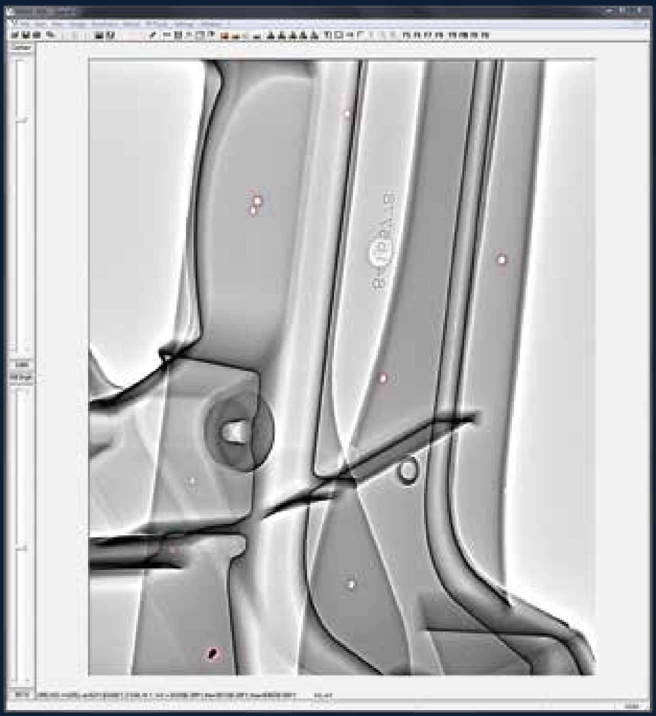
YXLON



WHITE PAPER

X-Ray and CT Automation Advances Make Aerospace Inspection Easier

What you will learn in this paper:

- Non-destructive testing in conformity with ASTM, MAI, DICONDE, and Nadcap
- Automatic Defect Recognition (ADR) for safety and reliability
- Comprehensive data collection and archiving of each inspected part
- Time savings, yield enhancement, and process optimization – ultimate efficiency

X-Ray and CT Automation Advances Make Aerospace Inspection Easier

Standards and regulations rule the Aerospace industry. Inspections and reviews are crucial to passenger and flight safety, but compliance with these standards can become time consuming and expensive. Advances in technology put more pressure on the inspection process. Luckily, technological advances also benefit the inspection systems, namely x-ray and computed tomography (CT) systems, by making processes faster and more cost effective.

Newer x-ray and CT inspection systems can automate many of the inspection standards that engineers must comply with during the inspection of aerospace products. A compliant system should be capable of automation for calculating and producing statistical reports, as well as for the general workload inspection. Based upon the programmed thresholds, the inspection system can alert inspectors or supervisors if too many parts fall outside of the range.

In addition, the inspection systems offer higher quality images and cut down on review and decision time for engineers…or removes manual decision making altogether by utilizing automated defect recognition (ADR). ADR not only speeds up the inspection process, but automatically stores the data recorded for each part. This is helping to push the modernization to digital radiography as the database doesn't require a warehouse for the storage of conventional radiographs and there is no degradation of the files.

This white paper focuses on how the advances in x-ray and CT automation are benefitting aerospace engineers, design engineers, mechanical engineers, operators and quality control engineers with increased flexibility, improved image quality, better reporting and data storage capabilities. All of these are helping to make their inspections easier and more effective.

During the creation of an instructional video now available, the YXLON MU60 AE is shown to inspect a large and intricate automotive cast part placed inside the system by automatic loading. (Note the doorway has dual control operation and an automatic light curtain for operational safety.)

An example of a cast part which the system can inspect following an automated inspection procedure

Automated System Requirements Compliance

As mentioned above, the Aerospace industry requires compliance with standards and regulations. This is key to the safety of the aircraft passengers. One of the main ASTM (formerly known as American Society for Testing and Materials) requirements that affect x-ray and CT inspection is DICONDE (Digital Imaging and Communications in Non-Destructive Evaluation). This standard abbreviation is in place to make all image data (including any tags such as inspector, x-ray parameters, and even geo-positioning) available and able to be displayed on imaging/analysis devices. It also includes the provisions that images be stored for reference in a viewable format.

Given the industry standards must be met and that significant amounts of time go into manually setting up and making the required calculations, some inspection systems are able to automate the process. The system integrates a default program shell for the manufacturer to define the specifications and thresholds. The system can then calculate and automatically report on the statistics. This saves the engineer time from having to do it manually in order to qualify their work.

For example, if a project requires a plate of a certain thickness, another plate with double the thickness, and multiple gauges; the system can automatically take images of the plates and produce a statistical report including signal-to-noise ratios, contrast sensitivity, spatial resolution, etc.

There are controlled processes in place to verify the image quality. Some manufacturers will proof the image quality at the start of their shift and again at the end (with any other prescribed intervals also available). If the quality of both tests match, it can be reasonably assumed everything in between has the same quality.

Another controlled process example is an automated system validation. The engineer sets up the test specifications and runs the following baseline performance tests:

Offset level evaluation: Determines whether the detector is responding within the specified range with x-rays off

Lag test: Analyzes detector exposure and ensures that image lag (also known as ghosting) will not affect imaging performance

Burn-in test: A longer term test to ensure the detector does not have residual image lag issues

Spatial resolution test: The manipulator sets the prescribed geometric magnification, and the line profile is placed automatically for Duplex Wire IQI (E2002) analysis

Contrast sensitivity test: ASTM E1025 IQI holes are evaluated; image registration is performed to detect the holes for thin and thick materials

Signal-to-noise ratio test: Measures signal-to-noise ratio at the predefined areas in both material thicknesses of the duplex phantom

Bad pixel report form: This report indicates the total number of pixel clusters and bad lines as well as the size and position of the indications; after entering the limits, the status is processed automatically

System test results form: The test results form (also generated as a pdf) is defined in the ASTM E2737 and contains all measured parameters describing core image quality, material thickness range, and detector degradation.

Flexible Programming

Advances in x-ray and CT automation systems allow for more flexible programming features. It is possible to run standard inspections, mixed program inspections, and CT inspections for 3D inspecting. The accuracy and repeatability of the imaging can equal fully robotic systems while maintaining maximum flexibility for other uses. These systems also keep statistics on the inspection failures to track issues and manufacturing trends that might not have been caught before.

The operator can live view the part as it moves through a series of programmed views without any operator interaction once programmed.

The imaging process has also been updated in the way the part is positioned and the images are taken. Rather than using a robotic arm, the system automatically shifts the part, as well x-ray tube and detector positions to get the images required. In many cases, this allows for multiple part fixturing, imaging of multiple parts at one time (for small part examination), or the complete inspection of very heavy or over-sized parts. This covers most applications, but the ability to use the robotic arm is still present for specific requirements.

Improved Image Quality

Brilliant image quality is essential, especially for the rigorous demands of aerospace. When it comes to safety-critical and structural cast part testing, the right tools make a big difference. A 16-bit detector with premium pixel quality and a Variofocus x-ray tube are among the most powerful tools available. Whichever detector and x-ray tube are selected, the goal is to ensure reaching the optimal values for the focal spot size, detector resolution, magnification, and required inspection speeds.

Beyond selecting the high-quality components, the operator needs to understand how they work together. Since this can require a particular level of experience and training, it is best if the system can automatically adjust to predetermined values that are recommended for the given application.

The image acquisition parameters must be adjusted for the unique inspection task. This includes adjusting for imaging speed, radiographic contrast, and gray value ranges. It would also need an assessment of the part geometry in the image so the system can make the right decision about the part. Since the imaging typically occurs far faster than a single operator could review, the system applies the programmed settings, takes the images at specific programmed locations, and then feeds the images to a separate machine for offline review. If desired, the engineer can instead choose to review images and positions as they are acquired. The system can also be run so it pauses at each position, as well as be run manually to provide interaction with the system (rotating, tilting, etc.) to acquire views that will be eventually programmed or to manually inspect the part.

Automatic Defect Recognition

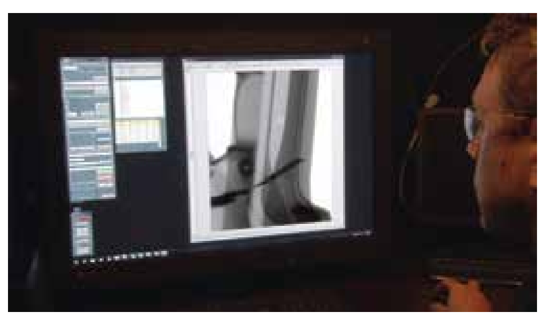
Automatic Defect Recognition (ADR) in industrial x-ray applications allows the ability to automate the pass/fail decisions on individual parts based on system settings programmed by a quality engineer. These systems are designed to enable repeatable, reliable, documented results independent of human inspection error.

The ADR software makes it easier to detect defects difficult to see with older techniques. With the appropriate software tools, systems can help inspectors find, characterize, and disposition anomalies. There are two applications of ADR, automatic and assisted. With full Automatic Defect Recognition, the system takes the image from the machine and makes a decision based on the programmed specifications, such as flaw sizes and number of flaws in a certain area. In this case, the software will judge the part and present a final result. The Assisted ADR takes a step in between. It does the same processing, but instead of just presenting the final result, it presents the image complete with markings of potential defects. Based on the preselection of defects, the operator makes the pass/fail decision. In some cases, the specifications may dictate the part is inspected by a certified inspector. The Assisted application of ADR speeds up the judgment time in this case.

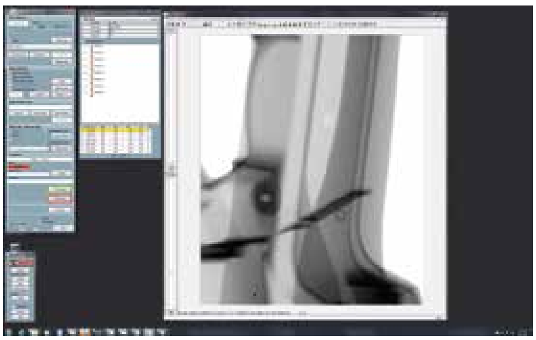
During the part scanning process, the images are sent to an offline work station allowing the engineer to analyze results and parameters separately while the system is in operating mode. The engineer can:

- Pull data of the part for each view
- View part defects, including the ability to view an entire list
- View the physical measurement to identify the size of the defect
- Enhance the image for manual inspection
- Visually inspect the part in conjunction with ADR
- View individually or with another for assisted, double scrutiny

However, ADR is a holistic approach that involves more than just a sophisticated processing of images. From manipulation and infrastructure to greater learning and adaptation, ADR gives managers and operators the tools they need to make intelligent adjustments. These critical adaptations improve their learning, reduce production cycle time, improve quality, and contribute to statistical process control (SPC) programs.



An operator reviews ADR results, choosing the part data and looking at images taken to see the individual defects provided with physical measurement, determining if they meet pass/fail criteria.



The benefits of ADR affect both the efficiency and profitability of the business. ADR provides more accurate, reliable and repeatable evaluations, and it increases the speed of inspection. It helps to reduce the operator's workload, scrap or wasted parts, and enhances the security of parts produced. In addition, the data is automatically added to the database. ADR software classifies flaws by categories and types to track the statistics to identify any trending issues. Example issues include:

- Single flaw
- Flaw distance
- Flaw density
- Porosity
- String flaw
- Inclusion
- Shrinkage
- Gas holes

This data helps the manufacturer improve how the parts are made. Without ADR, it is much harder to identify statistical trends. With manual systems, operators would have to examine several images and markings which would be difficult to aggregate. This data also can help identify if the manufacturer needs to repair or replace equipment or part molds/forms due to wear or system degradation.

One of the inspection issues, especially for manual inspection, is parts that show as failing but actually are compliant. ADR software helps avoid this. The failed parts are proven through the customers' specific settings, the before and after tests, and the series of ADR tests. Additionally, there is usually a 30-day test run to get statistical data tracking that would identify if results start to trend in a way which would indicate a problem. Some organizations use a remotely stationed operator to review all suspect images at a networked PC and eliminate any false rejects.

Digital Database Advantages

Most aerospace companies require part images be stored for a specific number of years. The requirement is generally based on the lifetime of the part and can be anywhere from five to 30+ years. Most companies are transitioning to digital databases from film. Below are key disadvantages of film:

- Film cataloged and stored in warehouses degrades to the point of becoming unreadable
- Film stored in warehouses can be lost due to disasters including flood, earthquake, fire, and more
- It is more expensive and takes longer to share the data with other manufacturing sites and engineers around the world which can cause tasks to be duplicated

In addition to programming a chain of images, advanced x-ray and CT automation systems allow integration into networking. Storing the images on a network server keeps a database of all the information associated with the part:

- X-ray settings used
- Detector settings used
- Inspection and creation dates
- Pass/ Fail criteria
- Double scrutiny results

and many more inspection criteria parameters

Another big advantage of digital networks is that systems are backed up with separate storage protocols and maintained by IT professionals. And, as mentioned earlier, DICONDE compliance ensures ease of viewing the data in the near and distant future.

YXLON MU60 AE System
In an industry in which safety is such a critical component, x-ray and CT inspection advances need to make the inspection process easier, faster and more cost effective.

YXLON's MU60 AE X-ray system with ADR does just that by helping its users achieve excellent results through an automated process which speeds up the testing and streamlines the pass/fail judgment process. This system is scalable and covers the widest variety of sizes and materials.
The YXLON MU60 AE X-ray system meets all relevant ASTM standards and MAI guidelines, is DICONDE compliant, and supports Nadcap certification with tools such as automatic system tests per ASTM E2737.

With so much required of aerospace and automotive engineers and manufacturers, the time and cost savings of the automated system allows their process to move faster. The ease with which they can save, access, view, and share part images and data also saves time making the whole operation more efficient and cost effective.

YXLON International designs and produces radioscopic and CT inspection systems for a broad variety of industrial applications. Whether in the aerospace, automotive, foundries, or electronics industries, our customers are among the largest manufacturers in the world – major enterprises that place their confidence in our outstanding products and services. Visit www.yxlon.com.

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