What is Tuner Loss?

The only Tuner Loss that matters, is the Available Loss of the 'Source Tuner and Fixture to DUT section' at high VSWR" (because it limits the power injected into the DUT). Check Focus' RF Calculator for Tuner and Fixture Loss.

Specifying the "Tuner Insertion Loss at Minimum VSWR", or "Maximum Tuner loss at VSWR=10:1" are either useless or misleading. For example it is useless to specify the "Tuner Insertion Loss at VSWR.min" since a tuner is not supposed to be used as a perfect transmission line in the setup. In addition the loss of the tuner is supposed to be calibrated and taken into account by the measurement software. It is also misleading to specify the maximum loss of a mechanical tuner at its internal ports, without further explanation, as some tuner vendors do. In general this loss does not differ much among the different models of mechanical tuners available on the market, since the transmission media is air. Electronic tuners have more loss since they use microstrip dielectric material. The important quantities are the "operating tuner losses" (for the input tuner this equals to "available loss", for the output tuner to "power loss").

But the only quantity of real practical importance is the "available loss of the input tuner under operating (high VSWR) conditions". The reason is that this loss is the one which will limit the power available at the input port of the DUT when this tuner is used to prematch the device. This loss in power must be overcompensated by expensive, high power, input driver amplifiers. Another important issue is that both the input and especially the output tuner loss will create power consumption and heating in the tuners at high VSWR with the risk of thermal failure. This thermal problem may be particularly critical in the case of electronic tuners which include a number of electronic components and microstrip structures.

How is loss created in a tuner?

The operating loss of both the input and output tuner is directly proportional to the insertion loss between the DUT and the tuner probe (slugs, or diodes). The proportionality factor depends on the reflection factor created by the tuner probe at its reference plane and increases sharply for Gamma>0.8. At Gamma=1 this factor reaches infinite since there is no power transfer to the load. As a rule of thumb "the operating loss, at Gamma=0.95 on probe level, resulting from additional insertion loss before the tuner probe, is 15 times higher than this additional insertion loss".

In the case of millimeterwave waveguide tuners the input section of the waveguide stands out of the tuner body by about 2 inches in order to fit on the wafer probe. This explains loss of up to 10dB typical for this type of tuner at high VSWR (15:1). The insertion loss of such tuners at VSWR. min is around 1.25 dB. Therefore the extra loss due to the mounting on to the probe is approximately: 2.0 / 8.3 * 1.25 * 15 = 4.5 dB; where 2.0 = extended waveguide length (inches), 8.3 = total waveguide length (inches), 1.25 = insertion loss at VSWR.min 15 = mismatch factor (we must assume an internal reflection factor at the probe level of about 0.95, which does not appear at the input port of the tuner, because of the insertion loss of the section between “Probe” and “Input-Port”). The remaining loss of about 5.5 dB is due to the tuner itself (at a reference plane close to its walls) , but this value is not of any practical use , since the tuner will, ultimately, have to be connected to a DUT or a wafer probe. In fact also any additional “probe insertion loss” will create extra “overall operating loss” due to the same mismatch effect and following the same rule of thumb.