the construction site, he shall notify the Engineer in writing at least two weeks prior to the commencement of such activities. The Engineer may require additional vibration monitoring instruments at each location depending on site parameters. No vibration producing activities may be started until the appropriate instrumentation is provided by the Contractor and approved by the Engineer.

All vibration instruments shall be powered with rechargeable batteries, and the Contractor shall supply extension geophone and microphone cables so that the instruments can be placed within structures if outside temperatures drop below 32 degrees Fahrenheit.

All vibration instruments shall be supplied with current calibration documents and shall be recalibrated on approximately a six-month use interval. At a minimum, instrument specific calibration curves of peak particle velocity input to peak particle velocity output shall be provided over the specified frequency ranges at both 0.5 and 1.0 ips for each instrument.

The Contractor shall be responsible for instrument maintenance. If the Contractor does not maintain a sufficient number of instruments to monitor the buildings/structures adjacent to the vibration producing activity, the Engineer may direct that all vibration activities cease until a sufficient number are working. Recording tape shall be supplied by the Contractor and at least a two-week supply maintained.

The Contractor shall designate an individual in his organization or under contract to him, who will be responsible for instrument coordination. The Contractor will be responsible for placing the instruments at measuring locations designated by the Engineer, and reading and recording the pertinent vibration event data. The Contractor will report the data to the Engineer at the completion of each vibration event.

The amplitude/frequency vibration monitor shall be an InstanTel Blastemate II, or equivalent, available from Walter & Associates, 9241 Ravenna Road, C-6, Twinsburg, OH 44087, phone 800-964-0540, website [www.drwalter.com](http://www.drwalter.com). This instrument shall be capable of measuring, recording and producing a hard copy of the frequency and peak particle velocity in three mutually perpendicular axes. ("Vector sum" instruments are not acceptable). This instrument shall be capable of measuring Linear Scale (dB-L) sound levels.

#### S- .5 Public Relations

The Contractor is required to have both letter and personal contact with residents and owners or operators of the buildings that are adjacent to the construction area or near enough to it for ground vibrations from construction operations to affect the personal property, displays or merchandise of these buildings. This contact will be made prior to the beginning of any vibration producing activity. The Contractor will furnish a list of those contacted to the Engineer.

As described elsewhere in these provisions, the ground vibration resulting from construction work will be monitored by the Contractor. The Contractor will measure the magnitude of each vibration event with at least two vibration instruments, generally located adjacent to the closest or most critical structures.

#### S- .6 Record Keeping

The Contractor shall maintain a log of all vibration-producing activities at which ground vibrations were measured. The log shall include the maximum peak particle velocity and its associated frequency, type and location of the vibration producing event, location of the geophones and closest distance from the vibration-producing event to the geophone(s). When vibration-producing activities are in progress, the Contractor shall submit daily reports to the Engineer which include all the vibration log data from that day. These reports shall be submitted at the end of each day, and no further vibration producing activity will be allowed until such reports are received by the Engineer.

The Contractor shall be responsible for removing all vibration records produced by the vibration instruments and attaching them to the corresponding Blast Log for submittal to the Engineer as part of the daily report.

The Contractor shall maintain a complaint log of all vibration related complaints, contacts and actions, and shall furnish copies to the Engineer on request.