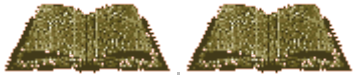
ANIL AGGRAWAL'S
Internet Journal of Forensic Medicine and Toxicology
The world's first online journal devoted entirely to forensic medicine and toxicology · Published 1 January and 1 July

VOL. 2, NO. 2
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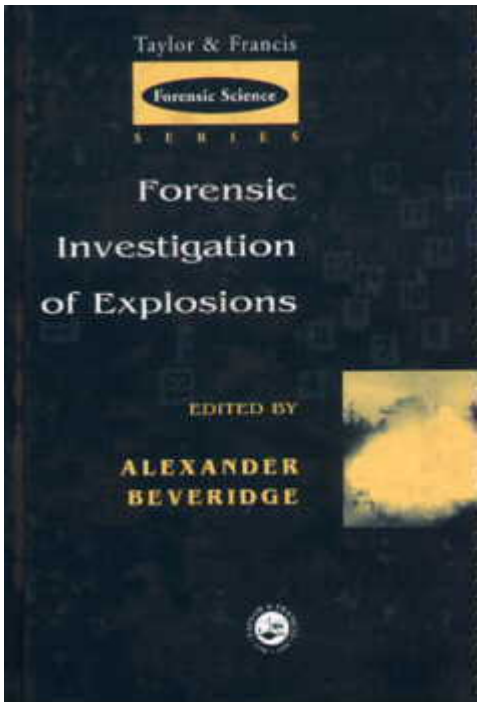
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## A USEFUL GUIDE FOR EXPLOSION INVESTIGATION

Forensic Investigation of Explosions, 1st Edition *edited by* Alexander Beveridge, Hard Bound, 246x174 mm.
(A Book from Taylor & Francis Forensic Science Series edited by James Robertson)
Taylor & Francis, 11 New Fetter Lane, London EC4P 4EE; . ; 496 pages; illus. 100 b+w line drawings and photos: ISBN 0-7484-0565-8. Publication Date March 1998: Price, £95.00.

**Click cover to buy from Amazon**




Alexander Beveridge

Sandy Beveridge, the editor of this book, is the Head of the Chemistry Section of the Vancouver Laboratory of the Canadian Mounted Police Forensic Science Laboratories. His primary research interest is in explosive residue analysis and he has testified, published and lectured extensively on the subject.

Let us start with some trivia. What is common between these dates - June 23, 1985, December 21, 1988, April 19, 1989, February 23, 1993 and April 19, 1995? If you have ever been associated with explosive investigation, you would have no trouble answering this question. On all these dates, a terrible explosion occurred somewhere - in aeroplanes, skyscrapers, even ships - causing the death of several people. At least four of these incidents were criminal in nature.

On June 23, 1985, Air India Flight 182, a Boeing 747 aircraft, blew up at an altitude of 31,000 feet over the south-west tip of Ireland, killing all 329 aboard including 60 children under the age of 10. Someone had checked in powerful explosives in the luggage compartment of the huge airliner, and had cunningly timed it to explode when it was over the Atlantic, making the recovery of clues difficult or even impossible. This is one of the worst ever examples of an explosion disaster that we in India remember. An hour earlier to this disaster, an attempt to sabotage Air India Flight 301 out of Tokyo failed when a bag bomb blew up at the New Tokyo Airport at Narita, Japan, killing two baggage handlers and maiming four. Although the perpetrators of this heinous crime had made work difficult for investigators, careful and meticulous investigation did bring the culprits to the book albeit 15 years later. But thanks to forensic science, it did happen.

What happened on rest of the dates? On April 19, 1989 an unexplained explosion occurred on USS Iowa killing 47 seamen; on December 21, 1988, a Pan American Boeing 747 exploded over northern England and Scotland killing not only all 259 people aboard, but also 11 more on the ground; on February 23, 1993, an explosion occurred in the basement of the northernmost tower of New York's World Trade Center killing 6 people, and on April 19, 1995 a similar incident occurred in Alfred P. Murrah Federal Building in Oklahoma City, Oklahoma, killing 168 people. Barring the USS Iowa

incident, all the other incidents were criminal in nature. Even in the USS Iowa case, it was initially believed that there was a deliberate attempt at sabotage, but later on a detailed forensic investigation revealed that the incident was the result of an accident.

**A full listing of the Contents of *Forensic Investigation of Explosions***

**Table of contents**

**1.** The History, Development, and Characteristics of Explosives and Propellants
**2.** Physics of Explosion Hazards
**3.** Detection of Hidden Explosives
**4.** General Protocols at the Scene of an Explosion
**5.** Recovery of Material from the scene of an explosion and its subsequent Forensic Laboratory Examination - A Team Approach
**6.** Aircraft Explosive Sabotage Investigation
**7.** Investigation of Gas Phase Exploison in Buildings
**8.** Chromatography of Explosives
**9.** Analysis of Explosives by Infrared Spectrometry and Mass Spectrometry
**10.**Quality control in the Detection and Identification of Traces of Organic High Explosives
**11.**Analysis of Low Explosives
**12.**The Significance of Analytical Results in Explosive Investigation
**13.**Evidence of Explosive damage to Materials in Air Crash Investigation
**14.**The Use of Vibration Spectrograms in Aircraft Accident Investigation
**15.**Forensic Pathology of Victims of an Explosion
**16.**Presentation of Explosive Casework Evidence

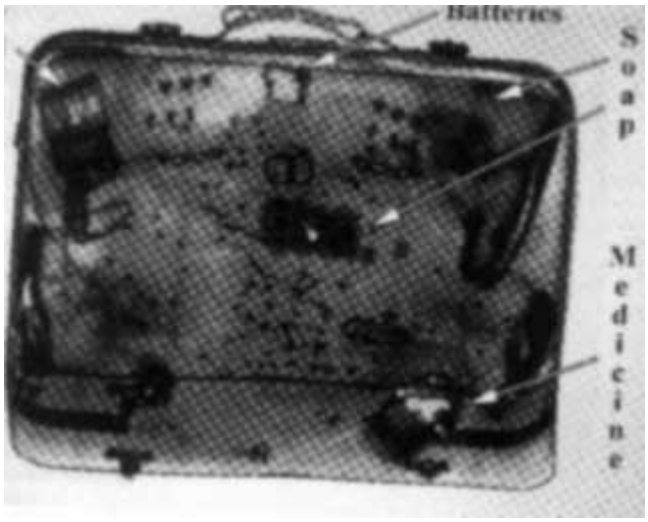
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Whether we like it or not, we, in the modern world, have to live with explosions. How do forensic scientists investigate explosions? How is the relevant evidence from such wreckage retrieved? Which explosives are currently in vogue? What is the chemistry of explosives and how is it exploited in the detection of explosives? Whether a given incident of explosion was criminal in nature, or just accidental? Questions like these - and a host of other questions - are dealt with in this book, which surely is one of the most authoritative books on explosive investigation ever written.

Alexander Beveridge, the editor of this book has roped in a number of experts from several countries (including USA, Canada, UK and Israel) and has asked them to write in their area of expertise. The result is this 16-chapter book, which I found extremely informative.

The sixteen chapters can broadly be classified into eight different headings - explosives (Chapter 1), explosions (Chapter 2), detection of hidden explosives (Chapter 3), processing scenes of explosions (Chapters 4,5,7), forensic chemistry (Chapters 8-12), aircraft sabotage investigation (Chapters 6,13,14), forensic pathology (Chapter 15) and expert testimony (Chapter 16).

**Output from dual energy X-ray system (normal three colors). This device can effectively detects bulk explosives. This diagram appears on page 48 of the book.**

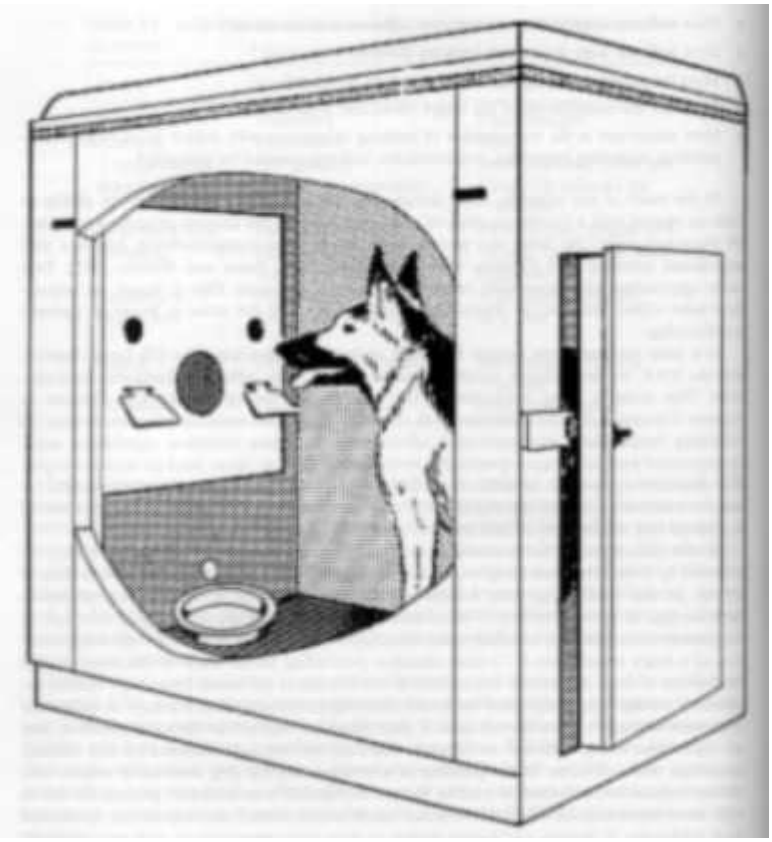



The book begins with a chapter on the history and development of explosives, which sets the stage - so to say - for the rest of the book. Written by Bob Hopler - who incidentally has only recently retired as Corporate Manager of Technical Services with Dyno Nobel Inc., Salt Lake City, Utah, after almost 35 years in the explosive industry - it discusses a range of explosives, including solid propellants, military explosives and commercial explosives. Black powder, which comes in 20 varieties and several sub-varieties, was one of the earliest explosives, but it could not be used as a military explosive because of two main reasons; it gave out a dense black cloud making the position of the attacker very obvious, and after a number of rounds were fired, so much smoke was produced that it resulted in a general chaos and confusion in the very army which was using it. To get round these problems, the so-called "smokeless" powders were developed. Although they are called smokeless, they do produce some, albeit in very minute quantities.

The main military explosives are picric acid, trinitrotoluene (TNT), Tetryl, Pentaerythritol Tetranitrate (PETN), RDX (Research Department Explosive), HMX (High Melting Explosive) and plastic explosives. PBX is an acronym for Plastic Bonded Explosive. These are a fairly recent development in the military area. The author also explains in great detail, the commercial explosives such as Nitroglycerine, Dynamite, Liquid Oxygen Explosives (LOX), Ammonium Nitrate (AN), Ammonium Nitrate/Fuel Oil (ANFO), slurry explosives, emulsion explosives and a host of other explosives.

Chapter 3 is entitled "Detection of Hidden Explosives", and it deals with how forensic scientists detect hidden explosives. A criminal may be trying to check in luggage full of explosives, into an aircraft, and it is vital for law enforcement officials to be able to detect the explosives within a short time, so that undue delay is not caused to the genuine passengers. Explosives generally carried by terrorists are referred to as IED or Improvised Explosive Device.

**Canine testing apparatus. Very useful for detection of trace explosives. This diagram appears on page 60 of the book.**



We are told that there are two broad categories of technological development in this area - bulk and trace. Bulk detection obviously refers to detection of, say, a baggage full of explosives. Trace detection technology, on the other hand detects traces of explosives found sticking on the outside of baggage. This could be due either to contamination or to vapors emanating from the explosive. Both categories of detection employ different technologies. For bulk detection, the general technique is to direct some form of radiation to the suspect material, and then check the outcoming radiation, if it carries the "signatures" of explosives or not. Most often this is done by X-rays or computed tomography. The diagram on the above right illustrates this.

Several techniques are discussed for the detection of trace explosives, not the least interesting of which is the use of sniffer dogs. There are important and interesting sections on dogs vs. instruments, dog training issues, testing of dogs and so on. We are reproducing the "canine testing apparatus" on the above left, so that readers could have an idea, what we are talking about.

The use of taggants is discussed at the end of this chapter.

Taggants are substances, which are more easily identified than the explosive itself, and if addition of taggants to explosives could be made legally necessary, the task of detecting explosives could become lot more simpler. In fact US has passed an Act in 1996 (Antiterrorism Effective Death Penalty Act), under which the US Treasury Department can suggest regulations to tag explosives. Of course the taggants must meet certain criteria: they must substantially assist law enforcement, should not pose a risk to human life or safety, should not impair the quality of explosive for their intended lawful use, should not unduly increase the cost of the explosive and should not adversely affect the environment.

**These four very illustrative photographs appear in chapter 4 of the book entitled "*General Protocols at the Scene of an Explosion*" (i)A grid system surrounding a bombed car (above left) (ii) Narita airport, Japan: bomb scene 1985 (above right) (iii)Individual items, Narita airport bomb**

**scene (below left) and (iv) Measurement of a bomb crater (below right) [Click all photographs to enlarge].**





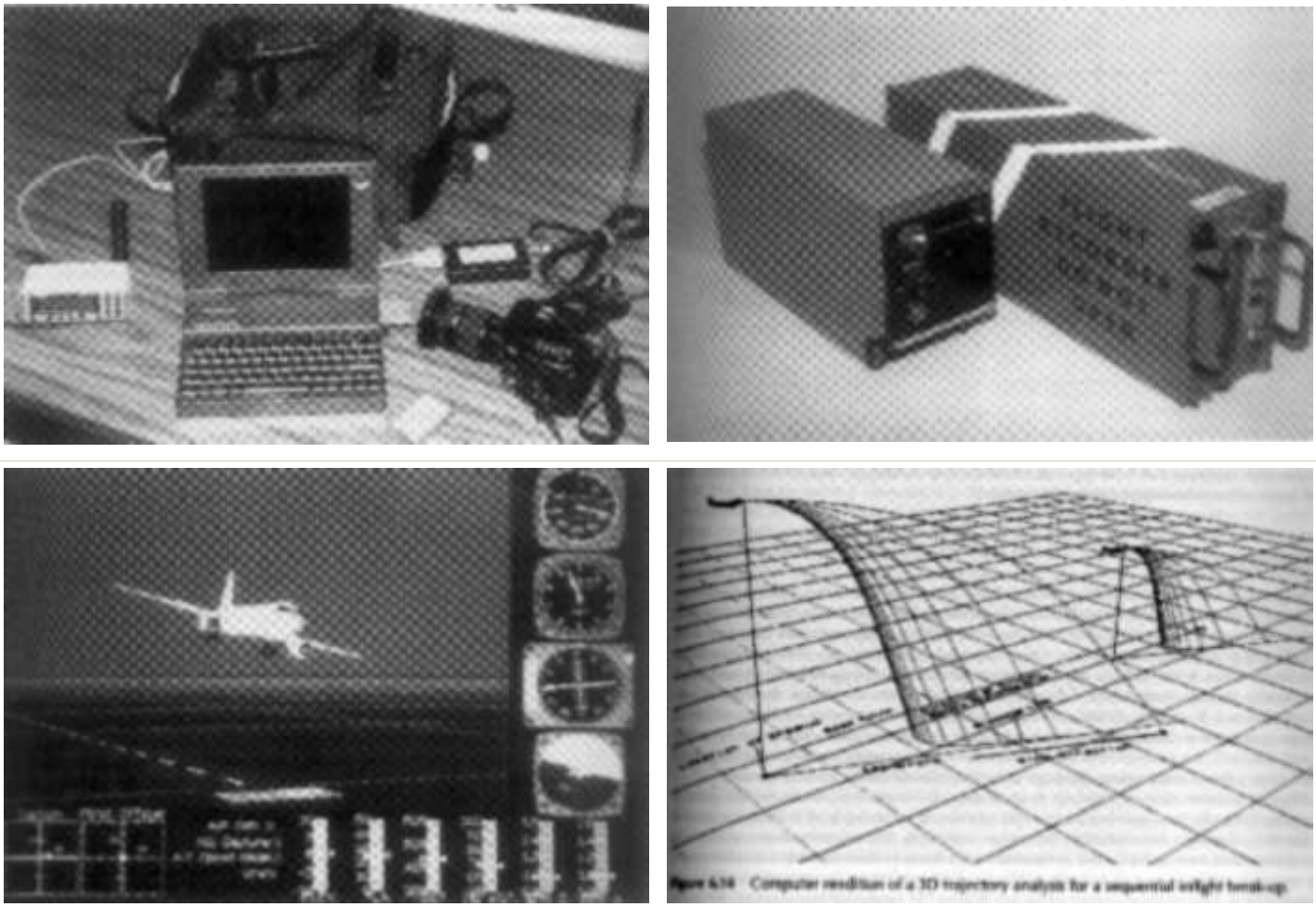

Now even chemical markers are available which assist in post-blast identification. These are based on isotope labeling. Other tagging options as suggested by *The Institute of Makers of Explosives* (IME) are discussed. These include multicolored, multilayered plastic particles, rare-earth elements, isotopically labeled trace components, inert chemicals identifiable by specific antibodies, polymeric microbeads, and slow release microcapsules containing perfluorodimethylcyclohexane or perfluoromethylcyclohexane to enhance detectability.

Chapter 5 deals with the recovery of material from the scene of an explosion. We are told about low and high explosives, their residues and signatures, and how they can be detected. Discovery of a bomber's signatures could be one of the most valuable leads. An interesting example is given of 'UNABOMER' in the United States, who always included the initials 'FC' on an internal component of his devices. Interestingly, the initials were written on those components which could survive the blast and could easily be picked up by the law enforcement authorities! Advanced psychological profiling techniques could be used in such cases to model the personality of the bomber.

One of the most interesting and useful chapters is the sixth entitled "Aircraft Explosive Sabotage Investigation", written by John H. Garstang, a mechanical engineer in the Transportation Safety Board of Canada (TSBC). At the outset he outlines the enormous difficulties encountered in this task. Most modern jetliners cruise at great heights and at great speeds. The height could be anywhere upto 6 miles, and speeds could be upto 575 miles an hour. If we consider that an average airliner is

about 350 tons (200 tons of structure, 100 of fuel, and 50 of cargo and passengers), one can easily imagine what is going to happen if such an aircraft suffered an explosion damage in mid-air.

**These four very illustrative photographs appear in chapter 6 of the book entitled "*Aircraft Explosive Sabotage Investigation*" (i)Portable multimedia GIS system(above left) (ii) Oblique view of a CVR and FDR. There is an underwater acoustic homing beacon, which is clearly visible near the handle of the FDR (above right) (iii)Frame from a computer simulation showing selected data recovered from the FDR (below left) and (iv) Computer rendition of a 3D trajectory analysis for a sequential inflight break-up (below right).**



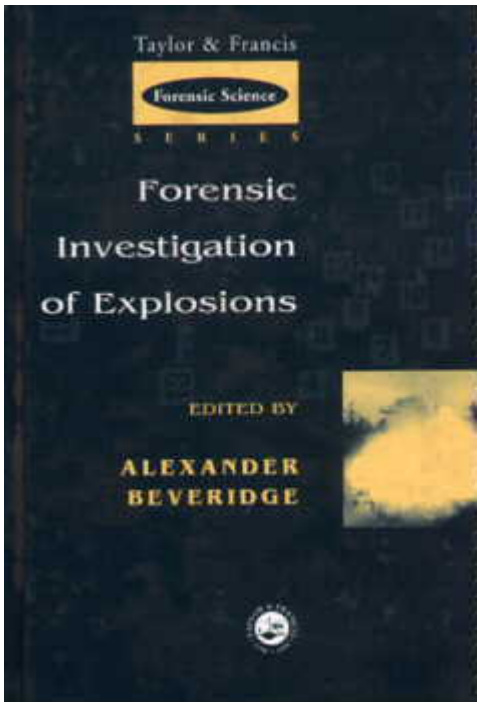
The resulting wreckage could be spread over hundreds of miles, and recovering material of importance may not be a very enviable task for the forensic scientist. The remnants of Pan American Boeing 747, involved in the notorious Lockerbie disaster (which occurred on December 21, 1988), had drifted in two trails of wreckage covering an area of almost a thousand square miles of northern England and part of Scotland! Yet - thanks to modern recovery techniques - the investigators recovered more than 4 million pieces from this vast area, and were able to reconstruct as much as 90% of the airplane's structure.

What are these recovery techniques? The author discusses these as well as a variety of other tools which the investigators may use in such cases. These include electronic office, project management software, Geographic Information System (GIS), remote sensing, photogrammetry, Global Positioning System (GPS), analysis of Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR), trajectory analysis of wreckage, reconstruction of wreckage, post-blast structural analysis and analysis of documents such as luggage tags, shipping labels, cargo manifests and personal effects.

GIS is defined by the United States National Science Foundation as 'a computerized database management system used for the capture, storage, retrieval, analysis and display of spatial data'. The 'Digital Chart of the World' (DCW) is currently available for potential GIS use. It is a 1:1 million scale comprehensive spatial vector database of the world, showing all the surface features of the earth. All the six continental regions are contained on four CD-ROMS having a total capacity of two gigabytes! It is divided into 17 thematic and topographic layers with 31 feature classes. A much more detailed description of GIS and DCW in the book explains how exactly this system can help retrieve and organize data.

Global Positioning system (GPS) enables the investigators to locate the exact co-ordinates of the wreckage. It is a satellite based system, and is very nicely explained in the chapter. Readers wanting to know more about GPS can refer to completely dedicated books on GPS. This journal has already reviewed one such book in this very issue.

**QUICK NOTES**




Some major highlights of *Forensic Investigations of Explosions* at a glance:

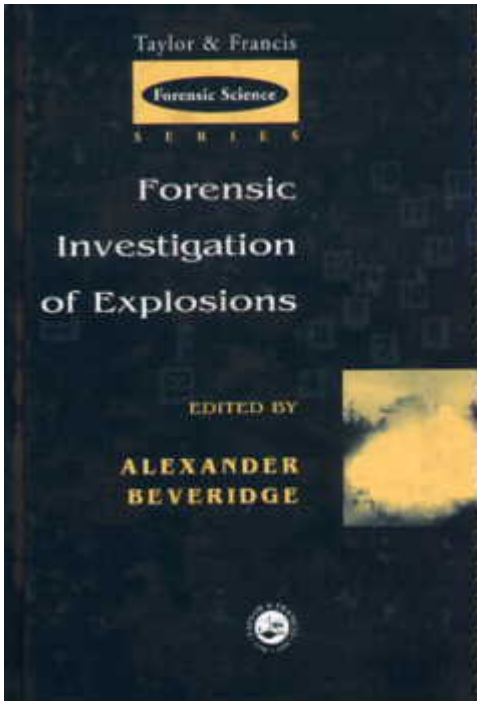
& Definitive multidisciplinary reference.
& Each chapter written by an expert in his own field of expertise.
& Richly illustrated.
& Comprehensive coverage of physics and chemistry of explosions.
& Reasonably priced so that everyone can have his or her own copy.
& Technical jargon kept at a minimum, so should be useful to even beginners trying to explore this relatively virgin field.
& Presentation of expert testimony discussed in great detail - a feature often missing in other books of similar nature.

Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR) are so well-known these days that even lay persons have some knowledge about them. These devices are designed to record and

preserve key information about the operation of the aircraft should an accident occur. These recordings are also useful after a criminal act. These devices are so designed that they could be recovered even when they have gone miles down in bodies of water such as oceans. Equipped with radio and sonar transponders, they can be traced with suitable detection apparatus.

What is interesting, and was not known to me earlier, was that the CVR can also be used to pick up vibrations, which can be of further help in investigation. Chapter 14 entitled "The use of vibration spectrograms in Aircraft Accident Investigation" enlarges on that. This chapter is written by Frank Slingerland, a mechanical engineer, who has recently retired as Director of the Aeroacoustics Facility at the National Research Council of Canada. This new method has been developed by him, and he has reportedly been using it since 1985. Vibration spectrograms aim at analyzing fuselage vibration data from which the damaging event can be identified and located. The interesting thing is that CAM (Cockpit Area Microphone) is never designed to record this additional data. It is designed merely to hear the airborne sound of speech by the aircrew. It is usually mounted on the 'eyebrow' panel above the crew's heads. However when an explosion occurs, the fuselage vibrates in a radial direction. CAM is so sensitive that it can record a vibration as mild as that caused by a hand-slap on the fuselage. In contrast, even bomb explosions and tire bursts may not be heard by the aircrew above the ambient noise. I found this chapter particular useful, not only because it is so well-written, but also because it describes a new technique in plain and simple language, and we can all make use of this technique.

How would I rate this book? In one word - 'outstanding'. Undoubtedly it is a very valuable addition to the extant literature on explosion investigation. The book is useful not only for experts working in the field of explosion investigation, but also for post-graduate students studying to get a degree in Forensic medicine, forensic pathology, explosion investigation and so on. It explains a number of concepts related to explosives in a relatively easy and simple-to-understand manner.




***Contrary to popular belief, Cockpit Voice Recorders are not only useful for picking up the chattings of the aircrew. It can accomplish much more. Among other things, it can pick up***

***vibrations emanating from explosions. This data can be very useful in explosion investigation.***

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Take for instance the case of low and high explosives. I have seen that a number of my post-graduate students are quite vague about a proper conception of these terms. This book has a full chapter on low explosives (chapter 11, pages 343-388), but before that - on page 107 - the book explains what these are. If in a particular explosive, the reaction front proceeds through the unexploded material at velocities less than the speed of sound, it is termed as a low explosive; if it proceeds at greater velocities, it is a high explosive. Low explosives need to be confined, in order to produce a reasonably strong explosion. Most often it is done in a metal pipe and such bombs popularly go by the name "pipe bomb". High explosives don't need to be confined. Typical low explosive is black powder, while RDX is the typical example of a high explosive. Post-graduate students are going to love these explanations in such simple language.

The book goes on to explain a lot of such concepts, which are very useful to beginners and experts alike. The book is very richly illustrated with lot of black and white photographs. It is going to be a very valuable addition to my personal forensic library, and I would believe every expert working in the field would find the book as useful and valuable as I have found it.

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