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Tire Forensic Investigation

Analyzing Tire Failure

Thomas R. Giapponi
To my daughter, who inspires me,
and to my wife, who encouraged me,
not only in life, but to actually sit down and write this book.
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Foreword

Tire forensics is the methodical analysis of failed tires in the pursuit of and the identification of the cause(s) or root cause(s) of the disablement of a tire. A combination of science, experience, and some art goes into the research and analysis of a tire failure. By using the laws of physics, math, chemistry, and engineering, mixed with the expert’s real-world tire background and experience in the design, testing, and tire development and manufacturing processes, tire forensic experts determine the most likely events that led up to and caused the tire to fail.

Unlike a forensic pathologist analyzing a body in a criminal case, a failed tire in a civil suit typically is considered evidence that cannot be dissected and destructively analyzed without agreement by all sides. The analysis by the tire expert also may not occur until years later, with a chain of custody that may or may not be tidy and with storage conditions that can be less than optimal. Given these conditions, the forensic tire expert’s background, knowledge, and ability to determine pre-, during, or post-accident damage can be crucial to determining failure causation.

The same sidewall that will cut and tear during a curb scuff event can impact a road hazard to bend the wheel flange backwards and show relatively little damage on the exterior of the tire. It takes a trained eye working in a systematic fashion to find the unusual detail that leads to the root cause contributors to the failure. I say “root cause” because the type of failure should not be the end result of the investigator’s work. It usually is the beginning. The goal of the tire forensic expert is to keep digging backwards, looking for root cause(s) and putting as much of the tire story together as possible.

In this book, I cover the many ways that a tire can fail and how to identify that failure. However, I will not be going into anything but minor depth in several sections on defectively manufactured tires. It is my opinion that an expert tire forensic investigator looking into manufacturing or design defects requires knowledge of not only tire failure mechanics, but also a solid grounding in several areas such as tire manufacturing, tire mechanics, testing, and tire design, as well as some familiarity with quality control parameters. The total range of parameters,
how all the various pieces are supposed to fit and operate together, and what are the correct or incorrect manufacturing details in a tire will contain subtleties and nuances; thus, at times, only experience can dictate the outcome. These subtleties will make each tire its own case with particular circumstances and therefore will be covered only generally here. However, while the tire forensic expert is performing the inspection, he or she must always examine the tire with an open mind, looking for all possibilities of failure modes, including an improperly manufactured tire or a badly designed tire.

The terms "accident sequence," "pre-accident," and "post-accident" are used frequently in this book. Most tire failures do not result in vehicle damage, collisions, rollovers, and so forth. However, litigation-related tire failures tend to involve at least some vehicle damage. By using these terms, I am relating the tire conditions that are seen to the sequence of events after tire disablement, whether or not vehicle damage or an accident has occurred.

In nearly all of the text, I discuss passenger car and light truck tires with two-belt systems. There is passing mention of other belting structures, as well as medium/heavy truck tires. However, when the #1 or #2 belt is mentioned specifically, it is in the context of a two-belt tire.

In this book, when I mention root causes, it is not with the intent to gloss over the fact that, by definition, there cannot be multiple root causes. However, in tire forensics, considering damage factors to the tire during the accident sequence, sullied chains of custody, and other factors, it will not be unusual for the expert to opine that more than one reason caused the tire disablement and to determine that one and only one cause is simply not possible.

This book will not cover the following items:

- An overview of general tire basics or basic tire mechanics is not included. The list of references in Appendix A covers basic tire mechanics in depth. I assume the reader already has a basic understanding of the tire. This book provides the tire expert a compilation of the latest references on various subjects and serves as a reference itself.

- All possibilities of failure combinations or of what can be seen or photographed in the examination of a tire are not included. There can be details that can merge to bring out the correct causation, and at times, that subtle grouping and the nuances that come with it will come from the expert's background.

- The root causes of tire failure can involve chemistry and chemical forensic analysis of the tire. If this kind of analysis and information is required, then
expert advice in those areas should be sought. This type of analysis is beyond the scope of this book.

• The photographs within this book are not in any way meant to cover the range of possibilities of the various appearances of tire forensic examination points. They are examples intended only to help the reader with the discussion topic at hand.

What will be covered in this book are the methodical, physical, visual, and tactile examination of failed tires, a discussion and identification of the various failure modes for passenger car and light truck-type tires, and how to determine some of the past history of a tire. Interspersed among various factors, I will share what general wisdom I have learned in 30 years in the tire industry.

My apologies to anyone who is unfamiliar with the terms used in this book because those terms tend to vary among those of us from different tire backgrounds. Appendix B provides definitions of terms as an aid to readers.

Finally, please read all the footnotes. These important footnotes add information to the text or indicate exceptions; however, they serve only as guide posts and are not meant to be all encompassing in all situations.

Although specific page numbers are listed with the cited references scattered throughout this book, these references provide a great deal of general support and knowledge to tire forensics and tire failure analysis.
Many years ago when I was a young tire engineer, an R&D bias medium/heavy truck tire was on the table for examination. A more senior engineer had already looked at the tire and proclaimed it an over-deflected tire (which it was). The lower sidewall turn-ups for approximately 30 cm (12 in.) lay open, and when I asked why the tire came apart, over-deflection was the answer. I later examined the separated area carefully with a scalpel, peeling away pieces as one would peel an onion. I had found the #1 and #2 turn-ups were folded back onto themselves. Cutting the tire circumferentially in the lower sidewall 360 degrees revealed that while the tire had small turn-up separations at various locations, it had folded back turn-ups only in the blown-out area. This discovery never left me. As an engineer, I find that the enjoyment of determining why something comes apart is the same as building something from scratch.

I hope this book opens the possibility of discovery for you and in a real sense provides the technical background for that discovery.