# Computed Tomography (CT) – for failure analysis of Delay Pyro

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## Abstract

Aerospace industry has several mission critical components of complex shape and size that are manufactured to meet functional requirements and flight worthiness. Delay pyro is one such mission critical component of single shot application device, whose failure can jeopardize the mission. The paper discusses how Computed Tomography (CT) has assisted over X-ray Radiography to assess the cause of failure in Delay pyro. In view of this, we studied the changes in internal configuration of failed, used (successfully tested) and unused delay pyros using CT and Radiography, results were compared for assessing the cause of failure. Tomogram of failed pyro revealed absence of resistor wire, whereas corresponding radiograph did not reveal the same. Thus Tomogram of failed pyro revealed the absence of resistor wire that lead to non-ignition of explosive material that inferred as the cause of failure, whereas Radiography has not detected the same as overlaying structurewas superimposed with this feature. Thus CT has an edge over Radiography and emerged as anindispensable NDE tool in failure analysis of delay pyros.

**Keywords:**Delay pyro, Computed Tomography**,** Radiography, Resistor wire, Explosive material

## 1. Introduction

Aerospace industry has several mission critical components of complex shape and size that are manufactured to meet functional requirements and flight worthiness. Delaypyro is one such mission critical component of single shot application device, whose failure can jeopardize the mission either by non-performing or mal-functioningdue to its individual constituents.

Non Destructive Evaluation (NDE) deals with the evaluation of structural integrity of hardware without affecting its functionality and useful lifetime.X-ray Radiography is one such method extensively used in evaluating the internal details of an object under test. However, Radiography compresses 3D information of an object into a 2D image due to which the internal details get overlapped that hinders to obtain the details of features of interest. This may result in as drawback at times. Further, the features in the path of X-rays are difficult to obtain.

Computed Tomography (CT) generates a thin cross-sectional (slice) image of an object and the image represents point-by-point distribution of linear attenuation coefficients of the object. CT images are free from overlying and underlying areas of the object and are highly sensitive to small density differences (<1%) between structures[1]. 3D information of an object can be obtained by stacking the slices one over the other in case of linear detector array or by using flat panel array detector with proper reconstruction algorithm.These 3D images can be viewed for extent of internal features in three dimensions.

The paper discusses how Computed Tomography (CT) has assisted over X-ray Radiography to assess the cause of failure in Delay pyro. In view of this, we studied the changes in internal configuration of delay pyros of failed, used (successfully tested) and unused delay pyros using CT and RT, resultswere compared for assessing the cause of failure.

## 2. Experimental Procedure

RT and CT were carried out on Delay pyros. RTwas carried using film Radiography, whereas CT was done using DRDL’s indigenously developed X-ray Industrial Computed Tomography (ICT) system. The ICT system consists of a 450 kV X-ray source, 256-channel detector array with 18 bit dynamic range and a 6-axes mechanical object manipulator [2]. The resolution of CT system is 500 µm with 1 mm slice thickness.

## 3. Results and Discussion

Fig 1 (a): Photos of used, Unused, failed delay pyros

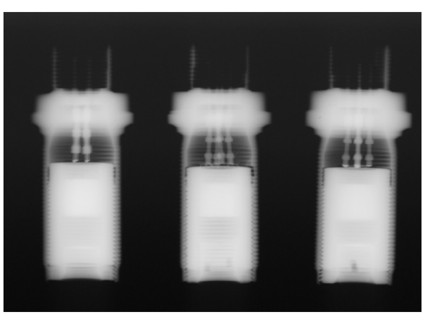

Fig 1(b): Radiographs of used, unused, failed delay pyros

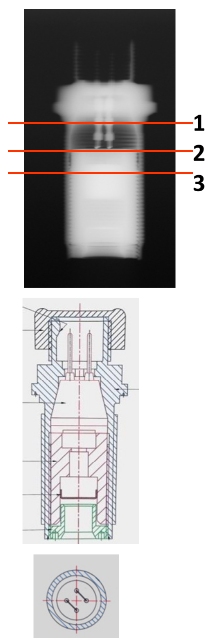


Fig: 1(c): Delay pyro Drawing and locations where Tomograms taken

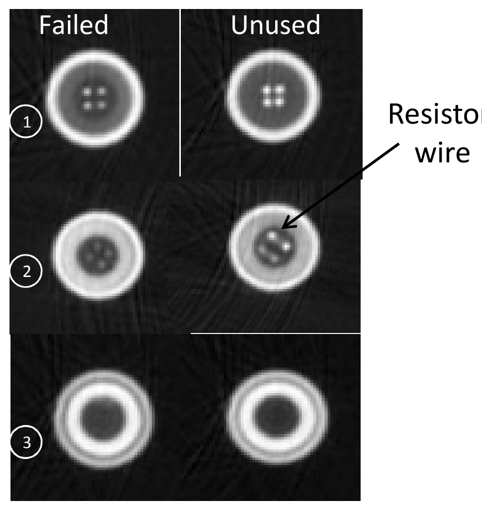


Fig 1(d):Tomograms of delay pyros revealed absence of resister wires In failed pyro against unused

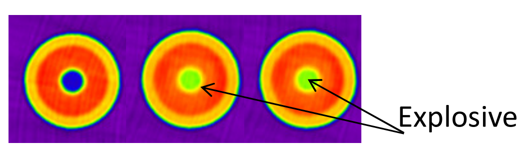


Fig 1(e): Pseudo color Tomogram revealed absence of explosive in used pyro

Fig. 1 (a) shows the photo Delay Pyros of used (successfully tested), unused and failed. Fig. 1 (b) shows the Radiographs of used, failed and unused pyros, Fig. 1 (c) shows pyro drawing and the locations where Tomograms taken, Fig. 1 (d) shows the absence of resistor wires in Tomograms of failed pyro, whereas presence of resistor wires in unused delay pyros. Fig. 1 (e) shows the absence of explosive material in fired, whereas presence of explosive material in failed and unused pyros.

To identify the cause of failure, CT images of failed device are compared before and after firing. The firing is successful as Delay pyro ignites the explosive charge. The presence of explosive in the failed pyro indicated that no ignition has taken place. CT revealed the presence of resistor wires before and after firing in the respective Tomograms of used (successfully tested) and unused pyros, whereas Tomogram of the failed pyro revealed absence of resistor wire at the respective location. Thus Tomogram of failed pyro revealed the absence of resistor wire that lead to non-ignition of explosive material that inferred as the cause of failure, whereas Radiography has not detected the same as overlaying structure of pyro was superimposed with this feature. On the other hand, CT could provide the slice by slice internal mapping of the failed device, by comparing with its original CAD design, detected the missing of resistor wires that lead to the malfunctioning of the device. Thus CT has eliminated the ambiguity in identifying the cause of failure over Radiography.

As is evident from above, the evaluation of Aerospace components is a challenging task due to its complex shapes and its stringent quality requirements to be met. Hence, conventional NDE methods such as Radiography alone are not sufficient to qualify the critical Aerospace components. Thus CT has eliminated the ambiguity in identifying the cause of failure over Radiography. Therefore CT has an edge over Radiography and emerged as anindispensable NDE tool in failure analysis of delay pyros.

## 4. Conclusion

Tomogram of failed pyro revealed the absence of resistor wire that lead to non-ignition of explosive material that inferred as the cause of failure, whereas Radiography has not detected the same. Thus CT has an edge over Radiography and emerged as anindispensable NDE tool in failure analysis of delay pyros, being mission critical Aerospace components.

## 5. References

[1] Michael J. Dennis, in ASM Handbook Vol. 17, “Non-Destructive Evaluation and Quality Control”, ASM International (1997) 754-811.

[2] C. Muralidhar, G.V. Siva Rao, K. Kumaran, M.P. Subramanian, M.R. Vijaya Lakshmi, Sijo N. Lukose and M Venkata Reddy “Industrial Computed Tomography (ICT) System - An Indigenous development” Proc. of National workshop on Applications of Computer Aided Tomography, India( 2004) 2-13.