

Evaluation of Installation Methods for Streckeisen STS-2 Seismometers

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A: Introduction

It is well known that the Streckeisen STS-2 seismometer is at long periods not as sensitive as its predecessor, the STS-1, however it is still the most sensitive seismometer currently available on the market. While it has been demonstrated that at selected sites the vertical component of the STS-2 seismometer in the band 1-5 mHz is only 6-10 dB less sensitive than a well performing STS-1 (Widmer-Schmidrig, 2003), this gap is often in the range 20-25 dB (e.g. Berger et al., 2004). Hanka (2000) has shown that the noise performance of the STS-2 at long periods can be much improved by extensive thermal shielding. How best to install and shield these sensors remains a matter of debate and is the topic of this poster. Rather than conducting a huddle test of differently shielded STS-2s we compare data from different networks which all operate STS-2 seismometers and assume that within a given network the shielding can - at least to a limited extent - be considered uniform. We compare free oscillation spectra of the 2004 Sumatra event to evaluate horizontal component performance and Hum detections (see below) to evaluate the vertical components.

B: Vertical Performance

The permanently excited background free oscillations (Hum) in the band 2-7 mHz (Suda et al., 1998) constitute a signal well suited for instrument comparisons as it has an almost constant amplitude in space and time. The *rms* amplitude of a single fundamental spheroidal mode belonging to the Hum is approximately 1 ngal over 0.1mHz bandwidth. We have inspected data from all available stations of the following networks: GRSN, GEOFON, FNET (Japan) and the Swiss CHnet. For every station we gleaned at least 12 months of continuous data in an effort to find as many stations as possible which can be used to investigate the still uncertain excitation mechanism of the Hum (see Kurrle and Widmer-Schmidrig, 2006). As an aside this study enables us to evaluate the performance of the above networks as judged by the percentage of stations which see the Hum (Table 1).

Table 1: Hum detections

Network	yes	maybe	no
GRSN+	9 (82%)	1 (9%)	1 (9%)
GRSN-	3 (50%)	1 (17%)	2 (33%)
FNET	15 (26%)	11 (19%)	32 (55%)
CHnet	3 (11%)	3 (11%)	20 (78%)
GEOFON	10 (19%)	6 (11%)	38 (70%)

C: Horizontal Performance

To characterize the horizontal component performance of the STS-2 at long periods we plot E-W component spectra of the Mw=9.2 Sumatra event. All time series have been visually inspected and spikes or other short noise bursts removed. An effort has been made to show data from every available station.

We first note that the data quality is surprisingly consistent within a given network, reflecting the effort and care taken for site selection, installation and shielding of the sensors.

A ranking sees GRSN+ and FNET with the best signal-to-noise ratio followed by CHnet, GRSN- and GEOFON. While several STS-2s in the GRSN+ and FNET see the twisting mode σ_{T2} at 0.4 mHz, σ_{S6} at 1.04 mHz is the first mode that can be seen at the majority of GEOFON stations.

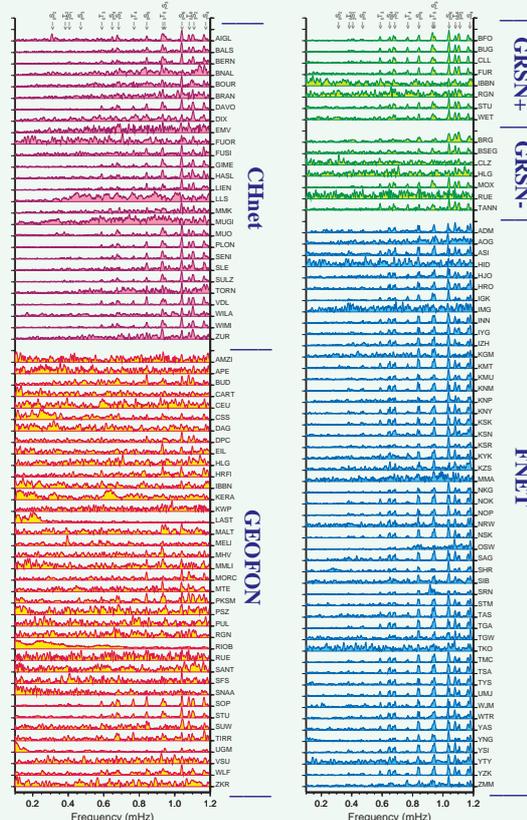


Fig. 1 Linear Fourier amplitude spectra of free oscillations based on 60 hours of data following the 2004 Sumatra event. Only E-W components of STS-2 seismometers are shown. All spectra are normalized with their maximum amplitude and no instrument correction was applied. Predicted mode frequencies are indicated along the top. GRSN+ and GRSN- indicate the two types of sensor shielding used in the GRSN.

D: STS-2 Shielding

GRSN+: hermetically sealed pressure vessel with rigid gabbro base plate and compliant stainless steel pot. Ambient pressure variations are attenuated by 40dB by this vessel. Further thermal insulation added inside and outside the pressure vessel. The above sequence of pictures shows the prototype GRSN+-shielding first implemented in Stuttgart (Th. Forbriger, 1998).

GRSN-: thermal shielding only.

GEOFON: hermetically sealed Aluminum pressure vessel with only 3 times thicker bottom than top. Thermal insulation added inside the pressure vessel.

CHnet: extensive thermal shielding consisting of a brick wall enclosure filled with styrofoam beads.

FNET: no immediate shielding of the sensors. However all sensors are at least 40m below the surface in dedicated vaults.

E: Conclusions

The subset of GRSN+ stations equipped with the GRSN+ pressure vessel (Wielandt and Widmer-Schmidrig, 2003) excel both with their vertical and horizontal component spectra. The E-W components of the FNET also perform very well which seems surprising considering that the sensors in this network stand naked on the piers. This goes to show that sensor shielding is less important in underground installations. GEOFON and CHnet perform similarly on the vertical but on the horizontal component GEOFON is considerably more noisy than CHnet. We attribute the poor horizontal performance of GEOFON to tilt noise caused by a compliant vessel floor warping under ambient air pressure fluctuations. Comparing FNET with GRSN+ (Table 1) shows that for the vertical component the benefit of the GRSN+ pressure vessel cannot be offset by deep underground installation.

For future installations of broad-band seismometers such as the STS-2, GRSN+-type shielding seems highly recommended. This shield also protects the sensor from high humidity and subsequent damage by corrosion.

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Table 1 Summary of Hum detections listed by network. Listed is the station count. GRSN+ (GRSN-) denotes the subset of GRSN stations equipped with (without) the gabbro base plate and shielded as in the picture sequence above.