

## How to use data files of rubber material tests

7 February, 2006

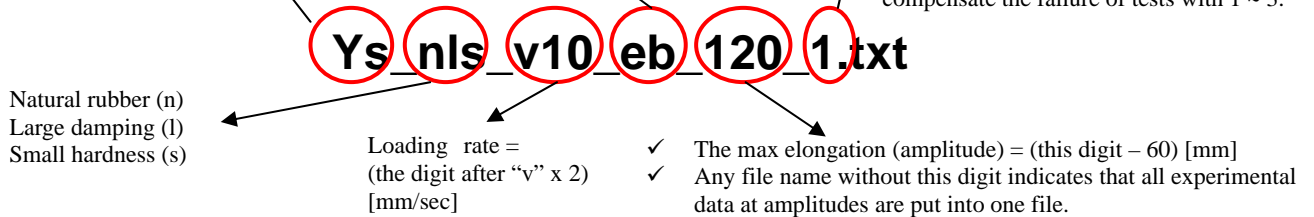
### (1) Cyclic loading test with multiple amplitudes

Rubber made by  
YAMASHITA RUBBER CO., LTD.

Test types:

eb: equi-biaxial tension test  
sb: strip-biaxial tension test  
u: uniaxial tension test

The number of a specimen used in the same type of tests for the same rubber. This parameter is normally taken as 1 ~ 3 for uniaxial tension tests, while 1 for others. However, any number other than 1 ~ 3 indicates that another test was re-done to compensate the failure of tests with 1 ~ 3.



#### a) Loading rate in Tension Test(s) (Triangular waveform of tensile displacement is given to a test device)

- Uniaxial tension tests and strip-biaxial tension tests (pure shear tests) are carried out at 20 mm/sec and 2mm/sec.
- Equi-biaxial tension tests are carried out at 20 mm/sec, 2 mm/sec, and 0.6 mm/sec.
- The data sampling is conducted with 50 Hz for tests with loading rate 20 mm/sec (implying 50 data points are recorded per second), with 5 Hz for those with 2 mm/sec and with 2 Hz for those with 0.6 mm/sec.

#### b) The number of specimens

- There is a possibility that similar tests are carried out three times with different specimens only for uniaxial tension tests, to make sure that there are no differences among test results with different specimens. only one test is conducted for some loading rates.
- For trip-biaxial and equi-biaxial tension tests, only one test is conducted with one loading pattern.

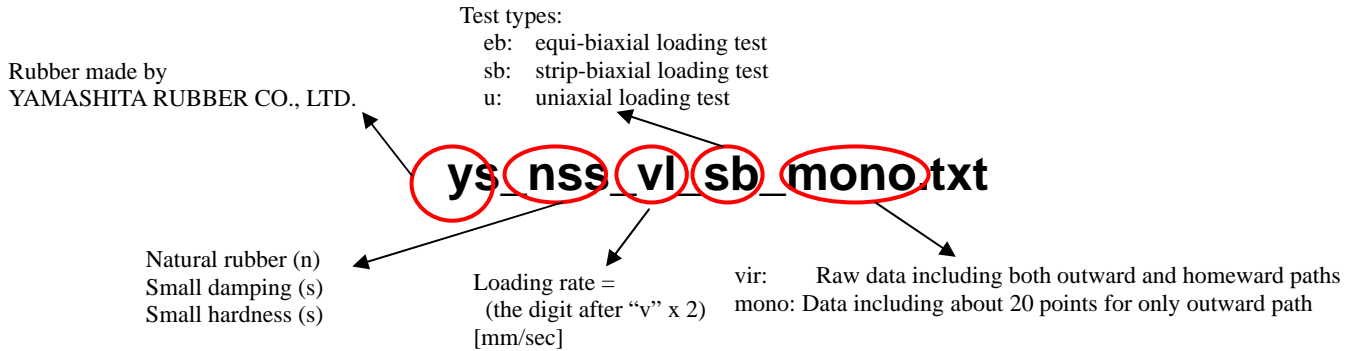
#### c) Loading amplitude

- Starting with small amplitude of loading, three cycles of loading per amplitude are applied and, 10-30 seconds after a test completion, another test is carried out on the same specimen, but with increased amplitude. Since each test is conducted until the specimen breaks, the number of amplitudes varies depending on the specimens and loading rates.
- Basically, strip-biaxial and equi-biaxial tension tests are started with amplitude of 60 mm and continued by increasing 15 mm for each set of cycles.
- Uniaxial tests are started with amplitude of 60 mm (sometimes with 30 mm) and continued by increasing 30 mm (sometimes with 15 mm) for each set of cycles.

#### d) Others

All the tests were carried out at temperature range  $20 \pm 2^\circ \text{C}$ .

(2) Single loading test with large amplitude



Single tests are conducted on virgin specimens by applying a cyclic loading with large single amplitude. There are two data types; a file name with "vir" indicates that the raw data contains both outward and homeward paths of cyclic loading, while a file name with "mono" indicates that only about 20 data points are taken by thinning the raw data down only for the outward path in a cyclic loading. Other conditions such as the patterns of loading rates and the way of data sampling are the same as those of the "cyclic loading test."

(3) Data format

A data file that contains an experimental result consists of four columns for an equi-biaxial tension test, three columns for a strip-biaxial tension test, and two columns for a uniaxial tension test, into which the following records are written, respectively.

(1) Equi-biaxial tension tests:

The first column indicates the stretch in the X direction, the second column the nominal stress in the X direction, the third column the stretch in the Y direction, and the fourth column the nominal stress in the Y direction.

(2) Strip-biaxial tension tests:

The first column indicates the stretch in the X (tension) direction, the second column the nominal stress in the X direction, and the third column the nominal stress in the Y (restraint) direction.

(3) Uniaxial tension tests:

The first column indicates the stretch in the X (tension) direction, and the second column the nominal stress in the X direction.

Note: "Stretch is dimensionless." "The unit for nominal stress is N/mm<sup>2</sup>"

Table-1 Basic data used for tension tests

Material	Natural Rubber	Natural Rubber	Natural Rubber	Natural Rubber
Hardness	50	65	50	65
tanδ	0.03	0.05	0.20	0.27
Young's module [MPa]	3.60	7.39	5.52	9.71
Mnemonic name in a file	nss (Small damping Small hardness)	nsl (Small damping Large hardness)	nls (Large damping Small hardness)	nll (Large damping Large hardness)
Specific heat [J/g·K]	1.55	1.43	1.47	1.40
Heat conductivity [W/m·K]	0.23	0.23	0.22	0.22