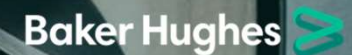




Remote Visual Inspection NDE Method: Fluorescent Penetrant Inspection (FPI)

Tom Britton
Waygate Technologies



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Today's presenter



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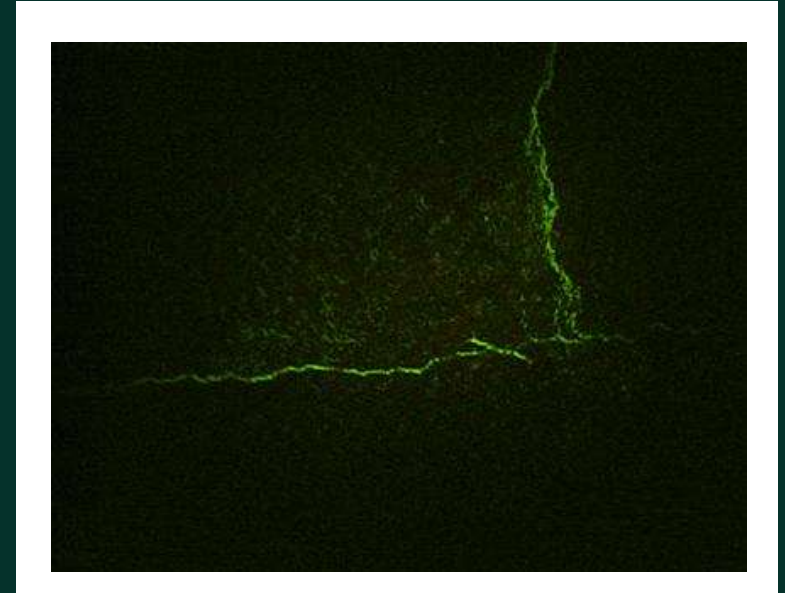
tom.britton@bakerhughes.com

Agenda

1. FPI overview
2. FPI process –WT/RVI components
3. FPI – technical specifications
4. Industry specifications
5. MViQ, XL Flex, & XL Detect UV products
6. Determining resolution using the USAF 1951 Test Target
7. Choosing the correct Optical Tip Adapter
8. Stereo Measurement under UV light
9. Application examples

What is FPI ?

- Fluorescent penetrant inspection (FPI) is a type of Non-Destructive Testing (NDT) method used to detect linear indications, surface cracks, or other defects in parts.
- A fluorescent dye is applied to the surface of a non-porous material in order to detect those defects
- The FPI dye becomes stuck in an indication after the part is processed in accordance with ASTM E1417 or other part preparation standards
- The dye which becomes stuck in the part becomes observable to the naked eye or a camera system under UV-A (365 nm) black light illumination
- FPI is noted as a low cost and simple process and is used widely in a variety of industries.



Video borescope FPI image

STEPS IN PERFORMING AN FPI

1. Initial cleaning of part
2. Penetrant application
3. Excess penetrant removal
4. Developer application
- 5. Inspection***
6. Final cleaning



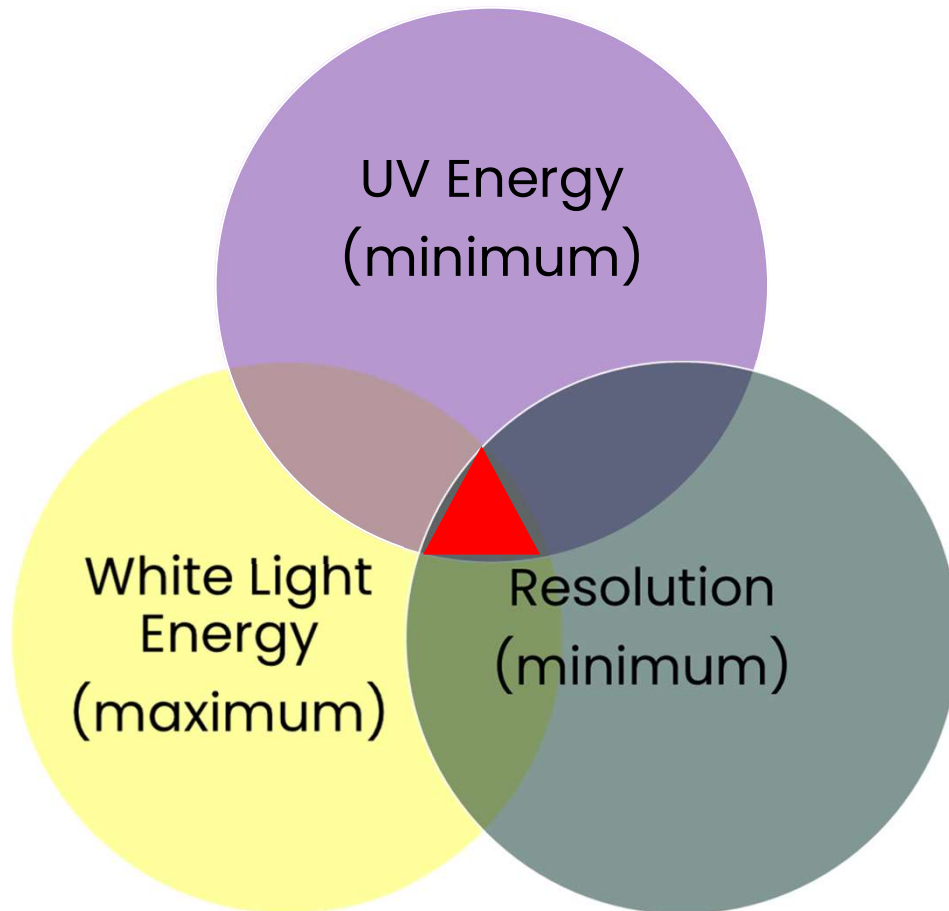
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Equipment to prepare & deliver FPI

Performance Requirements for an FPI Inspection



Depending on applicable industry standards – all metrics must be overlapping ▲

1. A minimum amount of **UV** Energy must be delivered to the surface being inspected ($\mu\text{W}/\text{cm}^2$)
2. The White Light (**WL**) “pollution” must not exceed a maximum WL energy level (lx or fc)
3. The optical system **Resolution** must be able to resolve a minimum level of detail (lp/mm)

Industry & OEM Standards

ASTM E1417 / E1417M - 16

- Standard Practice for Liquid Penetrant Testing
- UV irradiance at inspection distance 1000uW/cm²
- Max White light pollution at inspection distance 21.5 lux (2 fc)

EN ISO 3059

Non-destructive testing
- Penetrant testing -
Viewing conditions

- UV irradiance at inspection distance 1000uW/cm²
- Max White light pollution at inspection distance 20 lux

ISO 3452-1:2013

Non-destructive testing
— Penetrant testing

GE Aviation Standards

SPM 70-32-02

- UV Energy
- White Light Pollution
- Optical resolution
- Measurement Accuracy

P3TF44

Optical resolution
Measurement accuracy

P3TF47

UV Energy
White Light Pollution
Optical resolution

ASTM E3022-18

Procedures for testing the performance of ultraviolet A (UV-A), light emitting diode (LED) lamps used in FPI & magnetic particle testing

1.3 ***This practice is not applicable*** tolamps or light guides (for example, borescope light sources).

Rolls Royce Specification RRES 90061

Requirements for the control of Ultra-Violet sources utilising Light Emitting Diodes (LED's) for Non Destructive Testing

Waygate Technologies VideoProbes™ can be configured to meet most international & OEM FPI standards when configured properly.

It is the responsibility of the Client's FPI Level 3 to test all equipment to ensure it meets the specifications for their applications. The Waygate Technology engineering team has put this data together to make it easier for your customer to evaluate our equipment quickly.

The above standards documents are not available from Waygate Technologies.

Custom UV VideoProbes



- Includes UV filter in camera head
- Utilizes quartz light-guide fibers
- Requires an external UV light source



Without
UV Camera Filter

With
UV Camera Filter

MViQ – UV VideoProbe FPI / UV Configuration



QuickChange™ UV VideoProbe™

UV / White light switchable
Stereo measurement capable



MViQ Image Menu

Imaging Mode
UV / White Light



MViQ UV QuickChange™ Probes

The following quartz fiber QuickChange probes have

Model number	Diameter	Length	Illumination fibers	Optical tips
MVIQAP3920-9167	3.9 mm (0.15")	2.0 m (6.6 ft.)	Quartz	Standard
MVIQAP3930-9168	3.9 mm (0.15")	3.0 m (9.8 ft.)	Quartz	Standard
MVIQAP4020-8947	4.0 mm (0.15")	2.0 m (6.6 ft.)	Quartz	Standard
MVIQAP4030-8890	4.0 mm (0.15")	3.0 m (9.8 ft.)	Quartz	Standard
MVIQAP4035-9021	4.0 mm (0.15")	3.5 m (11.5 ft.)	Quartz	Standard
MVIQAP6120-8948	6.1 mm (0.24")	2.0 m (6.6 ft.)	Quartz	Custom
MVIQHP6120-9255 (New HD)	6.1 mm (0.24")	2.0 m (6.6 ft.)	Quartz	Custom
MVIQAP6130-8889	6.1 mm (0.24")	3.0 m (9.8 ft.)	Quartz	Custom
MVIQAP6160-9101	6.1 mm (0.24")	6.0 m (19.7 ft.)	Quartz	Custom
MVIQAP61100-8960	6.1 mm (0.24")	10.0 m (32.8 ft.)	Quartz	Custom
MVIQAP8420-8949	8.4 mm (0.33")	2.0 m (6.6 ft.)	Quartz	Standard
MVIQAP8430-8937	8.4 mm (0.33")	3.0 m (9.8 ft.)	Quartz	Standard
MVIQAP8445-8956	8.4 mm (0.33")	4.5 m (14.8 ft.)	Quartz	Standard
MVIQAP84100-8982	8.4 mm (0.33")	10.0 m (32.8 ft.)	Quartz	Standard

*Subject to change, custom parts continue to be released as needed

XL Flex & XL Detect – UV VideoProbes™

Product	Diameter	Length	Part Number
XL Flex	4.0 mm	3.0 m	XLFLA4030UV-9269
XL Flex	6.1 mm	2.0 m	XLFLA6120UV-9234
XL Flex	6.1 mm	3.0 m	XLFLA6130UV-9268
XL Flex	8.4mm	2.0 m	XLFLA8420UV-9254
XL Flex +	4.0 mm	3.0 m	XLFPA4020UV-9325
XL Flex +	6.1 mm	2.0 m	XLFPA6120UV-9235
XL Flex +	6.1 mm	8.0 m	XLFPA6180UV-9348
XL Flex +	8.4mm	2.0 m	XLFPA8420UV-9253
XL Detect	6.1 mm	4.5 m	XLDEA6145UV-9282
XL Detect	8.4mm	3.0 m	XLDEA8430UV-9327
XL Detect +	4.0 mm	2.0 m	XLDPA4020UV-9326
XL Detect +	6.1 mm	2.0 m	XLDPA6120UV-9338
XL Detect +	6.1 mm	3.0 m	XLDPA6130UV-9339
XL Detect +	6.1 mm	6.0 m	XLDPA6160UV-9334
XL Detect +	6.1 mm	8.0 m	XLDPA6180UV-9347
XL Detect +	8.4mm	3.0 m	XLDPA8430UV-9364



UV Optical Tip Adapters (OTAs)

- All 4.0mm OTAs transmit UV light
- Black 4.0 mm forward-view tip (T40115FN) has limited UV light output
- Some standard **6.1mm** MViQ OTAs do not efficiently transmit UV light, and require customized OTAs to optimize UV light transmission.
- All 8.4mm standard OTAs work with the UV probe

6.1mm UV-Optimized Tips

Optical tips	Color	FOV (deg)	DOF mm	(in)
Forward view				
XLG3T61UV-8528	White	50	12-200	(.47-7.87)
XLG3T61UV-8553	Orange	80	3-20	(.12-.79)
XLG3T61UV-8581	Black	120	5-120	(.20-4.72)
XLG3T61UV-8593	Yellow	90	20-inf	(.79-inf)
Side view				
XLG3T61UV-8535	Green	50	9-160	(.35-6.30)
XLG3T61UV-8582	Blue	120	4-100	(.16-3.94)
XLG3T61UV-8554	Red	80	1-20	(.04-.79)

MViQ UV Shipping Configuration

Probe Storage Case Can Accommodate:

- UV Probe
- ELS-50LEDUV Light Source & power supply
- Optical Tip Case
- Documents in slot in case lid
- Accessory - UV Light Meter (such as Labino Apollo 1.0 - not sold by Waygate Technologies)
- Accessories - miscellaneous cutout for test targets, blades, etc.



UV Data Sheets



Mentor Visual IQ UV VideoProbe™ Fluorescent penetrant testing with UV light

The Mentor Visual IQ VideoBorescope, combined with a UV light source, integral quartz light fibers and convex UV optics and filters, presents the optimal solution for fluorescent penetrant inspections. This solution delivers maximum UV light levels, with low reflection, and the ability to access small remote areas of equipment.

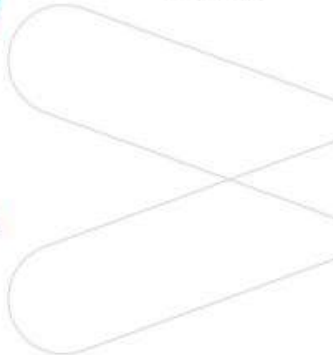
Functional principle of the fluorescent penetrant test

The surface is first cleaned, then wetted with a fluorescent penetrant. The penetrant is drawn into small surface defects by capillary action. After a rinse step, the penetrant remains only in the defect, which can be seen and measured with Reso™ measurement using the UV light.

Scope of application

The compact size of the integrated probe and UV light makes new applications possible. Difficult to access components such as turbine blades or weld seams can be examined in situ. In automotive manufacturing, some manufacturers add UV fluorescent substance to auto body coating to inspect and verify the coating process. The Mentor Visual IQ system with UV is available from 3.9 mm to 8.4 mm diameter probes, so inspections are possible in equipment with access of only 4.0mm.

*Mentor Visual IQ UV probe has been tested using Ushio Apollo 10 to meet UV and visible light outputs as specified in ASTM E347/E347M - 08



UV light source

In order for UV versions of the Mentor Visual IQ system to meet ASTM Specification E1417 (E1417M - 16), it is recommended that the UV light source used to supply UV light energy to the Mentor Visual IQ system be Waygate Technologies FN ELS-50LEDUV. FN is a 9Watt-light/UV-light selectable light source that when used with the Mentor Visual IQ UV probe allows conformance with ASTM E1417/E1417M - 16 UV and visible light specifications. See product specification data sheet for the ELS-50LEDUV for full technical specifications.



Quartz Fiber QuickChange™ probe with quartz light guide and 100 UV/White Light Source FN. FN is a 9Watt-light/UV-light selectable light source connector.



Mentor Visual IQ UV QuickChange probe and UV light source standard case and accessories.

Mentor Visual IQ UV QuickChange™ Probes

Model number	Diameter	Length	Illumination Fibers	Optical tips
MVQAP3920-9957	3.9 mm (0.15")	2.0 m (6.6 ft.)	Quartz	Standard
MVQAP3930-9958	3.9 mm (0.15")	3.0 m (9.8 ft.)	Quartz	Standard
MVQAP4020-9967	4.0 mm (0.15")	2.0 m (6.6 ft.)	Quartz	Standard
MVQAP4030-9966	4.0 mm (0.15")	3.0 m (9.8 ft.)	Quartz	Standard
MVQAP4035-9021	4.0 mm (0.15")	3.5 m (11.5 ft.)	Quartz	Standard
MVQAP620-9946	6.3 mm (0.24")	2.0 m (6.6 ft.)	Quartz	Custom
MVQAP620-9256 (New ID)	6.3 mm (0.24")	2.0 m (6.6 ft.)	Quartz	Custom
MVQAP620-8889	6.3 mm (0.24")	3.0 m (9.8 ft.)	Quartz	Custom
MVQAP620-9901	6.3 mm (0.24")	6.0 m (19.7 ft.)	Quartz	Custom
MVQAP620-8960	6.3 mm (0.24")	10.0 m (32.8 ft.)	Quartz	Custom
MVQAP620-9949	8.4 mm (0.33")	2.0 m (6.6 ft.)	Quartz	Standard
MVQAP620-9937	8.4 mm (0.33")	3.0 m (9.8 ft.)	Quartz	Standard
MVQAP620-8966	8.4 mm (0.33")	4.5 m (14.6 ft.)	Quartz	Standard
MVQAP620-9962	8.4 mm (0.33")	10.0 m (32.8 ft.)	Quartz	Standard

6.3mm UV-Optimized Tips

Optical type	Color	FOV (deg)	DOF mm (in)
Forward view			
XLO376UV-8528	White	50	12-200 (.47-7.87)
XLO376UV-8553	Orange	60	3-20 (.10-.79)
XLO376UV-8561	Black	120	5-120 (.20-4.72)
XLO376UV-8593	Yellow	90	20-inf (.79-inf)
Side view			
XLO376UV-8505	Green	50	9-160 (.35-6.30)
XLO376UV-8563	Blue	120	4-100 (.16-3.94)
XLO376UV-8564	Red	60	1-20 (.04-.79)

The 6.3 mm diameter Mentor Visual IQ uses custom optical tips with superior UV transmitting material to optimize UV output performance.



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USHIO Applying Light to Life

ELS-50LEDUV

Made in USA

MIDORI ULB-35

UV Fiber-Optic LED Light Source

For decades, Ushio America, Inc. has consistently provided high-quality illumination products in specialty markets worldwide. Responding to needs of customers with discerning applications, Ushio engineers have developed exceptional LED fiber-optic illuminators in compact sizes.

The Midori™ fiber-optic LED light source series combines state-of-the-art, solid-state illumination technology with Ushio's distinctive optical design to create a compact and lightweight fiber-optic lightbox with very high output efficacy that is ideal for industrial applications where space is a premium. This mercury-free, long-life ULB-35 LED light source has instant-on and extended electronic intensity dimming capabilities. The ULB-35 series light sources conveniently accept a 12VDC input voltage for portable battery operation.

The ULB-35v is a single UV output unit that is equipped with an ACMI fiber receptacle, as well as separate Storz and Olympus screw-in adapters are available to accommodate most common fiber cable types. The ULB-35vnd is a dual channel unit with both UV and VIS output capability to meet the most demanding applications by rotating the Olympus style adapter to the preferred output. Both light sources are equipped with an integrated filter to significantly reduce visible light in UV operation mode to meet the most demanding FPI applications.

Consider Ushio America's eco-friendly Midori ULB-35 fiber-optic LED light source for your next specialty lighting project. The lightbox can also be configured to OEM custom specifications for private labeling. For more information, please contact our customer service group at 800.838.7446 or customerservice@ushio.com.

FEATURES & BENEFITS

- Ultra Compact - Small Footprint Takes Very Little Space
- Energy Efficient - Increased Light Intensity Coupled Into Small Fibers at Lower Wavelength Operation
- Electronic Dimming - High Dynamic Range for Intensity Control
- Lightweight - Less Than 1lb (0.45kg) for Exceptional Portability
- External Power Supply - Utility for Both AC and DC Operation
- Long Life - Less Maintenance and No Lamp Replacement Costs
- Low Noise - Both Electrical EMI and Audible Sound
- UV Output/Low VIS - Enhanced FPI Contrast Images

APPLICATIONS

- Industrial NDT Inspection
- Flexible Videoscopes
- Remote Visual Inspection
- Industrial Fiber Optics
- Borescopy
- UV Fluorescent Penetrant Inspection
- Fiberscopes

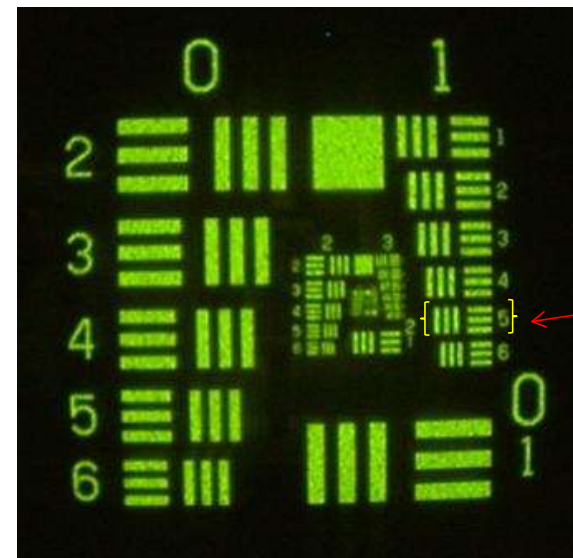
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Resolution Specifications: USAF-1951 Target

Resolution specifications are typically defined as having a requirement to resolve a certain Group & Element in the USAF-1951* resolution target

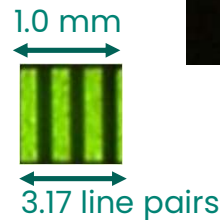
Element	Group Number					
	0	1	2	3	4	5
1	1.00	2.00	4.00	8.00	16.0	32.0
2	1.12	2.24	4.49	8.98	18.0	35.9
3	1.26	2.52	5.04	10.1	20.2	40.3
4	1.41	2.83	5.66	11.3	22.6	45.3
5	1.59	3.17	6.35	12.7	25.4	50.8
6	1.78	3.56	7.13	14.3	28.5	57.0



Group 1, Element 5

USAF 1951 Test target:

- Resolution expressed as line pairs/mm
- Example: Group 1, element 5 has 3.17 line pairs/mm



Fluorescent USAF 1951 Test Target

*As defined in U.S. Air Force MIL-STD-150A standard of 1951

UV Test Target Performance Commercial Test Coupons

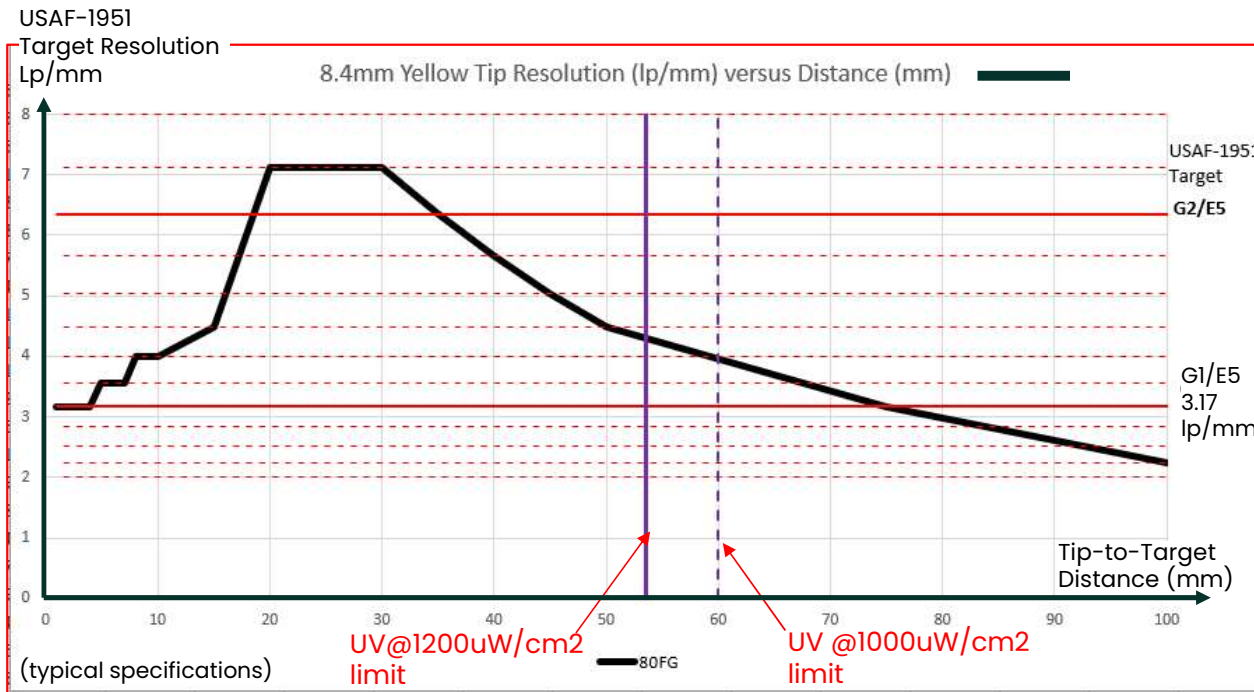


Cracks of 10 μm (0.0004 in) can be resolved



1.5mm / 0.059"
1.1mm / 0.043"
0.7mm / 0.027"

Choose the Correct Probe Diameter, Length & Optical Tip Adapters (OTAs) for the Application

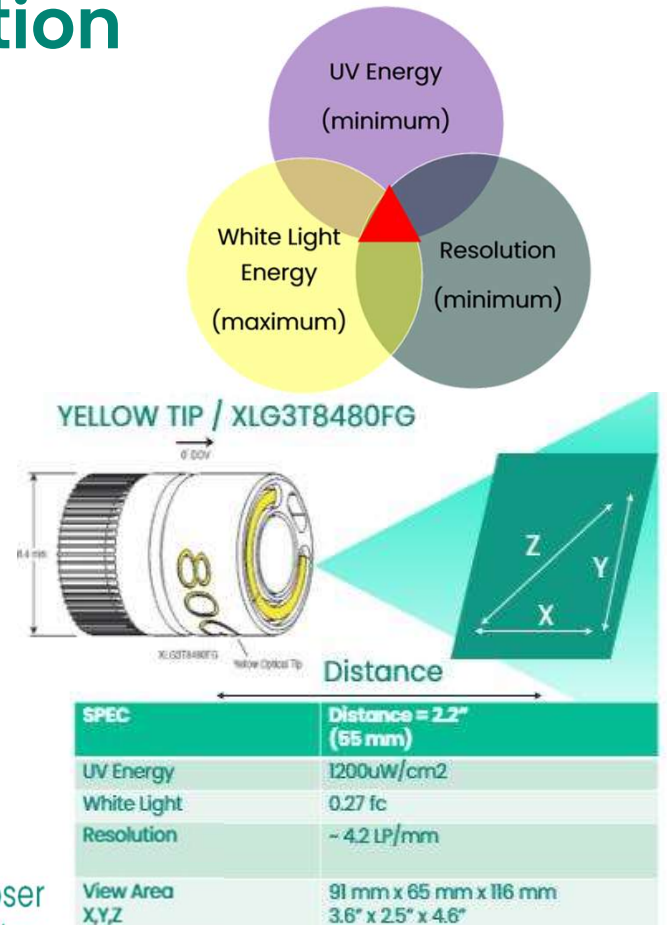


UV Inspection Requirements

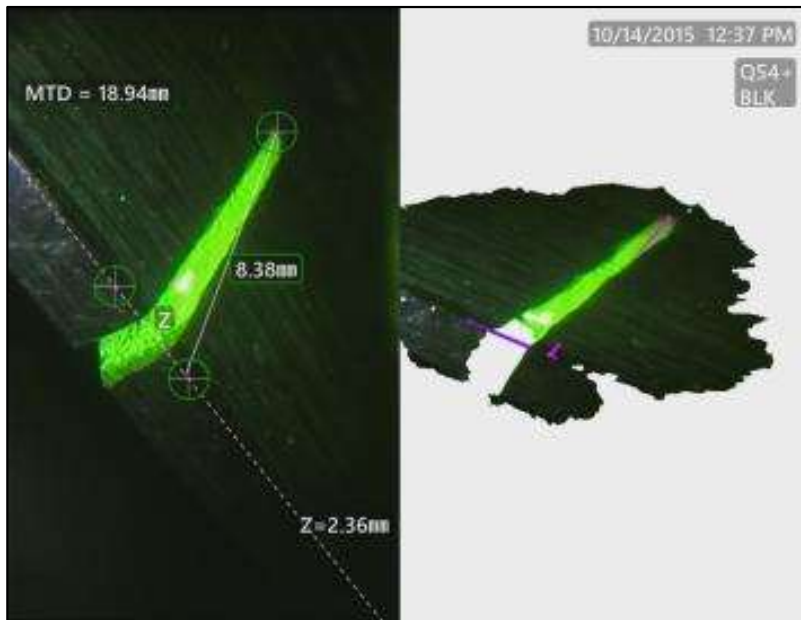
- 1200 uW/cm² UV
- <2 fc illuminance
- Minimum G1/E5 resolution
- Maximize viewing area

Yellow Tip Performance Ranges

- UV energy > 1200 uW/cm² = 55 mm or closer
- White Light energy < 2 fc = 10mm or further
- Resolution USAF 1951 G1/E5 or greater = 5mm to 75mm



Stereo Measurement

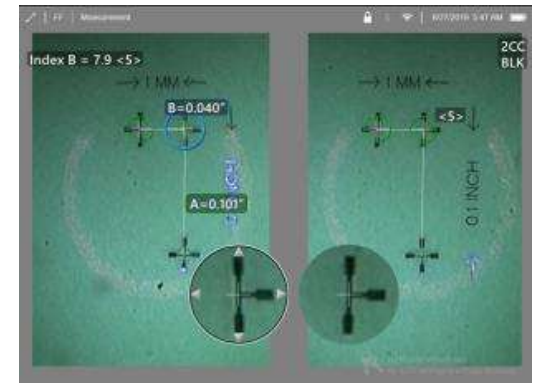


3D & Traditional Stereo Measurement Best Practices and Important Tips:

- Traditional Stereo may provide better results than 3DST
- Only linear measurements are supported (no depth)
- Fluorescing green is in the middle of the visible light spectrum - accuracy is equivalent to white-light measurement.
- UV measurements are not available with 3DPM measurement techniques
- A calibrated UV Measurement Verification Block is supplied with measurement systems



Measurement Verification Block With UV Target



8.4mm Measurement Verification Block Optical Target

Application: Crack in vessel wall



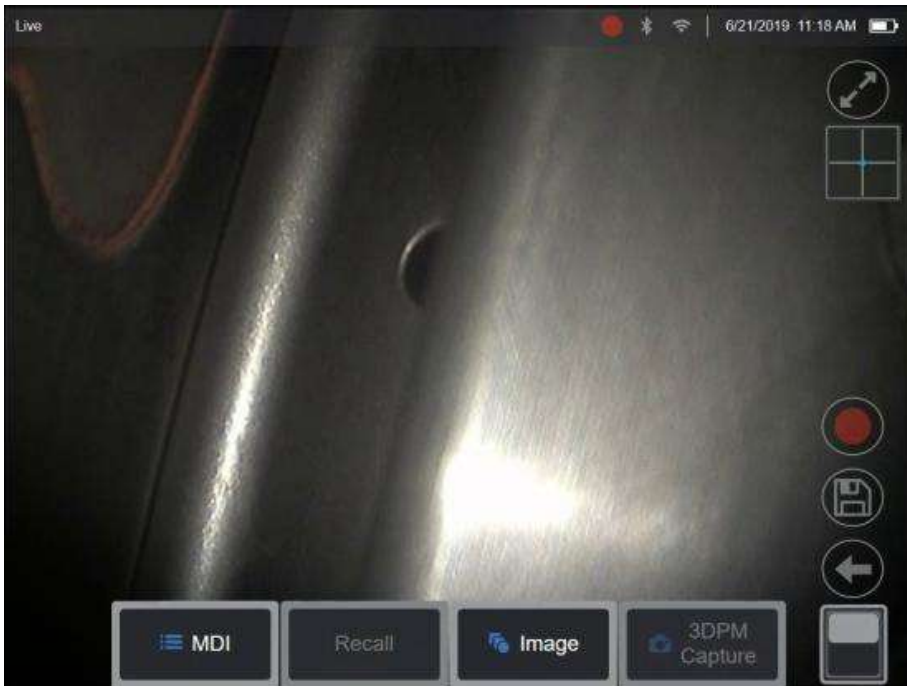
White Light



UV Light

Application - CFM56 Engine Oil Seal *

Jet oil fluoresces with a blue hue



White Light



UV Light

* Sometimes associated with "dirty socks" cabin smell issue

Application Automotive Anti-Corrosion Coatings



Anti-Corrosion Wax application
Q/C in Car Bodies



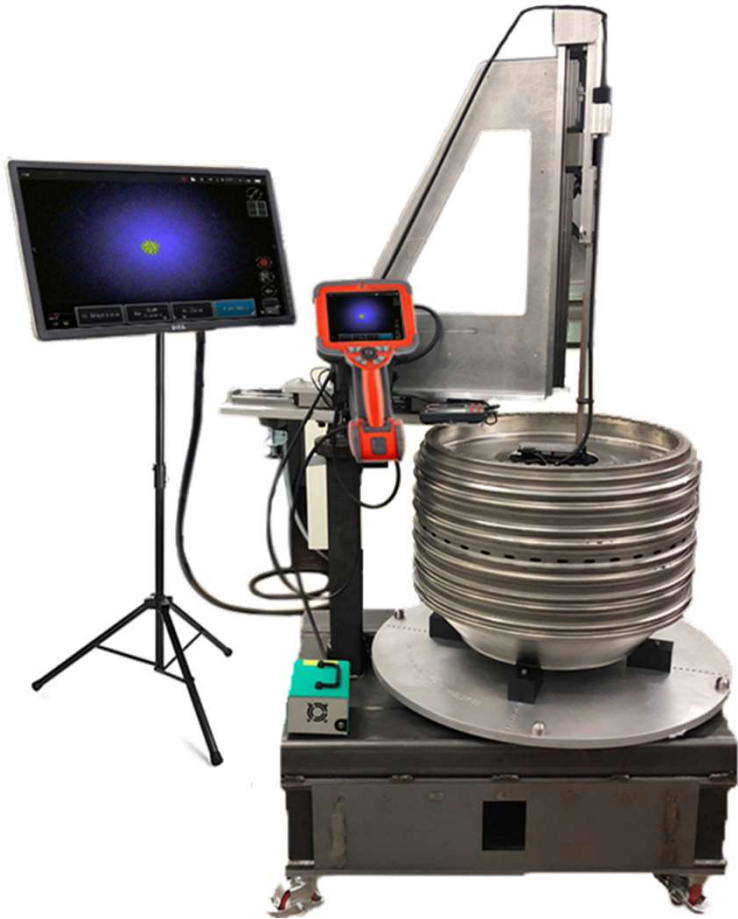
Good Coverage



Incomplete Coverage

Application: Deep Well Spool Inspection

- When used with the Waygate Technologies MViQ 8.4mm UV probe kit & appropriate optical tips, this tool is approved by GE Aviation to meet SPM 70-32-02, P3TF47, & P3TF44 Specifications.
- Solution compliant with ASTM E1417/E1417M – 13



Canyon Run Engineering Technologies Deep Well Spool Inspection System

Accepted by GE Aviation Models P3TF44, P3TF47 and SPM 70-32-02 requirements

Deep well spool inspection solution with Waygate Technologies' Mentor Visual IQ UV VideoProbe™ kit

Kit contents
 Deep well inspection system
 Canyon Run Engineering Technologies (CRET) has developed an inspection system which accepts the Mentor Visual IQ (MViQ) 8.4mm UV VideoProbe to provide an inspection of aviation turbine spool assemblies. The system can be configured for specific spool dimensions.

Mentor Visual IQ UV VideoProbe
 Waygate Technologies DB 8.4mm Mentor Visual IQ UV/white light video for scope kit. The MViQ VideoProbe supports stereo measurement techniques allowing linear defect measurements under UV illumination using a fully surfaced XYZ point cloud.

Kit applicability and approvals
 The combined system of the Waygate Technologies DB 8.4mm Mentor Visual IQ UV VideoProbe and the CRET Deep Well Spool Inspection turn table assembly have been tested and accepted by GE Aviation to meet the requirements of GE Aviation SPM 70-32-02, P3TF44 and P3TF47 specifications.

Canyon Run Engineering Technologies deep well inspection tool

MViQ VideoProbe™ Stereo UV measurement

8.4mm VideoProbe and UV/white light source

Canyon Run turntable assembly technical description

Feature	Manufacturer/Option
System	30.2" x 37" x 51"
Maximum DB size	400 lbs.
Max turntable velocity	33.20" inches/minute both clockwise/counter clockwise
Turntable diameter	36" (36" standard for complete point inspection)
Turntable rotation path	Angular speed fluctuations within limits to allow in-rotation location
Turntable measurement type	XYZ
Z axis clearance dimension range	18.20" additional loading and system configurations available for deeper spool inspection
Z axis measurement type	Decoded digital readout display
T table maximum traverse range	6.00" Additional loading and system configurations are also available
T table measurement type	Decoded digital readout display
Manual	Back in handle and loading center wheel for manual movement
Integration	IO-Link cables
Machine assisted transportation	Mounted 2PC, 4K, 5860 x 280-rotation (3-AX) size (30")
Turntable/accessories	Loading post of steel plate arms for vertical post loading
Accessories	Custom end of arm tooling, spotlights, speakers, interchangeable loading and location for varying part sizes
Storage	Linear tooling storage on most configurations
Notes	*Note all features are customizable upon request

Mentor Visual IQ 8.4mm Optical Tip Adapters (OTA) white light and UV performance (typical)

Optim.	Part Number	Transmission (%)	FOV	White light range (in)	Resolution	Maximum	Minimum	1000nm	1500nm	2000nm	2500nm
8.4mm	R03784A001	FX, F, for DOF, IR	40°	<15in.	N/A	N/A	0 - 1.37	0 - 1.4			
8.4mm	R03784B001	FX, F, for DOF, white	40°	<15in.	0.5	2.5	0 - 2.4	0 - 2.2			
8.4mm	R03784C001	FX, F, for DOF, white	40°	<15in.	N/A	N/A	0 - 1.38	0 - 1.2			
8.4mm	R03784D001	FX, Neo-DOF, Black	100°	<15in.	0.1	2.0	0 - 1.17	0 - 1.8			
8.4mm	R03784E001	FX, for DOF, white	40°	<15in.	N/A	N/A	0 - 1.19	0 - 1.7			
8.4mm	R03784F001	St, Neo-DOF, Blue	100°	<15in.	0.1	2.0	0 - 1.17	0 - 1.8			
8.4mm	R03784G001	FX, for DOF, green	40°	<15in.	0.1	2.5	0 - 1.17	0 - 1.4			
8.4mm	R03784H001	FX, St, Neo-DOF, Black	100°/20°	<15in.	0.1	2.0	0 - 1.19	0 - 1.7			
8.4mm	R03784I001	FX, St, Neo-DOF, Blue	100°/20°	<15in.	0.1	2.5	0 - 1.19	0 - 1.7			

Ordering Information

Canyon Run Engineering Technologies
 One Westwood
 1930 W. State Rd. Bldg. 1100, OH 43123
 M 617.216.9555
 W www.canyonrun.com
 E gerry@crtech.com

Waygate Technologies
 For configuration regarding the Mentor IQ UV VideoProbe contact your local Waygate Technologies sales representative or email: more@wgt.com
 T +1 440.941.2484 (USA)
 www.waygate-tech.com

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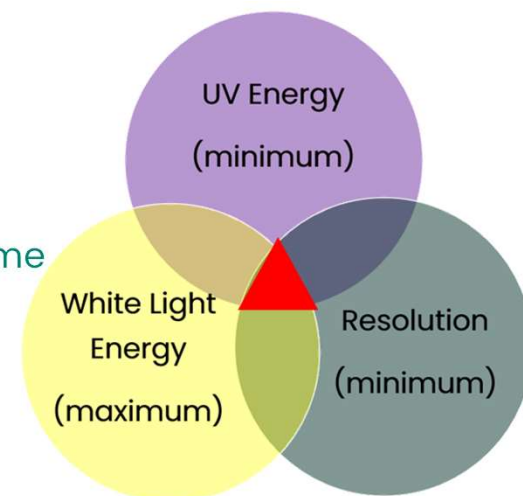
Canyon Run Engineering UV/FPI Deep Well Spool Inspection System



Application Review: Selecting the Right Probe & Tip

Customer Requirements

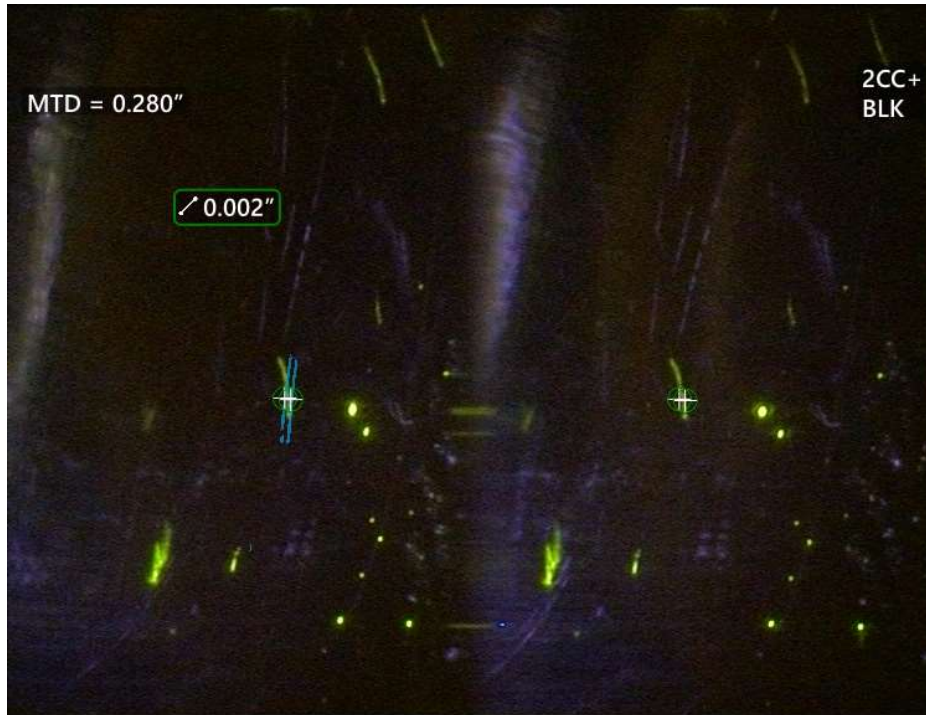
1. App: Forward view with maximum viewing area to minimize inspection time
2. App: No restriction on probe diameter – 8.4mm OK
3. UV: At least 1200uW/cm² UV energy on target
4. WL: Less than 2 fc White Light on target
5. Res: At least 3.17 lp/mm resolution (USAF-1951 G1/E5)



Mentor iQ 8.4mm Optical Tip Adapters (OTA) White Light & UV Performance (typical)

Diam.	Part Number	Characteristics FV = Forward SV = Side ST = Stereo	FOV°	White Light Range (in) <2FC	G1/E5 Res. Range (in)		UV Range (in)	
					Minimum	Maximum	1000uW	1200uW
8.4mm	XLG3T8440FF	FV, Far DOF, HG	40°	>0.5 in	N/A	N/A	0 - 3.7	0 - 3.4
8.4mm	XLG3T8480FG	FV, Far DOF, Yellow	80°	>0.5 in	0.2	2.5	0 - 2.4	0 - 2.2
8.4mm	XLG3T8440FG	FV, Far DOF, White	40°	>0.5 in	N/A	N/AX	0 - 3.6	0 - 3.2
8.4mm	XLG3T84120FN	FV, Near DOF, Black	120°	>0.5 in	0.1	2.0	0 - 1.7	0 - 1.6
8.4mm	XLG3T8440SF	SV, Far DOF, Brown	40°	>0.5 in	N/A	N/A	0 - 1.9	0 - 1.7
8.4mm	XLG3T84120SN	SV, Near DOF, Blue	120°	>0.6 in	0.1	2.0	0 - 0.7	0 - 0.6
8.4mm	XLG3T8480SG	SV, Far DOF, Green	80°	>0.5 in	0.1	2.5	0 - 1.7	0 - 1.4
8.4mm	XLG3TM846060FG	FV, ST, Near DOF, Black	60°/60°	>0.5 in	0.1	2.2	0 - 1.9	0 - 1.7
8.4mm	XLG3TM846060SG	SV, ST, Near DOF, Blue	60°/60°	>0.5 in	0.1	2.5	0 - 1.9	0 - 1.7

Typical Deep Well Spool UV Inspection Image



8.4mm Forward Black Stereo Tip
0.280" tip-to-target

Deep Well Spool Inspection

Deep Well Spool Inspection Application

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PDF

The ASNT **NDT Technician** A Quarterly Publication for the NDT Practitioner ... Focus: Fluorescent Penetrant Inspection of Drum Rotors, **Deep Well** ... ultraviolet or ultraviolet-A (UV-A) lamp to ... TNT wishes you a happy and prosperous new year.

GE Licensed MRO Shops New Requirement

In Q2 2021, GE Aviation expected to issue updated SPM 70-32-02 requiring all GE Aviation licensed MRO shops to perform UV spool inspections after engine disassembly.

"New-make" shops already have this requirement.

Deep Well Spool Inspection Tool Access

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Focus

Fluorescent Penetrant Inspection of Drum Rotors, Deep Well Spools and Other Components with Internal Cavities

by Lisa J.H. Brasche

With nearly 40,000 installed engines in the civil turbine engine fleet in 1999 and similar numbers in military use, the jet aircraft engine plays a vital role in public transportation and in our nation's defense. Magnetic particle, eddy current, ultrasonic and radiographic testing are among the methods commonly used in production and in-service inspection of engine materials and components. However, the method most widely used for engine components is fluorescent penetrant inspection (FPI). Over 90 percent of propulsion components are inspected with this method at least once in their lifetime. During the years from 1996 to 2000, the Federal Aviation Administration (FAA) issued nearly 200 airworthiness directives (ADs) for the use of FPI. Additionally, several industry specifications exist providing guidance for FPI with Society of Automotive Engineers (SAE) 2847R, the standard put in place to address aerospace-specific requirements. For most critical rotating components, Type 1, Level 4 ultrahigh sensitivity penetrants are required, either Methods C (solvent removable) or D (non-amendable, hydrophobic).

Most engine components are inspected with FPI as part of production qualification and will be inspected in-service for detection of service-induced cracking. Attention must be paid to each step in the process to ensure process performance.

Need for Best Practice Document

The size, weight, and shape of many engine components warrant special consideration and are the focus of a recent industry initiative to generate a best practice

document. Figure 1 shows a typical drum rotor and spray application of penetrant. Drum rotors are comprised of several disks or stages that are welded or bonded together. With weights in excess of 200 to 300 kg, these components present many challenges for FPI including the need for special handling equipment. While the sling shown in Fig. 1 prevents metal-to-metal contact, precautions should be taken to ensure that contact points on the rotor bore are not affected by the sling. This includes ensuring that penetrant is applied beneath the sling and is not smeared at the contact points. Similar precautions are needed at each step in the FPI process, particularly at the developer stage.



Figure 1. Surface of drum rotor is covered thoroughly and systematically during penetrant application. UV-A source is used to ensure all surfaces have been covered.

Complexity of Internal Cavities Though the exposed external surface offers geometrical complexity similar to single-stage disks, the interior is even more challenging with internal cavities with tight clearances and deep wells. In addition to making interior inspection surfaces hard to view, the complex internal cavities tend to trap fluids and are difficult to

Focus continued on page 2.

CONTENTS

Volume 6, Number 1

January 2007

Focus: Fluorescent Penetrant Inspection of Drum Rotor, Deep Well Spools and Other Components with Internal Cavities	1
From the Editor	2
Tech Topic	2
Feature: Job Safety - Personal Protective Equipment for Eyes	6
Inbox	7
Practitioner Profile: Matthew Mead	8
ASNT Student Poster Presentation Winners	9
Crossword Challenge: Magnetic Particle Testing	10

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