



FLEXWELL® Elliptical Waveguide



Introduction

Waveguides are used for the transmission of RF energy at microwave frequencies. The traditional rigid rectangular and circular waveguide configurations have been supplemented for the last 40 years by elliptical corrugated FLEXWELL® transmission lines.

Today, rectangular waveguides are mainly used for short connecting pieces, bends and twists, and sometimes in the form of UHF rectangular waveguides as very low loss TV antenna feeders

Elliptical waveguides have helical corrugations and thus are suited for bending and winding on drums. These waveguides are recommended, due to their low attenuation and ease of handling, for microwave antenna feeders in the 2-40 GHz frequency range.

For some frequency bands elliptical waveguides have been developed with extra low attenuation, achieved by overmoding.

RADIO FREQUENCY SYSTEMS is the originator and designer of continuous seam welded corrugated transmission lines. FLEXWELL® is RFS's brand name for the highest quality, best performing, and most reliable elliptical waveguide in the industry. FLEXWELL® designs are constantly proven successful in thousands of installations throughout the world. FLEXWELL® elliptical waveguide is the ideal choice for microwave antenna systems and offers quality and reliability that you can depend on.

Wide Selection

FLEXWELL® waveguides are available in a wide selection of frequency bands throughout the 3 GHz to 40 GHz microwave bands. The waveguides are equivalent in sizes to rectangular waveguide R32 (WR284) through R320 (WR28).

Three versions of FLEXWELL® elliptical waveguide are offered: FLEXWELL® "Standard" waveguide, low VSWR "Premium" waveguide and "Overmoded waveguide". Standard and premium waveguide differ only in testing and guaranteed attainable VSWR. FLEXWELL® "standard" waveguide is recommended for low and medium capacity radio relay systems, while FLEXWELL® "premium" elliptical waveguide assemblies are recommended for high capacity radio systems. Overmoded waveguides offer exceptionally low attenuation characteristics compared with conventional waveguides. The waveguide operates above the cut-off frequency of higher order modes utilizing the lowest attenuation characteristics of the waveguide. Connectors for overmoded waveguide include filters which eliminate distortion due to mode conversion.

FLEXWELL® elliptical waveguide is constructed of pure electrolytic copper strip which uses a special RFS process to butt weld, corrugate and form into an approximate elliptical shape. The copper waveguide is covered with a black polyethylene jacket for protection during transport and installation.

Special fire retardant jacketing is available for FLEXWELL® waveguide on request. The manufacturing process of FLEXWELL® elliptical waveguide is

continuous and so the waveguide can be supplied in long lengths.

Maximum Strength and Flexibility

The corrugation design achieves high transverse stability, flexibility and crush strength for superior handling and forming at an installation. The inherent strength and flexibility of FLEXWELL® waveguide allows a continuous length of waveguide to be run directly from a tower-mounted antenna to the equipment building, eliminating flange joint discontinuities and the use of bends and twists associated with a rigid rectangular waveguide system.

Less Planning and Reduced Installation Cost

FLEXWELL® elliptical waveguide feeder systems requires less planning and reduces installation costs when compared to a feeder system using a rigid rectangular waveguide. FLEXWELL® waveguide is available cut to length with factory attached connectors or in continuous lengths for termination in the field.

Excellent Electrical Performance

FLEXWELL® elliptical waveguide has set an industry standard for excellent electrical performance. Each waveguide has been carefully designed for low loss and low VSWR in specific frequency bands. For optimum system performance, there is no substitute for FLEXWELL® waveguide.

Complete Feeder System from One Reliable Source

In addition to waveguides, RFS offers a complete range of waveguide connectors, installation accessories, and high quality pressurization systems. This means no hassles, no multiple shipments and no out of sequence deliveries. With RFS, you get a total feeder system from one reliable source.

Waveguide Theory

Waveguides are used for the transmission of RF energy at microwave frequencies. The traditional rigid rectangular and circular waveguide configurations have been supplemented for the last 40 years by elliptical corrugated Flexwell® transmission lines.

Today, rectangular waveguides are mainly used for short connecting pieces, bends and twists, and sometimes in the form of UHF rectangular waveguides as very low loss TV antenna feeders.

Flexwell® waveguides

have helical corrugations and thus are suited for bending and winding on drums. These waveguides are recommended, due to their low attenuation and ease of handling, for microwave antenna feeders in the 2 to 40 GHz frequency range.

For some frequency bands Flexwell® transmission lines have been developed with extra low attenuation, achieved by the use of overmoding.

Radio Frequency Systems is the originator and designer of FLEXWELL® Elliptical Waveguides. It is a continuous seam welded corrugated transmission line.



Propagation Mechanism

Whereas the propagation mechanism of coaxial cables can be explained in terms of current, voltage and characteristic impedance, we must in the case of waveguides use such terms like electromagnetic wave propagation, field configuration and wavemode.

Maxwell's equations are the basis for all considerations. If we assume a good conductivity of the waveguide walls (e.g. copper) and all fields being in a steady state condition, then the complex rms-values of the electromagnetic field are in accordance with Maxwell's equations.

$$\nabla \times \vec{E} = -\mu \frac{\partial \vec{H}}{\partial t}$$

$$\nabla \times \vec{H} = \varepsilon \frac{\partial \vec{E}}{\partial t}$$

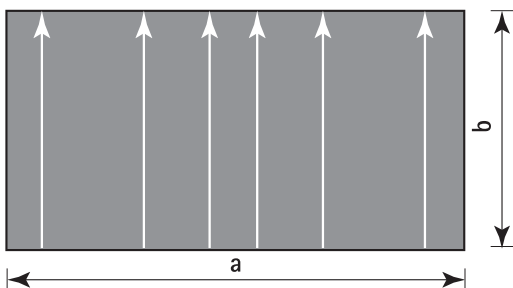
if $\vec{E} = \text{Re}(\vec{E} \cdot e^{j\omega t})$
and $\vec{H} = \text{Re}(\vec{H} \cdot e^{j\omega t})$

then $\nabla \times \vec{E} = -j\omega\mu\vec{H}$
 $\nabla \times \vec{H} = j\omega\varepsilon\vec{E}$

In order to obtain suitable solutions to the Maxwell equations it is useful to describe the electrical and magnetical field strength in a system of coordinates which includes the metallical boundary of the waveguide. Following, the practical application of the Maxwell equations is explained:

Cut-off frequency and cut-off wavelength

Rectangular Waveguide



Cartesian coordinates are best suited to describe the field in a rectangular waveguide. If we consider transverse electrical fields (TE_{mn} waves or H_{mn} waves), then the cut-off wavelength is as follows:

$$\lambda_c = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}}$$

The cut-off wavelength of the fundamental H₁₀ wave is then:

$$\lambda_c = \frac{2}{\sqrt{\left(\frac{1}{a}\right)^2 + \left(\frac{0}{b}\right)^2}} = 2 \cdot a$$

The cut-off frequency f_c above which energy transmission is possible follows to be:

$$f_c = \frac{c}{\lambda_c} = \frac{c}{2a} \quad \text{with } c = \text{velocity of light} \\ = 299.792 \cdot 10^6 \text{ m/sec}$$

$$f_c \text{ (GHz)} = \frac{299.792}{2a \text{ (mm)}}$$

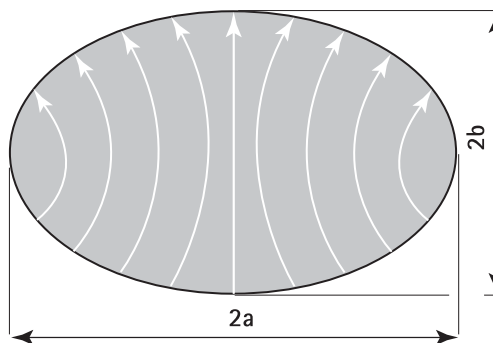
Example: rectangular waveguide size R 70 with:

$$a = 34.849 \text{ mm:}$$

$$f_c = \frac{299.792}{2 \times 34.849} \text{ (GHz)} = 4.301 \text{ GHz}$$

Elliptical Waveguide

E field lines of H_{c11} mode



The cut-off wavelengths of the various modes that can propagate in an elliptical waveguide are derived from the parametric nulls of the modified Mathieu's functions (first type) for the E waves and their differential quotient for the H waves.

In an elliptical waveguide the H waves can be either cosines elliptical H_{cm,n} waves, or sine elliptical H_{sm,n} waves.



Propagation Mechanism

The fundamental wavemode is the H_{c11} wave and its cut-off wavelength is as follows:

$$\lambda_{\text{cHC11}} = \frac{\pi a \sqrt{1 - \frac{b^2}{a^2}}}{\sqrt{q_{c11}}}$$

In this equation, the expression $\sqrt{1 - \frac{b^2}{a^2}}$

is the eccentricity e and q_{c11} is the first parametric null of the modified cosine elliptical Mathieu function of first type and first order.

Once cut-off frequency is known, then for any waveguide the important terms: group velocity, phase velocity and wavelength can be calculated as follows:

$$V_{gr} = c \sqrt{1 - \left(\frac{\lambda_c}{\lambda}\right)^2}$$

$$V_{ph} = \frac{c}{\sqrt{1 - \left(\frac{\lambda_c}{\lambda}\right)^2}}$$

With v_{gr} - group velocity
 V_{ph} - phase velocity
 λ_H - wavelength in waveguide
 λ - wavelength in free space
 f - frequency

$$\lambda_H = \frac{\lambda}{\sqrt{1 - \left(\frac{\lambda_c}{\lambda}\right)^2}}$$

frequencies of some higher modes. For example Flexwell® waveguide E015;

$f_c = 5.21$ GHz:
 $12.7 \text{ GHz} < f < 15.35 \text{ GHz}$
 $2.43 \cdot f_c < f < 2.95 \cdot f_c$

In case of discontinuities the higher modes H_{s11} , H_{c21} , E_{c01} and E_{c11} are excited and a part of energy is converted from fundamental to higher modes. This effect results in attenuation ripple versus frequency. Group velocity of higher modes is low compared to fundamental mode, so mode reconversion to the dominant mode results in group delay distortion. The reconverted mode level is minimized by mode filters which are incorporated in the terminations. To minimize the effect of unwanted trapped modes, a minimum length is recommended.

Noise Contribution

In order to achieve the lowest possible noise contribution of the waveguide system it is necessary to fulfill the following requirements:

- 1 Low reflection factor (= good longitudinal uniformity)
- 2 Good mechanical and electrical contact

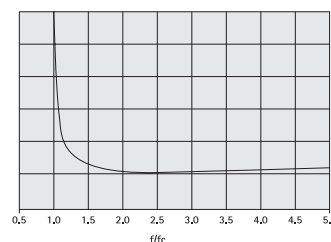
Requirement 1 is fulfilled by highly precise manufacturing and checking of waveguides and accessories, whereas requirement 2 is guaranteed by construction and handling measures, such as contact pressure, flanging with special tools, silver-plating of the contact surfaces, and avoidance of the use of tuning-screws.

Attenuation

The attenuation of waveguides is in principle like shown in the diagram. It is obvious, that a waveguide is a highpass. Starting at cutoff frequency with infinite attenuation the curve decreases rapidly with rising frequency. The increase at higher frequencies is caused by the skin effect.

For corrugated elliptical tubes the attenuation is described by numerical methods.

The attenuation is influenced by the dimensions, the shape, the material and the temperature. As the specific electrical resistance of copper increases with rising temperature, the attenuation values rise by 2% for every 10° increased temperature.



Frequency Range of Operation

a) Rectangular waveguide

Rectangular waveguides are used in the following frequency range of operation:

$$1.25 \cdot f_c \leq f \leq 1.9 \cdot f_c$$

The upper frequency limit $1.9 f_c$ is due to the fact that above that limit other wavemodes can exist. For the very common axis ratio of b over $a = 0.5$ the two wavemodes H_{01} and H_{20} can exist from $2 \cdot f_{cH10}$ and onwards.

Taking a safety factor of $0.1 f_c$ gives the upper frequency limit of $1.9 f_c$ for the fundamental wavemode.

b) Elliptical waveguide

Other than the H_{c11} fundamental wavemode, the next possible modes are the H_{s11} or H_{c21} mode, dependent upon the axis ratio b over a .

For Flexwell® transmission lines with an axis ratio b over $a = 0.52$ (Which is the case for most types) the operating frequency range is as follows:

$$1.48 \cdot f_c \leq f \leq 1.8 \cdot f_c$$

c) Overmoded elliptical waveguide

The energy is transmitted by the fundamental H_{c11} mode. For use of the physical minimum of attenuation, the operating frequency range has to be above the cutoff

Theory of Overmoded Waveguide

Waveguides are preferred as feeders for microwave antennas due to their low attenuation. The laws of physics however set a limit to this performance depending on the material used and the mechanical structure of the waveguide. Typical attenuation values vary between 1–2 dB/100 m at 3 GHz and 60–110 dB/100 m at 40 GHz.

Flexwell® elliptical transmission lines are, electrically, comparable to rectangular waveguides. The mode of propagation is the TE_{C11} (H_{C11}) in the elliptical cross-section, which is very similar to the TE_{10} (H_{10}) in the rectangular cross-section. Flexwell® transmission lines have substantial mechanical advantages. The manufacturing process is continuous, so long lengths can be produced. As the waveguide is flexible due to its corrugations, installation is easy and straight forward almost as known from the as well corrugated 'usual' RF coaxial cables. Because of the long sections flanges are only at the ends, so the number of typical intermodulation sources is kept to a minimum.

For some RF link systems, however, even the low attenuation of elliptical waveguides may be too high, either due to low transmitter power being available, or because tower load precludes the use of large dishes with their concomitant high windloads. A third application is the satellite uplink, where very high power transmission is necessary. This power, provided by expensive amplifiers, is in case of single-mode waveguides mostly lost by the attenuation. Thereby e.g. the single-mode waveguide E150 would heat up to unacceptable 190°C at a power of 4 kW, whereas the overmoded waveguide EO 15 at the same condition remains 65°C cold.

In these situations, Overmoded Flexwell® Waveguides are recommended. Signal transmission is carried out by the fundamental TE_{C11} (H_{C11}) mode, but at frequencies well above the cutoff frequencies of higher modes. Consequently, additional unwanted higher order modes are excited. Although this leads to distortions of the transmitted signal, these effects are kept below the technically allowed limits.

Main Influencing Modes

The attenuation curve versus frequency is in principle the same for all possible modes. Near cutoff frequency the attenuation is infinite, with increasing frequency the curve has a minimum. From this consideration it is obvious, that modes with low cutoff frequency will provide the highest contribution to the signal distortions. Modes with cutoff frequency near the

operating frequency band will be much more attenuated than the fundamental mode.

The unwanted modes are mainly excited at discontinuities. The biggest change of the cross-section is the transition from single-mode rectangular to overmoded elliptical waveguide.

The higher order modes are trapped in the elliptical waveguide between the connectors. So the waveguide performs as a resonator.

This results in ripples of the signal over frequency, both in terms of amplitude and group delay. We have observed that group delay distortion has much lower impact on a link system than amplitude ripples. Therefore only the latter has to be observed.

To get low signal distortion, the conversion and reconversion between higher order modes and fundamental mode has to be minimized.

This is achieved by special connectors made by electroforming. The applied NC technology allows the production of moulds with prescribed mathematical functions. Mode filters additionally minimize the signal distortion.

Length of Waveguide and Modulation Techniques

The amplitude ripples are nonlinear distortions. They decrease with increasing waveguide length. The effects are the same as known from filters after tuning: they do not change after installation. That is why correction by an equalizer is possible.

OVERMODED WAVEGUIDE	FREQUENCY RANGE, GHz	MIN. RECOMMENDED LENGTH, M
EO11	10.7 - 11.7	35
EO15	12.7 - 15.35	20
EO19	17.3 - 19.7	15
EO22	21.2 - 23.6	10
EO38	37.0 - 39.5	5

For analogue modulation techniques a slight increase of harmonic distortion will be observed. Technically there is no limitation for the use of Overmoded Flexwell® transmission lines when considering the recommended minimum length.

For digital modulation techniques we have to respect certain limits for the ripples. In general, the simpler the technique is, the higher the allowed ripples can be.



Modulation

The simplest form of digital modulation is the conversion of the binaries L and H to two states, either in amplitude or in phase. This is the most uneconomical use of existing frequency bandwidth.

In consequence more complex systems with 2^m states are used. The necessary frequency bandwidth is divided by m at same bit rate.

Every discrete point in an IQ diagram is described by amplitude $A(t)$ and phase $f(t)$. A well defined combination of amplitude and phase represents one symbol. In case of distortions the received symbol may be wrong.

The permissible amplitude ripple can be estimated from Fig. 2.

However, the waveguide is not the only source of distortions in a link. We have calculated the possible application of digital modulation schemes: we assume that the waveguide contributes 1/3 (10 dB) of the totally allowed distortion. The minimum length can be read directly from Fig. 3 for the specific modulations.

The S/I level (signal to interference) is calculated from the amplitude ripple as:

$$S/I = -20 \cdot \log \frac{10^{\Delta\alpha/20} - 1}{10^{\Delta\alpha/20} + 1}$$

For 256-QAM we end up in a minimum length of 65 m for EO15 ($f = 12.7...15.35$ GHz) and for 64-QAM the length can be reduced to 20 m.

Up to now Overmoded Flexwell® transmission lines are installed in many terrestrial radio links and different satellite uplinks

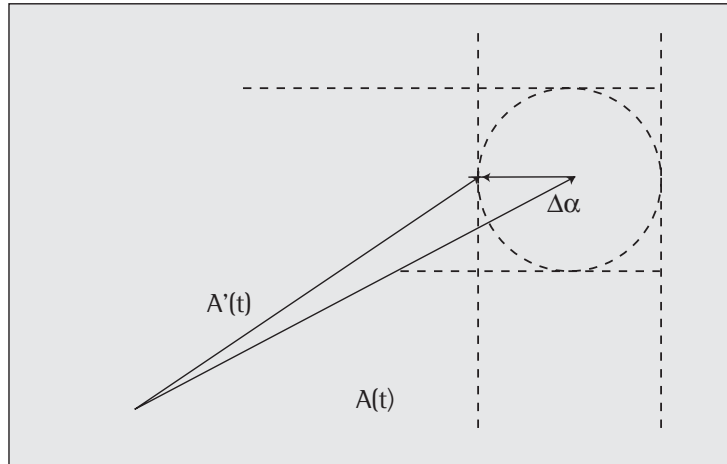
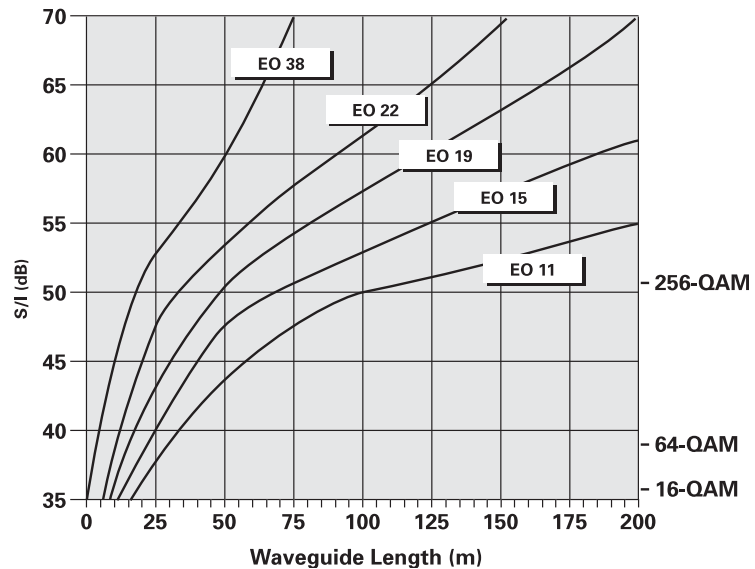


Fig. 2 Graph for the max. amplitude ripple $\Delta\alpha$

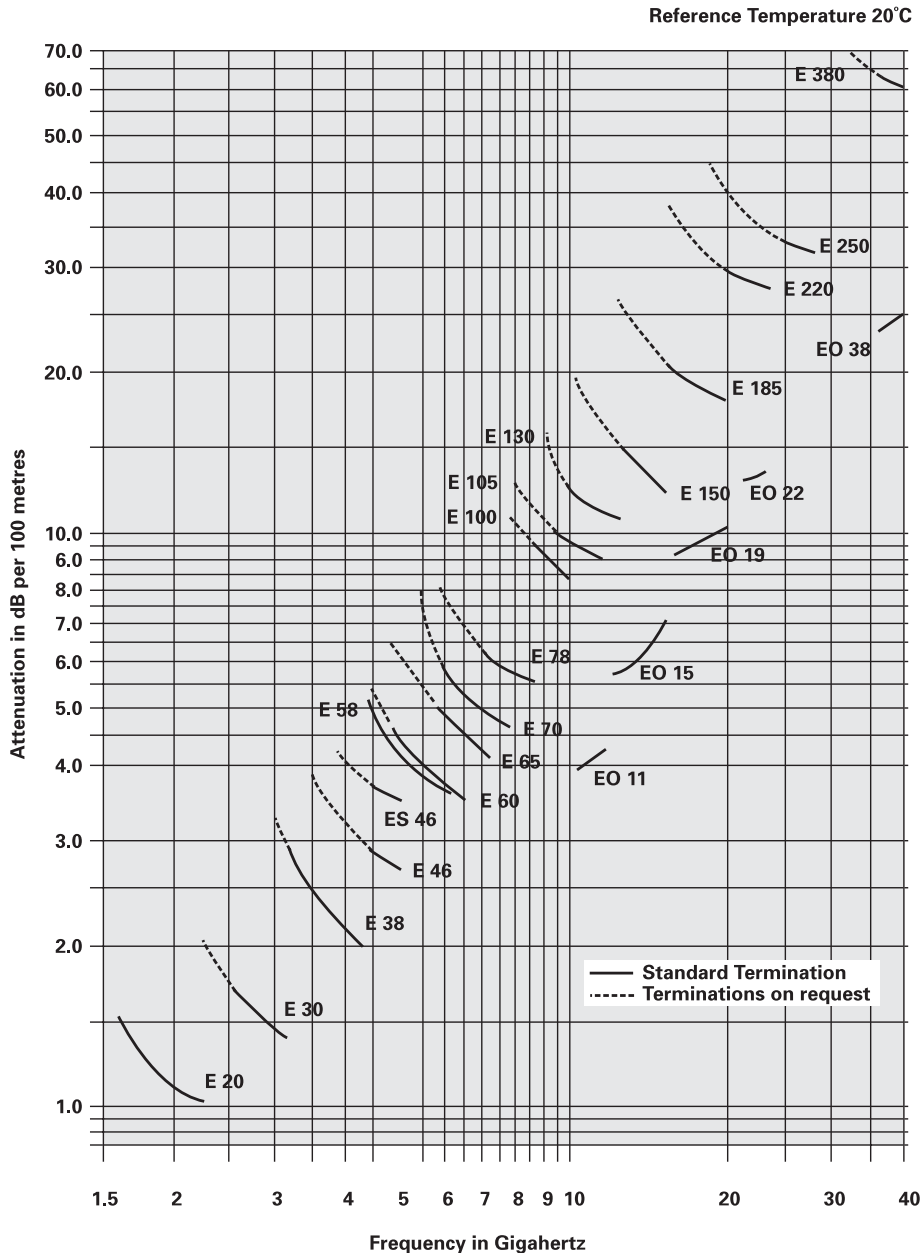
Permissible Amplitude Ripple

	4-PSK	16-QAM	64-QAM	256-QAM
$\Delta\alpha_{max}$	3,0 dB	1,41 dB	0,62 dB	0,14 dB





Waveguide Attenuation Chart



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FLEXWELL® Elliptical Waveguide

Product Overview, Mechanical

WAVEGUIDE TYPE	WEIGHT kg/m (lb/ft)	AIR VOLUME l/m (l/ft)	BENDING RADIUS W/O REBENDING mm (inch) E-PLANE	BENDING RADIUS W/O REBENDING mm (inch) H-PLANE	BENDING RADIUS WITH REBENDING mm (inch) E-PLANE	BENDING RADIUS WITH REBENDING mm (inch) H-PLANE	MAX. PULLING LENGTH PER HOISTING GRIP m (ft)	STANDARD HANGER SPACING m (ft)
E30	3.0 (2.01)	4.25 (1.3)	550 (21.8)	1500 (60)	700 (27.6)	2000 (79)	100 (305)	2 (6.6)
E38/EP38	2.1 (1.4)	2.34 (0.71)	300 (11.9)	800 (31.6)	400 (15.8)	1000 (39.5)	100 (305)	1.2 (4)
E46/EP46	1.5 (1.0)	1.68 (0.51)	280 (11.1)	700 (27.6)	380 (15)	850 (33.6)	100 (305)	1.2 (4)
ES46/ESP46	1.6 (1.1)	1.58 (0.48)	150 (5.9)	500 (19.8)	150 (5.9)	600 (23.7)	100 (305)	1.2 (4)
EP58	1.1 (0.73)	1.08 (0.33)	250 (9.9)	600 (23.7)	350 (13.8)	800 (31.6)	100 (305)	0.9 (3)
E60/EP60	1.1 (0.73)	1.02 (0.31)	200 (7.9)	550 (21.8)	300 (11.9)	800 (31.6)	100 (305)	0.9 (3)
E65/EP65	1.0 (0.67)	0.83 (0.25)	200 (7.9)	500 (19.8)	300 (11.9)	600 (23.7)	100 (305)	0.9 (3)
EP70	0.9 (0.60)	0.72 (0.22)	200 (7.9)	500 (19.8)	300 (11.9)	600 (23.7)	100 (305)	0.9 (3)
E78/EP78	0.7 (0.47)	0.60 (0.18)	200 (7.9)	500 (19.8)	250 (9.9)	600 (23.7)	100 (305)	0.9 (3)
EP100	0.6 (0.40)	0.38 (0.116)	150 (5.9)	350 (13.9)	200 (7.9)	400 (15.8)	100 (305)	0.6 (2)
E105/EP105	0.6 (0.40)	0.31 (0.094)	130 (5.1)	280 (11.0)	150 (5.9)	300 (11.9)	100 (305)	0.6 (2)
E130/EP130	0.4 (0.27)	0.24 (0.073)	130 (5.1)	280 (11.0)	150 (5.9)	300 (11.9)	100 (305)	0.6 (2)
E150/EP150	0.4 (0.27)	0.18 (0.055)	130 (5.1)	280 (11.0)	150 (5.9)	300 (11.9)	100 (305)	0.6 (2)
E185/EP185	0.3 (0.20)	0.11 (0.034)	130 (5.1)	280 (11.0)	150 (5.9)	300 (11.9)	100 (305)	0.6 (2)
E220	0.3 (0.20)	0.08 (0.024)	110 (4.3)	230 (9.1)	130 (5.1)	250 (9.9)	100 (305)	0.6 (2)
E250	0.2 (0.13)	0.06 (0.018)	90 (3.6)	150 (5.9)	100 (3.9)	180 (7.1)	50 (164)	0.5 (1.6)
E300	0.15 (0.1)	0.037 (0.011)	90 (3.6)	150 (5.9)	100 (3.9)	180 (7.1)	50 (164)	0.5 (1.6)
E380	0.1 (0.07)	0.03 (0.009)	80 (3.1)	140 (5.5)	90 (3.6)	150 (5.9)	50 (164)	0.3 (1.0)
EO11	1.1 (0.73)	0.89 (0.27)	400 (15.9)	900 (35.6)	NA	NA	100 (305)	0.9 (3)
EO15	0.9 (0.60)	0.58 (0.18)	300 (11.9)	600 (23.7)	NA	NA	100 (305)	0.9 (3)
EO19	0.6 (0.40)	0.31 (0.094)	200 (7.9)	400 (15.9)	NA	NA	100 (305)	0.6 (2)
EO22	0.4 (0.27)	0.24 (0.073)	200 (7.9)	400 (15.9)	NA	NA	100 (305)	0.6 (2)
EO38	0.2 (0.13)	0.07 (0.02)	150 (0.9)	300 (11.9)	NA	NA	100 (305)	0.6 (2)

GENERAL FEATURES:

Waveguide structure:	Elliptical corrugated copper tube
Jacket, standard:	J (Polyethylene black)
optional:	JFN (fire retardant)

RECOMMENDED TEMPERATURE RANGE

operation:	-50°C to +85°C
storage:	-70°C to +85°C
installation J-jacket:	-40°C to +60°C
installation JFN-jacket:	-25°C to +85°C

MAXIMUM PRESSURE

operation:	0.3 bar
test:	0.5 bar

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FLEXWELL® Elliptical Waveguide

Product Overview, Electrical

WVG. TYPE	OPER. FREQ. GHz	CUT OFF FREQ. GHz	MAX. VSWR/ RETURN LOSS, dB	ATTENUATION dB/100m (ft)			AVG. POWER kW MID BAND	GROUP VELOCITY %c MID BAND	GROUP DELAY ns/100m (ft) MID BAND
				IN THE OPERATING FREQUENCY BAND					
				LOW BAND	MID BAND	HIGH BAND			
E30	2.7 - 3.1	1.8	1.128/24.4	1.61 (0.49)	1.49 (0.45)	1.4 (0.43)	30.37	78.4	425.4 (129.7)
E38	3.6 - 4.2	2.4	1.15/23.1	2.37 (0.72)	2.20 (0.67)	2.08 (0.63)	16.27	78.8	423.2 (129.0)
EP38	3.6 - 4.2	2.4	1.083/28.0	2.37 (0.72)	2.20 (0.67)	2.08 (0.63)	16.27	78.8	423.2 (129.0)
E46	4.4 - 5.0	2.88	1.15/23.1	2.92 (0.89)	2.80 (0.85)	2.73 (0.83)	10.93	79.0	422.1 (128.7)
EP46	4.4 - 5.0	2.88	1.083/28.0	2.92 (0.89)	2.80 (0.85)	2.73 (0.83)	10.93	79.0	422.1 (128.7)
ES46	4.4 - 5.0	3.08	1.15/23.1	3.69 (1.12)	3.55 (1.08)	3.49 (1.06)	8.39	75.5	441.6 (134.6)
ESP46	4.4 - 5.0	3.08	1.073/29.1	3.69 (1.12)	3.55 (1.08)	3.49 (1.06)	8.39	75.5	441.6 (134.6)
EP58	4.4 - 6.2	3.56	1.083/28.0	5.10 (1.55)	3.96 (1.21)	3.60 (1.10)	6.54	74.1	450.3 (137.2)
E60	5.6 - 6.425	3.65	1.15/23.1	4.15 (1.27)	3.95 (1.20)	3.80 (1.16)	7.24	79.4	420.3 (128.1)
EP60	5.6 - 6.425	3.65	1.062/30.5	4.15 (1.27)	3.95 (1.20)	3.80 (1.16)	7.24	79.4	420.3 (128.1)
E65	5.9 - 7.125	4.01	1.15/23.1	4.9 (1.50)	4.5 (1.37)	4.25 (1.30)	5.26	78.7	423.8 (129.2)
EP65	5.9 - 7.125	4.01	1.062/30.5	4.9 (1.50)	4.5 (1.37)	4.25 (1.30)	5.26	78.7	423.8 (129.2)
EP70	6.4 - 7.75	4.34	1.062/30.5	5.5 (1.68)	5.0 (1.52)	4.8 (1.46)	4.65	79.1	421.5 (128.5)
E78	7.1 - 8.5	4.72	1.15/23.1	6.2 (1.89)	5.8 (1.77)	5.6 (1.71)	3.67	79.6	419.0 (127.7)
EP78	7.1 - 8.5	4.72	1.062/30.5	6.2 (1.89)	5.8 (1.77)	5.6 (1.71)	3.67	79.6	419.0 (127.7)
EP100	9.0 - 10.0	6.43	1.105/26.0	9.5 (2.90)	8.9 (2.71)	8.4 (2.56)	1.91	73.6	453.1 (138.1)
E105	10.0 - 11.7	6.49	1.15/23.1	9.6 (2.92)	9.2 (2.79)	8.9 (2.71)	1.77	79.9	417.3 (127.2)
EP105	10.0 - 11.7	6.49	1.062/30.5	9.6 (2.92)	9.2 (2.79)	8.9 (2.71)	1.77	79.9	417.3 (127.2)
E130	10.7 - 13.25	7.43	1.15/23.1	12.6 (3.84)	11.5 (3.52)	11.1 (3.39)	1.22	78.5	424.8 (129.5)
EP130	10.7 - 13.25	7.43	1.083/28.0	12.6 (3.84)	11.5 (3.52)	11.1 (3.39)	1.22	78.5	424.8 (129.5)
E150	13.4 - 15.35	8.64	1.15/23.1	14.6 (4.44)	14.0 (4.26)	13.7 (4.16)	0.88	79.7	418.6 (127.6)
EP150	13.4 - 15.35	8.64	1.083/28.0	14.6 (4.44)	14.0 (4.26)	13.7 (4.16)	0.88	79.7	418.6 (127.6)
E185	17.3 - 19.7	11.06	1.15/23.1	20.3 (6.17)	19.4 (5.92)	18.9 (5.75)	0.51	80.2	416.1 (126.8)
EP185	17.3 - 19.7	11.06	1.083/28.0	20.3 (6.17)	19.4 (5.92)	18.9 (5.75)	0.51	80.2	416.1 (126.8)
E220	21.2 - 23.6	13.36	1.105/26.0	28.8 (8.77)	28.3 (8.63)	28.1 (8.56)	0.31	80.3	415.6 (126.7)
E250	24.25 - 26.5	15.06	1.15/23.1	33.2 (10.1)	32.4 (9.88)	32.0 (9.75)	0.31	80.5	414.2 (126.3)
E300	27.5 - 33.4	19.05	1.15/23.1	50.0 (15.2)	46.0 (14.0)	44.4 (13.5)	0.14	78.1	427.1 (130.2)
E380	37.0 - 39.5	23.45	1.15/23.1	61.3 (18.7)	60.7 (18.5)	60.0 (18.3)	0.09	79.1	421.9 (128.6)

WVG. TYPE	OPER. FREQ. GHz	MAX. VSWR/ RETURN LOSS, dB	ATTENUATION dB/100m (ft)			GROUP VELOCITY %c MID BAND	GROUP DELAY ns/100m (ft) MID BAND
			IN THE OPERATING FREQUENCY BAND				
			LOW BAND	MID BAND	HIGH BAND		
EO11	10.7 - 11.7	1.073/29.1	3.95 (1.20)	4.10 (1.25)	4.25 (1.30)	93.2	358.0 (109.1)
EO15	12.7 - 15.35	1.083/28.0	5.80 (1.77)	6.09 (1.86)	6.93 (2.11)	92.6	360.4 (109.8)
EO19	17.7 - 19.7	1.083/28.0	9.24 (2.82)	9.52 (2.90)	9.97 (3.04)	92.5	360.5 (109.9)
EO22	21.2 - 23.6	1.105/26.0	12.5 (3.81)	13.0 (3.97)	13.7 (4.18)	93.4	357.2 (108.9)
EO38	37.0 - 39.5	1.15/23.1	24.5 (7.46)	24.7 (7.52)	25.0 (7.61)	93.1	358.4 (109.2)

MICROWAVE ANTENNA SYSTEMS

4



FLEXWELL® Elliptical Waveguide

Packing information

FLEXWELL® transmission lines are shipped coiled in crates or cartons, or on non-returnable or returnable deposit type wooden reels. Although waveguide on reels is protected by wooden lagging it should be handled carefully. Reels must rest face down on their flanges, not layed on their side, and never dropped during handling. If fork lifts are used, the forks must be long enough to engage both flanges to avoid waveguide damage.

When waveguide is ordered with factory installed terminations the antenna end is wound on the outside of the coil. After carefully unlagging the reel, inspect the waveguide carefully for any signs of shipping damage.

Please ask RFS for final packing dimensions.



Drums packed on pallets with reduced protection



Short lengths can be shipped in crates or cartons. This package is available for E70 and smaller waveguide sizes.



Drums packed on pallets protected by wooden lagging

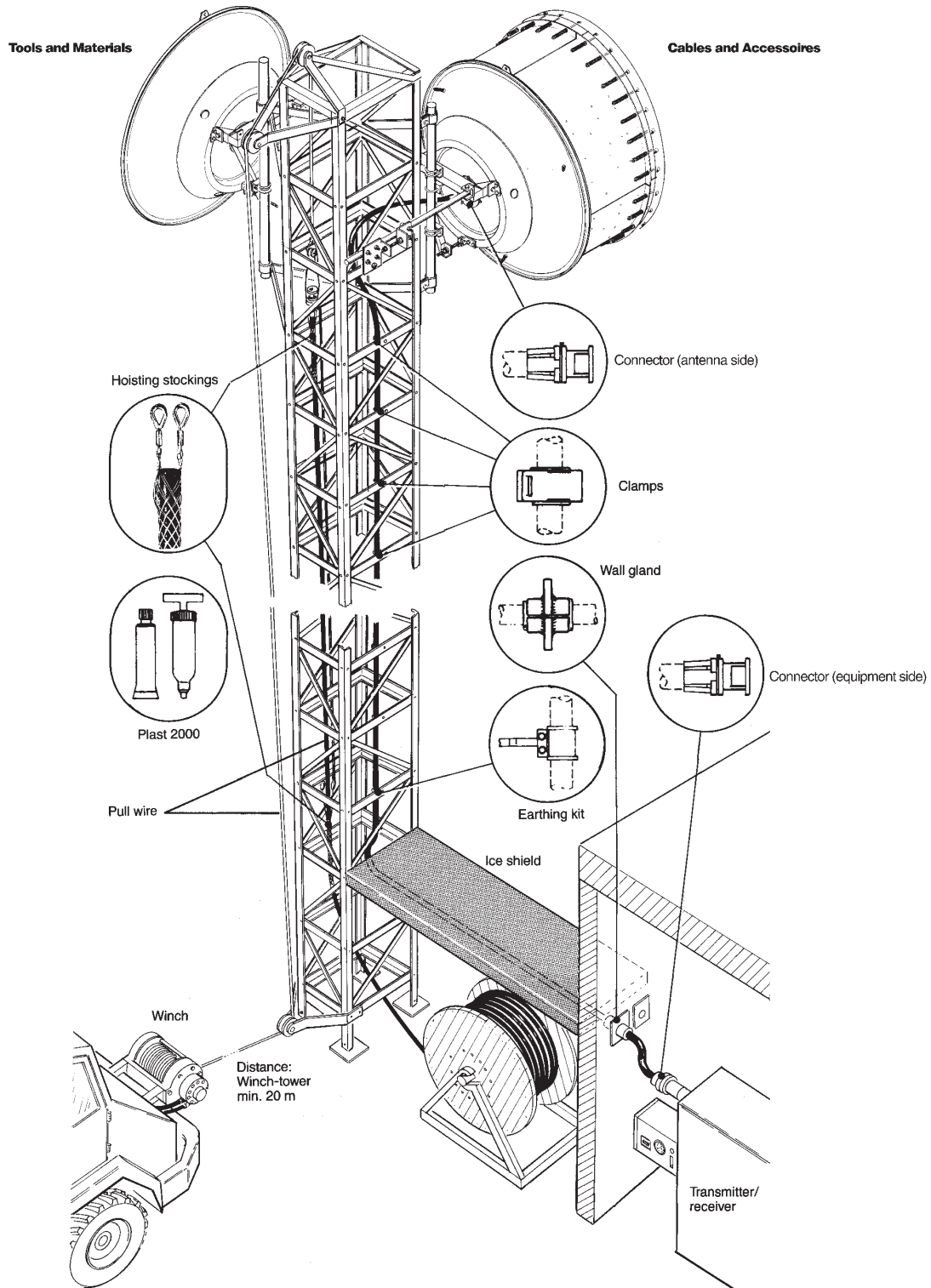


FLEXWELL® Elliptical Waveguide

Typical Installation Approach

RFS offers all necessary tools, materials and accessories to provide a complete transmission line and antenna system.

A typical installation approach is shown below.



MICROWAVE
ANTENNA
SYSTEMS

4



FLEXWELL® Elliptical Waveguide Connectors

Introduction



RFS supplies a complete line of high quality, premium performance elliptical waveguide connectors. These connectors provide a low VSWR transition to a rectangular waveguide interface.

RFS waveguide connectors are machined with a multi-step transition from elliptical to rectangular cross-section. This multi-step transition results in a compact design with superior electrical performance. Connectors are available with either EIA or IEC flange interfaces.

Sealing Method

RFS offers two types of connectors for sealing purposes.

Plast 2000 Sealing

Plast 2000 has a very good adhesion to the metallic parts of the connector and to the waveguide. The curing process depends on the humidity and temperature of the air. Under normal conditions, sealing against moisture is accomplished in a very short time. Plast 2000, to be purchased separately, is supplied in tubes of 20ccm and 70ccm. The 20ccm tube can be inserted directly into connector body. An injection gun is recommended when installation is carried on a large number of connectors. These connectors have been carefully designed for excellent VSWR performance without the use of any tuning screws. Model numbers on these connectors end with a letter "P" to designate the use of Plast 2000 sealing.

Exception all connectors with gasket and shrinking sleeves for E250, E300 and E380 series as well as all overmoded waveguides.



Gasket Sealing

In this design, the connector is sealed between the backnut and the waveguide with a conical shaped threaded gasket. The threaded gasket is held in place with an internal pressure plate to create a gas tight waveguide assembly that will not leak even if the waveguide is flexed near the connector. A seal between the connector backnut and the waveguide transition is achieved with a specially shaped flat gasket that encompasses the waveguide flare and connector bolt holes. Careful dimensional tolerances assure a safe contact between the flare and the waveguide transition, which includes a 1/8" NPT female pressure inlet and plug. A heat shrink boot is supplied for application over the elliptical waveguide and the connector backnut to provide strain relief and additional weatherproofing. Model number on these connectors end with a letter "G" for designation of gasket sealing.

Quick and Easy to Install

FLEXWELL® waveguide connectors are designed for quick and easy assembly in the field using either standard hand tools or flanging tools depending on connector type.

Connector Types

FLEXWELL® elliptical waveguide connectors are available in standard (non-tuneable), tuneable pre-tuned and fixed tuned versions. Fixed tuned connectors are available only with pressurized flanges (P-type). U-type flanges can be provided by the use of a shim.

FLEXWELL® connectors are offered with interface to EIA and IEC standard waveguide flanges.

Waveguide Splices

Electrically compensated elliptical waveguide splices, which do not degrade system performance, are available for field repairs of damaged waveguide runs. The construction and assembly of the waveguide splice is similar to the waveguide connector design.





FLEXWELL® Elliptical Waveguide Connectors

Connector Overview

Standard

WAVEGUIDE TYPE	FREQUENCY BAND, GHz	FLANGE IEC-TYPE	FLANGE EIA-TYPE
E30	2.3 - 2.5		7/8 EIA
	2.5 - 2.7		7/8 EIA
	2.7 - 3.1	PDR 32	
E38	3.6 - 4.2	PDR 40	CPR229G
E46	4.4 - 5.0	PDR 48	
ES46	4.4 - 5.0	PDR 48	UG148/149/U
	4.4 - 5.0		CPR187G
E60	5.6 - 6.425	PDR 70	
	5.725 - 6.425		UG343/344/U
	5.925 - 6.425		UG343/344/U
	5.925 - 6.425		CPR137G
E65	5.9 - 7.15	PDR 70	
	6.4 - 7.15	PDR 70	
	5.725-6.875		CPR137G
	6.425 - 7.125		UG343/344/U
	6.425 - 7.125		CPR137G
E78	7.1 - 8.5	PDR 70	
	7.1 - 7.8	PDR 84	CPR137G
	7.75 - 8.5	PDR 84	
	7.1 - 8.5	PBR 84	
	7.125 - 8.5		CPR112G
	7.1 - 7.8	PBR 84	
	7.75 - 8.5	PBR 84	
E105	10.0 - 11.7	PDR 100	
	10.5 - 11.7		CPR90G
E130	10.7 - 12.75	PDR 120	
	11.7 - 13.25		WR75 Choke/Cover
	12.2 - 13.25	PDR 120	
E150	12.2 - 13.25	PBR 120	
	13.4 - 14.5	PBR 120	WR75 Contact WR75 Choke/Cover
	13.4 - 14.5		
E185	14.0 - 15.35	PDR 140	
	14.0 - 15.35	PBR 140	
E185	17.3 - 19.7	PDR 180	
	17.7 - 19.7	PBR 220	UG595/596/U
E220	21.2 - 23.6	PBR 220	
E250	24.25 - 26.5	PBR 220	
E300	24.25 - 26.5	PBR 260	
	27.5 - 33.4	PBR 320	
E380	37.0 - 39.5	PBR 320	

Overmoded

WAVEGUIDE TYPE	FREQUENCY BAND, GHz	FLANGE IEC-TYPE
EO11	10.7 - 11.7	PDR 100
EO15	12.75 - 14.5	PDR 120
	14.0 - 15.35	PDR 140
EO19	17.7 - 19.7	PBR 220
EO22	21.2 - 23.6	PBR 220
EO38	37.0 - 39.5	PBR 320

Premium

WAVEGUIDE TYPE	FREQUENCY BAND, GHz	FLANGE IEC-TYPE
EP38	3.6 - 4.2	PDR 40
EP46	4.4 - 5.0	PDR 48
ESP46	4.4 - 5.0	PDR 48
EP58	4.4 - 6.2	PDR 48
EP60	5.6 - 6.425	PDR 70
EP65	5.9 - 7.15	PDR 70
	6.4 - 7.15	PDR 70
EP70	6.4 - 7.8	PDR 70
EP78	7.1 - 8.5	PDR 70
	7.1 - 7.8	PDR 84
	7.75 - 8.5	PDR 84
	7.1 - 8.5	PBR 84
	7.1 - 7.8	PBR 84
EP100	7.75 - 8.5	PBR 84
	9.0 - 10.0	PBR 100
EP105	10.0 - 11.7	PDR 100
EP130	10.7 - 12.75	PDR 120
	12.2 - 13.25	PDR 120
	12.2 - 13.25	PBR 120
EP150	13.4 - 14.5	PBR 120
	14.0 - 15.35	PDR 140
	14.0 - 15.35	PBR 140
EP185	17.3 - 19.7	PDR 180
	17.7 - 19.7	PBR 220

PLAST 2000 CONSUMPTION

FLEXWELL	Minimum Capacity in cm ³
E30	120
E38	100
E46	70
ES46	70
EP58	60
E60	50
E65	50
EP70	50
E78	50
EP100	20
E105	20
E130	20
E150	20
E185	20
E220	20



FLEXWELL® Elliptical Waveguide Accessories

Grounding Kits

Radio Frequency Systems offers three types of Grounding kits.

- Pre-formed Grounding Kit
- Standard (non Pre-formed) Grounding Kit
- High Speed Grounding Kit

Pre-formed Grounding Kit, GKIT

The grounding kit with pre-formed copper strap facilitates installation with a pre-formed copper strap that eliminates the need for a coiling tool. This kit has been verified by independent labs to protect coax from the damaging effects of lightning current in excess of 200kA. One 3/8" two-hole ground lug and all bus bar attachment hardware are also included along with the required mastic and electrical tape for weatherproofing. 1/pkg



Standard Grounding Kit

Standard (Non Pre-formed) Grounding Kit, GKIT-ST

Grounding Kits are used to ground the waveguide to the steel construction of the tower. The contact parts are made of solid copper to guarantee high current conduction. The grounding kits include a copper strip already for simple installation. A watertight installation is ensured. The kits are available for waveguides E30 to E380.



High Speed Grounding Kit

High Speed Grounding Kit, GKIT-HS

For different waveguides sizes high speed grounding kits are available too. The high speed grounding kit is pre-assembled. The grounding body consists of stainless steel, which is vulcanized with Ethylene-Propylene rubber. The contact surface is a tinned copper mesh. The standard grounding wire is pre-assembled with stainless steel screws. Safety washers prevent the screws from loosening. A simple but helpful detail, especially when mounting the grounding kit on the top of a tower.



Standard Hanger Kit (Non-Insulated)

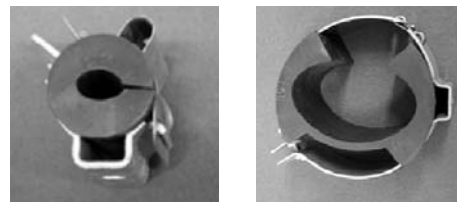
Hangers

Radio Frequency Systems offers three types of hangers:

- Standard (non insulated) hanger
- Universal Clamps
- RSB clips

Standard Hanger Kit (Non-Insulated), CLAMP

Stainless steel hangers are available to fix elliptical waveguides to tower. Hanger spacing is depending on waveguide size. Hanger may be attached to angle adapters, tower standoffs, member mounting holes with up to 3/8"-16 hardware or to round member adapters through slot in the hanger. 10/pkg



Universal Clamps

Universal Clamps, CLAMP-R

The universal clamp can be used for the installation of FLEXWELL elliptical waveguides for proper and secure

tension. The clamps can be used as universal device for mounting of waveguide on any profile. Hot galvanized steel clamps are available for E30 to E220 waveguides.

All clamps are provided with a rubber clamp lining to secure a proper installation and to avoid any damage of the waveguide. The clamps can be fixed on different profiles. Suitable fixing hardware is available. 10/pkg



FLEXWELL® Elliptical Waveguide Accessories

RSB Clip

The RSB clip is designed for installation of FLEXWELL elliptical waveguide types E105 to E380 and overmoded waveguide types E022 and E038. The clip is a universal clamp device which can be used in many mounting configurations. The clip is manufactured from stainless steel and is resistant against most environmental conditions. 10/pkg.

All RSB clips are provided with a rubber clamp lining for proper installation. 10/pkg.

A 'Rucksack' option is available for small waveguide sizes E220 to E380 and E038. It provides an optimal use of existing space.

Angle Member Adapter Kit

Fastens hangers to tower angle members without drilling. Angle adapter includes a tower member set screw and a 3/8" hanger mounting screw. The hanger mounting screw may be located in either of two mounting holes. 10/pkg.

Installation tools

Hoisting Grips

Hoisting grips are used to distribute the force introduced into a waveguide when hoisted using a winch which is usually the case when waveguide size and/or length lead to an overall weight that cannot be operate manually. They consists of a wire mesh and hold the waveguide by means of friction over the complete length when pulled.

Two types are available for each waveguide size; the closed version -used when the top connector is installed after the waveguide is hoisted- and the open version - used in case where the top connector is installed prior to hoisting the waveguide. Also in the later case the closed version might be used if it shall be left on the waveguide replacing the top cable clamp. Waveguide with factory-installed connectors can be delivered with pre-installed hoisting grips on customer request. The maximum hoisting length per grip is 70 m (230 ft). 1/pkg

Bending Tool

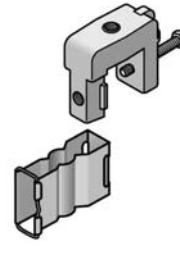
Bending Tools provide perfect forming of FLEXWELL Elliptical waveguide bends during installation. The tool avoids undercutting of the minimum bending radii. Two forms included, one for E plane and one for H plane bends. 1/pkg.



Bending Tool



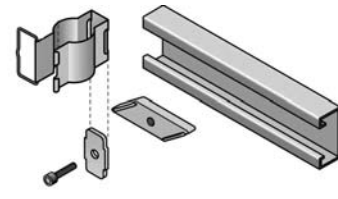
RSB Clip



RSB-Cleat



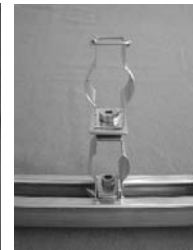
Universal Clamping Plate (HUA-M8)



RSB Clamping Plate (RSB-315)



Tube mounting (TRB-8)



Rucksack option



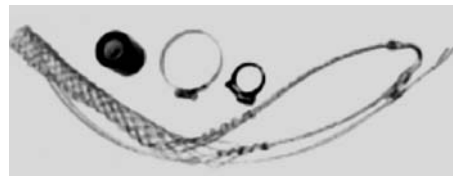
Round Member Adapter



Angle Member Adapter Kit



Universal Installation Cleat (MKD-001-01)



Hoisting Grips



FLEXWELL® Elliptical Waveguide Accessories

Flanging tools

Flanging tools* have been developed to simplify the installation and thus reducing costs. The flanging tools from RFS are designed to produce a perfect termination every time eliminating the need for any reworking of the termination.

The tool consists of two parts. The tool and a die.

Different types of flanging tools are available depending on waveguide sizes:

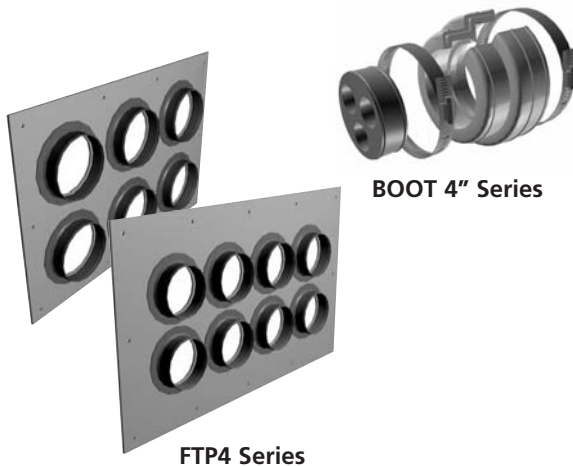
- A Basic Tool for E30 to E150
- A Compact Tool for E105 to E380
- A Mini Tool for E185 to E380

A separate die is required for each waveguide size.

* Not applicable for gasket type connectors

Round Member Tower Stand-off Kit

Constructed of heavy stainless steel, the stand-offs provide 2-1/2" (63 mm) tower clearance to hangers when running waveguide over tower cross members, flanges and other tower obstacles. The kit consists of ten stainless steel tower stand-offs with stainless steel hardware. Use with threaded rod kit for additional tower clearance. 1/pkg.



FTP4 Series

BOOT 4" Series



Basic Tool w/o die



Compact Tool with die



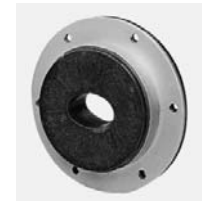
Mini Tools



WFS Series



WF Series



WFT Series

ORDERING INFORMATION

FEED-THROUGH ENTRY PANELS

Model	Description
FTP4-1X1	Feed through entry panel, 102mm (4"), 1 hole, 1x1
FTP4-1X2	Feed through entry panel, 102mm (4"), 2 holes, 1x2
FTP4-1X3	Feed through entry panel, 102mm (4"), 3 holes, 1x3
FTP4-1X4	Feed through entry panel, 102mm (4"), 4 holes, 1x4
FTP4-2X2	Feed through entry panel, 102mm (4"), 4 holes, 2x2
FTP4-2X3	Feed through entry panel, 102mm (4"), 6 holes, 2x3
FTP4-2X4	Feed through entry panel, 102mm (4"), 8 holes, 2x4
FTP4-2X5	Feed through entry panel, 102mm (4"), 10 holes, 2x5
FTP4-2X6	Feed through entry panel, 102mm (4"), 12 holes, 2x6
FTP4-3X3	Feed through entry panel, 102mm (4"), 9 holes, 3x3
FTP4-3X4	Feed through entry panel, 102mm (4"), 12 holes, 3x4

PORT COVER FOR ENTRY PANELS

Model	Description
FTP4-PC	Port cover for 102mm (4") entry panel

Wall / Roof Feed Through

RFS offers two types of Wall/Roof feed through systems:

WFT Series Single Entry Feed Through

The single entry feed through system seals elliptical waveguide at building entrance. It consists of a rubber boot and aluminum split fastening ring.

WF Series Standard Feed Through

The standard feed through system consists of a rubber boot, stainless steel clamp, fixing and sealing material.

Waveguide Repair Kit

The repair kit is used to mend a small puncture hole in the outer conductor of copper elliptical waveguide. The kit is not intended to repair crushed waveguide. Supplied components include copper foil wrap (1-1/2" dia.), adhesive tape, sanding cloth and wrap-around heat shrink sleeve. Required tools are; sharp knife, alcohol cleaner, heat gun or wide flame torch. 1/pkg.



FLEXWELL® Elliptical Waveguide

Connector & Accessory Reference Guide (See installation hardware on separate table)

E30 (2.7 - 3.1 GHz)

Connector, PDR32, 2.7 - 3.1 GHz, Plast 2000	D32-030FP-U
Connector, 7/8" EIA (GB), 2.5 - 2.7 GHz, Gasket	78EB-030FG
Connector, 7/8" EIA (GP), 2.5 - 2.7 GHz, Gasket	78E-030FG
Splice, 2.5 - 3.1 GHz, Gasket	SPLICE-030
Grounding Kit, Pre-formed Copper Strap-Factory attached Lug-24" Wire	GKIT-24-030
Grounding Kit, Pre-formed Copper Strap-Field attachable Lug-60" Wire	GKIT-60-030
Grounding Kit	GKIT-ST-030
Standard Hanger Kit, Non-insulated, stainless steel	CLAMP-030
Universal clamp with clamp lining for angle iron 50 mm (1.9 inch)	CLAMP-R-030-A5
Universal clamp with clamp lining for angle iron 80 mm (3.2 inch)	CLAMP-R-030-A8
Universal clamp with clamp lining for anchor bars with 18 to 22 mm (0.7 to 0.8 inch) slot	CLAMP-R-030-AC
Universal clamp with clamp lining for flat iron up to 15 mm (0.6 inch)	CLAMP-R-030-AF
Hoisting Grip, Lace-Up, single loop configuration	HOIST1-030L
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L09
Wall/Roof Feed-Through, Aluminum plate	WFT-030
Flanging die, basic Tool	FDIE-B030*
Basic Tool	FTOOL-B020030*

E38 SERIES (3.6 - 4.2 GHz)

Connector, PDR40, 3.6 - 4.2 GHz, Plast 2000	D40-038FP-U
Connector, CPR229G, 3.6 - 4.2 GHz, Gasket, only E38	C229-038TG
Splice, N/A, 3.4 - 4.2 GHz, Gasket	SPLICE-038
Grounding Kit, Pre-formed Copper Strap-Factory attached Lug-24" Wire	GKIT-24-038
Grounding Kit, Pre-formed Copper Strap-Field attachable Lug-60" Wire	GKIT-60-038
Grounding kit	GKIT-ST-038
Universal clamp with clamp lining	CLAMP-R-038
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L08
Bending Tool Kit	BENDTOOL-038060
Wall/Roof Feed-Through, Aluminum plate	WFT-038
Wall/Roof Feed-Through, Stainless Steel plate	WF-038
Feed Through Boot Assembly w/1 hole - 4"	BOOT4-038
Flanging die, basic tool	FDIE-B038*
Basic Tool	FTOOL-B038150*

E46 SERIES (4.4 - 5.0 GHz)

Connector, PDR48, 4.4 - 5.0 GHz, Plast 2000	D48-046FP
Splice, N/A, 4.4 - 5.0 GHz, Gasket	SPLICE-046
Grounding Kit	GKIT-ST-046
Universal clamp with clamp lining	CLAMP-R-046
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L07
Bending Tool Kit	BENDTOOL-038060
Wall/Roof Feed-Through, Aluminum plate	WFT-046
Wall/Roof Feed-Through, Stainless Steel plate	WF-046
Flanging die, basic Tool	FDIE-B046*
Basic Tool	FTOOL-B038150*

ES46 SERIES (4.4-5.0 GHz)

Connector, PDR48, 4.4 - 5.0 GHz, Plast 2000	D48-S46FP
Connector, CPR187G, 4.4 - 5.0 GHz, Gasket, only ES46	C187-S46FG
Connector, CPR187G, 4.4 - 5.0 GHz, Gasket, only ES46	C187-S46TG
Connector, UG-148/149/U, 4.4 - 5.0 GHz, Gasket	G148-S46TG
Splice, N/A, 4.4 - 5.0 GHz, Gasket	SPLICE-S46
Grounding Kit, Pre-formed Copper Strap-Factory attached Lug-24" Wire	GKIT-24-046
Grounding Kit, Pre-formed Copper Strap-Field attachable Lug-60" Wire	GKIT-60-046

ES46 SERIES (4.4-5.0 GHz) CONT'D

Grounding Kit	GKIT-ST-S46
Standard Hanger Kit, Non-insulated, stainless steel	CLAMP-046
Universal clamp with clamp lining	CLAMP-R-S046
Hoisting Grip, Lace-Up, single loop configuration	HOIST1-046L
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L07
Bending Tool Kit	BENDTOOL-038060
Wall/Roof Feed-Through, Aluminum plate	WFT-046
Wall/Roof Feed-Through, Stainless Steel plate	WF-046
Feed Through Boot Assembly w/1 hole - 4"	BOOT4-046
Flanging die, basic Tool	FDIE-B546*
Basic Tool	FTOOL-B038150*

EP58 (4.4 - 6.2 GHz)

Connector, PDR48, 4.4 - 6.2 GHz, Plast 2000	D48-058FP
Grounding Kit	GKIT-ST-058
Universal clamp with clamp lining	CLAMP-R-058
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L06
Bending Tool Kit	BENDTOOL-038060
Wall/Roof Feed-Through, Stainless Steel plate	WF-058/060
Flanging die, basic Tool	FDIE-B058*
Basic Tool for E38 to E150	FTOOL-B038150*

E60 SERIES (5.6 - 6.425 GHz)

Connector, CPR137G, 5.725 - 6.425 GHz, Gasket, only E60	C137-060FG
Connector, PDR70, 5.6 - 6.425 GHz, Plast 2000	D70-060FP-W
Connector, CPR137G, 5.925 - 6.425 GHz, Gasket, only E60	C137-060TG
Connector, UG-343/344/U, 5.925 - 6.425 GHz, Gasket	G343-060FG
Connector, UG-343/344/U, 5.925 - 6.425 GHz, Gasket	G343-060TG
Grounding Kit, Pre-formed Copper Strap-Factory attached Lug-24" Wire	GKIT-24-060
Grounding Kit, Pre-formed Copper Strap-Field attachable Lug-60" Wire	GKIT-60-060
Grounding Kit	GKIT-ST-060
Standard Hanger Kit, Non-insulated, stainless steel	CLAMP-060
Universal clamp with clamp lining	CLAMP-R-060
Hoisting Grip, Lace-Up, single loop configuration	HOIST1-060L
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L06
Bending Tool Kit	BENDTOOL-038060
Bending Tool Kit	BENDTOOL-058078
Wall/Roof Feed-Through, Aluminum plate	WFT-060
Wall/Roof Feed-Through, Stainless Steel plate	WF-058/060
Feed Through Boot Assembly w/1 hole - 4"	BOOT4-060
Flanging die, basic Tool	FDIE-B060*
Basic Tool	FTOOL-B038150*

E65 SERIES (5.9 - 7.15 GHz)

Connector, UG-343/344/U, 6.425 - 7.125 GHz, Gasket, only E65	G343-065FG
Connector, CPR137G, 6.425 - 7.125 GHz, Gasket, only E65	C137-065FG
Connector, PDR70, 6.4 - 7.125 GHz, Plast 2000	D70-065FP-U
Connector, PDR70, 5.9 - 7.125 GHz, Plast 2000	D70-065FP-W
Connector, UG-343/344/U, 5.725 - 7.125 GHz, Gasket	G343-065TG
Connector, CPR137G, 5.725 - 6.875 GHz, Gasket	C137-065TG
Connector, PDR70, 6.4 - 7.125 GHz, Plast 2000	D70-065FP-U
Splice, N/A, 6.425 - 7.125 GHz, Gasket	SPLICE-065
Grounding Kit, Pre-formed Copper Strap-Factory attached Lug-24" Wire	GKIT-24-065
Grounding Kit, Pre-formed Copper Strap-Field attachable Lug-60" Wire	GKIT-60-065
Grounding Kit	GKIT-ST-065
Standard Hanger Kit, Non-insulated, stainless steel	CLAMP-065

* Not applicable for gasket type connectors



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Connector & Accessory Reference Guide (See installation hardware on separate table)

E65 SERIES (5.9 - 7.15 GHz) CONT'D

Universal clamp with clamp lining	CLAMP-R-065
Hoisting Grip, Lace-Up, single loop configuration	HOIST1-065L
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L05
Bending Tool Kit	BENDTOOL-065078
Wall/Roof Feed-Through, Aluminum plate	WFT-065
Wall/Roof Feed-Through, Stainless Steel plate	WF-065
Feed Through Boot Assembly w/1 hole - 4"	BOOT4-065
Flanging die, basic Tool	FDIE-B065*
Basic Tool	FTOOL-B038150*

EP70 (6.4 - 7.8 GHz)

Connector, PDR70, 6.4 - 7.75 GHz, Plast 2000	D70-070FP
Grounding Kit	GKIT-ST-070
Standard Hanger Kit, Non-insulated, stainless steel	CLAMP-070
Universal clamp with clamp lining	CLAMP-R-070
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L05
Bending Tool Kit	BENDTOOL-058078
Wall/Roof Feed-Through, Stainless Steel plate	WF-070
Flanging die, basic Tool	FDIE-B070*
Basic Tool	FTOOL-B038150*

E78 SERIES (7.1 - 8.5 GHz)

Connector, PDR70, 7.125 - 8.5 GHz, Plast 2000	D70-078FP-W
Connector, UG-51/52/U, 7.125 - 8.50 GHz, Gasket, only E78	G51-078FG
Connector, CPR137G, 7.125 - 7.75 GHz, Gasket, only E78	C137-078FG
Connector, UG-343/344/U, 7.125 - 7.75 GHz, Gasket, only E78	G343-078FG
Connector, CPR112G, 7.125 - 8.50 GHz, Gasket, only E78	C112-078FG
Connector, PDR84, 7.1 - 7.8 GHz, Plast 2000	D84-078FP-L
Connector, PDR84, 7.125 - 8.5 GHz, Plast 2000	D84-078FP-W
Connector, PBR84, 7.1 - 7.8 GHz, Plast 2000	B84-078FP-L
Connector, PDR84, 7.75 - 8.5 GHz, Plast 2000	D84-078FP-U
Connector, PBR84, 7.75 - 8.5 GHz, Plast 2000	B84-078FP-U
Connector, PBR84, 7.125 - 8.5 GHz, Plast 2000	B84-078FP-W
Connector, CPR112G, 7.125 - 8.50 GHz, Gasket	C112-078TG
Connector, UG-51/52/U, 7.125 - 8.50 GHz, Gasket	G51-078TG
Connector, CPR137G, 7.125 - 7.75 GHz, Gasket	C137-078TG
Connector, UG-343/344/U, 7.125 - 7.75 GHz, Gasket	G343-078TG
Splice, 7.125 - 8.5 GHz, Gasket	SPLICE-078
Grounding Kit, Pre-formed Copper Strap-Factory attached Lug-24" Wire	GKIT-24-078
Grounding Kit, Pre-formed Copper Strap-Field attachable Lug-60" Wire	GKIT-60-078
Grounding Kit	GKIT-ST-078
Standard Hanger Kit, Non-insulated, stainless steel	CLAMP-078
Universal clamp with clamp lining	CLAMP-R-078-E
Hoisting Grip, Lace-Up, single loop configuration	HOIST1-078L
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L05
Bending Tool Kit	BENDTOOL-065078
Bending Tool Kit	BENDTOOL-058078
Wall/Roof Feed-Through, Aluminum plate	WFT-078
Wall/Roof Feed-Through, Stainless Steel plate	WF-078/L15
Feed Through Boot Assembly w/1 hole - 4"	BOOT4-078
Flanging die, basic Tool	FDIE-B078*
Basic Tool	FTOOL-B038150*

EP100 (9.0 - 10.0 GHz)

Connector, PBR100, 9.0 - 10.0 GHz, Plast 2000	B100-100FP-U
Grounding Kit	GKIT-ST-100
Universal clamp with clamp lining	CLAMP-R-100
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L04

EP100 (9.0 - 10.0 GHz) CONT'D

Bending Tool Kit	BENDTOOL-100220
Wall/Roof Feed-Through, Stainless Steel plate	WF-100
Flanging die, basic Tool	FDIE-B100*
Basic Tool	FTOOL-B038150*

E105 SERIES (10.7 - 11.7 GHz)

Splice, 10.5 - 11.70 GHz, Gasket	SPLICE-105
Connector, CPR90G, 10.50 - 11.70 GHz, Gasket, only E105	C90-105FG
Connector, PDR100, 10.0 - 11.7 GHz, Plast 2000	D100-105FP-W
Connector, CPR90G, 10.50 - 11.70 GHz, Gasket, only E105	C90-105TG
Grounding Kit, Pre-formed Copper Strap-Factory attached Lug-24" Wire	GKIT-24-105
Grounding Kit, Pre-formed Copper Strap-Field attachable Lug-60" Wire	GKIT-60-105
Grounding Kit	GKIT-ST-105
Standard Hanger Kit, Non-insulated, stainless steel	CLAMP-105
Universal clamp with clamp lining	CLAMP-R-105
RSB Clip with clamp lining	RSB-105
Hoisting Grip, Lace-Up, single loop configuration	HOIST1-105L
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L04
Bending Tool Kit	BENDTOOL-100220
Bending Tool Kit	BENDTOOL-105185
Wall/Roof Feed-Through, Aluminum plate	WFT-105
Wall/Roof Feed-Through, Stainless Steel plate	WF-105/L19
Feed Through Boot Assembly w/1 hole - 4"	BOOT4-105
Flanging die, basic Tool	FDIE-B105*
Flanging die, compact Tool	FDIE-C105*
Basic Tool	FTOOL-B038150*
Compact Tool	FTOOL-C105380*

E130 SERIES (10.7 - 13.25 GHz)

Connector, WR75 choke/cover, 11.7 - 13.25 GHz, Gasket, only E130	G75-130FG
Connector, PDR120, 10.7 - 12.75 GHz, Plast 2000	D120-130FP-L
Connector, PDR120, 12.2 - 13.25 GHz, Plast 2000	D120-130FP-U
Connector, PBR120, 12.2 - 13.25 GHz, Plast 2000	B120-130FP-U
Connector, WR75 choke/cover, 11.7 - 13.25 GHz, Gasket, only E130	G75-130TG
Splice, 10.95 - 13.25 GHz, Gasket	SPLICE-130
Grounding Kit, Pre-formed Copper Strap-Factory attached Lug-24" Wire	GKIT-24-130
Grounding Kit, Pre-formed Copper Strap-Field attachable Lug-60" Wire	GKIT-60-130
Grounding Kit	GKIT-ST-130
Standard Hanger Kit, Non-insulated, stainless steel	CLAMP-130
Universal clamp with clamp lining	CLAMP-R-130
RSB Clip with clamp lining	RSB-130
Hoisting Grip, Lace-Up, single loop configuration	HOIST1-130L
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L03
Bending Tool Kit	BENDTOOL-100220
Bending Tool Kit	BENDTOOL-105185
Wall/Roof Feed-Through, Aluminum plate	WFT-130
Wall/Roof Feed-Through, Stainless Steel plate	WF-130
Feed Through Boot Assembly w/1 hole - 4"	BOOT4-130
Flanging die, compact Tool	FDIE-C130*
Compact Tool	FTOOL-C105380*

E150 SERIES (13.4 - 15.35 GHz)

Connector, UG-419/541/U, 13.40 - 15.35 GHz, Gasket, only E150	G419-150FG
Connector, PBR120, 13.4 - 14.5 GHz, Plast 2000	B120-150FP
Connector, PDR140, 14.0 - 15.35 GHz, Plast 2000	D140-150FP

* Not applicable for gasket type connectors



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Connector & Accessory Reference Guide (See installation hardware on separate table)

E150 SERIES (13.4 - 15.35 GHz) CONT'D

Connector, PBR140, 14.0 - 15.35 GHz, Plast 2000	B140-150FP
Connector, UG-419/541/U, 14.40 - 15.35 GHz, Gasket, only E150	G419-150TG
Connector, PBR140, 13.40 - 15.35 GHz, Gasket	B140-150TG
Connector, WR75 contact, 13.40 - 14.50 GHz, Gasket	K75-150TG
Connector, WR75 choke/cover, 13.40 - 14.50 GHz, Gasket	Z75-150TG
Splice, N/A, 13.40 - 15.35 GHz, Gasket	SPLICE-150
Grounding Kit, Pre-formed Copper Strap-Factory attached Lug-24" Wire	GKIT-24-150
Grounding Kit, Pre-formed Copper Strap-Field attachable Lug-60" Wire	GKIT-60-150
Grounding Kit	GKIT-ST-150
Standard Hanger Kit, Non-insulated, stainless steel	CLAMP-150
Universal clamp with clamp lining	CLAMP-R-150
RSB Clip with clamp lining	RSB-150
Hoisting Grip, Lace-Up, single loop configuration	HOIST1-150L
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L03
Bending Tool Kit	BENDTOOL-100220
Bending Tool Kit	BENDTOOL-105185
Wall/Roof Feed-Through, Aluminum plate	WFT-150
Wall/Roof Feed-Through, Stainless Steel plate	WF-150
Feed Through Boot Assembly w/1 hole - 4"	BOOT4-150
Flanging die, compact Tool	FDIE-C150*
Compact Tool	FTOOL-C105380*

E185 SERIES (17.3 - 19.7 GHz)

Connector, PDR180, 17.3 - 19.7 GHz, Plast 2000	D180-185FP
Connector, PBR220, 17.7 - 19.7 GHz, Plast 2000	B220-185FP
Connector, UG-595/596/U, 17.70 - 19.70 GHz, Gasket, only E185	G595-185TG
Splice, N/A, 17.70 - 19.70 GHz, Gasket	SPLICE-185
Grounding Kit, Pre-formed Copper Strap-Factory attached lug-24" Wire	GKIT-24-185
Grounding Kit, Pre-formed Copper Strap-Field attachable lug-60" Wire	GKIT-60-185
Grounding Kit	GKIT-ST-185
High Speed Grounding Kit	GKIT-HS-185
Standard Hanger Kit, Non-insulated, stainless steel	CLAMP-185
Universal clamp with clamp lining	CLAMP-R-185
RSB Clip with clamp lining	RSB-185
Hoisting Grip, Lace-Up, single loop configuration	HOIST1-185L
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L02
Bending Tool Kit	BENDTOOL-100220
Bending Tool Kit	BENDTOOL-105185
Wall/Roof Feed-Through, Aluminum plate	WFT-185
Wall/Roof Feed-Through, Stainless Steel plate	WF-185
Feed Through Boot Assembly w/1 hole - 4"	BOOT4-185
Flanging die, compact Tool	FDIE-C185*
Flanging die, mini Tool	FDIE-M185*
Compact Tool	FTOOL-C105380*
Mini Tool	FTOOL-M185380*

E220 (21.2 - 23.6 GHz)

Connector, PBR220, 21.2 - 23.6 GHz, Plast 2000	B220-220FP
Grounding Kit	GKIT-ST-220
Universal clamp with clamp lining	CLAMP-R-220
RSB Clip with clamp lining	RSB-220
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L02
Bending Tool Kit	BENDTOOL-100220
Wall/Roof Feed-Through, Stainless Steel plate	WF-220/L38
Flanging die, compact Tool	FDIE-C220*
Flanging die, mini Tool	FDIE-M220*

E220 (21.2 - 23.6 GHz) CONT'D

Compact Tool	FTOOL-C105380*
Mini Tool	FTOOL-M185380*

E250 (24.25 - 26.5 GHz)

Connector, PBR220, 24.25 - 26.5 GHz, Gasket with Shrinking Sleeve	B220-250FP
Connector, PBR260, 24.25 - 26.5 GHz, Gasket with Shrinking Sleeve	B260-250FP
Grounding Kit	GKIT-ST-250
RSB Clip with clamp lining	RSB-250
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L01
Wall/Roof Feed Through	WFS-2
Flanging die, compact Tool	FDIE-C250
Flanging die, mini Tool	FDIE-M250
Compact Tool	FTOOL-C105380
Mini Tool	FTOOL-M185380

E300 (27.5 - 33.4 GHz)

Connector, PBR320, 27.5 - 33.4 MHz, Gasket with Shrinking Sleeve	B320-300FP
Grounding Kit	GKIT-ST-300
RSB Clip with clamp lining	RSB-300
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L01
Wall/Roof Feed-Through	WFS-2
Flanging die, compact Tool	FDIE-C300
Flanging die, mini Tool	FDIE-M300
Compact Tool	FTOOL-C105380
Mini Tool	FTOOL-M185380

E380 (37.0 - 39.5 GHz)

Connector, PBR320, 37.0 - 39.5 GHz, Gasket with Shrinking Sleeve	B320-380FP
Grounding Kit	GKIT-ST-380
RSB Clip with clamp lining	RSB-380
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L01
Wall/Roof Feed Through	WFS-1
Bending Tool Kit	BENDTOOL-L38380
Flanging die, compact Tool	FDIE-C380
Flanging die, mini Tool	FDIE-M380
Compact Tool	FTOOL-C105380
Mini Tool	FTOOL-M185380

EO11 (10.7 - 11.7 GHz)

Connector, PDR100, 10.7 - 11.7 GHz, Gasket with Shrinking Sleeve	D100-L11FP
Grounding Kit	GKIT-ST-L11
Universal clamp with clamp lining	CLAMP-R-L11
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L05
Bending Tool Kit	BENDTOOL-058078
Wall/Roof Feed-Through, Stainless Steel plate	WF-L11
Flanging die, basic Tool	FDIE-BL11
Basic Tool	FTOOL-B038150

EO15 (12.75 - 15.35 GHz)

Connector, PDR120, 12.7 - 14.5 GHz, Gasket with Shrinking Sleeve	D120-L15FP
Connector, PDR140, 14.0 - 15.35 GHz, Gasket with Shrinking Sleeve	D140-L15FP
Grounding Kit	GKIT-ST-L15
Universal clamp with clamp lining	CLAMP-R-L15
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L05
Bending Tool Kit	BENDTOOL-058078
Wall/Roof Feed-Through, Stainless Steel plate	WF-078/L15
Flanging die, basic Tool	FDIE-BL15
Basic Tool	FTOOL-B038150

* Not applicable for gasket type connectors



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Connector & Accessory Reference Guide (See installation hardware on separate table)

EO19 (17.7 - 19.7 GHz)

Connector, PBR220, 17.7 - 19.7 GHz, Gasket with Shrinking Sleeve	B220-L19FP
Grounding Kit	GKIT-ST-L19
Universal clamp with clamp lining	CLAMP-R-L19
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L04
Bending Tool Kit	BENDTOOL-100220
Wall/Roof Feed-Through, Stainless Steel plate	WF-105/L19
Flanging die, compact Tool	FDIE-CL19
Compact Tool	FTOOL-C105380

EO22 (21.2 - 23.6 GHz)

Connector, PBR220, 21.2 - 23.6 GHz, Gasket with Shrinking Sleeve	B220-L22FP
Grounding Kit	GKIT-ST-L22
Universal clamp with clamp lining	CLAMP-R-L22
Hoisting grip, Lace-up, two loop configuration	HOIST2-L03
Wall/Roof Feed-Through	WFS-4
Bending Tool Kit	BENDTOOL-100220
Flanging die, compact Tool	FDIE-CL22
Compact Tool	FTOOL-C105380

EO38 (37.0 - 39.5 GHz)

Connector, PBR320, 37.0 - 39.5 GHz, Gasket with Shrinking Sleeve	B320-L38FP
Grounding Kit	GKIT-ST-L38
High Speed Grounding Kit	GKIT-HS-L38
RSB Clip with clamp lining	RSB-L38
Hoisting grip, Lace-Up, two loop configuration	HOIST2-L02
Bending Tool Kit	BENDTOOL-L38380
Wall/Roof Feed-Through, Stainless Steel plate	WF-220/L38
Flanging die, compact Tool	FDIE-CL38
Flanging die, mini Tool	FDIE-ML38
Compact Tool	FTOOL-C105380
Mini Tool	FTOOL-M185380

MICROWAVE
ANTENNA
SYSTEMS

4

Installation Hardware

INSTALLATION HARDWARE	MODEL NUMBER	USABLE WITH
AC-profile 200mm with 2 holes	AC7-020H	
Universal clamping plate for slot anchor bar (Kit of 10)	HUA-M8	Universal clamp, Standard Hanger Kit
Universal installation cleat including screw M8 (Kit of 10)	MKD-001-01	Universal clamp, Standard Hanger Kit
Angle Member Adapter, 3/8"	ANGLE-CLPI	Standard Hanger Kit, non insulated
Hardware for clamps on tubes bigger 1"	TRB-8	RSB-clip, Universal clamp, Standard Hanger Kit
RSB Cleat	RSB-310	RSB-clip
RSB clamping plate for anchor bar	RSB-315	RSB-clip
Rucksack option for RSB Clip	RSB-78-R	RSB-clip
Round Member Adapter, 25-40 mm	RMA-40	RSB-clip , TRB-8
Round Member Adapter, 40-60 mm	RMA-60	RSB-clip , TRB-8
Round Member Adapter, 60-80 mm	RMA-80	RSB-clip , TRB-8
Round Member Adapter, 80-100 mm	RMA-100	RSB-clip , TRB-8
Round Member Adapter, 100-120 mm	RMA-120	RSB-clip , TRB-8
Round Member Adapter, 120-140 mm	RMA-140	RSB-clip , TRB-8
Round Member Adapter, 140-160 mm	RMA-160	RSB-clip , TRB-8
Round Member Adapter, 1-2"	RMA-AI	
Round Member Adapter, 2-3"	RMA-BI	
Round Member Adapter, 3-4"	RMA-CI	
Round Member Adapter, 4-5"	RMA-DI	
Round Member Adapter, 5-6"	RMA-EI	
Round Member Adapter, 6-7"	RMA-FI	
Stainless stell strapping kit	STRAP-1	
Stainless stell strapping kit, tube mounting with fasteners	STRAP-2	