Appendix A

A.1 ITU-T fibre recommendations

Recommendation G.652 applies to S-SMF designed for 1.3 μ m operation and G.653-G.654 refers to DSFs designed for 1.55 μ m operation. The following set of nominal values and maximum tolerance for physical parameters are taken from the ITU-T recommendation.

	G.652 fibres	G653 fibres	
	(S-SMF)	(DSF)	
Mode field	$2w_0 = 10 \ \mu m \pm 10\%$	$7 \mu m < 2w_0 < 8.3 \mu m$	
diameter		with $2w_0 \pm 10\%$	
Cladding diameter	$125 \ \mu m \pm 2 \ \mu m$	125 μm ± 2 μm	
Zero dispersion wavelength	$1.3 \ \mu m \le \lambda_0 \le 1.324 \ \mu m$		
	< 18 ps/(nm•km)	< 3.5 ps/(nm•km)	
Dispersion	$1.5 \ \mu m \le \lambda \le 1.58 \ \mu m$	$1.525 \ \mu m \leq \lambda \leq 1.575 \ \mu m$	
D	<3 ps/nm/km		
	$1.28 \ \mu m \le \lambda \le 1.335 \ \mu m$		
PMD	$< 0.5 \ ps/\sqrt{km}$		
Attenuation			
$\lambda = 1.31 \ \mu m$	<0.35 dB/km		
$1.525 \ \mu m \leq \lambda \leq 1.575 \ \mu m$	<0.22 dB/km		
Cut-off wavelength	$1.1 \ \mu m \le \lambda_C \le 1.28 \ \mu m$	≤ 0.25 at $\lambda = 1.55 \mu m$	
Cable	$\lambda_C < 1.27 \ \mu m$	< 0.1 at $\lambda = 1.55 \mu m$	
cutoff wavelength			
Dispersion slope	0.093 ps/nm ² •km	0.085 ps/nm ² •km	
$\mathbf{S}_{0,\max}$			
Mode field noncircularity	not fixed	not fixed	
Cladding noncircularity	< 2%	< 2%	
Concentricity error between			
mode field and cladding	$< 1 \ \mu m$	< 1 µm	

Table A.1 ITU-T fibre recommendations

The fibres used for the measurements in Chapter 6 and 7 are S-SMFs, DSFs and spun DSFs, EDFs and DEDFs which are from Corning USA, Lycom Denmark (AT&T), Optical Fibres UK (Corning), and from BT Labs. Given that the majority of fibres used are Corning products, the table below gives some general information taken from Corning product information data sheets.

	Corning SMF-	Corning SMF-	SMF-28 TM
	LS TM (DSF)	DS TM (DSF)	(S-SMF)
Manufacturing	Outside Vapor	Outside Vapor	Outside Vapor
technique	deposition (OVD)	deposition (OVD)	deposition (OVD)
Attenuation (dB/km)	≤ 0.25 at $\lambda = 1.55 \mu m$	≤ 0.25 at $\lambda = 1.55 \mu m$	≤ 0.25 at $\lambda = 1.55 \mu m$
	≤ 0.5 at $\lambda = 1.31 \mu m$		≤ 0.35 at $\lambda = 1.31 \mu m$
			$9.3\pm0.5~\mu m$
Mode field diameter	$8.4\pm0.5~\mu m$	$8.10 \pm 0.65 \ \mu m$ at	at 1.31 µm
$2w_0$	at 1.55µm	at 1.55µm	$10.5\pm1~\mu m$
			at 1.55 µm
Zero dispersion	$\lambda_0 \ge 1560 \text{ nm}$	$1535 \text{ nm} \le \lambda_0 \le 1565$	1301.5 nm $\leq \lambda_0 \geq$
wavelength		nm	1321.5 nm
Zero dispersion slope	0.092 ≤	≤0.085 ps/(nm²•km)	≤0.090 ps/(nm²•km)
(S_0)	psec/(nm ² ×km)		
Total Dispersion:	$\leq 3.5 \text{ ps/(nm^2 \cdot km)}$	≤2.7 ps/(nm•km)	
	$1530 \le \lambda \le 1560 \text{ nm}$	$1525 \le \lambda \le 1575 \text{ nm}$	
PMD	$\leq 0.5 \ ps/\sqrt{km}$		$\leq 0.5 \ ps/\sqrt{km}$
Cladding diameter	$125 \pm 1.0 \mu m$	$125.0\pm1.0\mu m$	$125.0\pm1.0\mu m$
Core-clad	≤ 1µm	≤ 1.0 µm	≤ 0.8 µm
concentricity			
Cladding non-	≤ 1.0%	≤ 2.0%	≤ 1.0%
circularity			
Coating diameter	$245 \pm 10 \mu m$	$245\pm10~\mu m$	$245\pm10\mu m$
Coating-cladding	< 12µm	≥0.70	≥0.70
concentricity			
Core diameter			8.3µm
Typical dispersion	1.5 ps/(nm•km)		

A III

Effective Group	1.471 at 1310 nm	1.4718 at 1310 nm	1.4675 at 1310 nm
Index of Refraction	1.470 at 1550 nm	1.4711 at 1550 nm	1.4681 at 1550 nm
(n_{eff}) :			
Fibre cutoff		$1.12 \ \mu m \le \lambda_C \le$	1.19 $\mu m \le \lambda_C \le$
wavelength		1.35µm	1.33 µm
Refractive index			0.36%
difference			
Zero dispersion			$\lambda_0=1312m$
wavelength			

Table A.2 Corning fibre product information

The main difference between the Corning LS and DS fibre is that for the LS fibre, the dispersion zero is outside the $1.53 - 1.56 \mu m$ operating band, suppressing non-linear effects, such as, four wave mixing, which might otherwise limit multiple channel operation in the erbium window.

Figure A.1 shows the index profiles for S-SMF and DSF (from Corning). For the dispersion shifted fibre, the core is divided into two layers. The inner core has a refractive index graded with a triangular profile which is surrounded by a lower index silica layer. This, in turn, is surrounded by a layer with higher refractive index, but which is lower than the inner core, and finally with an outer low index cladding. This design shifts the chromatic dispersion zero from 1.3 μ m for normal step index fibre to 1.55 μ m at the attenuation minima of the fibre.



Figure A.1 (a) S-SMF profile and in (b) DSF with segmented refractive index profile, dashed line indicates DS step index fibre as used for simulation in the Sections 3.2 and 3.3.