HOW RELIABLE IS YOUR NDT SYSTEM ?

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Contents

Definition of NDT

- NDT is the Use of non-invasive techniques to determine the integrity of a material, component or structure; or quantitatively measure some characteristics of an object., i.e, inspect or measure without doing harm.

Remarks:

- NDT is considered a Special Process.
- NDT is predominantly an Operator Dependent process.
- NDT is a relative judgement process.

Introduction to NDT

- General Introduction to NDT
- Introduction to NDT Methods - ASNT
- Nondestructive Testing at TWI – Video
- Applus RTD Rotoscan
- Applus RTD NDT Techniques Video

Conventional NDT

- **Visual**
- **Liquid Penetrant**
- **Magnetic Particle**
- **Eddy Current**
- **Radiography**
- **Ultrasonic A-Scan**
- **Coating Measurement**

Advanced NDT Technologies

- Permanent monitoring ®
- ToFD
- Corrosion mapping
- Long Range Ultrasonic Inspection
- RTD-INCOTEST®
- Phased Array weld inspection
- Chime support inspection
- Guided Waves pipe inspection
- EMAT
- IRIS Tube Inspection
- Hydrogen Induced Cracking inspection
- Computed Radiography
- Pipeline Inspection Tools ®
- Rope Access
- Spectrum analysis
- IWEX ®
- Concrete thickness measurement
- Rayscan ®
- Subsea examinations

Importance of NDT

- The global NDT industry had an estimated turnover in 2012 of $5.6b including products and services. *
- Annual global market for equipment is approx $1.5b.*
- NDT has maintained growth exceeding 3% per annum in spite of the difficult economic conditions.

- * Ref: ICNDT Guide on Research and Development in NDT – 2015

Importance of NDT (Contd)

- NDT and Safety go hand in hand.
- Examples of Industrial Accidents relevant to NDT
- Inadequate Welding and Testing Caused 2003 Tank Accident in Iowa
- Special Investigation Report - Inspection and Testng of Railroad Tank Cars
- Mihama Nuclear Power Plant Disaster in 2004
- Enhancing Rail Safety - NTSB Investigations and Recommendations
- Railway Investigation Report R13E0142 - TSBC

NDT Systems

NDT System is a combination of:

- Personnel
- Equipment
- Calibration Standards
- Procedures / Techniques / Reports
- Processes
- Documentation and Records

Quality Management System

- A sound Quality Management System is a basic pre-requisite for a reliable NDT System.
- NDT System should be an integral part of an approved / accredited Quality Management System (QMS). Examples:
  - ISO 9001:2008
  - AS 9001C
  - ISO 17025: 2005
  - AC7004

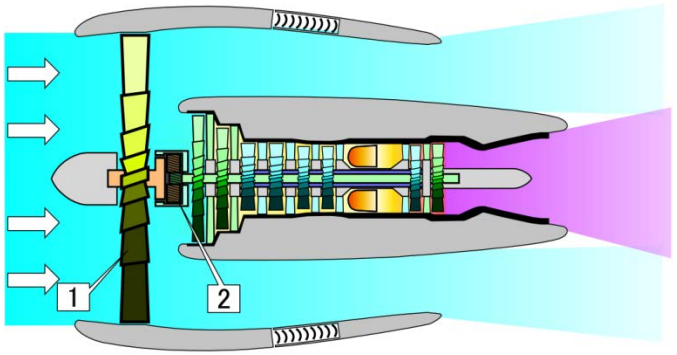
- ISO 9001:2008 - QMS Model:
  - Plan →Do →Check →Act
  - Process Approach

Key Elements of QMS/NDT Systems

- Personnel Qualification
- NDT Facilities / Field Operations
- Health, Safety and Environment
- Equipment Maintenance
- Procedures / Techniques
- Calibration Control
- Process Control
- Identification & Traceability
- Non-conformance Control
- Document Control
- Records Management

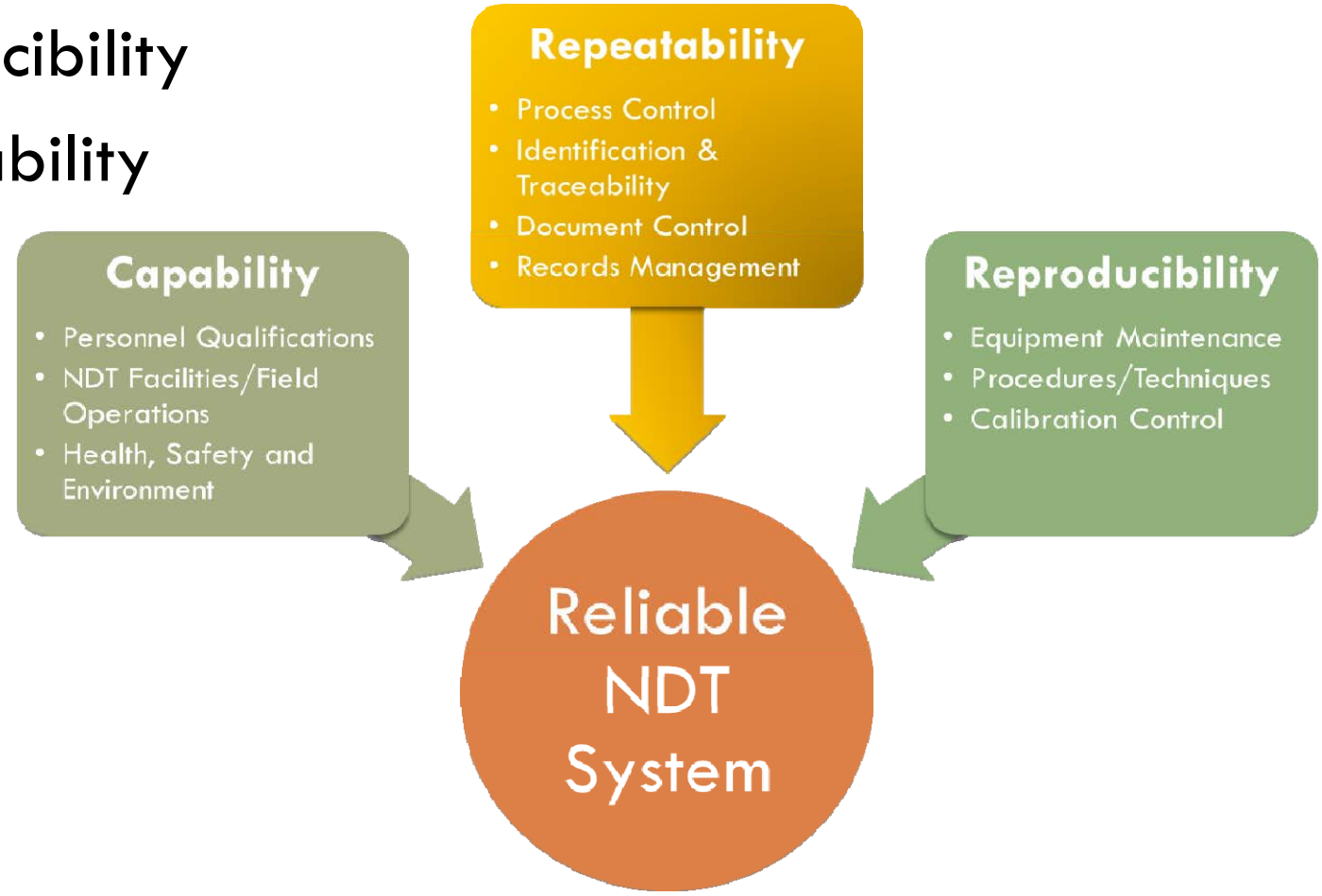
Definition of Reliability

- Reliability can be defined as the probability that a product, system or service will perform its intended function adequately for a specified period of time, operating in a defined operating environment without failure.



Characteristics of Reliable NDT Systems

- Capability
- Reproducibility
- Repeatability



Factors affecting Reliability of NDT Systems

- Personnel Competency
- Input variables (P.O Flow Down)
- NDT Equipment Variables
- Test Object Variable
- Calibration Variables
- NDT Method Variables
- NDT Technique Variables
- Materials Variables
- NDT Process Variables
- Human Factors

Capability – Basic Requirements

- Defect Detection
- Classification
- Analysis
- Judgement

Capability - Probability of Detection

- Probability of Detection (PoD) is a statistical method used to establish the capability of an inspection system to detect flaws. It is generally expressed as a PoD curve, which shows the relationship between the likelihood of detection and the size of the flaw.
- PoD is a quantitative analysis used to demonstrate compliance with standard requirements for inspection qualification, such as '90% probability of detection (PoD) with 95% confidence'

Probability of Detection (PoD)

- PoD relates to the capability of the NDT System – not personnel capability of the Operator.
- PoD is an integrated output metric, not a constant.
- PoD is unique to each technique and application.
- Due to large sample size required for statistical analysis, determination of PoD is cost prohibitive in most cases.
- In real world, customers will be more concerned about missing a large defect than detecting a minute flaw.

Personnel Competency

- NDT is predominantly an Operator Dependent process. Therefore, "Personnel Competency" is a vital factor in assuring the reliability of NDT.
  - The ability of the NDT Inspector not only to detect the flaws, but also to distinguish among the Relevant, Non-relevant and False indications is essential while making the accept / reject decisions.
  - Even if the data collection and analysis can be automated, the final 'accept / reject' decisions shall be made by the qualified NDT Operator / Inspector.

Written Practice

- NDT and Inspection Service Providers are required to establish and implement a Written Practice for Qualification and Certification of NDT Personnel in accordance with one of the following National / International Standards:

  - NAS 410 – applicable to Aerospace industry
  - SNT-TC-1A – Recommended Practice for any industry
  - ANSI/SNT CP-105 – American Standard (new)
  - CGSB 48.9712 – 2014- Canadian Standard*
  - ISO 9712-2012 – International Standard*

* Canadian Standard has been harmonized with the ISO 9712-2012

Qualification and Certification

- Qualification & Certification Requirements:
  - Formal Training in the NDT Method
  - Working Experience
  - Written Examinations
  - Practical Examinations
  - Near Vision Acuity / Colour Vision
  - Code of Ethics

- Levels of Qualifications:
  - Level 1
  - Level 2
  - Level 3

Responsible Level 3

- Applicable to Aerospace Industry
- Mandated by NAS 410 Standard
- Dual roles – Technical and Management

- RL 3 is Responsible for
  - Review of NDT Requirements
  - Sequence of NDT operations
  - NDT Procedure Development / Review / Approvals
  - Training of NDT personnel
  - Examination of NDT personnel

Calibration System

- NDT is the art and science of detecting and evaluating unknown flaws in the test objects in comparison to known flaws in reference (calibration) standards.
- The inspection results depend on how good the calibration system is maintained and applied to calibrate the NDT equipment.
- Therefore, calibration standards and techniques are crucial to the reliability of NDT.

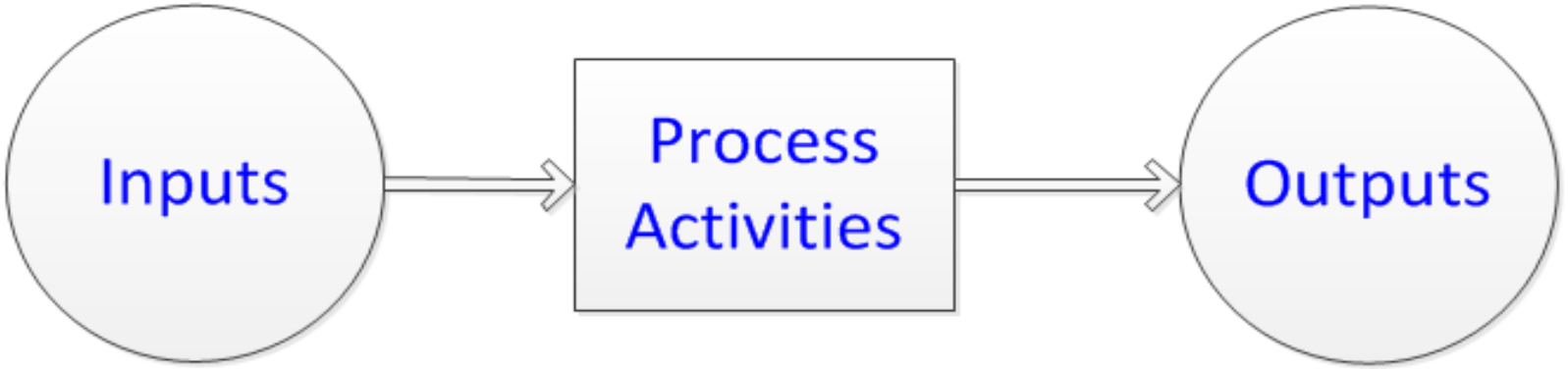
Process Control

- The Repeatability of NDT results depends on how good the NDT process is controlled.
  - Process Controls should be defined in every step of the NDT process.
  - NDT Procedures and Techniques should be approved by qualified individuals (usually NDT Level 3).
  - System capability tests and Daily Checklists are required to verify the Essential Variables.
  - Data Collection and Analysis tools and Software shall be validated before implementation.
  - Operators shall be trained on data collection and analysis.
  - Operator performance shall be verified through periodic demonstration of the process.

Process Control

- Records shall be traceable to the customer, project and the parts examined.
- NDT Reports shall be retained for the specified period and easily retrievable.
- Calibration records, and Technique approval records shall be retained for the specified period.
- Regular Internal Audits shall be conducted to assure that NDT system is working in compliance to the applicable Codes & Standards and Customer Specifications.

NDT Process Model



- Customer Specifications
- Purchase Order
- Codes and Standards
- Calibration Standards

- Contract Review
- P.O Flow-down
- Receiving Inspection
- Approved Procedures
- Approved Techniques
- Qualified Personnel
- Calibrated Equipment
- Approved materials
- Test Preparation
- System Capability Tests
- Process Control Checklists
- Internal Audits

- NDT Reports
- Material Certificates
- Identification & Traceability
- Shipping Documents

Essential Process Variables

Example: Liquid Penetrant Inspection (LPI)

- Surface Preparation
- Method of Applying Penetrant
- Penetrant Dwell Time
- Method of Removing Excess Penetrant
- Min & Max time periods between steps and drying aids
- Method of Applying Developer
- Developer Dwell Time
- Minimum Light Intensity

Liquid Penetrant Inspection Systems

Penetrant Types:

Type I —Fluorescent dye.

Type II —Visible dye.

Method:

Method A —Water washable.

Method B —Post-emulsifiable, lipophilic.

Method C —Solvent-removable.

Method D —Post-emulsifiable, hydrophilic.

Sensitivity (applicable to Type 1 only):

Sensitivity Level 1/2 —Very low.

Sensitivity Level 1—Low.

Sensitivity Level 2—Medium.

Sensitivity Level 3—High.

Sensitivity Level 4—Ultrahigh.

Developer Forms:

Form a — Dry powder.

Form b — Water-soluble.

Form c — Water-suspendable.

Form d — Non-aqueous for Type I fluorescent penetrant.

Form e — Non-aqueous for Type II visible dye.

Form f — Specific application.

Ref: ASTM E1417-13

LPI Material Verification

Material Or Test Type	Verification Frequency
Brightness - Fluorescent	Monthly
Water Content - Method A	Monthly
Penetrant Removability	Monthly
Penetrant Sensitivity	Monthly
Emulsification Removability	Monthly
Emulsifier Concentration	Weekly
Dry Developer Condition	Each Shift
System Performance - Capability	Each Shift
Penetrant Contamination Check	Each Shift

LPI – Equipment Calibration

Instrument Type	Calibration Frequency
Light Meters	Semi Annually
Pressure Gauges	Semi Annually
Temperature Gauges	Semi Annually
Timers	Semi Annually
Test Panels - Master / Working	Semi Annually
Drying Ovens	Quarterly
Oven Temperature Controllers	Quarterly
Measuring Gauges	Annually

LPI System Capability - Daily Checks

Equipment Tested	Specification	Frequency
Water Pressure	25 - 40 psi	Each Shift
Water Temperature	50 - 90 ^{o} F	Each Shift
Oven Temperature	145 ^{o} F Max	Each Shift
Penetrant Tank Level	Satisfactory	Each Shift
Penetrant Contamination	Refer to Procedure	Each Shift
UV Lamp Filters (Visual)	No Cracks or damage	Each Shift
UV Light Intensity at the part (Inspection Station)	1200 µW / cm ^{2}Max at 15"	Each Shift
UV Light intensity at the Wash Station	50 µW / cm ^{2} Min	Each Shift
Ambient Light at the Wash Station	10 fc Max	Each Shift
Ambient Light at the Inspection Station	2 fc Max	Each Shift
Dry Developer Condition	No UV contamination	Each Shift

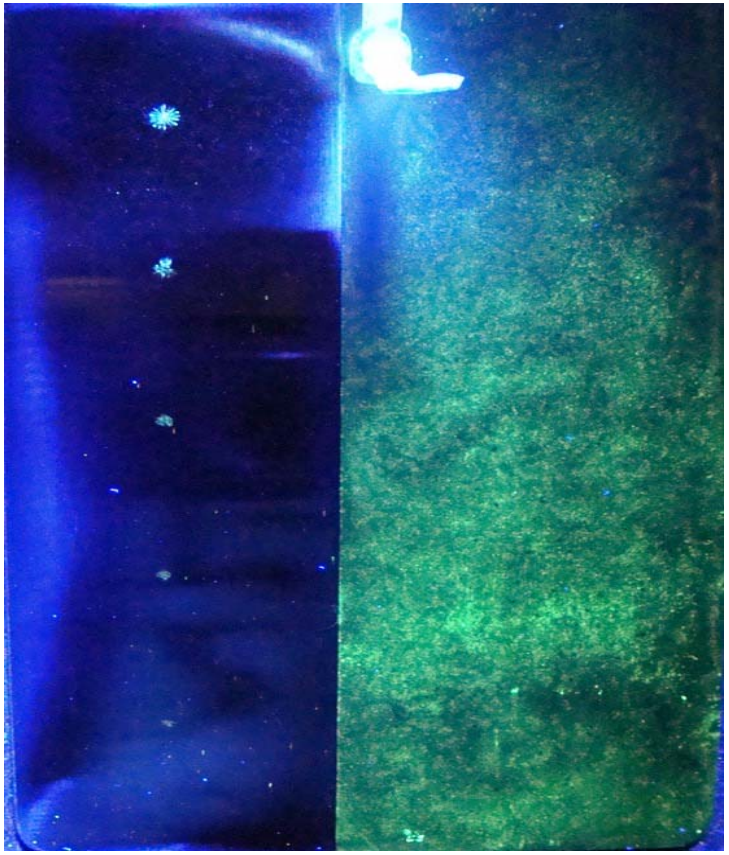
LPI System Capability Tests / Daily Checklist - Example

EQUIPMENT & MATERIALS TESTED			REQUIRED VALUE/DETAILS	DATE	DATE	DATE	DATE	DATE
UV Lamp filters check			Verify integrity					
Penetrant Contamination			Daily-App. A Sec. 10					
Inspection area purity			Verify cleanliness					
White Light Intensity – Inspection area			2 fc MAX					
White Light Intensity – at the part			100 fc MIN @ 8"					
UV Intensity – at the wash station (SMALL), s/n:			50 µW/cm² MIN					
UV Intensity – at the wash station (LARGE), s/n:			50 µW/cm² MIN					
Ambient Light at the Wash Station			10 fc MAX					
UV (µW/cm2) / WL (fc) S/N:			1200 µW/cm² / 2 fc MAX at 15"					
UV (µW/cm2) / WL (fc) S/N:			1200 µW/cm² / 2 fc MAX at 15"					
Water Pressure – Small Tank			25 – 40 psi					
Water Pressure – Large Tank			25 – 40 psi					
Water Temperature – Small Tank			50 – 90 °F					
Water Temperature – Large Tank			50 – 90 °F					
Oven Temperature								
	PYRADIA		145 °F (MAX)					
	Gordon Wright		145 °F (MAX)					
Ambient Temperature			50 °F (MIN) – 90 °F (MAX)					

TEST PANELS SENSITIVITY CHECK FOR PENETRANTS:			PER QP-PT200 APP. C	# stars	Ini-tial	# stars	Ini-tial	# stars	Ini-tial	# stars	Ini-tial	# stars	Ini-tial
WW	9702	Level 1	# stars as per established baseline										
WW	970P25E	Level 3											
PE	9813	Level 3											

PE Penetrant change			Record Disposal Date					
Emulsifier verification			QP-PT200 App. A-4.0; once per shift ± 2%					
Emulsifier change			Record Disposal Date					
Level of Penetrant Tanks			Satisfactory					
Dry Developer condition			No UV Contamination; assure it is fluffy					
FPI SYSTEM HAS BEEN CHECKED AND FOUND ACCEPTABLE IN ACCORDANCE WITH QP-PT200 CHECKED BY:			SIGNATURE and/or STAMP					
REPLENISHMENT INFORMATION								
COMMENTS and/or CORRECTIVE ACTION								

Penetrant System Sensitivity Check - Example



- TAM Panel ID:
- Serial#:
- Penetrant Type:
- Batch #:
- Date:

Example of a Post-Emulsification Penetrant System Sensitivity Check

Human Factors

- "… 'human error', we now know, is not a cause of failure. "Human error" is rather the effect, or symptom, of deeper trouble. It's connected—systematically—to people's tools, to their tasks, and to the environment in which they operate.
- And the people who establish the goals and the priorities and assign the resources, those who assign the tasks and determine the rules for the operating environment—are those typically higher up in an organization … meaning management. And their decisions can have a huge impact.
- (Excerpts from the "Speech to Economic Club of Canada" by Cathy Fox, Chairman of TSBC, Ottawa, 05 Feb 2015)

Ref: http://www.tsb.gc.ca/eng/medias-media/discours-speeches/2015/02/20150205.asp

Summary

- NDT is a Special Process (Competent Personnel, Qualified Equipment and Approved Procedures).
- NDT is predominantly an operator dependent process.
- NDT Reliability = Capability + Reproducibility + Repeatability
  - Personnel Competency
  - Calibration Control
  - Process Control
- "Human Factor" is inherent in all NDT Systems.

Applus Group

Applus

Applus automotive | Applus IDIADA | Applus laboratories | Applus RTD | Applus VELOSI | Applus norcontrol

- Vehicle inspection

- Engineering
- Type approval
- Testing

- Testing
- Engineering
- Certification

- NDT
- Adv NDT
- Inspections

- Vendor inspection
- Third party inspections
- Recruitment
- QA & QC

- Inspections
- Technical assistance

Applus+ Group (2014)

Revenue $1.8B USD

People 20,000

Countries 70+

Q & A

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