出國報告（出國類別：實習）

非破壞性檢查及評估訓練
Nondestructive Inspection and Evaluation course

服務機關：交通部民用航空局
出 國 人：約聘人員　李文孝
出國地區：美國
出國期間：103 年 07 月 27 日至 103 年 08 月 03 日
報告日期：103 年 10 月 08 日

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壹、 目的

此訓練課程介紹各種非破壞性檢查(NDI：Nondestructive Inspection)的方法、NDI 裝備設施的需求、NDI 檢驗人員的資格要求及認證，可提供飛航安全檢查員(ASI：Aviation Safety Inspectors)、結構與發動機工程師、及需要了解現代 NDI 技術之人員，對於 NDI 技術應用於航空產品檢查之瞭解及技巧。

目前國內各航空公司及維修廠皆自行建立 NDI 的檢驗能量,以確保航空器/航空產品於製造及後續使用時之品質及可靠度。本訓練提供檢查員執行查核非破壞性檢查實務所需之觀念、知識及相關之法源依據，有助於提升我國檢查員的專業知識及技能。

貳、 行程摘要

日期	行程	備註
07/27 ~ 07/28	啟程前往美國奧克拉荷馬	
07/29 ~ 08/01	參加訓練課程：非破壞性檢查及評估訓練	
08/01 ~ 08/03	返回桃園機場	

參、 課程內容摘要

課程內容分成 3 個主題，藉由影音、經驗分享、實作、學員與講師的互動討論等方式，使學員能夠得到執行非破壞性檢查評估時所需的知識與技巧。教材包含了 ATA 文件、FAA 檢查員手冊、FAA 民航通告及 FAA JOB AID。

課程包括：NDI 的方法與技術介紹、NDI 裝備設施及檢驗人員的認證、NDI 稽核需求及查核技巧、實際操作與練習。

此訓練課程主要提供檢查員如何執行 NDI 檢查工作之稽核、認證及瞭解各種 NDI 的方法，共分 3 項主題：

1. NDI 設施及操作人員資格之認證需求 (Qualification & Certification process)
2. 主要的 NDI 方法 (Major NDT methods)
3. 複合材料檢查方法 (Composite inspection methodology)

以下針對此 3 項主題摘要報告：

一、NDI 設施裝備及操作人員資格之認證需求 (Qualification & Certification process)：

航空業界提及非破壞性檢查時，常使用 NDI、NDE 及 NDT 幾個簡稱，分別表示非破壞性檢查(inspection)、測試(test)與評估(evaluations)，皆可用來代表非破壞性檢查。此檢查方法在不破壞物件特性的情況下，用以判斷結構或組件之完整性、組成、電導性、熱導性或材料的特質是否良好。

此主題共有幾項重點：

1. NDI 認證說明

2. NDI 適用之法規

3. NDI 組成要素

4. NDI 合格人員之資格及認證國際標準

5. NDI 標準之構成元件

6. NDI 稽核之工作輔助單 (JOB AID)

分別說明如下：

1.NDI 認證說明：

1. NDI 執行人員之資格證明，用以代表其所能執行之 NDI 等級及工作。
2. 此資格證明訂定了 NDI 人員能獨立完成之 NDI 檢查工作，並與雇主所編訂之 NDI 作業流程互相連結。
3. 維修廠初次申請 NDI 檢驗認證時，需經由系統化的評估程序，以確認符合法規的要求。

2.NDI 適用之法規，詳如下表：

FAA 法 規	內 容
CFR Part 23.621, 25.621, 27.621, 29.621 - Casting Factors	Each casting must receive 100% inspection by: visual, radiography, and magnetic particle or penetrant or approved NDI method
CFR Part 25.611 - Accessibility Provisions	Provides a means for inspection where it is impractical to provide means for direct visual inspection
CFR Part 145.61 - Limited Ratings	Issued to a domestic repair station doing specialized maintenance and may be issued for nondestructive inspection, testing and processing

CFR Part 147 - Appendix B	FAR 145.205 Maintenance, preventive maintenance, and alterations performed for certificate holders under parts 121,125,135,129.
CFR Part 25.611 – Appendix H, Section 25.3 (d)	Details for the application of special inspection techniques including radiographic and ultrasonic testing where such processes are specified

3.NDI 組成要素：包括合格的人員及合格的計劃

合格人員的定義：要得到可靠的非破壞性檢查結果需仰賴合格人員來執行，不論是測試的結果或對測試結果的判讀，皆需由合格完訓之人員完成，此人員需熟悉不同的 NDI 方法的應用及限制，以確認飛機結構與組件的損壞部位。

合格計劃的定義：人員的訓練、考核、資格及文件存檔皆需編訂計劃控管，此計劃需能維持人員工作的熟練度，例如施以複訓或重新認證，合格的人員需能展現令人滿意的工作表現。

FAA 於 2007 年發行 Handout HO-01-QCP，主題即為非破壞性檢驗人員之資格要求，內容說明見第 5 點。

4. NDI 檢查人員之資格及認證國際標準

A. 美國標準：常見有以下三種標準，其中 NAS-410 已完全取代 STD-410E。

MIL-STD-410E：Military standard, Nondestructive Testing Personnel Qualification and Certification

ATA Specification 105：Air Transport Association, Guidelines for Training and Qualifying Personnel in Nondestructive Testing Methods

AIA-NAS-410：Aerospace Industries Association, National Aerospace Standard, NAS Certification & Qualification of Nondestructive Test Personnel

B. 國際標準：常見有以下二種標準，但如果其他標準之內容包含 NDI 基本組成元素之規範，FAA 亦能接受。

Canada Can/CGSB-48.9712-95：Qualification and Certification of Nondestructive Testing Personnel IAW ISO 9712

prEN 4179 Aerospace Series：Qualification and Approval of Personnel for Non-destructive Testing

5.NDI 標準之構成元件如下：

A. 視力要求：需每年檢測視力及辨色力。

B. NDI 等級：較常分成 Trainee, Limited, Level 1, 2, 3，分別可執行不同等級的 NDI 工作。在台灣則只有 Level 1 以上的人員可執行相關授權之 NDI 工作。

C. 訓練：NDI 檢驗人員依執行的等級，需接受相關的初始訓練及複訓，包含課堂及實作訓練。

D. 測驗：不論課堂或實作皆需測驗，以證明檢驗人員夠資格執行該等級的工作。

E. 經驗：要保持各種 NDI 檢驗方法的資格，檢驗人員需於一定的期間內執行檢驗經驗，例如最近 6 個月曾使用該方法執行 NDI 檢查。

F. 資格保持：需制定程序，以判斷 NDI 人員是否仍符合要求。此程序需包括視力、經驗、檢查結果及人員是否複訓。

G. 文件符合：需有足夠的文件證明執行 NDI 之人員資格符合，對於每位檢驗員皆需保有此文件紀錄。

6. NDI 稽核之工作輔助單 (JOB AID)

此 JOB AID 可幫助檢查員(ASI)評估稽核 NDI 操作、設備及人員，以下單元所介紹之 NDI 檢查方法，皆有相對應的問題及步驟可供參考使用，可用於初始認證、後續稽核/評估及監理。詳細內容如附件二。

此工作輔助單對於航空安全檢查員在執行非破壞性檢測查核時，建議採取五大系統評估步驟，包括文件(Documentation)、組織(Organization)、環境(Environment)、校驗（Calibration)、訓練（Training）等項目進行查核，以確認其符合法規之要求。其中文件包括受檢者用來執行與管制非破壞性檢測之程序、流程、規範和方法等。組織則指非破壞性檢測單位在整個組織內之定位、其架構為何、資源（人力、設備）來源為何。環境則是考量其設施之清潔、舒適性、安全性、儲存與保存等。校驗則包括所有儀器是否按時校驗、是否有校驗程序、是否建立文件紀錄等。訓練則針對其訓練計畫、方法、標準等作檢查。

二、主要的NDI 方法 (Major NDI methods)

6 種常用的NDI 檢查方法：

1. 目視檢查Visual inspection

目視檢查之定義為運用眼睛，協同光線、鏡子、放大鏡等工具之輔助，來判別所檢查物品之狀況。此外，也可利用觸摸、嗅覺等其他感官來協助目視檢查；而其他五項非破壞性檢測亦使用目視檢查來判別檢測結果。

執行目視檢查之查核時可參用NDI Evaluation Checklist 之Visual Inspection 部分，並建議採取五大系統評估步驟進行查核，以確認其符合法規之要求：

(1)文件：應建立目視檢查程序、並確認核可之程序有照著執行、且檢查結果應以文件加以紀錄。

(2)組織：確認NDI 檢測單位與管理階層間之關聯性、執行目視檢查人員是否屬於NDI 檢測單位等。

(3)環境：具有充足之照明、檢驗之零件未受灰塵、油污等污染而影響檢驗結果、確保不合格之工具未被使用於目視檢查、受檢區域是否具備容易進入之特性。

(4)校驗：參考工具手冊以確定是否有適當之校驗程序與週期、目視檢查工具與參考標準應適當標示與貯存。

(5)訓練：應建立訓練計畫、且包含訓練標準與確認其有照著執行，個人訓練紀錄應加以評估是否符合訓練計畫。

2. 液滲檢查Liquid penetrant inspection

液滲透檢驗主用於檢查固體的、無孔的材料（例如金屬、陶瓷等，木材與複材則不行）表面之裂痕（Crack）。其利用毛細作用（Capillary action）之原理，藉由將零件浸入滲透液（Penetrant）中，滲透液會利用毛細作用滲入零件裂痕中，而裂痕經過黑光（紫外線）之照射後便會顯現出來。

執行螢光滲透檢驗之查核時可參用 NDI Evaluation Checklist 之 Liquid Penetrant 部分，並建議採取五大系統評估步驟進行查核，以確認其符合法規之要求：

(1)文件：所有發現之缺陷應加以文件化、申請檢定時應建立檢驗之程序、稽核時應檢查該程序之執行以確認其符合性。

(2)組織：確認 NDI 檢測單位與管理階層間之關聯性。

(3)環境：應考量受到電擊、可燃性揮發氣體、地板濕滑、紫外線照射等意外之安全性。注意 Liquid Penetrant 溶液不被濕氣、油脂、潤滑油、鐵銹、沙子和高溫所污染。紫外線強度應依照程序用設備供應商所提供之光度計加以檢查。

(4)校驗：應建立儀器校驗之程序、光度計須校驗且每次使用前皆須校正好、確認 Penetrant & Developer 之壽限沒有超過。

(5)訓練：一般螢光滲透檢驗之學科訓練為 16-20 小時，再加上實習訓練。訓練紀錄應加以評估是否符合訓練計畫，確認合格之檢查員能夠依據程序執行測試。

3. 磁粒檢測 Magnetic particle inspection

磁粒檢測之原理是基於磁性物質上之磁力線會因為物質本身連續性之變化而扭曲，而磁粒則會保留在磁力流場洩漏的地方。磁粒檢測被使用在發現磁性物質表面上或接近表面部位之缺陷，共有可見光和螢光磁粒檢測兩種方法。

檢查員執行磁粒檢測之查核時可參用 NDI Evaluation Checklist 之 Magnetic Particle 部分，並建議採取五大系統評估步驟進行查核，以確認其符合法規之要求：

(1)文件：所有發現之缺陷應加以文件化、申請檢定時應建立檢驗之程序、稽核時應檢查該程序之執行以確認其符合性。

(2)組織：確認 NDI 檢測單位與管理階層間之關聯性。

(3)環境：應考量受到電擊、可燃性揮發氣體、地板濕滑、紫外線照射等意外之

安全性。磁粒如發現退色或粘在一起時應不要使用；磁粒易受濕氣、油脂、潤滑油、鐵銹、沙子和過熱所污染，應加以注意。

(4)校驗：電流計應依據程序定時檢查與正確操作，執行檢測前可用已確知缺陷之測試片先作檢查，以確認整個系統運作正常。磁粒溶液的濃度、流量、壓力和溫度應依照建立之程序加以量測。

(5)訓練：一般磁粒檢測之學科訓練為 16-20 小時，再加上實習訓練。訓練紀錄應加以評估是否符合訓練計畫，確認合格之檢查員能夠依據程序執行測試。

4. 放射線檢查 Radiography inspection

放射性檢測用於檢查表面下之缺陷、內部結構、銹蝕、以及機體與發動機零件之對準與排列。放射性檢測之原理是依據物體內部各元件對 X 光之吸收程度的差異性，來辨別其缺陷部分。密度越高部分其暗黑程度越低，而因各元件之密度不同而有不同之對比（不同的暗黑程度）。民用航空所常用之放射性能量種類為 X 光和 γ 伽馬光；伽馬光因波長較短，故穿透力較強。

執行放射性檢測之查核時可參用 NDI Evaluation Checklist 之 Radiography 部分，並建議採取五大系統評估步驟進行查核，以確認其符合法規之要求：

(1)文件：所有發現之缺陷應加以文件化、申請檢定時應建立檢驗之程序、稽核時應檢查該程序之執行以確認其符合性。

(2)組織：確認 NDI 檢測單位與管理階層間之關聯性。

(3)環境：對管制放射性儀器之使用與進出必須建立嚴格之指引、像是 film badges and survey meters 這類測量幅射強度之設備應隨時備便供使用、應確保底片和處理藥水之正確清潔和分置、尚未曝光之底片應在所管制之溫度與濕度下儲存。

(4)校驗：手冊中應載明適當之校驗程序及週期、確認有依照程序執行校驗、IQI 應依程序所載明隨時備便供使用。

(5)訓練：一般超音波檢測之學科訓練為 40 小時，再加上實習訓練。

5. 渦電流檢查 Eddy current inspection

渦電流檢測是利用電磁傳導的原理來運作；利用將一個有交流電流動之電線圈靠近受檢零件，該交流電流會產生一個主要的磁場並感應受檢零件發生渦電流而在受檢零件上產生一個次要的磁場。其偵測結果則是依據次要的磁場上探針所感應到之變異。

檢查員執行渦電流檢測之查核時可參用 NDI Evaluation Checklist 之 Eddy Current 部分，並建議採取五大系統評估步驟進行查核，以確認其符合法規之要求：

(1)文件：所有發現之缺陷應加以文件化、申請檢定時應建立檢驗之程序、稽核時應檢查該程序之執行以確認其符合性。

(2)組織：確認 NDI 檢測單位與管理階層間之關聯性。

(3)環境：受檢區域應具備容易進入之特性，過大之噪音、溫度、風、雨以及其他天候因素會對檢測有不利之影響，探針應予適當之保存。

(4)校驗：儀器手冊應有適當之校驗程序與週期，並確認其有確實執行。作為參考標準之模擬試片應與受檢零件之材質相同。

(5)訓練：一般渦電流檢測之學科訓練為 40-60 小時，再加上實習訓練。

6. 超音波檢查 Ultrasonic inspection

超音波檢測之原理為利用高頻率聲波傳送至該零件內以進行調查，而藉由輸入與輸出訊號之差異來偵測該零件之缺陷。超音波檢測需要使用液體狀介質（Couplant）以讓聲波從電功率轉送器（Transducer）傳送進入零件，並偵測從零件傳回之聲波能量，而缺陷部位所顯示之訊號較正常為小；電功率轉送器可將電能轉變為超音波震波，並可將超音波震波轉換為電能。

執行超音波檢測之查核時可參用 NDI Evaluation Checklist 之 Ultrasonic 部分，並建議採取五大系統評估步驟進行查核，以確認其符合法規之要求：

(1)文件：所有發現之缺陷應加以文件化、申請檢定時應建立檢驗之程序、稽核時應檢查該程序之執行以確認其符合性。

(2)組織：確認 NDI 檢測單位與管理階層間之關聯性。

(3)環境：程序所引用之電功率轉送器的頻率與種類應適當，且確實被使用。Glycerin 不可使用以免造成鋁材之腐蝕，電功率轉送器應予適當之保存。

(4)校驗：執行檢測前可用已確知缺陷之測試片先作檢查，以確認整個系統運作正常。作為參考標準之模擬試片應與受檢零件之材質相同。

(5)訓練：一般超音波檢測之學科訓練為 40-60 小時，再加上實習訓練。

三、複合材料的檢查方法

複合材料由二種或二種以上的材料組合而成，分為基體(Matrix)及加強體(Reinforcement)。基體強度較低，但有較高的延展性；加強體有較高的強度，製成複合材料時能補足基體不足的強度，而達到高強度及高延展性的目的。

基於以上特性，近代研發的航空器，複合材料的應用越來越廣泛，可用於飛機的飛操面、發動機艙、內裝、蓋板、結構等處。

複合材料的檢查需求：

1. 修理前檢查：用於確認損壞的區域。

2. 修理後檢查：可發現維修後之脫層及孔洞問題

3. 扣件周圍需要特別檢查

4. 結構件內部及周圍的檢查

非破壞性檢查可應用於複合材料之方法：

1. 目視檢查：

   可用於發現表面或接近表面之損傷，如脫層、氣泡等。光點、不均勻的表面塗層及可見的裂痕皆是目視檢查可發現的缺點。

   優點：此方式容易執行且不需要龐大的裝備。

   缺點：檢查結果可能因人而異，只能看到表面的問題，較深層的損傷即不易發現，大範圍的檢查區域即不易執行。

2. 敲擊檢查：

   便利性僅次於目視檢查，使用小鄒頭或錢幣敲擊於複材表面，辨別聲音的變化，此方法可用於辨識大範圍的損傷。

   優點：快速、有效又容易的檢查方法，能用於發現脫層及嚴重的濕氣入侵。

   缺點：深層的損傷不易發現，檢查環境需不受外界干擾，檢查人必需知道檢查之材料背面的結構才能做正確的判斷，無法判斷損傷的嚴重程度，小區域的損傷不易發現。

3. 超音波檢查：

利用聲波遇物體反射的原理，偵測物件內部的損傷。最常用的方法有 A-SCAN 及 C-SCAN，而 C-SCAN 能更完整的掃瞄整面的物件。

優點：可發現深層的及細小的損傷，經由掃瞄一個面即可檢查整個物件，掃瞄可經由設定自動完成。

缺點：每種不同物件材質及厚度的檢查皆需校正標準，需能更確的判斷得到的結果，探頭與物件之間必需有媒介(Couplant)，必需將物件自飛機上移下才能執行 C-SCAN。

4. 放射線檢查(X-RAY)：

利用 X 光的高穿透性通過物件，以發現物件的損傷，可用於發現橫向裂痕。

優點：可用於各種材質及厚度，使用底片能將檢查結果永久紀錄下來，檢查玻璃纖維及人造纖維效果極佳。

缺點：實施此檢查需特殊裝備，較為昂貴，普及性不高，檢查時物件兩面皆需實施。

5. 熱顯像檢查：

使用紅外線感測物件表面的溫度，以顏色區分其顯示的溫度，偵測物件受潮時內部溫度變化。

優點：檢查可快速完成，不需接觸檢查物件即可完成。

缺點：裝備昂貴，普及性不高，且較不精確。

6. 雷射剪影檢查(Laser Shearography)：

使用雷射偵測物件表面的形變，此技術可偵測孔洞、脫層、表面損傷、接近表面損傷、物件核心損傷、衝擊損傷。

優點：可廣泛用於各種材料，檢查極微小的損傷及大範圍的檢查區域，裝備易於攜帶，檢查可快速完成。

缺點：檢查員需接受專業訓練才能判斷檢查結果。

肆、 心得及建議事項

此訓練利用 3 天半的課程，提供 NDI 檢查之基礎概念，並使檢查員瞭解執行 NDI 稽核時應知道之檢查重點，才能增進稽核時的效率及準確性。如同講師課堂時一直強調的「檢查員不需要有 NDI LEVEL 3 的檢驗能力，但是要具備 NDI LEVEL 3 的知識，如此才能發現 NDI 檢查工作前、中、後的問題」。

此課程針對檢查員而開設，上課時不但能與講師互動討論，透過實際操作 NDI 裝備及儀器加深印象，更能與其他檢查員經驗分享，瞭解實際執行 NDI 稽核檢查時遇到的問題，並於課堂上得到解答。FAA 另介紹其所建立使用中之五大系統評估步驟，並利用習題配合 NDI Evaluation Checklist 之使用來使學員瞭解查核之技巧，可謂獲益良多。

FAA 為航空監理單位的先趨，不但法規完備詳盡，並有龐大的資源，對於相關之航空檢查更累積了許多經驗。建議如有適當課程可多安排國籍檢查員赴美學習，以使國內飛安更加精實。

伍、附件：非破壞檢測評估檢查表（NDI Evaluation Checklist）

Nondestructive Inspection For Aviation Safety Inspectors

Online Job Aid

April 2013

Contact Information:
FAA Headquarters
Aircraft Maintenance Division (AFS-300)
950 L'Enfant Plaza, SW, 5th Floor
Washington, DC 20024

NONDESTRUCTIVE INSPECTION (NDI) ONLINE JOB AID

1. Introduction. You, an aviation safety inspector (ASI), can use this Nondestructive Inspection (NDI) online job aid as a tool in the certification, audit/evaluation, and surveillance of NDI organizations. We, the Aircraft Maintenance Division (AFS-300), designed this job aid to provide a standardized approach to evaluate an NDI organization.

2. Scope.

A. Using this job aid provides you with a standardized approach to assess compliance. You don't need to address all questions in the checklist in all situations, nor is it necessary to have an affirmative response to all questions. You may exercise your own judgment to determine compliance based on the NDI organization's ability to present reasonable and defensible responses to the issues contained in this job aid.

B. We provide this job aid as a tool for you to use when preparing to evaluate an NDI organization. However, you shouldn't use this job aid as a pass/fail checklist form during onsite visits.

3. Terminology. Industry often uses the terms Nondestructive Inspection (NDI), Nondestructive Evaluation (NDE), and Nondestructive Testing (NDT) interchangeably. However, for the purpose of this job aid, we use the term NDI.

4. Organization of the Job Aid. We organized this job aid in two parts: Part I, NDI Evaluation Process, and Part II, NDI Methods.

- Part I includes a general section to record pertinent information about the facility. This part also includes questions applicable to the NDI organization for audit and surveillance for each of the five elements described in Paragraph 5 below.
- Part II includes specific questions for the six most commonly used methods: visual inspections, liquid penetrant inspections, magnetic particle inspections, eddy current inspections, ultrasonic inspections, and radiographic inspections.

5. Elements of an NDI Organization. We organized this job aid around five elements used to assess an organization's ability to perform NDI functions. These five elements comprise a systematic NDI evaluation process that you can use to evaluate any NDI organization, from manufacturing to maintenance. We define the five elements as follows:

- **Documentation.** Documentation pertains to written procedures, processes, specifications, and/or methods that air operators or air agencies use to perform and control NDI activities.
- **Organization.** A corporation or other similar entity established to provide or receive NDI services.
- **Environment.** The general physical condition of the NDI facility (e.g., housekeeping, storage, safety, consumable management, equipment);
- **Calibration.** The process by which an item is checked against a standard.
- **Training.** Training ensures that NDI inspectors are qualified to perform NDIs. An NDI organization should maintain records in order to document the training and retraining of NDI personnel, including the methods used.

  NOTE: These five elements represent the underlying system that an NDI organization needs to have in place for satisfactory NDI operations.

Table of Contents

Part I
NDI Evaluation Process

Part II
NDI Methods

Part I

NDI Evaluation Process

Section A: General

Facility/Location:_____

_____

Dates: Started **Completed**

Inspectors	Facility Representatives	Title

Certificated NDI Inspectors	
Non-certificated NDI Inspectors (trainees)	
Repairmen	
Total Employees	

Facility Description: _____

_____

Work Performed:

☐ Visual	☐ Liquid Penetrant	☐ Magnetic Particle
☐ Eddy Current	☐ Ultrasonic	☐ Radiographic
☐ Other		

Section B: Documentation

	YES/NO	N/A	REMARKS
1. Does the facility have a manual specific to the NDI organization?			
2. Does the NDI manual contain an organizational chart detailing roles and responsibilities of individual functions?			
3. Does the NDI manual contain appropriate specifications or references to procedures and processes contained in other documents, such as original equipment manufacturer (OEM) NDI manuals?			
4. Are the specifications or referenced manuals current?			
5. Does the NDI manual define a Quality Management System (QMS) to ensure all activities are carried out per specified procedures?			
6. Does the facility have an approved/accepted document that defines duties and responsibilities of management personnel?			
7. Does the facility have an approved/accepted document for internal audit?			
8. Does the facility have an approved/accepted Quality Manual (QM)?			
9. Does the manual contain procedures for NDIs outsourced to vendors?			
10. Are manuals and procedures available to and used by the qualified personnel?			
11. Does the manual contain controls for managing NDI products, materials, and consumables?			

Section C: Organization

	YES/NO	N/A	REMARKS
1. Is there a separate NDI organization within the facility?			
2. Does the NDI manager or equivalent have direct line authority to the NDI qualified personnel?			
3. Are NDI requirements provided to the NDI inspection personnel by use of written procedures?			
4. Does the NDI manager, or equivalent, review the quality assurance system to monitor compliance to the FAA-approved data?			
5. Are proper shift change procedures in place to ensure communication of inspection status and to ensure inspections are properly performed and interpreted?			
6. Are documented procedures in place for inspector override authority; i.e., does the person with override authority meet or exceed the qualification of the inspector who documented the original discrepancy?			
7. Are procedures in place for qualified personnel to perform required vision exams; i.e., per qualification program requirements?			
8. Does the manual contain procedures for NDIs outsourced to vendors?			

Section D: Environment

	YES/NO	N/A	REMARKS
1. Is the size of the work area sufficient to perform the NDIs?			
2. Is there adequate work area for storing and separating NDI materials (e.g., equipment, chemicals, supplies)?			
3. Is there a method for controlling and segregating nonconforming NDI equipment and materials?			
4. Are appropriate manuals, procedures, and other documentation available for use by qualified personnel?			
5. Are adequate parts handling systems (e.g., cranes, hoists, lifts) available to the inspectors?			
6. Do routing documents specify the operations needed and in what sequence to do so?			
7. Is adequate protection provided to parts during handling and routing?			
8. Is metal-to-metal contact of finished surfaces prevented during handling?			
9. Are obsolete documents removed from inspection areas?			
10. Are materials with expiration dates managed using appropriate procedures?			

Section E: Calibration

	YES/NO	N/A	REMARKS
1. Is there a procedure for calibrating inspection devices to certified standards?			
2. Are there procedures for segregating functional and nonfunctional equipment?			
3. Is there a method for controlling and segregating nonconforming NDI equipment and materials?			
4. Are procedures in place to ensure repaired equipment is recalibrated?			
5. Are reference standards properly labeled, stored, and used?			
6. Are the calibration methods documented?			
7. Are setup verifications performed on all shifts, as appropriate?			
8. Are numerical values and signatures required for all calibration parameters?			

Section F: Training

(Classroom, On-the-Job Training (OJT), and Demonstration of Performance)

	YES/NO	N/A	REMARKS
1. Are training requirements identified in the NDI manual for the methods used?			
2. Are training, qualification, requalification, and certification done in accordance with criteria such as: • Recommended Practice SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing. • Airlines for America (A4A) Specification 105, Training and Qualifying Personnel in Nondestructive Testing Methods . • AIA-NAS-410, Aerospace Industries Association, National Aerospace Standard, NAS Certification & Qualification of Nondestructive Test Personnel • FAA Advisory Circular (AC) 65.31 (current edition), Training Qualification, and Certification of Nondestructive Inspection (NDI) Personnel. • Other:_____			
3. Are there procedures for maintaining training records for NDI personnel, and are they current and easily accessible?			
4. Is there a procedure to include OJT requirements for each qualification level in accordance with industry-accepted standards, and is OJT recorded?			
5. Is there a procedure to include demonstration of performance and its recording to meet the 6-month proficiency requirement?			
6. Is all data pertinent to individual training/qualification/requalification on file, including grandfathering or documentation for individuals previously qualified?			
7. Is there a procedure for recertification/decertification of NDI personnel in the case of an unsatisfactory performance, a past-due eye exam, or a 6-month period of inactivity?			
8. Are qualified personnel available for all required techniques and at all the required levels called for in the manual?			

Part II

NDI Methods

Audit and Surveillance

Audit/evaluation and surveillance are significant components of an ASI's responsibilities. Audit/evaluation includes verifying that the certificate or approval holder meets all regulatory requirements and operates in compliance with its manuals and operating procedures. Surveillance includes ensuring that the certificate or approval holder is maintaining compliance during day-to-day operations of the air agency for the certificate that they hold. There is limited specific regulatory guidance that focuses on NDI.

Section A: Visual Inspections

A visual inspection is the process of using the eye, either alone or with the help of various aids, as the sensing mechanism to determine the condition of a unit under inspection.

	YES/NO	N/A	REMARKS
1. Do written procedures define the visual inspection process, including specific targets?			
2. Are precautions taken to ensure that procedures that can adversely affect visual inspection are not performed prior to the inspection process; e.g., cleaning, paint striping, disassembly?			
3. Is adequate lighting available for performing the detailed inspection that is required?			
4. Does the organization utilize a training program for visual inspection?			
5. Does the organization require vision testing to ensure that visual inspectors possess binocular vision with good visual acuity?			
6. Does the organization utilize a maintenance program to ensure borescopes, fiberscopes, and other remote viewing equipment are properly stored, maintained, and calibrated?			
7. Do job procedure task cards specify the use of visual tools, such as flashlights, calipers, micrometers, rulers, and magnifying devices when required?			
8. Do inspectors have proper training for the instruments they are using?			

Section B: Liquid Penetration Inspections

A liquid penetrant inspection is used to reveal surface breaking cracks in solid, nonporous materials. While both fluorescent and nonfluorescent techniques are available, most aviation applications involve the use of fluorescent penetrants in a bulk process. A liquid penetrant inspection requires a series of steps involving pre-cleaning, application of the penetrant, removal of excess penetrant, application of developer, examination under appropriate light, and post-cleaning, if needed.

	YES/NO	N/A	REMARKS
1. Do written procedures define the penetrant inspection process, including specific targets?			
2. Is the proper light (black light or visible light) used for the penetrant inspection?			
3. Are light intensity readings taken per process specification verification requirements with specific readings recorded, and are they signed for?			
4. Are gauges, thermometers, and timers used to control the process adequate, easily accessible, and utilized?			
5. Are proper dwell times, dry times, and temperatures followed per standard practices detailed in process specifications?			
6. Is the examining area free of interfering debris and *stray* fluorescent materials and white light reflectors?			
7. Are tanks protected from possible contamination?			
8. Are procedures in place to ensure precleaning and postcleaning are performed properly? Have cleaners been trained for proper cleaning techniques?			
9. Is the correct penetrant sensitivity being used per job procedure cards?			
10. Are test panels used to verify system performance? Have the test panels been cleaned and checked for contamination?			
11. Is the penetrant solution compared to a standard for brilliance and color or sent for chemical analysis per manufacturers recommendations?			
12. If dry developer is used, is it dry, fluffy, and free of fluorescence?			
13. Are process controls in place for each step of the procedure, and are they checked at regular intervals?			

Section C: Magnetic Particle Inspections

A magnetic particle inspection is used to find surface and near-surface defects in ferromagnetic materials. Fluorescent and nonfluorescent, wet and dry methods are available. However, most aviation applications involve using the wet fluorescent method in a batch processing system, which is the most sensitive. Parts are usually magnetized in at least two directions at right angles to each other, and demagnetization of the part is required.

	YES/NO	N/A	REMARKS
1. Is the correct light type (visible or black light) used with intensity values checked and recorded per standard practices?			
2. Are reference standards available and used to measure magnetic field strength?			
3. Do procedures specify demagnetization of the part, and are the parts checked with a field meter?			
4. Is the examining area free of interfering debris and *stray* fluorescent materials, including white light reflectors?			
5. Are appropriate maintenance procedures for the inspection equipment followed as recommended in the equipment manuals or as required by the facility's calibration program?			
6. Is bath concentration measured using established procedures and results documented? Is suspension checked for contamination at established intervals?			
7. Can the magnetization equipment obtain the required amperage specified by the procedures?			
8. Is the equipment capable of adequately demagnetizing the part?			
9. Is there a documented cleaning process to be followed prior to inspection?			
10. After processing, are parts cleaned to remove evidence of magnetic substances?			

Section D: Eddy Current Inspections

An eddy current inspection is used to find surface and near-surface defects in conductive materials. The aviation industry uses these inspections to detect certain defects (e.g., cracks, corrosion damage), verify thickness, and determine material characterization, such as metal sorting and heat treatment verification. The range of applications includes fuselage and structural inspection, engines, landing gear, and wheels. An eddy current inspection, which is the technique most often used after a visual inspection, involves intensive setup and calibration procedures with known reference standards of the same material as the part. Probes of appropriate design and frequency must be used.

	YES/NO	N/A	REMARKS
1. Are appropriate probes and instrumentation being used as called for in the written procedure?			
2. Are appropriate procedures being followed to set up the instrument using reference standards as required by the written procedure?			
3. Are recommended templates and guides being used?			
4. If protective tape is used during the inspection, is it also used during setup and calibration?			
5. Do qualified personnel have proper documented training for the instrument/equipment they are using (e.g., phased array, scanners)?			
6. Does the written procedure spell out frequency, probe type, scanning speed, and scanning direction?			
7. Does the written procedure spell out accept/reject criteria as well as calibration criteria for reference standard calibration?			
8. Are reference standards traceable to required blueprints and specifications?			

Section E: Ultrasonic Inspections

An ultrasonic inspection involves high-frequency sound waves from a transmitting transducer (single or multiple element) being transmitted into or onto the surface of a part to interrogate the material. The sound waves travel on or through the material, then return to either the same transducer or a different transducer. An ultrasonic instrument displays the input and return signals. Differences between the input and output signals are analyzed to determine the flaws, defects, changes in thickness, and other material characteristics. The received signals are compared to the signals of a reference standard. Usually a couplant is used between the transducer and material.

	YES/NO	N/A	REMARKS
1. Are appropriate transducers and couplants being used as called for in the written procedure?			
2. Are recommended maintenance and instrument calibration procedures being followed?			
3. Are recommended templates and guides being used?			
4. Are procedures in place to ensure glycerin is *not* used on aluminum materials, as it causes corrosion?			
5. Do qualified personnel have proper documented training for the instrument/equipment (e.g., phased array, scanners) that they use?			
6. Does the written procedure spell out frequency, transducer type, scanning speed, and scanning direction?			
7. Does the written procedure spell out accept/reject criteria as well as calibration criteria for reference standard calibration?			
8. Are reference standards traceable to required blueprints and specifications?			

Section F: Radiographic Inspections

Radiographic inspections use radiation energy to detect variations in x-ray attenuation in the object under inspection and can detect inclusions, voids, cracks, and changes in geometry or material properties. The aviation industry typically uses two types of radiation energy: x-rays and gamma rays. X-rays are produced by electronic generators, while gamma rays are produced by isotope sources. Radiographic inspections can be used to inspect most materials for both surface and internal flaws, but the orientation of the flaw and source is critical.

	YES/NO	N/A	REMARKS
1. Do written procedures define the x-ray inspection process, including specific equipment?			
2. Are required film types and other detectors available and properly handled and stored?			
3. Are procedures in place to ensure that recommended source to film/detector distances?			
4. Are procedures in place to ensure proper alignment of the x-ray generator with respect to the part being inspected?			
5. Are procedures in place to ensure that film processing chemicals and film are properly stored and used?			
6. Are adequate darkroom facilities available, and are they properly maintained and clean?			
7. Do job procedure task cards specify accept/reject criteria?			
8. Is there a program in place to monitor radiation exposure (film badges, dosimeters, survey meters)?			
9. Is film viewing equipment in good working condition with background illumination controllable to a maximum of 2.5 foot-candles of ambient light for reading films?			
10. Are films properly identified with date, location, aircraft, and component information?			