

## MONITORING OF VIBRATIONS AND SOUND IMMISSIONS FOR RAILWAY MUNICH - VERONA IN THE LOWER INN-VALLEY/ AUSTRIA

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Since 1999 the project team arsenal research and TIWAG (Tirolean Waterpower) is involved into the railway project Unterinntal (lower Inn – valey). A new line with two tracks, mainly located in tunnels with a total length of about 40 km will be built until 2007. The project is one section of the new railway axis Munich – Verona. The line is erected by Brenner Eisenbahngesellschaft (BEG). The lower Inn-valley is densely populated, hence many buildings are very close to the new line. The task for the project team is the monitoring of vibrations and structure borne noise. The monitoring started with the assessment of the status in certain houses before the start of the project as a baseline. During the construction phase vibrations are monitored in order to protect the houses and to guarantee an acceptable situation for the users of the buildings. At the moment some preliminary construction work is carried out, especially the blasting of pilot galleries. The main construction phase will probably start in the 4<sup>th</sup> quarter of 2002. After the start of train operation the project team will also measure vibrations and structure borne noise due to train traffic in order to check if all means for vibration - protection (e.g. mass – spring – systems) work efficient and everything is according to the Austrian standard ÖNORM S 9012.

In order to be able to compare the state of buildings after the opening of the railway line to the previous condition it was necessary to assess the present state of several buildings. The necessary measurements were conducted in selected buildings in which vibrations already occur (e.g. residential houses near the existing Westbahn railroad or near frequently used roads). Furthermore measurements were carried out in firms which cause vibrations of their own because of the working processes running there (e.g.: Darbo, Tyrolit, Jenbacher Werke). There it is especially relevant to record the present state, since external vibrations could disturb the production process. Also some historical important buildings were examined, such as Schloss Matzen (castle Matzen) or Rolandsbogen (monument from the 10<sup>th</sup> century). Additional measurements were carried out on sensitive points in the terrain in order to be able to evaluate the danger of rock slides. Further, in some cases vibrations resulting from construction work (e.g. packing of ground) were recorded. For some buildings, which were included in our measurement program, measurement data and vibration prognosis data were available from earlier work for the declaration of environmental compatibleness.

Normally sensors were placed at the foundation level of the buildings, further in the middle of representative floors and also at load bearing walls in one or more upper storeys. Further, in order to calculate transfer spectra (differential spectra) it is advantageous to place sensors in the terrain near the building.

In many cases the recording of „*present state*“ was conducted through „*manned measurements*“. Vibrations were recorded in three orthogonal directions during an interval of several hours. The advantage of these manned measurements is, that unwanted disturbances can be detected during the recording. This makes it possible to distinguish vibrations caused by the inhabitants of a house from that ones created by trains or other sources. Further, additional information like type of the train and velocity can be provided at the same time. „*Unmanned measurements*“ are used where no additional observations are necessary.

For every examined building a report including a picture of the building and the most important data is available. The exact positions of each single sensor can be found in the materials. The reports contain tables with data about all recorded events, including the values for  $v_{\max}$  (maximum velocity vector of oscillation),  $KB_{F_{\max}}$  (normalized vibration magnitude), and also the frequency of the major component of oscillation. The values taken at the foundations and the floors are all listed separately.

After recording the „*present state*“ the measurements concentrate at the moment on areas where first construction work is conducted. All in all the number of objects being monitored during the construction phase will be much larger than the number of buildings where the „*present state*“ was recorded.

All results are stored in the ORACLE database VDB (run by TIWAG). The scheme of data transfer and of VDB is shown in Figure 1. The data for each object can be easily accessed. It is immediately evident whether the maximum values of velocity of oscillation ( $v_{\max}$ ) are within the limits set by the standard DIN 4150-3, depending on the type of the building (see. Figure 2). If the permissible values are exceeded, e.g. in the case of rock-blasting, the construction - supervisor is informed. Alarms are immediately submitted via SMS.

The last step of the investigations will take place after the opening of the railway when measurements of KB-values and of structure borne noise will be carried out during regular train service. Then it will become evident whether the peak values of the oscillation and the  $K_r$  values (weighted averages) are within the bounds set by the standard ÖNORM S 9012.

VDB is most of all a tool to preserve the collected data for a long time. BEG, arsenal and TIWAG have direct access to the data. A software for adding and requesting all data was developed. The system makes it possible to conduct standardized evaluations from the data through web-technologies. It supports efficient administration and is the basis for flexible future evaluations. The database is fully in use since September 2000. The VDB is mostly used for the continuous monitoring of buildings close to the construction site of tunnels. But in August 2000 also the data on the measured „*present state*“ of the buildings, which were conducted before the start of the construction work, were added to the database.

Data are recorded at the site by „intelligent sensors“ (WASAG-Chemie), temporarily stored and sent to the TIWAG headquarters in Innsbruck (Tyrol, Austria) through the transmission technology also used by mobile phones. The software which is provided by the manufacturer of the sensor and the measurement equipment visualizes, processes and evaluates the data and also generates additional graphs. The processed data and the graphs are then automatically transmitted to the VDB system. VDB controls all data points, sensors, measurements, generated alarms and further additional relevant information. Multiple backups of the raw data are created, which enables the engineers to re-evaluate all data.

The VDB system consists of the following main components:

- VDB-ORACLE server system: uses databases in ORACLE RDBMS for event specific saving of measurements and additionally required information
- VDB web application: access to the ORACLE database through web-technologies (web-generation from ORACLE Designer: HTML, JavaScript)
- VDB saves documents to the server
- VDB import interface: reception of graphs and files containing measurements (ASCII)
- VDB export Interface: the measurements from the database can be saved in ASCII format and evaluated with specialized Windows tools: e.g. Plotit, Statgraphics

VDB is able to show requested data for a specific time, place, event or alarm. The central strategy in the development of VDB was the ORACLE web-generation using the CASE- tool ORACLE Designer. The VDB database builds on already processed files (measured values and graphs).

After data transmission every night a program sequences starts, which extracts all information necessary to generate the tables and graphs for presenting the events from the previous day.

The system requirements are a Web browser Netscape Version 4.0 or higher/ Microsoft Internet Explorer Version 4.0 or higher, a TCP/IP connection to the local TIWAG area network or via extranet (i.e. analogue Modem/ ISDN modem). The handling of the system is basically easy and can be compared to the use of common web browsers.

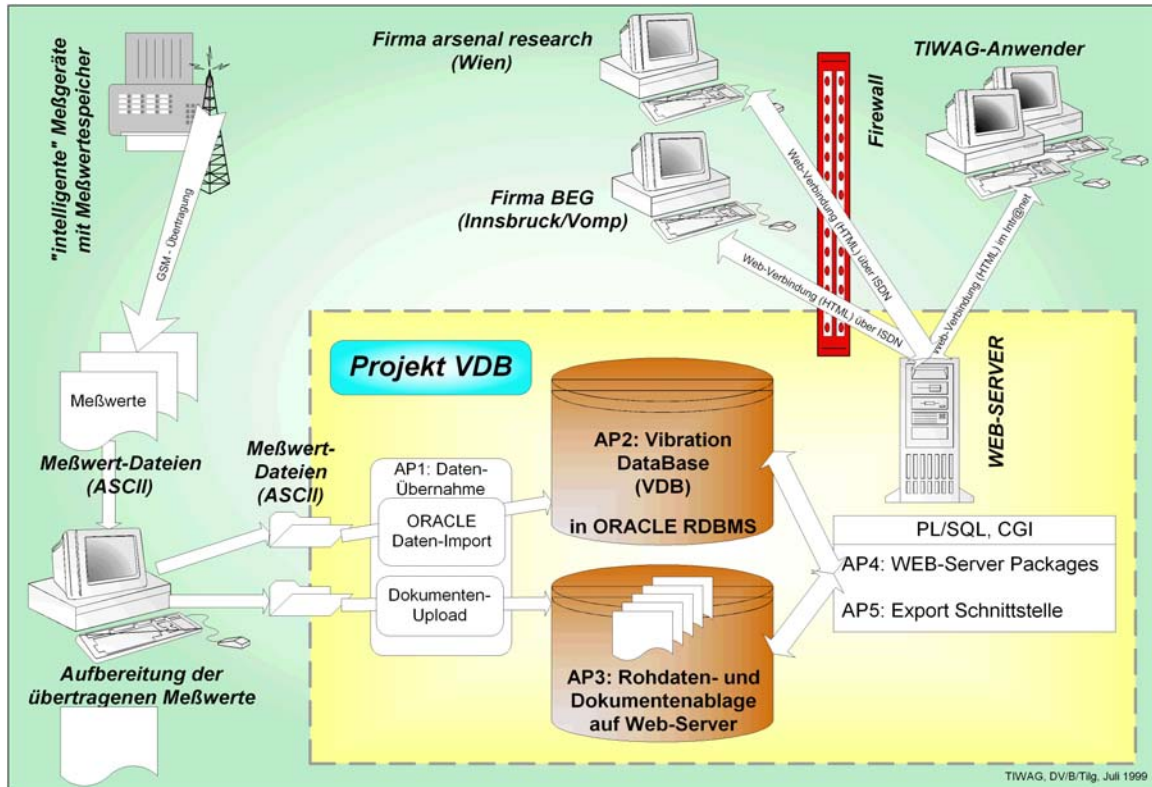


Fig. 1: Data transmission and scheme of VDB

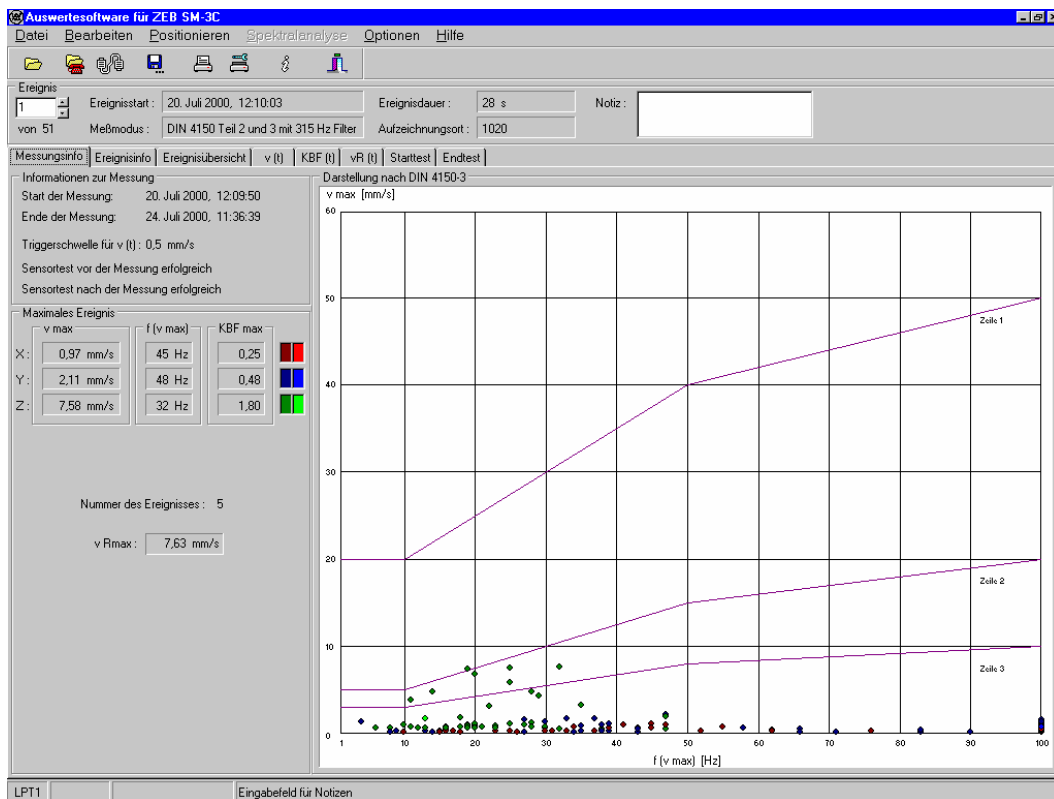


Fig. 2:  $v_{max}$  for a certain time intervall – interpretation according to DIN 4150-3