Introduction:

Informal document No.2 has been distributed during the 29th session of GRSP with the title:

„**PROPOSAL FOR DRAFT AMENDMENTS TO REGULATION NO. 17** (Rear Impact collision test procedure)

In the above mentioned document an equitation shows the calculation of the N_{km} value. In the following pages the N_{km} value will be explained.

On the web page www.agu.ch the following explanations and additional information to the item „Seats and Rear Impact" can be found.

Remark:
The above mentioned Informal document has been prepared by the expert from Germany, transfering the information of the web page www.agu.ch.

How to calculate the N_{km}

Definition:

Based on the hypothesis that a neck protection criterion should take into account a linear combination of shear forces and sagittal bending moments, the N_{km} was proposed to assess rear-end impacts.

The N_{km} criterion was defined according to the following equation:

$$N_{km}(t) = \frac{F_x(t)}{F_{int}} + \frac{M_y(t)}{M_{int}}$$

where $F_x(t)$ and $M_y(t)$ are the shear force and the flexion/extension bending moment, respectively. Performing crash tests using a standard dummy, both values should be obtained from the load cell positioned at the upper neck. F_{int} and M_{int} represent critical intercept values used for normalization.

Distinguishing positive shear, negative shear, flexion and extension, the N_{km} criterion identifies four different load cases: N_{fa}, N_{ea} N_{fp} and N_{ep}. The first index represents the bending moment (f: flexion, e: extension) and the second indicates the direction of the shear force (a: anterior, i.e., in positive x-direction, p: posterior, i.e., in negative x-direction). The sign convention according to SAE J211/2 was used. Consequently, positive shear forces measured at the upper neck load cell indicate that the head is moved backwards relative to the uppermost cervical vertebra.

The intercept values used to calculate the criterion are shown in Table 1 which exhibits the human tolerance levels for the

Table 1:

load case	value	
extension	47.5 Nm	Goldsmith and Ommaya, 1984 Mertz and Patrick, 1993
flexion	88.1 Nm	
negative and positive shear	845 N	

causation of AIS1 neck injury. These values were identified on the basis of volunteer experiments [Mertz and Patrick, 1993] and suggest tolerance levels up to which no injury is expected. For the maximum shear level tolerated, no difference was found with respect to the direction of the sagittal shear force.

For the computation of the N_{km}, the two bending modes and the two load types under investigation are identified, then the load curves measured are divided by the according intercept value. Finally the N_{km} values are obtained by adding the adequate shear force and moment curves, while keeping the time scale unchanged, and determining the maximum of the resulting curve. Hence, N_{ep} for instance represents the maximum value in time when extension and negative shear occur simultaneously. The other N_{km} values can be explained analogously.

To date, experience with N_{km} values was solely gained on the basis of data obtained from Hybrid III/TRID dummies. Resulting thereof, a critical N_{km} value of 1.0 was proposed taking into account that either a moment or a shear force exceeding the intercept value produces a risk of sustaining neck injuries.

Example:

Data:

Data representing the shear force and sagittal bending moment (i.e. extension, flexion) is needed to calculate the N_{km}. The sign convention according to SAE J211/2 has to be used, i.e. positive shear is directed from posterior to anterior and flexion is characterized by the positive values of the bending moment. The figure below shows an example of data obtained from a sled test experiment (the data can be downloaded in ASCII-format from http://www.agu.ch).
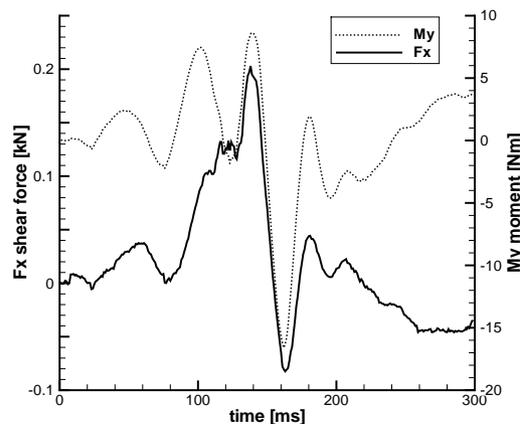
Step 1:

The shear forces are divided by 845 N (see diagram below).

Note: The units of the data and the intercept values have to be consistent.
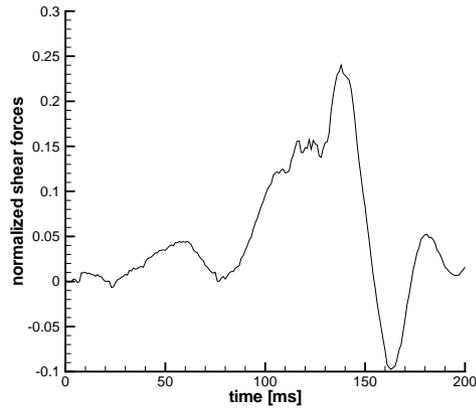
Step 2:

The data of the bending moment is analyzed and flexion (positive values) and extension (negative values) are determined. Afterwards flexion and extension values are divided by 88.1 Nm and 47.5 Nm, respectively.
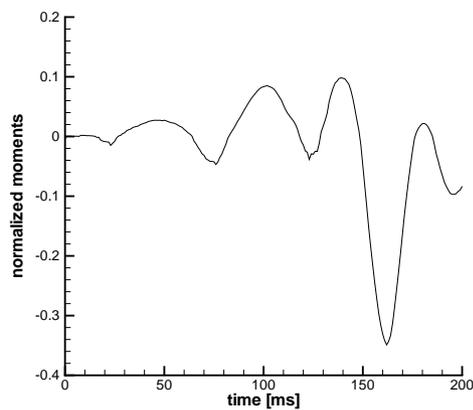
Step 3:

The normalized data for positive shear is added to the normalized flexion data. The maximum of resulting curve is taken as the N_{fa} value. In this example the N_{fa} value obtained is 0.337 (at 138 ms). For the N_{ep} value, the normalized data for negative shear is added to the normalized extension data and the maximum thereof is determined. This results in the example in a N_{ep} value of 0.444 (at 162 ms). Analogously the Nea is calculated by adding the normalized data for positive shear to the normalized extension data. Here the Nea reads 0.194 (at 154 ms). Finally the N_{fp} is obtained in a similar way. In our example, the N_{fp} value obtained is 0.0, i.e., this load case is not observed in the time interval under consideration. The following figure shows step 3. For better illustration a positive and negative scale was used, whereas the N_{km} is reported in absolute numbers only.
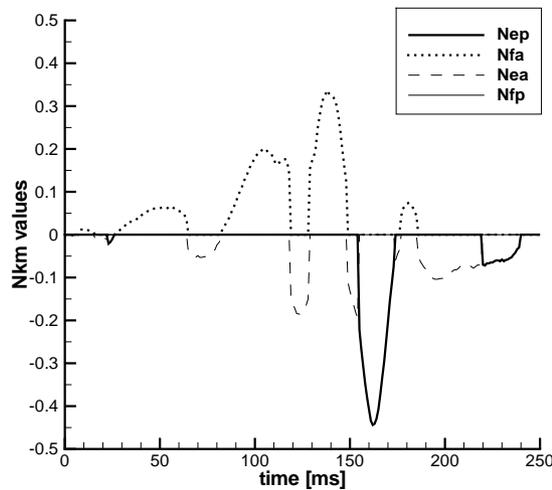
Note: It is necessary to check whether the results obtained are reasonable with respect to the crash test performed. If, for instance, one of the N_{km} values calculated occurs at a time which is not relevant for the test (e.g. at a time when the dummy is already restraint by a unrealistic seat belt), the next-to-highest peak prior to that point in time has to be taken.