New Standards for Submillimeter Waveguides

John S. Ward, Jet Propulsion Laboratory, California Institute of Technology,
M/S 168-314, 4800 Oak Grove Drive, Pasadena CA 91109, U.S.A.

Growth of the submillimeter-wave field has created the need for new standards for high frequency waveguides. The common "WR" standard for waveguide sizes gives no guidance for frequencies beyond 325 GHz, the upper band edge of WR-3 [1]. Similarly, standard waveguide flanges become increasingly problematic above about 100 GHz [2]. The result of this lack of standards is that hardware from different laboratories, universities, and commercial vendors is not in general intercompatible. Furthermore, adapters between incompatible waveguides typically introduce unacceptable performance degradation. It is clear that new standards are needed to maximize intercompatibility and minimize the costs associated with the proliferation of incompatible hardware.

The lack of waveguide standards beyond 325 GHz should not be solved by simply extending aging U.S. military standards. For example, the existing standards provide no guidance for selecting preferred sizes or for selecting in-between sizes, and the existing standards are in deprecated inch-pound units. A standard for waveguide sizes should, however, be based on existing widely-used international standards. It should provide guidance for selecting a minimum number of preferred sizes to provide continuous frequency coverage for generic laboratory equipment such as network analyzers, spectrum analyzers, sources, mixers, couplers, and horns. It should also provide guidance for choosing in-between sizes if the preferred sizes are not adequate for a particular application. Finally, it should include provisions for extending the standard indefinitely to higher and lower frequencies.

Table 1. The preferred series of waveguide sizes suitable for generic laboratory equipment like network and spectrum analyzers, sources, mixers, horns, directional couplers, etc. The table can be extended indefinitely to larger and smaller sizes by multiplying by powers of 10. See the proceedings for tables of second, third, and fourth choices of waveguide sizes as well as recommendations for circular waveguide.

Length (μm)		Cutoff (GHz)	
a	**b**	**TE_{10}**	**TE_{20}**
1000	500	150	300
630	315	238	476
400	200	375	750
250	125	600	1200
160	80	937	1874
100	50	1500	3000

ISO 497 is a widely used global industry standard familiar to many people as the basis for the sizing of a wide variety of commercially-available hardware such as metric fasteners and stock metals. The preferred sizes are a logarithmic scale starting at 1 mm and spaced 2 dB apart. For applications where in-between sizes are needed, the second choice is the series of sizes spaced by 1 dB, the third choice sizes spaced by 0.5 dB, etc. All sizes are rounded appropriately. The series repeats every decade by multiplying by a power of ten, making it quick and easy to memorize. By providing guidance for first, second, third, and fourth choices, ISO 497 maximizes the likelihood of compatibility between independently-developed hardware. Finally, since ISO 497 is an infinite series, it never needs to be revised to extend to larger or smaller sizes.

ISO 497 can be applied directly to the "a" dimension of rectangular waveguide. The resulting 2 dB spacing in the preferred sizes is ideally suited to provide complete frequency coverage for generic test equipment with the minimum number of different sizes. Table 1 summarizes the first-choice preferred sizes.

A new standard waveguide flange should be compact, provide a high degree of repeatability without requiring undue skill and attention of the user, should be robust against damage to precision surfaces, and should include only metric threads. This paper will discuss in more detail requirements and choices for submillimeter waveguide flanges, and will present a concept for gendered waveguide flanges for directional components like sources, mixers, isolators, and (eventually) amplifiers that eliminates the need for insertable gender changers.

The research described herein was carried out at the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA, under contract with the National Aeronautics and Space Administration.

[1] MIL-DTL-85/3B
[2] Kerr, A. R., Wollack, E., and Horner, N., "Waveguide Flanges for ALMA Instrumentation," ALMA Memo #278, 1999.