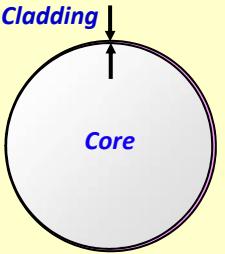
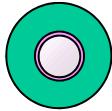


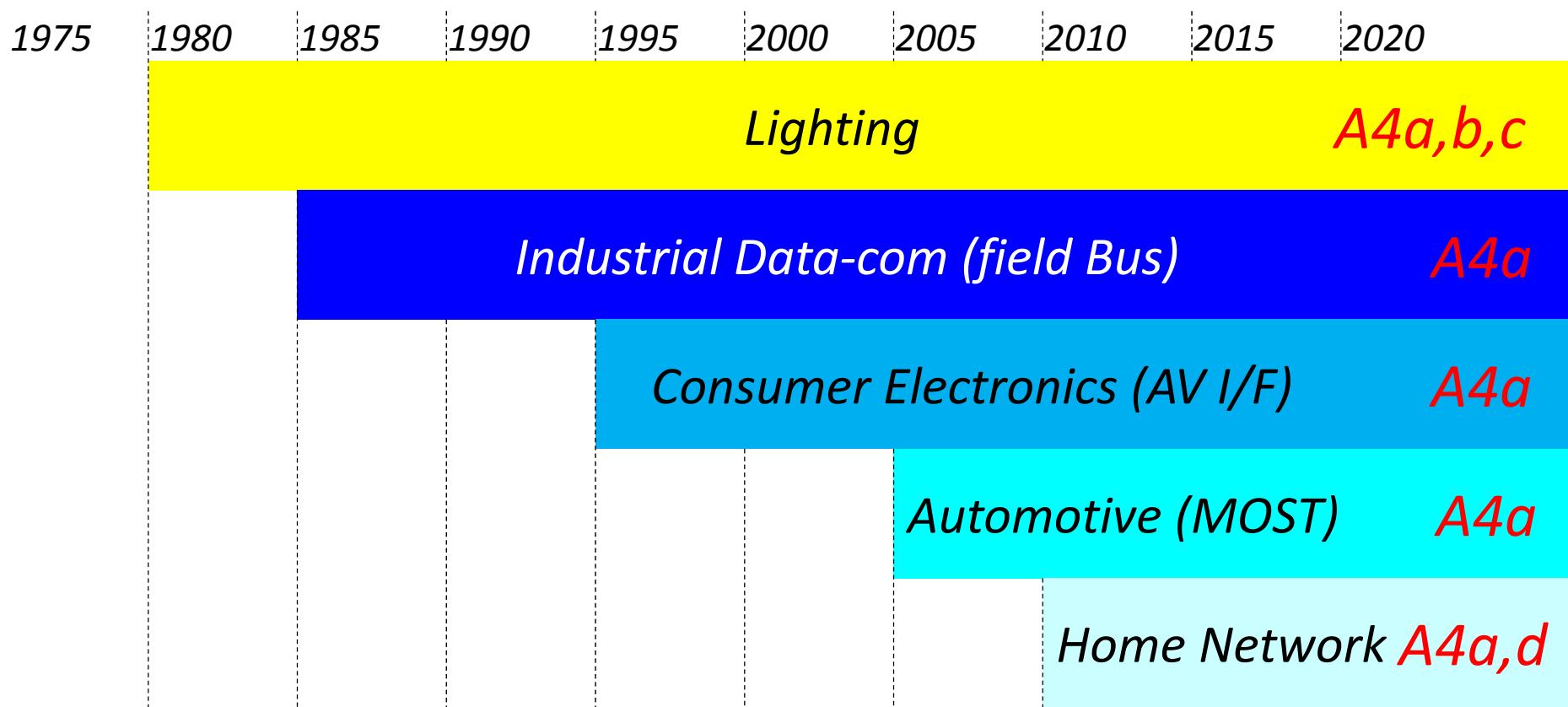
Plastic Optical Fiber (POF) technology for Automotive, Home network systems

Plastic Molding Material Department,
Mitsubishi Rayon Co., Ltd.

Fiber types and Materials/Constructions

Core/Cladding	Plastic/Plastic	Plastic/Plastic	Glass/Plastic	Glass/Glass
Known as	POF(A4a.2)	GI-POF(A4g)	PCF (HCS/HPCF)	GOF
Bandwidth (MHz-km)	3	20	20	300-1500
Fiber (corer) diameter (μm)	(250)750-1000	50-500	125-600	50-100
Transmission distance	Short	Medium	Medium	Long
Attenuation (dB/km)	250	6	6	4
Numerical Aperture	0.50	0.19-0.25	0.37	0.30
Wavelength (nm) of the source	650	650, 850	650, 850	1300,1550
Cross sections, typical sizes	 980/1,000 μm	 120/500 μm	 200/230 μm	 62.5/125 μm Singlemode Multimode

Expansion of Data Applications

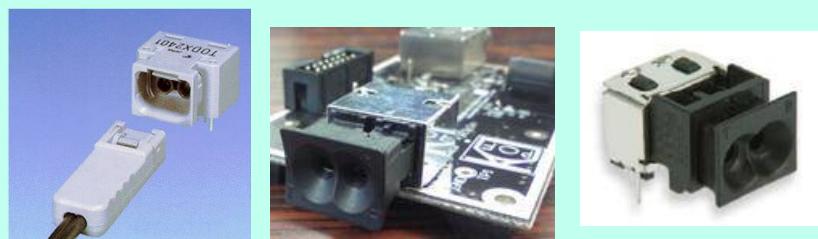


Plastic Optical fiber(POF)

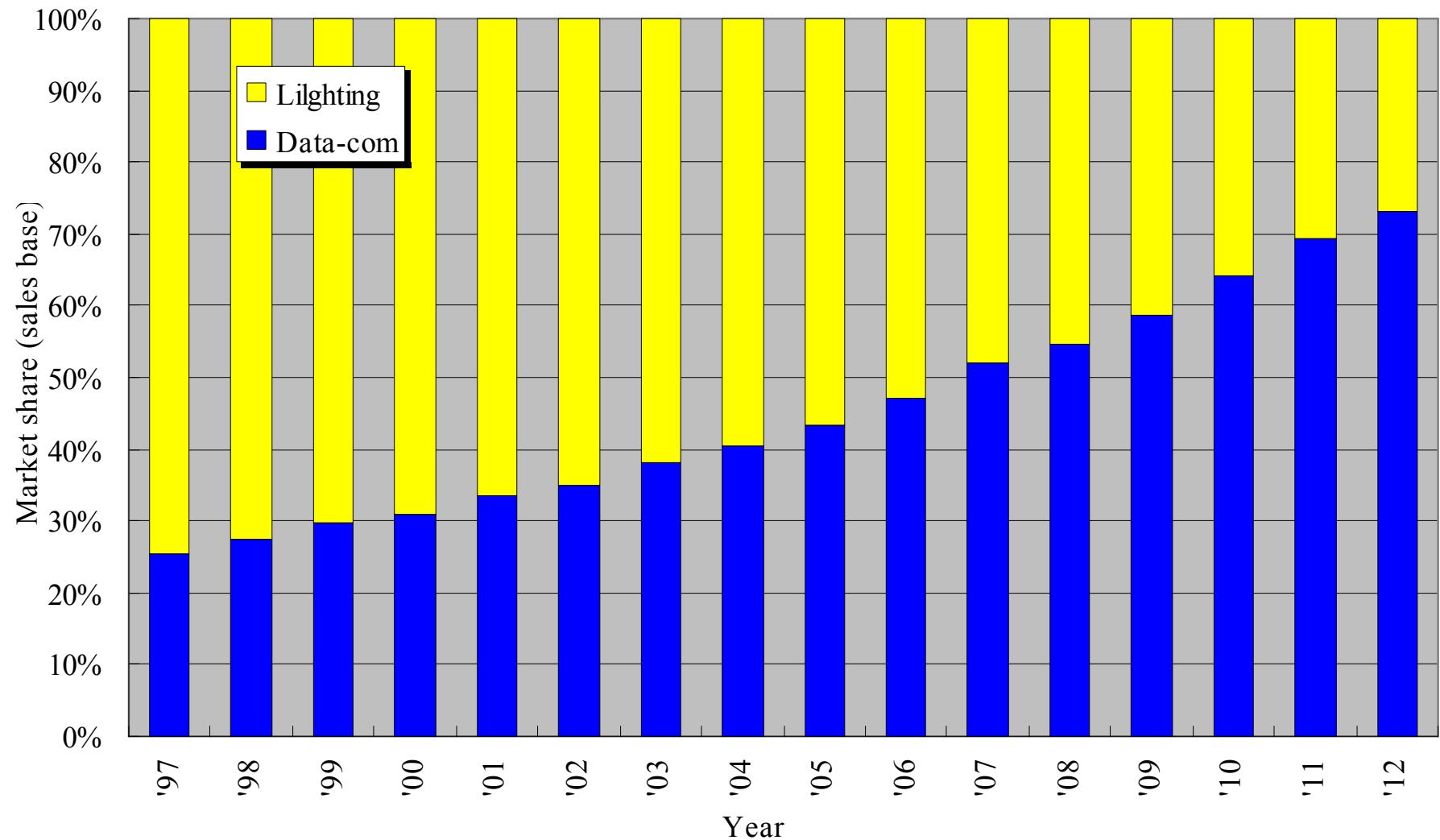
has more than 30 years, long history

has been used in several Data-com purpose(FA, Automotive, Home)

Connector interfaces for A4a POF

<i>Applications</i>	<i>Connectors</i>
<i>Industrial(Field Bus)</i>	SMA 905 
<i>Consumer(AV I.F)</i>	Versatile Link IEC 60874-17 Type F05 IEC 61754-16 Type PN 
<i>Automotive(MOST)</i>	MOST 
<i>Home Network</i>	IEC 61754-21 Type SMI Fiber-Lock Opto-Lock 

POF Market Trend



POF Application for Automotive, Home network

150 Car models with MOST systems over POF(A4a.2) since 2001

- Audi
 - A1, A3(12~)*, A5, A6, A7-sports back, A8
 - Q3, Q5, Q7
- BMW
 - 1s, 3s (12~), 5s, 6s, 7s
 - X1, X3, X5, X6, Z4
- Daimler-Chrysler
 - A(12~), B, C, CLS, E, S(14~)*, SL(12~), SLK, GL(12~), M, R, Maybach
 - Smart forfour
- VOLVO
 - C30, C70, S40, S60, S80, V40, V50, V60, V70,
 - XC60, XC70, XC90
- Land Rover
 - Range Rover, evoque, Freelander, Discovery3&4
- MINI (MINI, Coupe, Clubman, Countryman)
- Porsche:
 - Cayenne, Boxster, Cayman, 911('11), Panamera
- VW
 - Touareg
 - Golf(12~)*
- Hyundai
 - Genesis, Mohave, Equus
- Aston Martin, Bentley, Jaguar, Rolls-Royce

Note * MOST150



Source: MOST Cooperation

Parts Approval Process Based on MOST Test Guide Line

- Test Guidelines for Fibre Optic Cable = Prufrichtlinie fur LWL-Meterware
- Co-work by DC&BMW, Evaluation standard on POF cable
- Evaluation Items based on the Test guideline
 - Fiber/Cable construction: dimension etc. 18 items
 - Optical characteristics: Attenuation, bandwidth etc, 7 items
 - Mechanical: bending, twist, compression etc, 9 items
 - Material: restricted material, non-flamability etc, 5 items
 - Reliability: Aging, chemical durability, etc, 23 items
- Covering other items more in the future

3. Durability							No. of samples	Guidelines No. or reference
Sender:	Requirement	Unit	pass/fail	mean	deviation	min.	max.	
3.1 Against mechanical stress								
Static bending								
Max attenuation rise, new samples	≤ 0.5							
reversible attenuation rise, aged samples	≤ 0.5							
Tensile strength of inner jacket and fibre	≥ 9.0							
Durability against constant elongation	≥ 9.0							
3.2 Mechanical properties of the cable								
Adhesion								
Inner jacket to fibre	> 50							
Outer to outer jacket	20 ± 10							
2.1 Optical properties								
Tensile performance of the fibre with inner jacket								
Elongation	< 2.5							
Resistance to bending	10...18							
Bending radius								
Condition 1, new samples	< 10 mm							
Condition 2, aged samples	< 15 mm							
Repeated torsion	≥ 0.1							
Torsion strain at bending point	< 0.05							
R > 20mm, L > 50 mm, T: RT, new samples	≥ 0.8							
R > 20mm, L > 50 mm, T: RT, aged samples	≥ 0.8							
Orientation	< 0.2							
Shrinking	0.4							
Pistonning between Fibre and inner jacket	± 0.03							
Pistonning between inner and outer jacket	± 0.5							
Abrasion								
2.2 Properties of the cable materials								
Used materials								
Condition 2, new samples	< 0.52							
Use of allowed materials only	TRUE							
45 °C / -40 °C temperature and humidity	≤ 0.1							
85 °C / 85 % r.H., reversible	≤ 0.3							
85 °C / 85 % r.H., after conditioning in dry air	≤ 0.2							
UV-radiation	N/A							
2.3 Durability against chemicals								
Compatibility to chemical substances	0.04							
Colourfast								
Huftest auf (at T = 85 °C, 1.000 h, 0.8 m)	not staining	TRUE						
Bottling and (at T = 85 °C, 200 h, 0.8 m)	≤ 0.3							
	[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]
	green	green	red	red	red	red	red	red
PN 8.1								
4. Structure of the optic cable								
Outer jacket								
Condition 2, new samples	< 0.05							
Relative index profile								
Step index								
Outer jacket								
Outer diameter	600 ± 45							
Outer thickness	200 ± 25							
Outer wall thickness	180 ± 20							
Flame retardance	TRUE							
Flame retardance IEC60332-2-2	TRUE							
Without toxic substances during burning	TRUE							
Bandwidth								
Compatibility to other harnesses	0.04							
Colourfast								
Hygroscopicity (at T = 85 °C, 1.000 h, 0.8 m)	≤ 0.3							
Bottling and (at T = 85 °C, 200 h, 0.8 m)	≤ 0.3							
	[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]
	green	green	red	red	red	red	red	red
PN 8.2								
5. Numerical Aperture								
NA	0.22...0.05							
	Numerical aperture							
Relative index profile								
Step index								
Outer jacket								
Outer diameter	600 ± 45							
Outer thickness	200 ± 25							
Outer wall thickness	180 ± 20							
Concentricity of fibre	≤ 0.1							
Fibre diameter	600 ± 45							
Optical insulation	> 30							
	[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]
	green	green	red	red	red	red	red	red
PN 8.3								
Validation of Plastic Optical Fiber Cable for the MOST Harness								
Supplier and document information								
Customer	Toyota Motor Corporation	Date	Document number	Prepared by	Review	Approved by		
Customer address	67-1, Nagatoro-cho, Toyota City, Aichi 471-8506, Japan	2014/4/20	NAI-20140420	Iwao Maki	Iwao Maki	Kazuki Nakamura		
Plant location	100, Kagan-cho, Toyama-shi, Toyama-ken, Japan	2014/4/20	NAI-20140420	Isamu Kubo	Isamu Kubo	Yasuya Yamada		
Plant name	TOYOTA KAGAWA PLANT	2014/4/20	NAI-20140420	Naoto Kubota	Naoto Kubota	Kazuki Nakamura		
Facility name	TOYOTA KAGAWA PLANT	2014/4/20	NAI-20140420	Naoto Kubota	Naoto Kubota	Kazuki Nakamura		
Facility address	100, Kagan-cho, Toyama-shi, Toyama-ken, Japan	2014/4/20	NAI-20140420	Naoto Kubota	Naoto Kubota	Kazuki Nakamura		
Requirement #	Application note: fiber optic cable for wiring							
Test method	Test guidelines for Fiber Optic Cable ver.1.2							
Drawing #	Part No.							
Supplier and document information								
Customer	Toyota Motor Corporation	Date	Document number	Prepared by	Review	Approved by		
Customer address	67-1, Nagatoro-cho, Toyota City, Aichi 471-8506, Japan	2014/4/20	NAI-20140420	Iwao Maki	Iwao Maki	Kazuki Nakamura		
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Requirement #	Application note: fiber optic cable for wiring							
Test method	Test guidelines for Fiber Optic Cable ver.1.2							
Drawing #	Part No.							

Fire & Toxicity Rating

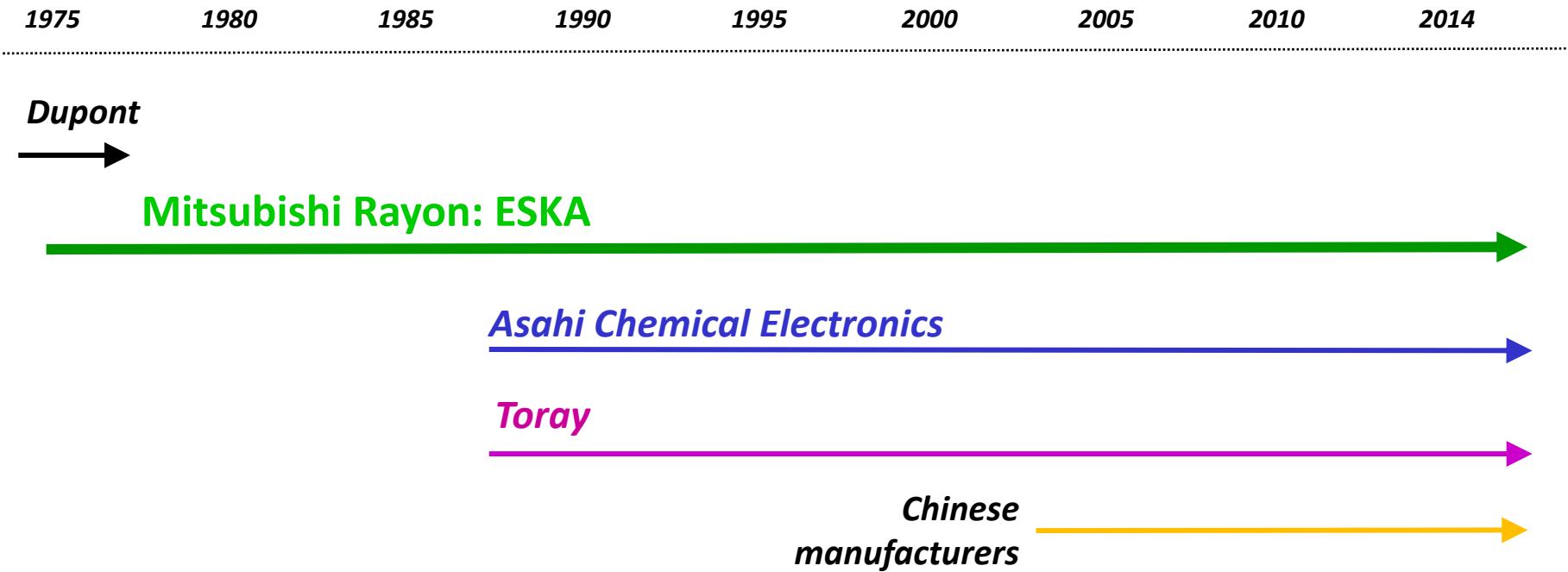
Cable Type	Standard cable	Riser & Plenum	LSZH
Burning image Of three different cables			
Flammability 	HIGH Burn rapidly Non-self extinguish	LOW Burns, but will self extinguish when flame removed	MEDIUM Burns, may will self extinguish when flame removed
Toxicity / Corrosive Level 	HIGH When burned gives toxic and corrosive gasses	HIGH When burned gives off toxic and corrosive gasses	LOW No corrosive gasses, but does give off carbon monoxide when burned
Typical Application	Most computer cabling found in offices and homes	Cabling found inside walls, ceilings and air plenums of office or private building	Cabling found in enclosed areas such as ships, submarines, high computer rooms, network centers and aircraft

Related standards and status of compliance

Items (OPTOHOME); RH series, simplex or duplex					
Standard				Status	
Category	Description	UL Standard	Materials		
Fire rating	Vertical specimen flame test	UL 758 UL1581	VW1	PVC, CPE	Available
	Test for flame propagation height of electrical and optical-fiber cables installed vertically in shafts	UL1651 UL 1666	OFNR, Riser	FR-PE(LSZH)	Sample distribution scheduled June '14
	Test for flame-propagation and smoke-density values for electrical and optical-fiber cables used in spaces transporting environmental air	UL1651 NFP262 (former UL910)	OFNP, Plenum	Fluorinated Polymer	Available

reference

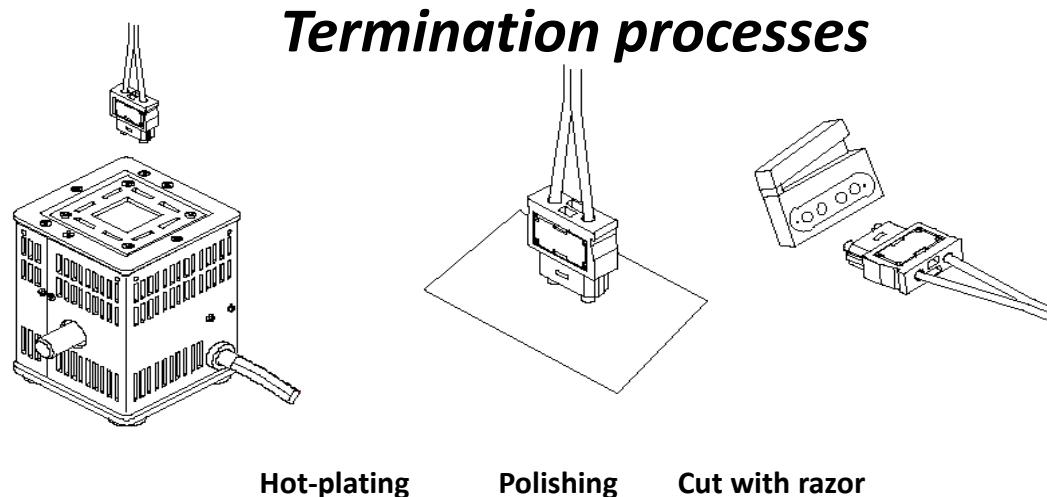
POF suppliers in the world



POF has
more than 30 years, long history.
has been used in several Data-com purpose(FA, Automotive, Home)

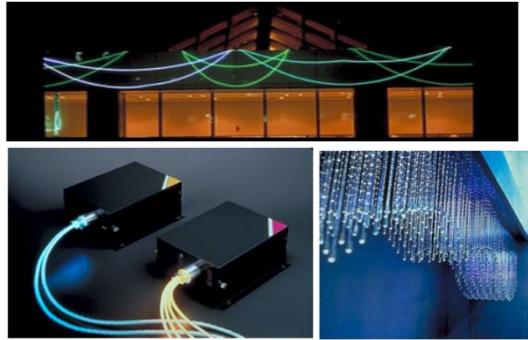
POF's Advantages

- Large core diameter allows
 - Easy handling/ termination with mechanical flexibility
 - Large tolerance shorten assembly man-hour with simple tools
 - Minimal assembly cost



- Optical media
 - Immune to EMI susceptibility and radiation along the media
 - Immune to lightning strikes
 - Will not produce sparks causing explosion and fire
 - No ground loop interference
 - Smaller cable and less weight than copper
 - Broad bandwidth over a longer distance

Expansion of applications



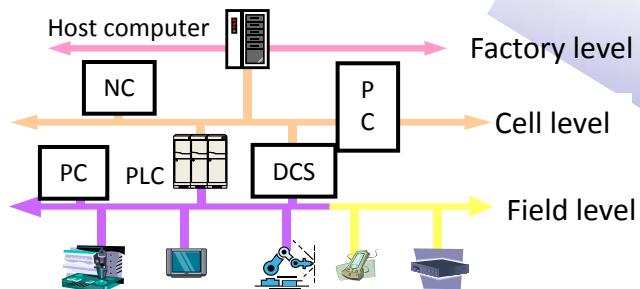
Lighting & Illumination



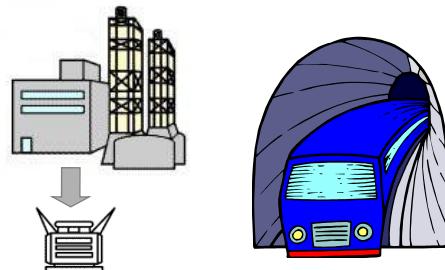
Industrial light for machine vision



Photo-electric switch



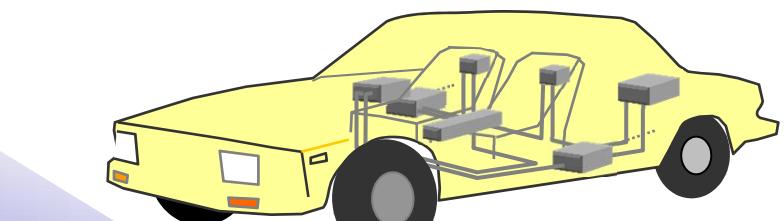
Field-Bus, Machine Control



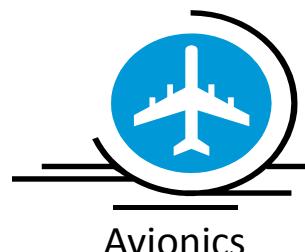
Power plant/substation, Locomotive/Train control



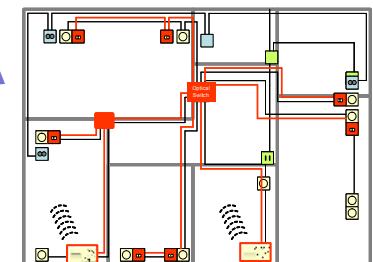
Digital audio



Automotive networking

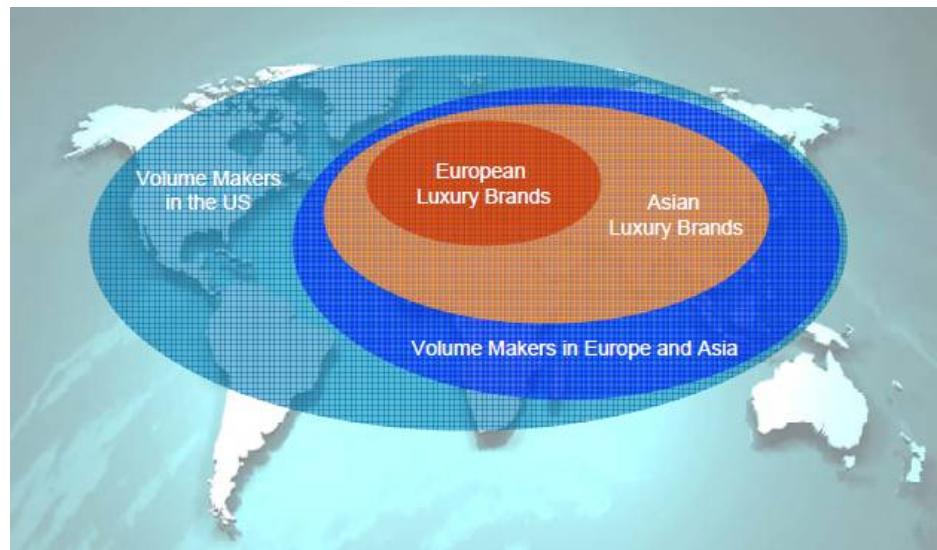
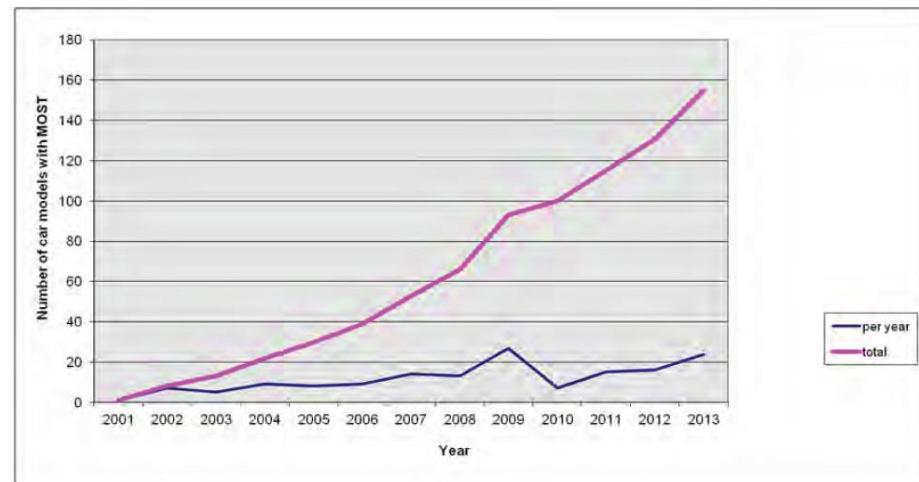
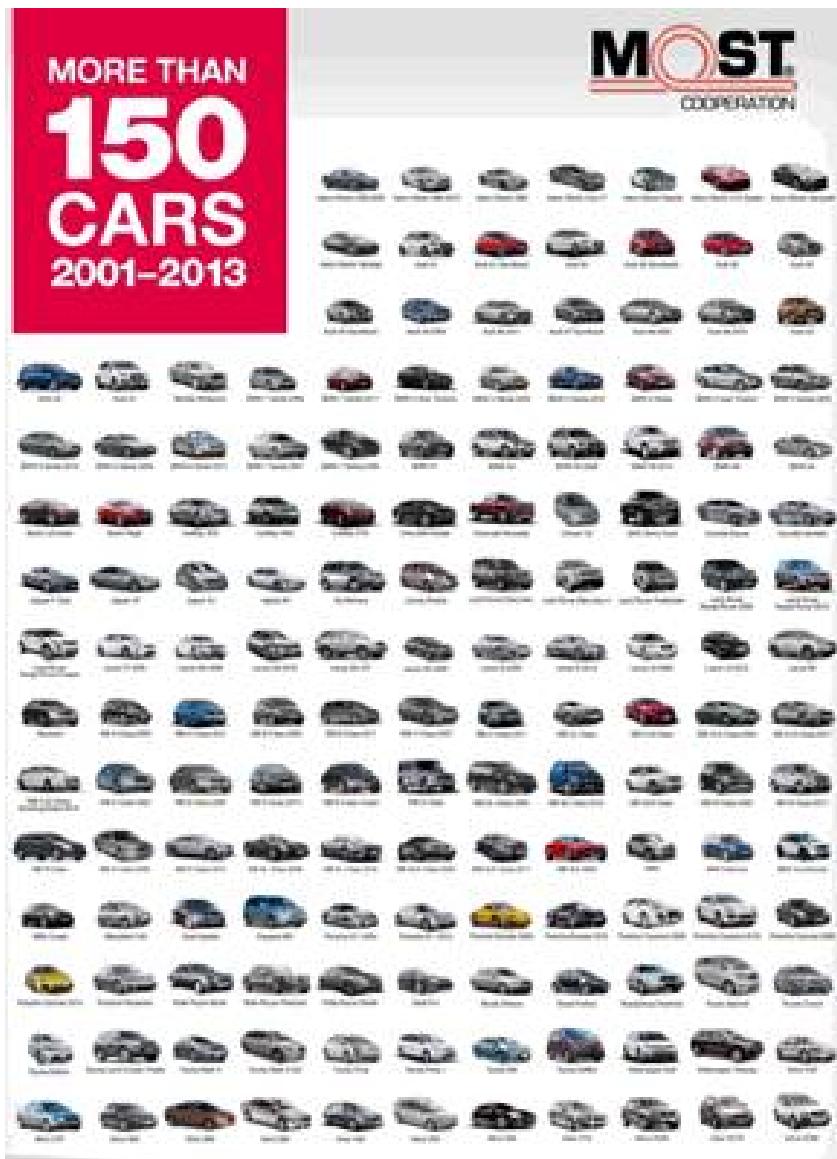


Avionics



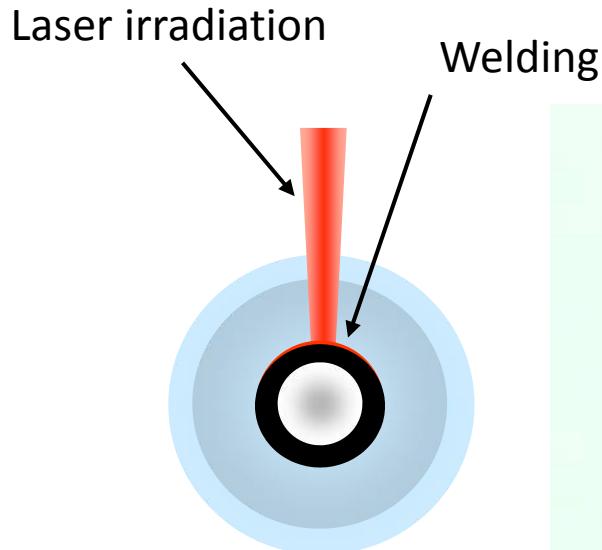
Residential data-com

Car models with MOST systems over POF since 2001



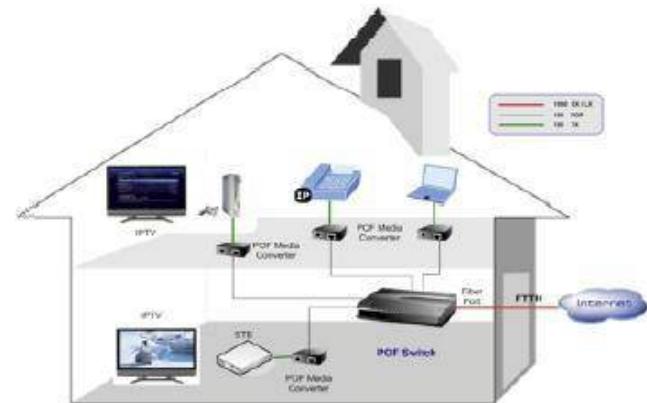
Source: MOST Cooperation(<http://www.mostnet.de/en/>)

Plastic ferrule for laser welding



Ferrule fixed with inner sheath by laser fusion

Home networking : IPTV application



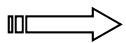
Background

IPTV: Telcos offer another option for consumers to watch digital TV services in addition to Terrestrial Broadcast, Cable, and Satellite.

Triple-play service benefits users with...

Unified Billing, Total Costs Saving, and new video services e.c. VOD

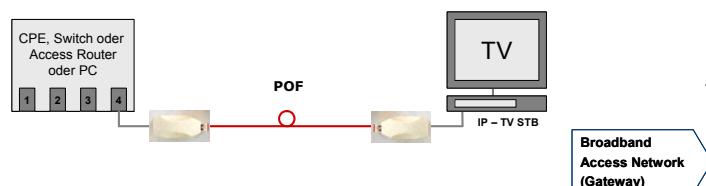
Point to Point



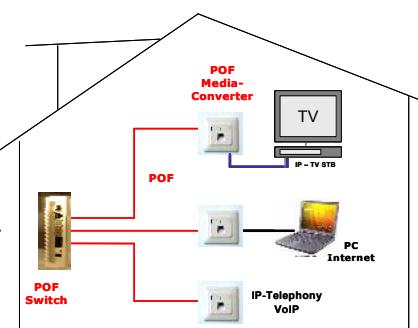
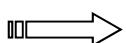
Structured Wiring



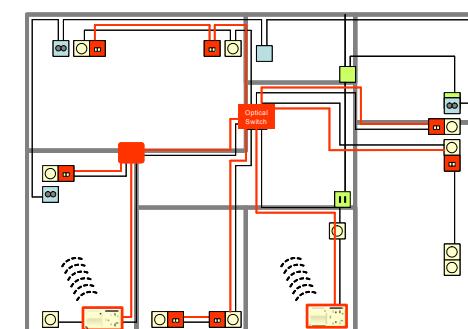
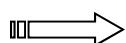
New Architecture



IPTV Telcos

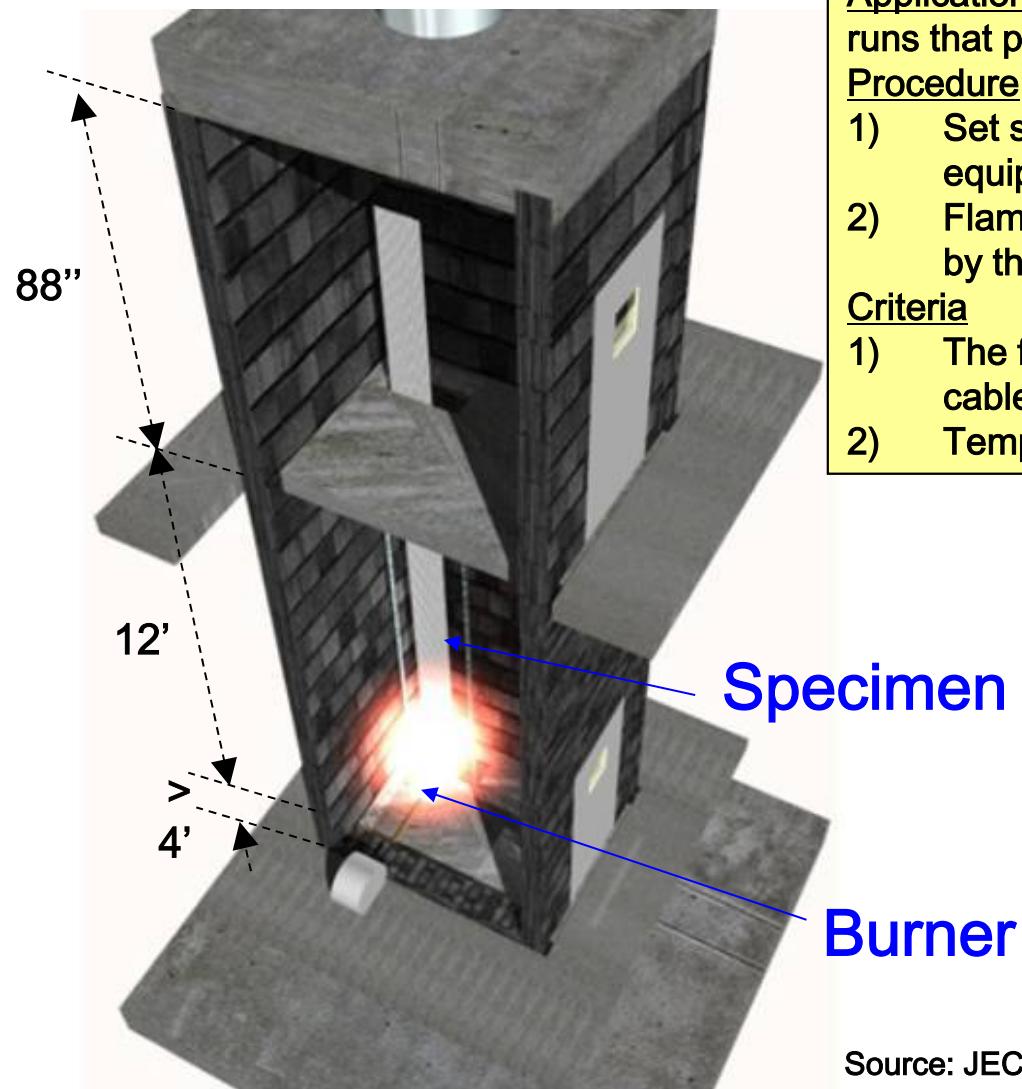


Cable Installers



System Vendors

UL1666(Riser): Vertical shaft test



Application: Installation vertically in shafts or in vertical runs that penetrate more than one floor

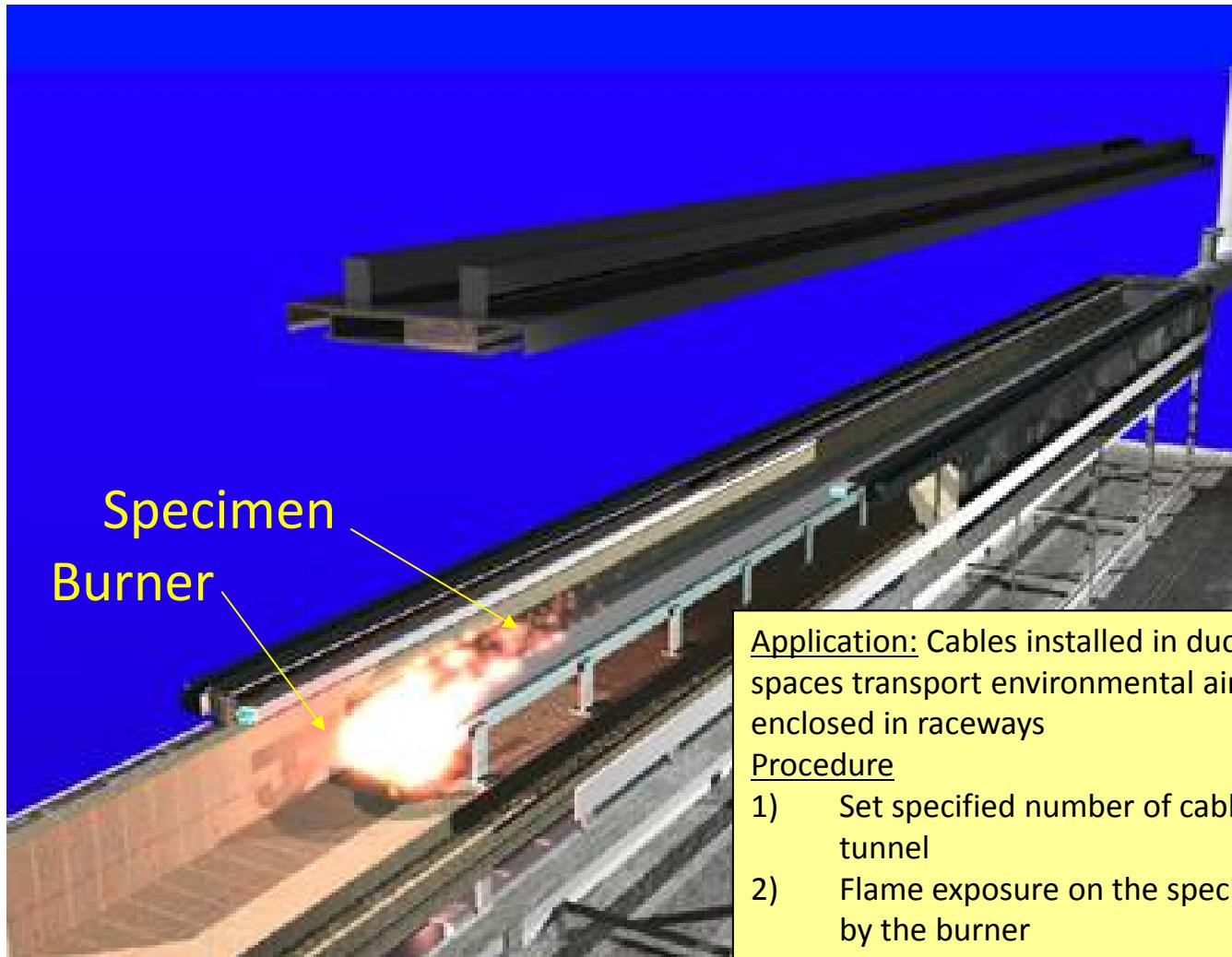
Procedure

- 1) Set specified number of cable specimen in the equipment
- 2) Flame exposure on the specimen for 30 minutes by the specified burner

Criteria

- 1) The flame propagation height of each set of cable specimens shall not equal or exceed 12ft
- 2) Temperature < 850°F

NFP262(Plenum) : Steiner tunnel test

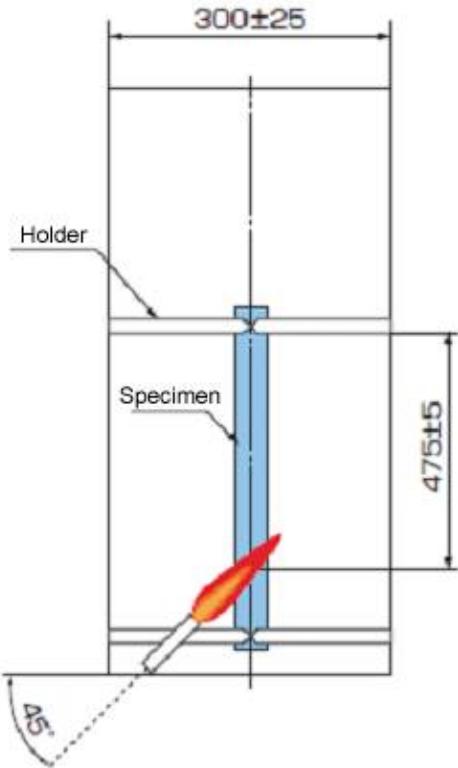


Source: JECTEC (Japan Electric Cable Technology Center, Inc.)

IEEE 802.3 GEPOF SG, May 2014 Interim

Slide 19

LSZH: IEC 60332-2, 60695-6, 60754



IEC 60332-1 Set-up (Unit mm)

Criteria	
Cable OD (mm)	Burning time (sec)
<25	60
25 < D < 50	120
50 < D < 75	240
75 < D	480

IEC60695

- Fire hazard testing

- Part 6: Guidance and test methods on the assessment of obscuration hazards of vision caused by smoke opacity from electro-technical products involved in fires

IEC 60754

- Test on gases evolved during combustion of materials from cables

- Part 1:Determination of the amount of halogen acid gas
 - Part 2: Determination of degree of acidity of gases evolved during the combustion of materials taken from electric cables by measuring pH and conductivity