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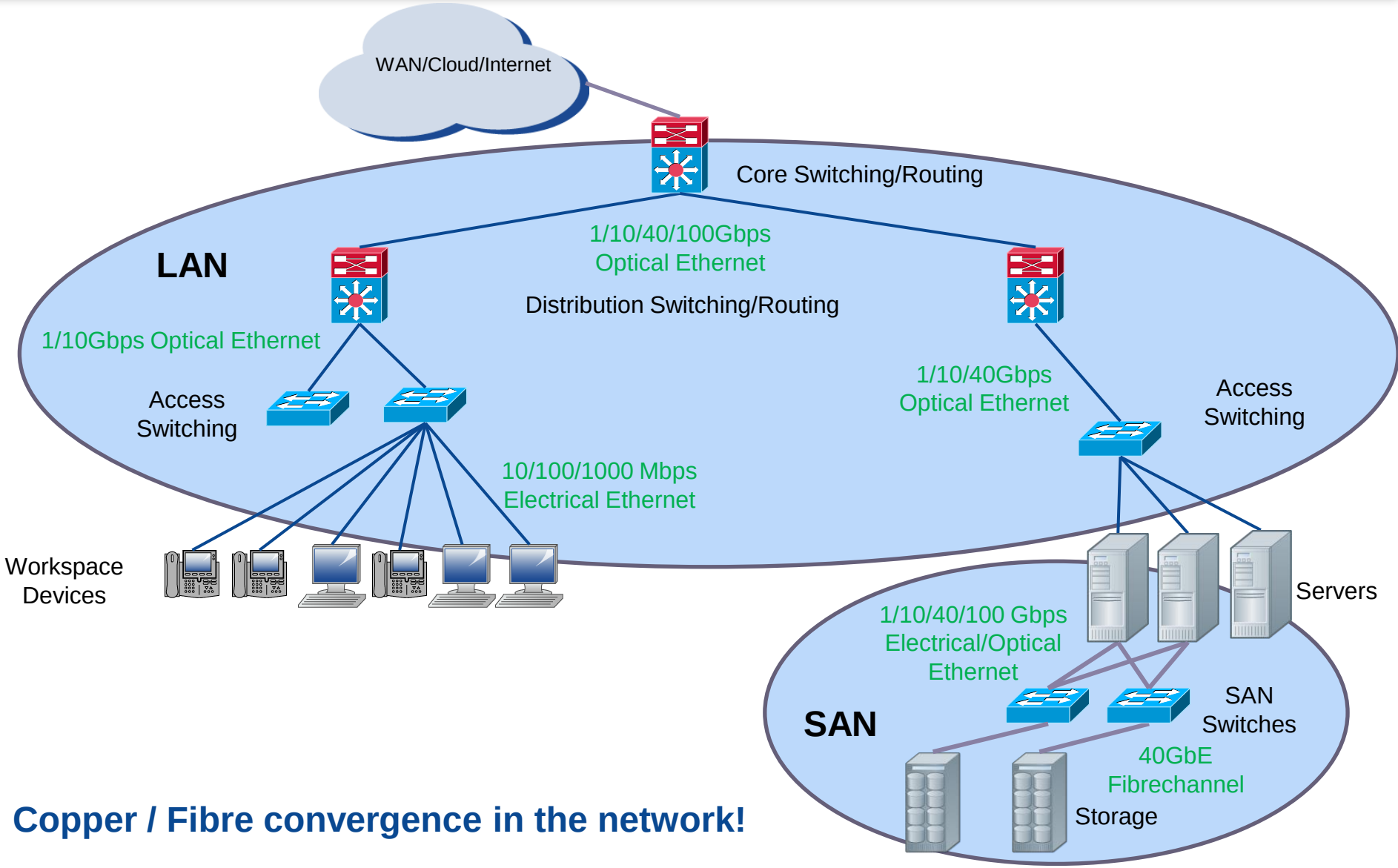
40G Cabling Testing: Opportunities and Challenges

David Zambrano, JDSU

Agenda

- Copper & Fibre Cabling infrastructure today
- 40GBASE-T – Is it possible?
- Fibre standards and the BS (EN) IEC 61300-3-35
- Fibre Testing in 40G – Opportunities and Challenges
- Conclusions

Enterprise Networks



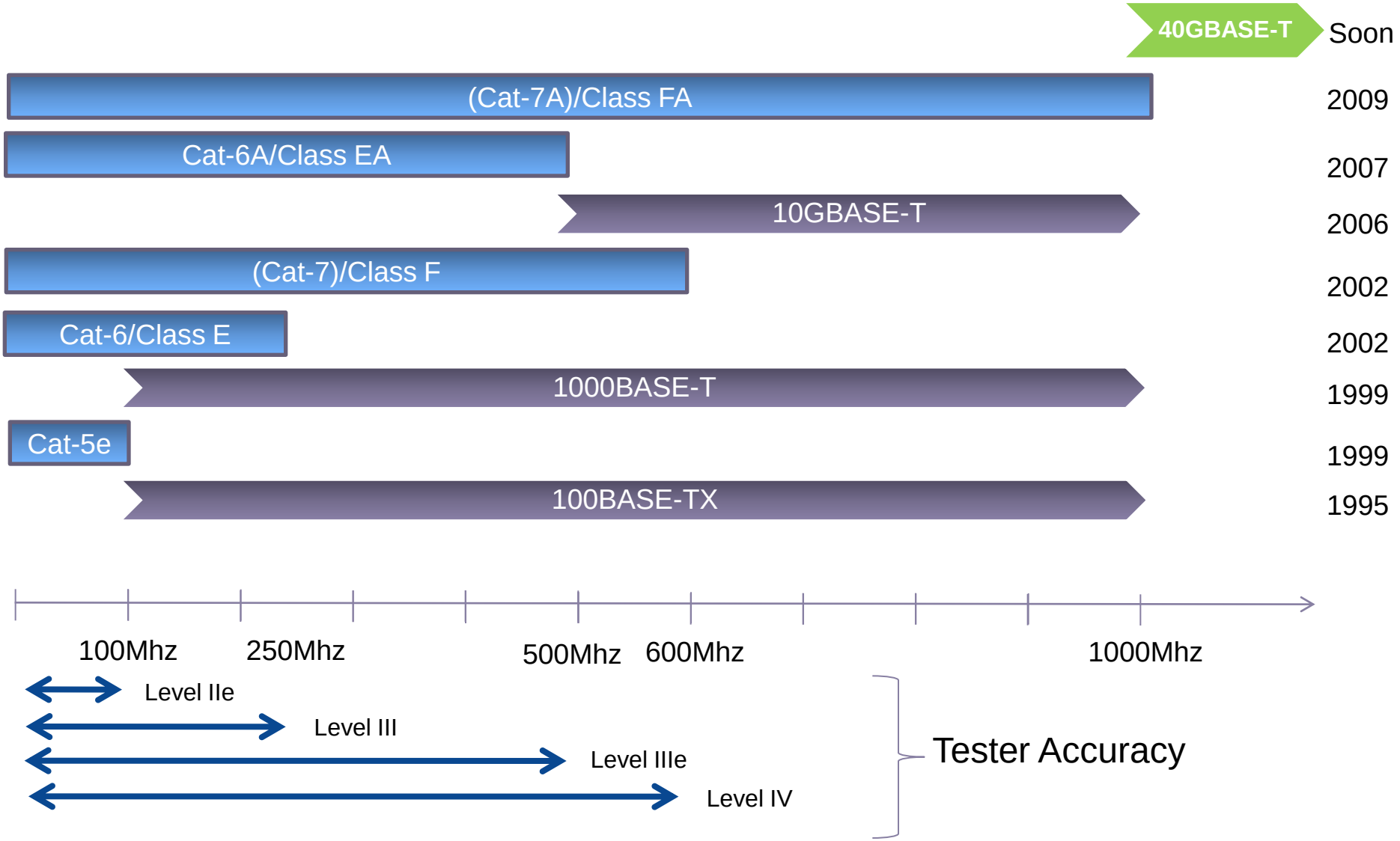
Copper / Fibre convergence in the network!

40G Ethernet Physical Layer Options

	Physical layer	40 Gigabit Ethernet
COPPER	at least 1 m over a backplane	40GBASE-KR4
	Approx. 7 m over copper cable	40GBASE-CR4
	at least 100 m over OM3 MMF	40GBASE-SR4
	at least 125 m over OM4 MMF	
	at least 10 km over SMF	40GBASE-LR4
	at least 40 km over SMF	
	serial SMF over 2 km	40GBASE-FR

No twisted pair structured cabling?

Evolution of Copper Cabling and Ethernet

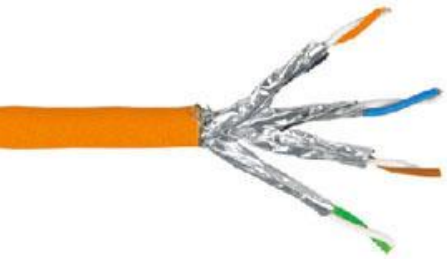


Ethernet Speeds 40GBASE-T

	10BASE-T	100BASE-TX	1000BASE-T	10GBASE-T	POTENTIAL 40GBASE-T
Rate	10 Mb/s	100 Mb/s	1 Gb/s	10 Gb/s	**40 Gb/s**
Bandwidth	20 MHz	31.25 MHz	62.5 MHz	413 MHz	**1000(+) MHz**
Efficiency	1 b/s/Hz	3.2 b/s/Hz	16 b/s/Hz	24.2 b/s/Hz	**TBD**
Modulation	Binary Manchester	MLT3	PAM-5	DSQ-128	**TBD**
BER	$<10^{-10}$	$<10^{-10}$	$<10^{-10}$	$<10^{-12}$	**$<10^{-12}$**
Pairs	2	2	4	4	**4**
Reach	100m	100m	100m	100m	**100m**
Class		Class D	Class D	Class EA	**Class FA (?)**

Are cable vendors ready for it?

- Multiple cable vendors with CAT7-A / Class FA solutions and cables tested beyond 1000MHz
- Advanced shielding systems to avoid interference ➔ Do not require AXT testing
- Advanced components ➔ Connectors TERA/GG45
- Some suggest to start with short distances (i.e. 40m.) and then upgrade to 100m.

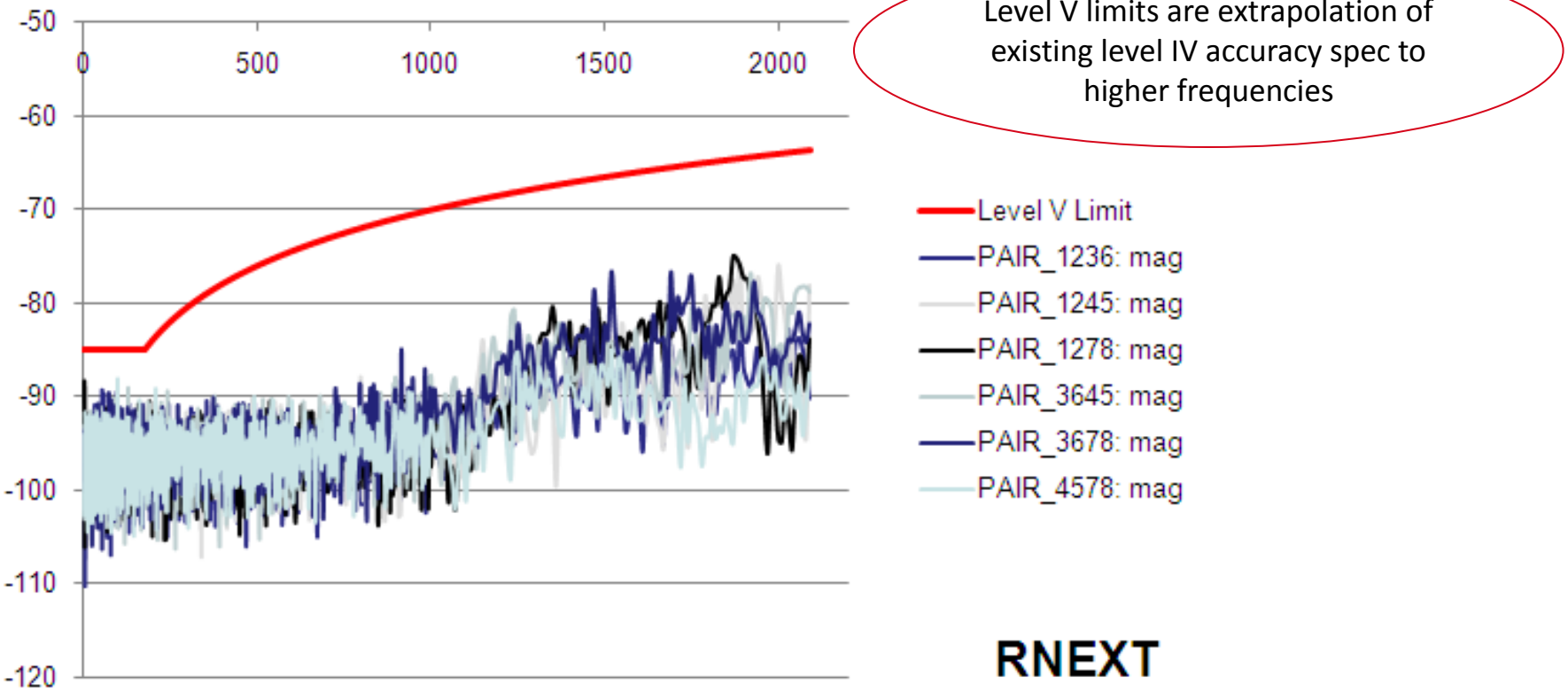


Field Tester Accuracy

- Defined in ISO/IEC 61935-1/Ed. 2 Level IV and TIA 1152 Accuracy
- Defines baseline, link and channel accuracy of a field tester in comparison with a network analyzer for various parameters
  - Residual Near End Crosstalk (RNEXT)
  - Directivity (a measure for dynamic range of return loss)
  - Common mode rejection (This is a differential measurement)
  - Output Signal Balance (a significant metric for alien x-talk)
- Ensures field testers are precise with minimal internal noise
- Level IV defines a measurement frequency to 600Mhz
- A new level of accuracy, with a higher frequency must be defined to support Class FA/Cat 7A channels and links that will be used for 40GBASE-T

New Generation Certifier
Baseline RNEXT vs Level IV limit

- RNEXT is the amount of near-end cross-talk experienced by test instruments when no cable is connected
- It says how good the internal hardware of the tester is regarding cross-talk



40GBASE-T today
Opportunities and challenges

Standard bodies **making good progress**

- TIA
  - Capacity task group discussing technical parameters (NEXT, FEXT, etc.)
  - Application space task group to define apps to serve
  - Cable/Components task group (Cat definition, frequency, etc.)
- ISO
  - TC46/WG9 to redefine tester accuracy beyond 1GHz
  - New tester accuracy level proposal (level V)
  - SC25 considering new cable specs to 2GHz
- IEEE
  - Start discussion on new 802.3 for 40GBASE-T
  - Reseach of feasibility and potencial users

Cabling solutions to support 40GBASE-T

- Cable (CAT7A/Class FA)
- Components (TERA, GG45)

Field Tester Limitations ➡ **Not all Cable Certifiers are prepared for 40G Testing!**

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Fibre

Fibre standards in place!

How do we ensure optimal fibre network performance?

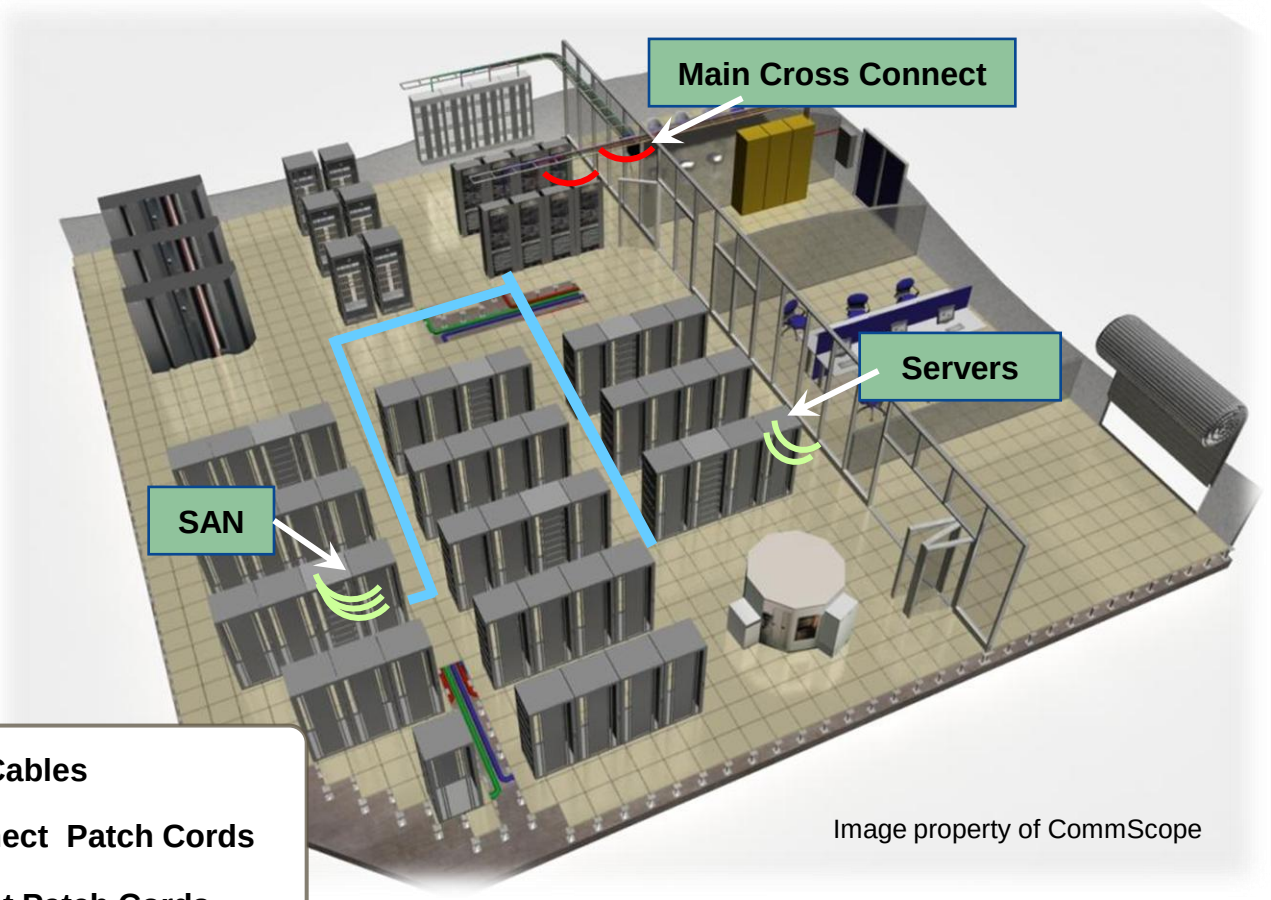
- The very first step is to certify all fibre connectors end-faces according **BS EN (IEC) 61300-3-35** criteria
  - ***JDSU is the reference in Fibre Inspection and has been educating the industry during the last 5 years!!!***

- Then we need to check fibre link parameters to ensure minimum losses and TIA 568.C standards compliance
  - *Tier 1 Fibre Certification Tests*
  - *Tier 2 Fibre Certification Tests*

Connectors Enable Network Adaptability

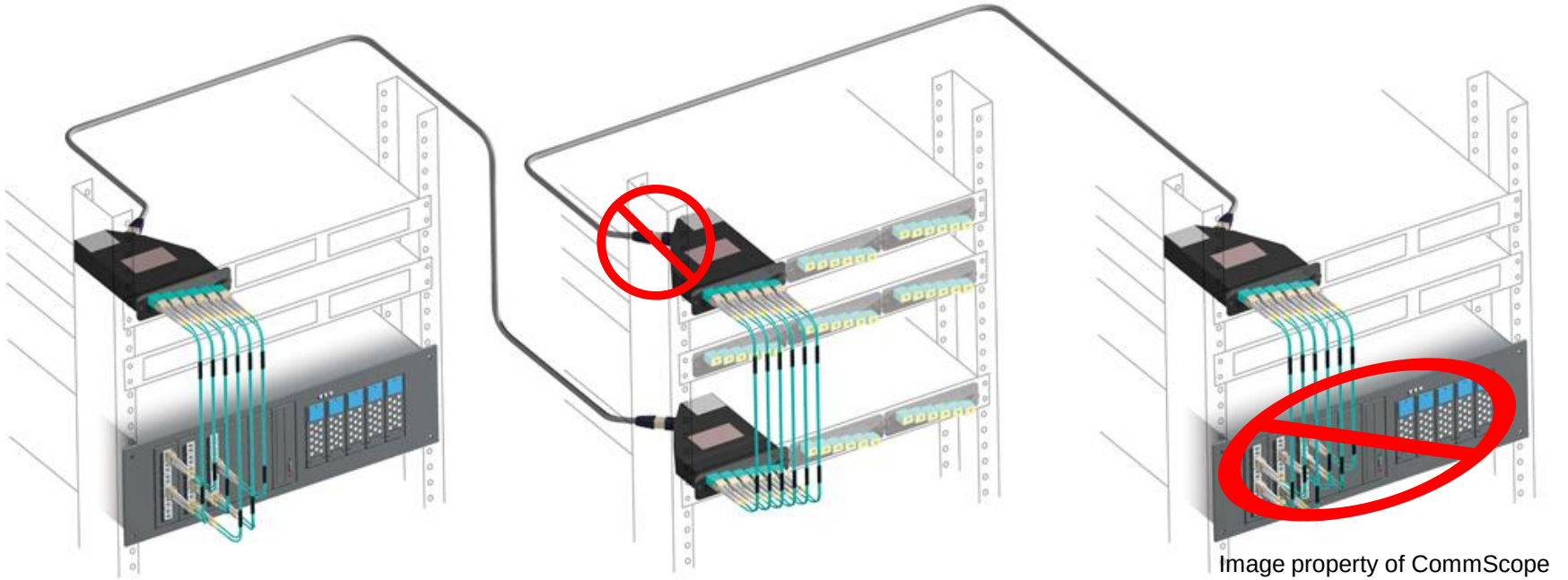
Connectors play an important role in Enterprise network architecture.

They give you the power to add, drop, move, and change the network.



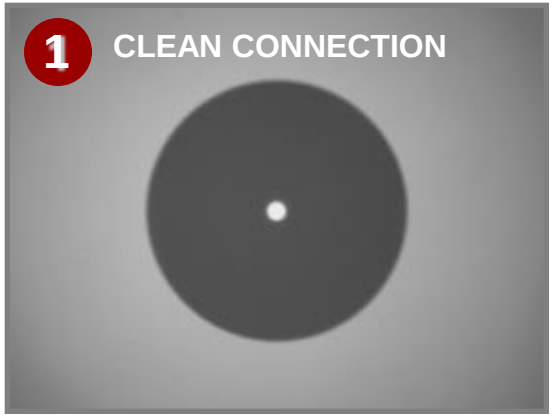
Exponential Impact

CONTAMINATION is the #1 source of troubleshooting in optical networks



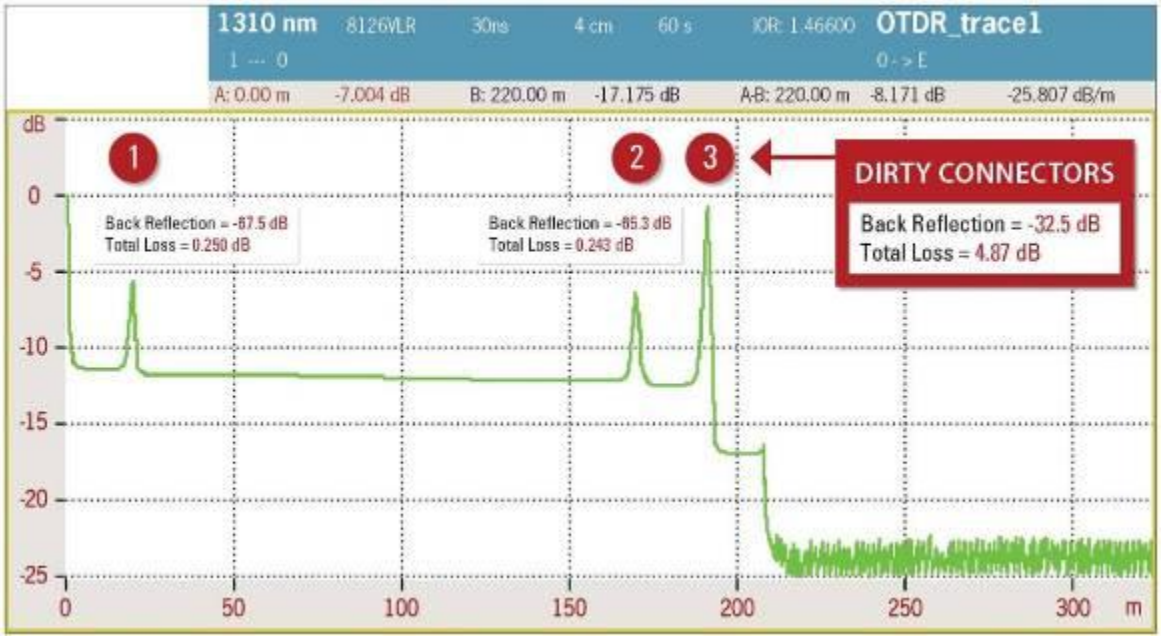
If a critical connection is affected, the impact can be exponential

Contamination and Signal Performance



Back Reflection = **-67.5 dB**
Total Loss = **0.250 dB**

Back Reflection = **-32.5 dB**
Total Loss = **4.87 dB**

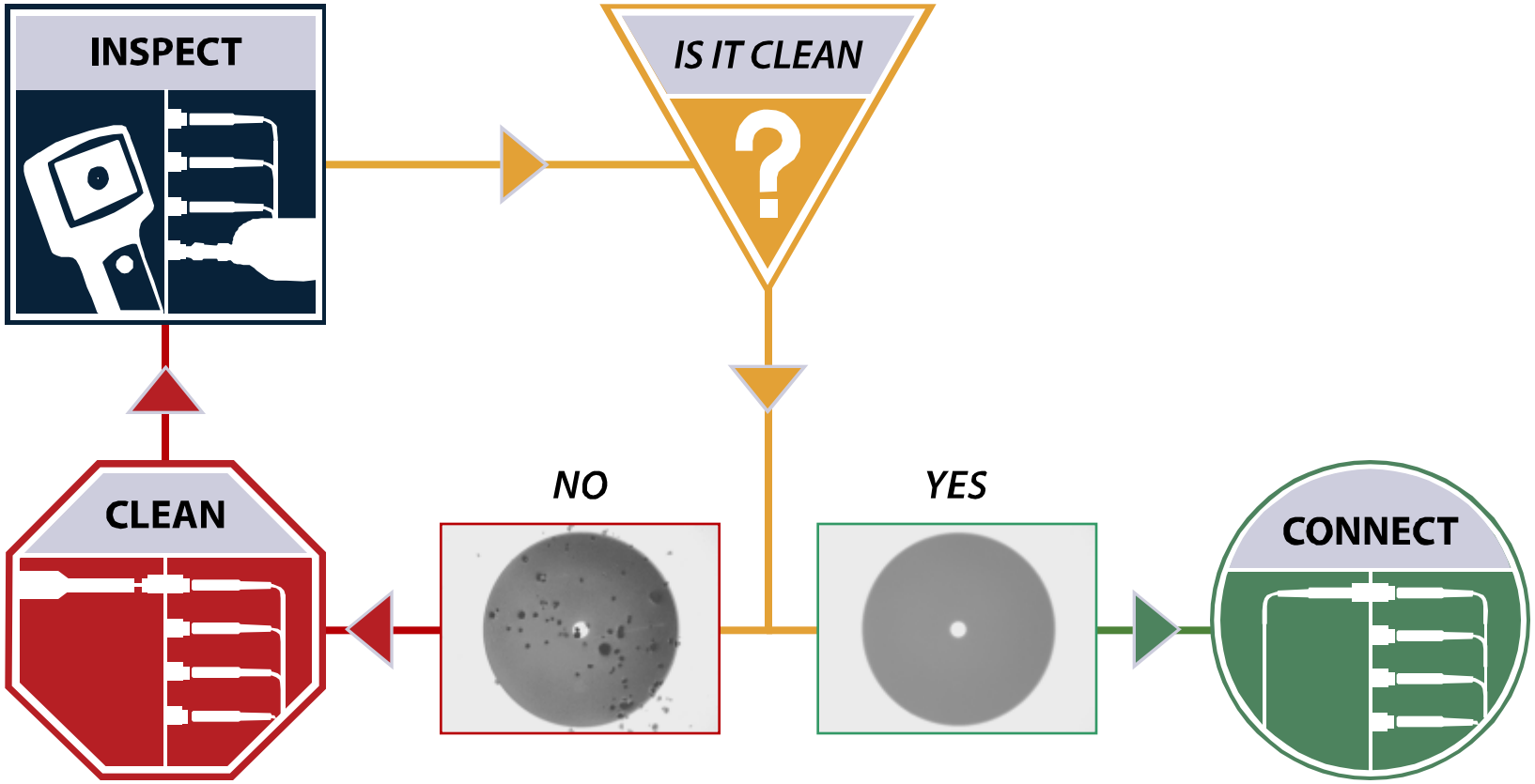


Clean Connection vs. Dirty Connection

OTDR trace illustration of the significant decrease in signal performance after mating dirty connectors

Inspect Before You Connect℠

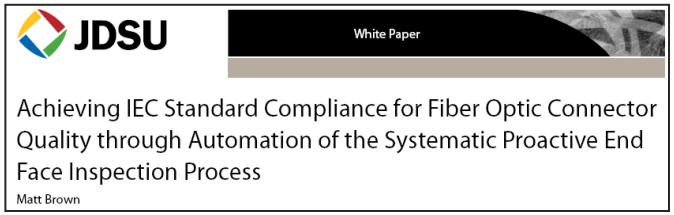
Follow the simple **“INSPECT BEFORE YOU CONNECT”** process to ensure fibre end faces are clean prior to mating connectors.



BS EN (IEC) 61300-3-35

- A set of requirements for Fibre Optic connector quality
- Designed to guarantee insertion loss and return loss performance
- Used as a common reference between supplier & customer or between work groups
- Used as a condition for accurate testing of components or links

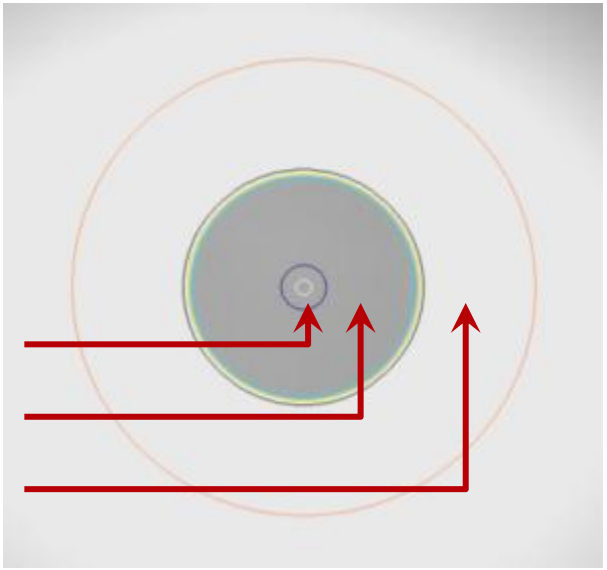
Please visit www.jdsu.com/inspect to learn more...
Paper on IEC Compliance available for download



BS EN (IEC) 61300-3-35 Acceptance Criteria

- These criteria are designed to guarantee a common level of performance
- Separate criteria for different connector types
  - SM-UPC (RL>45db)
  - SM-APC
  - SM-PC (RL>26dB)
  - MM
  - Multi-fibre

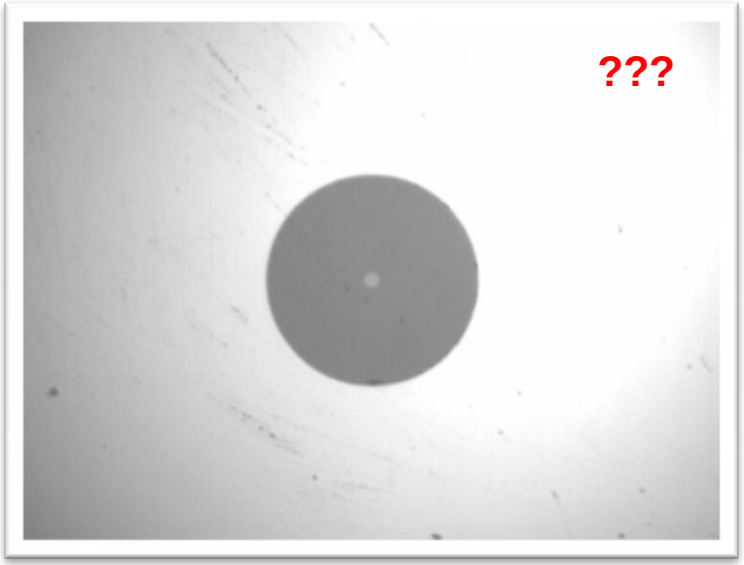
Example of Pass/Fail Criteria (SM-UPC)



ZONE NAME	SCRATCHES	DEFECTS
A. CORE (0–25µm)	None	None
B. CLADDING (25–120µm)	No limit <= 3µm None > 3µm	No limit < 2µm 5 from 2–5 µm None > 5µm
C. ADHESIVE (120–130µm)	No limit	No limit
D. CONTACT (130–250µm)	No limit	None => 10µm

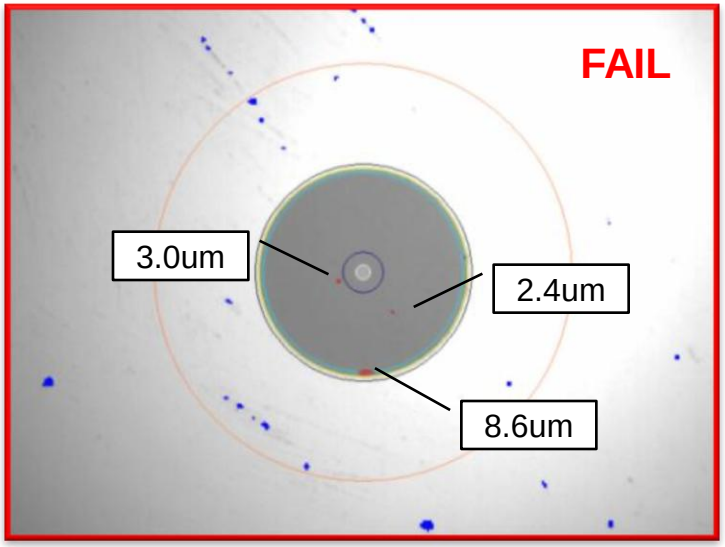
Does this connector PASS or FAIL?

SUBJECTIVE INSPECTION:



- Many Factors impact results:
  - Display settings
  - Ambient lighting
  - Operator eyesight
  - Operator judgment
- Actually testing is very difficult
- Certification is not practical

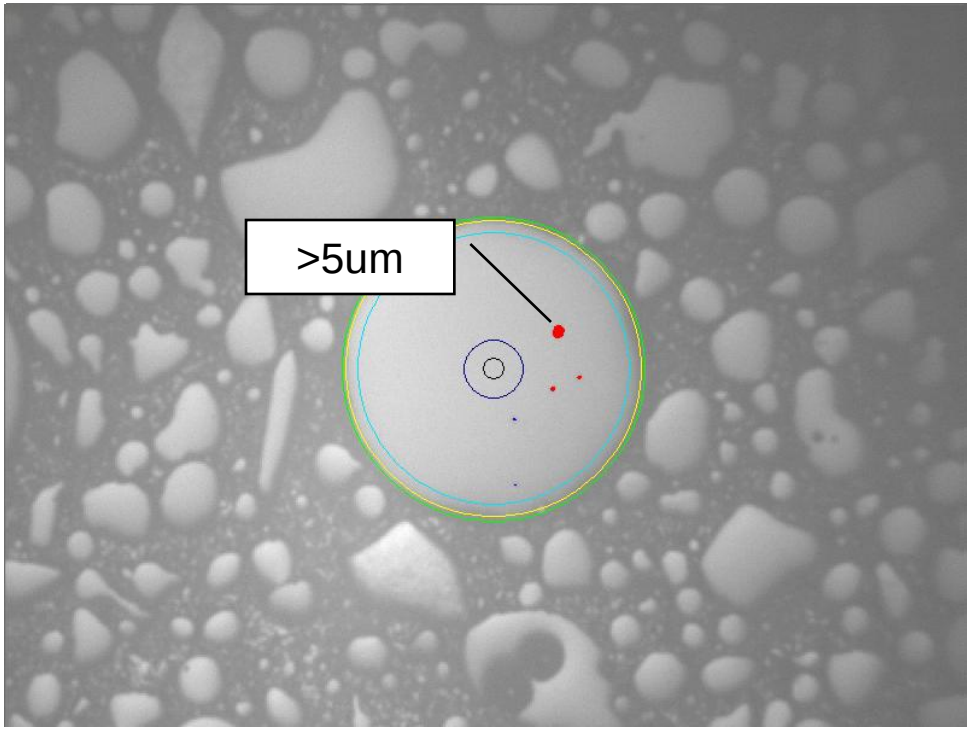
OBJECTIVE INSPECTION:



- Eliminate variation in results
- Certify and record product quality
- All skill levels can certify quality
- Make advanced criteria simple
- Improve performance & yields

Accuracy & Repeatability

- **Test:** MTP – Single mode Angled Polish (APC)
- **Question:** Does this connector pass or fail the specification?



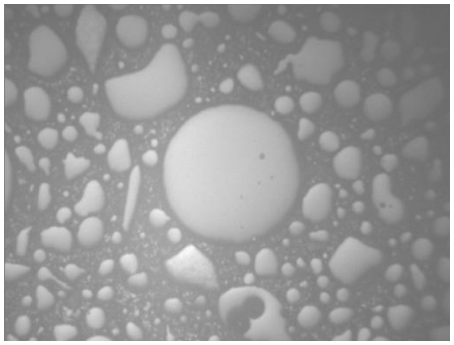
IEC 61300-3-35 – Table 4

ZONE	SCRATCHES	DEFECTS
A. CORE (0–25µm)	=> 4µm	None
B. CLADDING (25–115µm)	No limit	No limit < 2µm 5 from 2–5 µm None > 5µm

- Particles in Zone B >5µm (FAIL)

JDSU - P5000 with FiberChek2 (Test MTP APC)

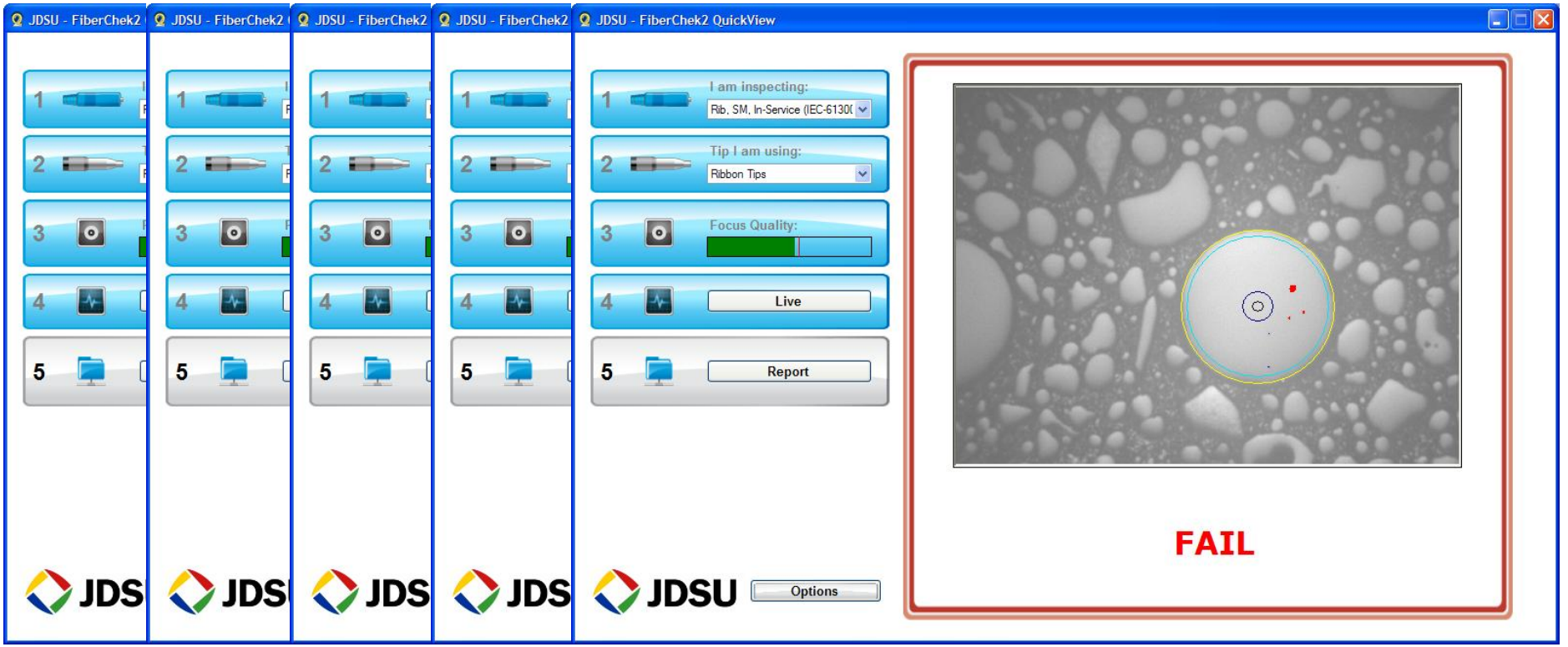
- Test 1 = FAIL
- Test 2 = FAIL
- Test 3 = FAIL
- Test 4 = FAIL
- Test 5 = FAIL



Conclusion:

☑ Repeatable

☑ Accurate

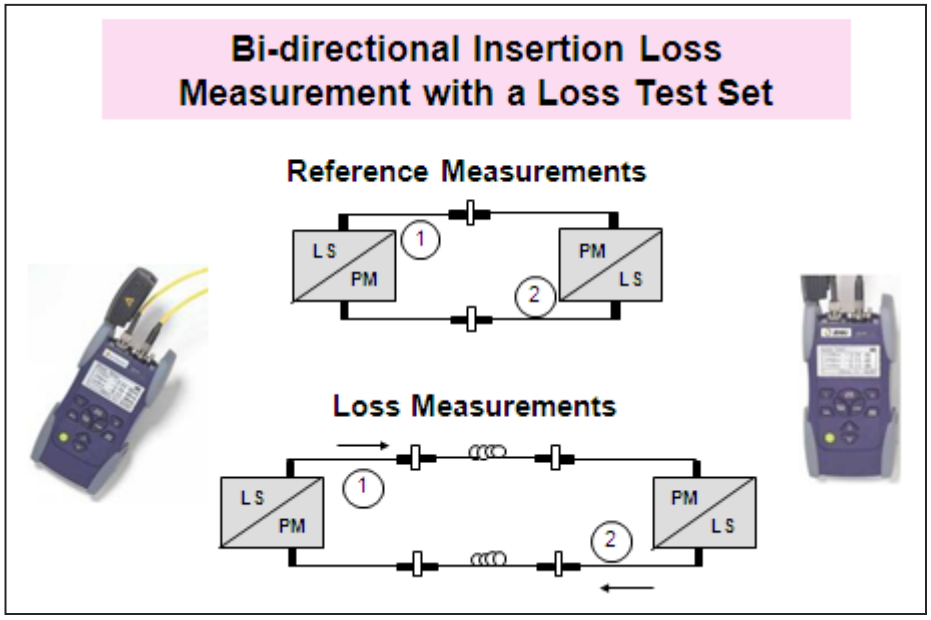


PASS/FAIL Analysis: Microscope Requirements

Requirement	JDSU
Accurate	• Identifies defects correctly and provides analysis details (*size, type, area, etc.)*
Repeatable	• Gives same result with each test performed
Comprehensive	• Supports ALL connector types in today's networks: simplex, ribbon, multiple polish types
Flexible	• Tests to ANY acceptance criteria • Dual Magnification (200X & 400X) analysis
Standardized	• Standardized by leading companies throughout industry • Used by the IEC when developing the standard
Easy to Use	• Auto Centering Image • Easy to Focus Microscope

Fibre Certification Tier 1

- **Polarity and LTS Tests**
- The cabling infrastructure should respect maximum channel attenuation to ensure a reliable signal transmission over distance. This attenuation value should consider end-to-end channel losses
- Maximum channel attenuation is specified in the ANSI/TIA-568-B.1 standard



Fibre cable length must be either calculated or measured

10 Gig Eth	Wavelength (nm)	Max. Channel Attenuation (dB) according to ANSI/TIA-568-B.1			
		62.5 µm MM	50 µm MM	850nm Laser-optimized 50µm MM	9µm SM
10GBASE-SX	850	2.5	2.3	2.6	--
10GBASE-LX4	1300	2.5	2.0	2.0	6.6

40GBASE-SR4 or 100GBASE-SR10 Link Power Budgets

Parameter	OM3	OM4	Unit
Effective modal bandwidth at 850 nm	2000	4700	MHz•km
Power budget	8.2		dB
Operating Distance	0.5 to 100	0.5 to 150	m
Channel insertion loss	1.9	1.5	dB
Allocation for penalties	6.3	6.4	dB
Unallocated margin	0	0.3	dB
Additional insertion loss allowed	0		dB

Table property of Corning

Fibre Certification Tier 2

- **Adds Fibre Plant Characterization with OTDR tests**
- An OTDR is the most powerful tool for certifying and troubleshooting fibre Optic networks
  - It provides the whole picture of the fibre link
  - Detects, locates and measures events at any location of the fibre link
- Some requirements are needed
  - SM/MM capabilities (850/1300/1310/1550nm)
  - Minimum ADZ/EDZ (Attenuation/Event Dead Zone) ➔ Short fibre patchcords
  - EF Compliance (IEC 61280-4-1) and end-face inspection (BS EN (IEC) 61300-3-35)

Parallel Optics: Challenges

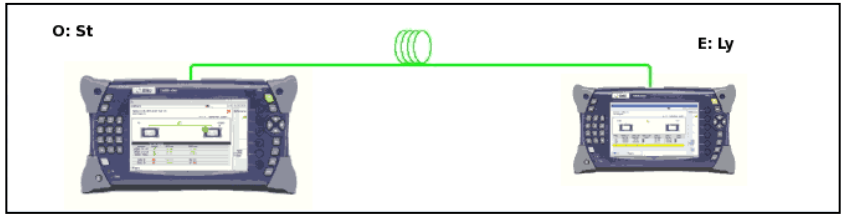
- MTP® connectors used for 40/100BASE-R
  - 12 fibres (40G - 4 lanes, 8 active fibres)
  - 24 fibres (100G - 10 lanes, 20 active fibres)
- At least 3 referencing methods available
  - One Jumper Method
  - Two Jumper method
  - “Golden” Jumper Method
- MM launch conditions (EF) and use of mandrels must be considered
- Link Loss: Need to test each of the fibres ➔ Multiple referencing

The trend: Fibre Tests Automation

- Fibre Tests Automation reduces operational expenses (OPEX) and minimizes training time with a simple, automated measurement process:
  - Minimize the number of connections
  - Guide the technician through the process
  - Generate the report on the fly
  - Allow uni-directional or bi-directional testing

- Fibre Test Automation examples:
  - Connector Inspection Pass/Fail Analysis
  - Bi-directional IL/ORL
  - Bi-directional OTDR
  - Full Fibre Characterization (IL/ORL/OTDR/Dispersion)

Automated bi-directional Insertion Loss / Return Loss and OTDR testing through a single fibre connection



IL/ORL Results

Wavelength	Pass/Fail	1310 nm	1550 nm	1625 nm
Loss B->A	✗	9.33	5.58	6.64
Loss A->B	✗	10.49	6.66	6.47
Avg Loss	✗	9.95	6.15	6.56
ORL A	✗	27.95	27.60	26.92
ORL B	✗	31.82	31.88	32.03

Conclusions

- Future applications will require Datacenters / Server Clusters to upgrade to 40G (Copper and/or Fibre)

- 40GBASE-T
  - Need standards and test procedures update
  - Availability of cable/components for New Gen Copper networks

- 40G/100G Fibre Links
  - Fibre Inspection is a must in 40/100G Fibre Networks
  - New BS EN (IEC) 61300-3-35 standard to certify connector end-faces
  - Fibre Certification: New testing opportunities and challenges

JDSU Solutions for Enterprise Networks

Copper & Fibre Cabling Certification Tools

Certifier40G
Next Generation Copper and Fiber Certification

SmartPocket family
Cost effective loss testing

T-BERD/MTS 2000
Compact Quad OTDR

T-BERD/MTS 4000
Modular upgradeable Quad OTDR

Connector End-face Inspection

P5000i probe Microscope
Handheld automated PASS/FAIL

Fiber Essentials Tool Kit
Integrated inspections, cleaning and testing

Active Network Test & Troubleshooting

ValidatorPRO family
Everyday use change management

ESAM Module for MTS-4000
Modular indepth network analysis

You know us because you depend on our technology every day.