In the

United States Court of Appeals

For the Seventh Circuit

No. 11-3313

LEONARD LAPSLEY, *et al.*,

Plaintiffs-Appellees,

v.

XTEK, INC.,

Defendant-Appellant.

Appeal from the United States District Court
for the Northern District of Indiana, Hammond Division.
No. 05-CV-00174—**Joseph S. Van Bokkelen**, *Judge.*

ARGUED MAY 23, 2012—DECIDED JULY 27, 2012

Before MANION, ROVNER, and HAMILTON, *Circuit Judges.*

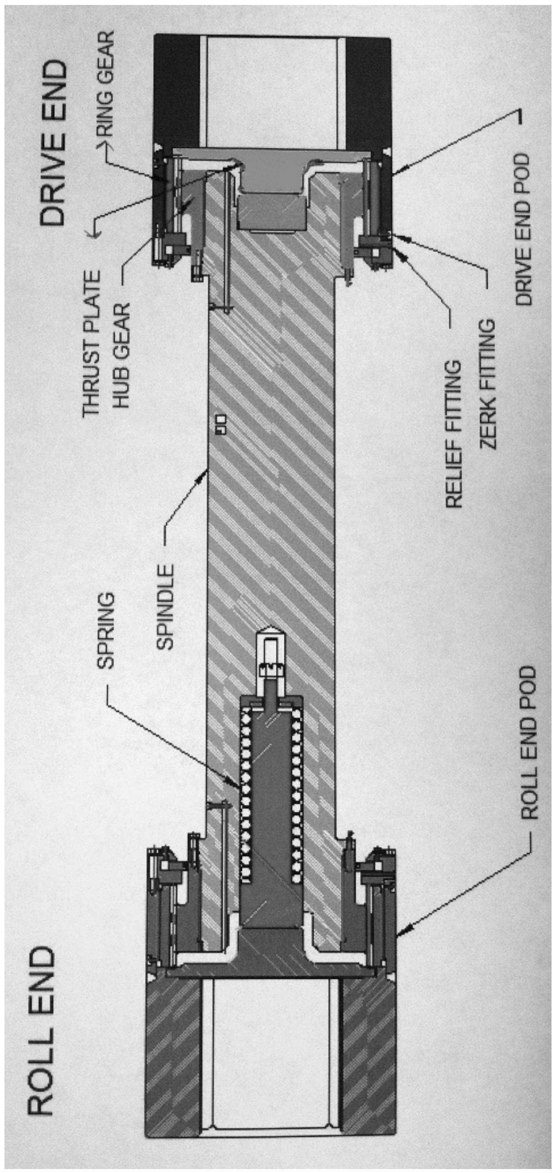
HAMILTON, *Circuit Judge.* This appeal arose from an accident at a steel rolling mill that permanently disabled one of the workers there. The circumstances of that accident were unusual. Industrial grease was propelled in a jet with enough energy to penetrate and pass through the human body like a bullet. That jet hit and disabled plaintiff Leonard Lapsley. At trial the jury found that the accident was caused by a design defect in a heavy industrial product designed and manufactured by defendant Xtek, and sold and installed in the mill. That equipment contained an internal spring that could exert over ten thousand pounds of force. The jury accepted the theory of plaintiffs' expert witness, Dr. Gary Hutter, that the spring was the culprit mechanism behind the accident and that an alternative design of a thrust plate in the equipment would have prevented the disabling accident. Xtek has appealed, challenging the district court's denial of its *Daubert* motion that sought to bar Dr. Hutter from offering his expert opinions, which were essential to the plaintiffs' case.

The purpose of the *Daubert* inquiry is to scrutinize proposed expert witness testimony to determine if it has "the same level of intellectual rigor that characterizes the practice of an expert in the relevant field" so as to be deemed reliable enough to present to a jury. *Kumho Tire Co. v. Carmichael*, 526 U.S. 137, 152 (1999). A *Daubert* inquiry is not designed to have the district judge take the place of the jury to decide ultimate issues of credibility and accuracy. If the proposed expert testimony meets the *Daubert* threshold of relevance and reliability, the accuracy of the actual evidence is to be tested before the jury with the familiar tools of "vigorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof." *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579, 596 (1993). Once the district court has adequately applied the *Daubert* framework, our review of the determination to admit or exclude the evidence is deferential. *E.g., United States v. Lupton*, 620 F.3d 790, 798-99 (7th Cir. 2010) (affirming exclusion of expert testimony); see also *Kumho Tire*, 526 U.S. at 152 (reversing court of appeals decision that failed to accord sufficient discretion to district court that admitted expert testimony). In this case, the district court's stated analysis of the proposed testimony was brief, but it was also directly to the point and was sufficient to trigger deferential review on appeal. We affirm the judgment of the district court.

I. *Factual and Procedural Background*

Plaintiff Leonard Lapsley worked for many years as a millwright at the old Bethlehem Steel works in Burns Harbor, Indiana. On May 19, 2004, Lapsley had just finished filling a large spindle mechanism with industrial strength grease, as he had many times before, using a grease wand of his own manufacture. The grease wand was connected by a hose to a pressurized grease distribution system in the mill. Suddenly, as Lapsley stood near the spindle, a loud "shotgun-like" bang was heard across the mill floor and Lapsley fell to the ground, covered in grease. Co-workers rushed to his aid. He had a hole in his chest and could not breathe properly. Lapsley was taken to the hospital, where it was discovered that grease had somehow been injected into his chest with enough force to break several of his ribs, fill his chest cavity, and even create an exit wound through his back. After eleven surgeries, doctors have been unable to remove all of the grease, some of which has fused with Lapsley's internal tissues. Lapsley survived, but he suffers constant pain so severe that he is unable to return to work or do many activities he once enjoyed. Leonard's wife Barbara also sought damages for the effect the accident has had on their life together.

The steel mill where Lapsley worked uses immense rollers to flatten ingots of hot steel. Those rollers are connected to drive motors by large drive shafts known as spindles. Rather than try to explain the design of a spindle with text alone, we include a diagram taken from Xtek's exhibits at trial:


DRIVE END
RING GEAR
THRUST PLATE
HUB GEAR
SPRING
SPINDLE
RELIEF FITTING
ZERK FITTING
DRIVE END POD
ROLL END POD
ROLL END

The drive end pod is turned by the mill's powerful drive motors. The spindle connects the drive end pod to the roll end pod, which connects to and turns the heavy steel rollers that flatten the steel ingots. Ring and hub gears at each end transfer the rotational energy from the motor to the spindle and then from the spindle to the roller. The spring inside the spindle pushes both ends of the spindle against a thrust plate. Keeping axial tension in this way helps hold the spindle tightly in place and limits its vibration as it turns. Because the spindle weighs several tons, the spring must be very powerful, exerting a lateral force of more than ten thousand pounds.

To reduce friction and wear, the gears at each end of the spindle need to be kept lubricated, so the empty spaces around each end of the spindle inside the end pods are filled with industrial grease. Just before the accident occurred, the spindle in question had been returned from reconditioning by Xtek and had been reinstalled. The roller was also installed in the roll end pod but the spindle had not yet operated because it needed to be greased. Lapsley filled the drive end pod with grease through the port labeled "zerk fitting" in the diagram above. He removed the actual zerk fitting (a one-way valve) to aid that process. Lapsley next started filling the roll end pod with grease. As the roll end had filled, he went back to the drive end and was about to replace the fitting there when he was hit in the chest by the jet of grease.

Hours after the accident the spindle was inspected and was put into service. It operated for two years without any further incident. Both sides' experts and an internal team from the mill investigated possible causes of the accident. No one was able to recreate it or to determine to an absolute certainty what was the precise cause.

As Lapsley lay stunned on the floor of the mill being helped by co-workers, he responded to the inevitable question "What happened?" by gasping that the grease wand had exploded. But witnesses testified that the actual wand — which was admitted into evidence at trial in pristine condition — had not exploded. In fact, the wand was still connected to the hose leading to the mill's centralized, high-pressure grease distribution system. Some inconsistencies in various witnesses' memories on this last point supported the hypothesis of Xtek's expert — that the jet of grease came from a pressurized disconnection of the wand from the hose. Lapsley's lawyers and expert criticized the hose-disconnection theory at trial. The jury did not accept it, and there were ample reasons for that decision.[1]

Lapsley's expert, Dr. Hutter, hypothesized that the internal spring must have become bound up or cocked

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[1] In addition to the lack of any direct evidence of disconnection or damage to the grease wand or any other malfunction in the grease distribution system, plaintiffs argued that a hose disconnection would not have produced the explosive sound heard across the mill. They also offered evidence that even the small amount of grease highly pressurized in a clogged wand would not have emerged as a jet, since incompressible liquids expand only a small degree as pressure is dissipated. We focus our further discussion only on the testimony of plaintiffs' expert challenged on appeal.

during reconditioning of the spindle or installation of the roller. His theory was that the spring must have suddenly let loose and expanded as the roll end pod filled with grease, creating the loud explosive sound heard across the mill and pushing the entire spindle deeper into the drive end pod. Since the space between the spindle and the drive end thrust plate was completely filled with incompressible grease, the spindle would have acted like a ram, pushing the grease away and out through any opening in the mechanism. Lapsley just happened to be standing two feet in front of the narrow, open grease port, which acted to focus the immense energy from the spring into a narrow, high-velocity jet of grease.

The grease port was not the only opening through which grease could escape under that pressure, but it was probably the path of least resistance. The pod had relief fittings, which would allow some grease to escape if the internal pressure exceeded five pounds per square inch, and rubberized "Glyd seals," which would give way at fifty to sixty pounds per square inch. Dr. Hutter accounted for these alternate grease pathways in his calculations. He still concluded that the effect of the spring unbinding and acting as a ram could produce sufficient grease velocity to cause Lapsley's injuries. He also calculated the possible effect of an alternative thrust plate design — the design actually used by Xtek both before and after the accident, but not with the spindle involved in the accident. That alternative design had grooves cut into it to assist grease flow throughout the mechanism. Dr. Hutter's calculations showed that those grooves could have rerouted some flow and thereby reduced the jet of grease out the grease port enough to reduce significantly the injury to Lapsley.

Long before trial, Dr. Hutter submitted a preliminary report and was deposed by Xtek's lawyers. The Lapsleys' lawyers did not provide all of Dr. Hutter's notes and calculations supporting his report until the day of the deposition. That is the sort of oversight that makes it more difficult to take an effective deposition. It should not have happened. But Xtek went forward with the deposition as scheduled. The remedy for the late disclosure of notes and calculations was left to the district court's discretion, and the district judge reasonably allowed Xtek to conduct a second deposition. See, *e.g.*, *Hunt v. DaVita, Inc.*, 680 F.3d 775, 780-81 (7th Cir. 2012) (deferring to district court's discretion in determining whether to impose sanctions for improper deposition tactics). The second deposition took place shortly before trial. At the same time the court ordered the second deposition, it also denied Xtek's *Daubert* motion to exclude Dr. Hutter's testimony entirely. The court based its decision on the preliminary report and calculations that had been disclosed, and the initial deposition testimony.

In its *Daubert* motion, Xtek had argued that Dr. Hutter's proposed testimony lacked scientific basis. The district court disagreed, pointing to the "commonly known methodologies and physics calculations" that Dr. Hutter used in reaching his conclusions. Those calculations included the use of Bernoulli's equation regarding energy in moving fluids and reference to "widely accepted factors concerning the force necessary to penetrate human skin." The court concluded that because "the principles upon which Hutter relied have long been established and accepted within the scientific and engineering community, both Hutter's methodology and his conclusions constitute admissible evidence." The court also found that the conclusions were relevant, correctly ruling that defendant's disagreement with Dr. Hutter's theory on causation could not be the sole reason for excluding it.

The district court also ruled on Xtek's summary judgment motions, granting summary judgment and dismissing plaintiffs' claims for manufacturing defect and failure to warn under Indiana law. The court held that plaintiffs' failure-to-warn claim failed as a matter of law because there was no evidence of similar prior incidents such that defendant should have been aware of, and expected to warn of, the risk of grease ejection. There was also no evidence of a manufacturing defect in the spindle. The district court denied summary judgment on plaintiffs' design-defect claim, however, allowing it to proceed to trial. The court found that Dr. Hutter's testimony about the alternative thrust plate design raised a genuine issue of fact with regard to that claim. Xtek argues on appeal that since a design-defect claim also incorporates an element of foreseeability under Indiana law, the lack of evidence fatal to the failure-to-warn claim should have doomed the design-defect claim, as well. But as we explain below, the argument overlooks Dr. Hutter's testimony about reasonable care in design. In the district court's view, that testimony foreclosed judgment as a matter of law, and his testimony on that point simply was not challenged at trial.

After a five-day trial, the jury returned a verdict of \$2.97 million against Xtek, after allocating 65 percent of the fault for the accident to Xtek and 35 percent to the mill owner, which was not a party. Represented by a new team of lawyers, Xtek filed a Rule 50(b) motion for judgment as a matter of law that asked the district court to reconsider its refusal to exclude Dr. Hutter's testimony. The district court denied that motion, referring to its earlier ruling on the issue. Xtek has appealed.

On appeal, Xtek objects to both the initial *Daubert* ruling and the denial of its Rule 50(b) motion for judgment as a matter of law. With regard to the Rule 50(b) denial, Xtek does not argue that the evidence as actually presented was insufficient to support the jury verdict, but that it would have been insufficient without Dr. Hutter's testimony. Xtek argues again that Dr. Hutter's expert opinions regarding causation, alternate design, and reasonable care or foreseeability lacked scientific basis and should have been excluded by the district court under Federal Rule of Evidence 702 and *Daubert*. We disagree on all counts. The district court did not abuse its discretion by admitting Dr. Hutter's testimony on each of these issues. In the face of that testimony, Xtek was not entitled to judgment as a matter of law. We discuss first the requirements of *Daubert* and Rule 702 as applied to Dr. Hutter's causation and alternate design testimony, and finally the issue of foreseeability.

II. *Daubert and Causation*

Determining the true facts of a case often requires "the application of some scientific, technical, or other specialized knowledge." Fed. R. Evid. 702, advisory committee's note to 1972 proposed rules. Federal Rule of Evidence 702 permits testimony by qualified experts where such testimony will help the trier of fact understand the evidence or decide the factual issues. As the Rule 702 committee notes and Rules 703 to 705 make clear, an expert may give an opinion to the jury concerning the facts, subject to cross-examination on the work forming the basis of that opinion, or may, less frequently, "give a dissertation or exposition of scientific or other principles relevant to the case, leaving the trier of fact to apply them to the facts." *Id.* Rule 702 requires that expert testimony be relevant, reliable, and have a factual basis — requirements that must be met before the jury is allowed to hear and perhaps be persuaded by the expert testimony. As the Supreme Court explained in *Daubert*, the trial judge must make a determination at the outset whether these factors are satisfied by the proposed testimony. 509 U.S. at 592-93. Under Rule 702, the trial judge stands as a gatekeeper to prevent irrelevant or unreliable testimony from being admitted.

Screening evidence pre-trial is a function squarely within the purview of the trial judge. We review a district court's decision to admit or exclude expert testimony for abuse of discretion, without substituting our own judgment for the district judge's exercise of discretion. *E.g.*, *Kunz v. DeFelice*, 538 F.3d 667, 675 (7th Cir.

2008). We review *de novo*, however, the district court's understanding and proper application of the multi-factor *Daubert* framework. For example, in *Metavante Corp. v. Emigrant Savings Bank*, 619 F.3d 748, 760 (7th Cir. 2010), we applied *de novo* review where the court "failed to perform a *Daubert* analysis" and articulated only a one-sentence conclusion. See also *Naeem v. McKesson Drug Co.*, 444 F.3d 593, 608 (7th Cir. 2006) (declining to apply deferential review where district court provided no analysis of methodology in its one-sentence determination). Similarly, we refused to defer to a conclusory *Daubert* determination in *Fuesting v. Zimmer, Inc.*, 421 F.3d 528, 534-35 (7th Cir. 2005), modified on rehearing on other grounds, 448 F.3d 936 (7th Cir. 2006), though we repeated the general rule: "Provided the district court adhered to *Daubert*'s parameters, we will not disturb the district court's findings unless they are manifestly erroneous."

The parties here disagree about whether the district court's brief written analysis of Dr. Hutter's testimony was sufficient to justify deferential review. We find that it was.

Xtek relies heavily on *ATA Airlines, Inc. v. Federal Express Corp.*, 665 F.3d 882 (7th Cir. 2011), in which we found erroneous the admission of a regression analysis that was based on only the district court's (correct) statement that regression is a widely accepted method. In fact, there were "grave questions concerning the reliability" of the expert's specific calculations. We noted that neither side's lawyers successfully conveyed their own understanding of the regression analysis they were arguing about. *Id.* at 889. As Lapsley points out, however, *ATA Airlines* did not change the standard of review established in our cases for appeals from *Daubert* decisions.

The district judge here did more than state the general acceptability of Dr. Hutter's methods and calculations. The judge provided specific examples that show he reviewed and understood the basis for Dr. Hutter's conclusions. As our discussion below makes clear, the math and science here are within the comprehension of judges and lawyers without extraordinary assistance. Xtek disputes the completeness and therefore the relevance of Dr. Hutter's calculations, but it has not identified, and we have not detected, any grave questions about the reliability of the calculations actually performed by Dr. Hutter. Under these circumstances, the district court's brief application of the *Daubert* framework is sufficient to warrant the deferential review we give it below.

The Rule 702 inquiry is fact-dependent and flexible. See *Kumho Tire*, 526 U.S. at 141 ("[A] trial court *may* consider one or more of the more specific factors that *Daubert* mentioned when doing so will help determine that testimony's reliability. But, as the Court stated in *Daubert*, the test of reliability is 'flexible,' and *Daubert*'s list of specific factors neither necessarily nor exclusively applies to all experts or in every case.") (emphasis in original). The non-exclusive list of *Daubert* reliability factors for scientific evidence includes whether or not the theory or technique has been (1) tested, (2) subjected to peer review and publication, (3) analyzed for known or potential error rate, and/or is (4) generally accepted within the specific scientific field. *Daubert*, 509 U.S. at 593-94. The purpose of the inquiry is to vet the proposed testimony under Rule 702's requirements that it be "based on sufficient facts or data," use "reliable principles and methods," and "reliably appl[y] the principles and methods to the facts of the case." Fed. R. Evid. 702. As the Supreme Court instructed in *Kumho Tire*, see 526 U.S. at 152-53, we "give the district court wide latitude in performing its gate-keeping function and determining both how to measure the reliability of expert testimony and whether the testimony itself is reliable." *Bielskis v. Louisville Ladder, Inc.*, 663 F.3d 887, 894 (7th Cir. 2011).

On appeal, Xtek argues that none of the reliability factors are satisfied by Dr. Hutter's opinions or the calculations underlying them. Xtek asserts that the opinions are "not science" because they were not physically tested, peer reviewed or published, or subject to the other factors. We disagree. Dr. Hutter applied reliable science to the known facts using well-established methods. The physics principles used by Dr. Hutter were published centuries ago by some of the most famous names in science, and those principles have been used and tested (*i.e.*, peer reviewed) by physicists and engineers for centuries. Dr. Hutter's mathematical models (a form of test) appear to be well-grounded in the facts and data available. If some of his simplifying assumptions failed to consider significant factors, such potential errors went undetected and unchallenged at trial.

Dr. Hutter's approach, starting from the known facts about the accident and eliminating other possible explanations (in this case, other possible sources of high velocity grease) until he was left with a hypothesis that was physically possible and that fit the evidence, is a good example of the scientific method.

Xtek also faults Dr. Hutter for not providing a sufficient explanation of his calculations. Xtek argues that these opaque calculations render his ultimate conclusions merely conclusory, and that unsupported opinions have no place at trial. Rule 705 provides that "an expert may state an opinion — and give the reasons for it — without first testifying to the underlying facts or data." Disclosure of the underlying facts or data may be left to cross-examination, and of course, an expert who plans to testify to an opinion must make the basis of that opinion available for evaluation by the court and opposing parties. Once evaluated and deemed sufficiently reliable for admission, that expert opinion is submitted to the "capabilities of the jury and of the adversary system generally." See *Daubert*, 509 U.S. at 596 (rejecting an "overly pessimistic" view of these capabilities).

We do not agree that Dr. Hutter's method and calculations were insufficiently detailed or inherently opaque to the district court or the lawyers here. We do not find, and the district court did not find, Dr. Hutter's analysis to be as difficult to understand as Xtek suggests. Lawyers and judges who were not trained in science can benefit from the famous "Two Cultures" lecture given in 1959 by British scientist and novelist C. P. Snow, in which he described the cultural gap between persons schooled in the sciences and those schooled in the humanities:

> A good many times I have been present at gatherings of people who, by the standards of the traditional culture, are thought highly educated and who have with considerable gusto been expressing their incredulity at the illiteracy of scientists. Once or twice I have been provoked and have asked the company how many of them could describe the Second Law of Thermodynamics. The response was cold: it was also negative. Yet I was asking something which is about the scientific equivalent of: Have you read a work of Shakespeare's?

Law must apply itself to the life of a society driven more and more by technology and technological improvements. Judges and lawyers do not have the luxury of functional illiteracy in either of these two cultures. Sometimes, as in this case, effective presentation, cross-examination, and evaluation of expert testimony require lawyers and judges to fill in gaps in their scientific, engineering, or mathematics educations or refresh their memories about them. We see no indication, either from the district court's *Daubert* ruling or its later discussions of the expert evidence during trial, of any deficiency in the court's preparation or in its understanding of the proposed evidence.

Dr. Hutter's calculations to support his theory of causation were attached to his report and made available to Xtek's counsel and the district judge prior to his ruling on Xtek's initial *Daubert* motion. Those calculations apply principles of classical mechanics commonly taught in high school physics classes. His notes, mistakenly disparaged by Xtek as "the instructive equivalent of Sanskrit," are in fact relatively straightforward to comprehend for those familiar with these basic mechanical principles and with the rudiments of scientific notation. If they appear opaque to some readers, it is more likely because of the "Two Cultures" problem rather than any inadequacy of presentation. As with most informal work-product, the notes could have been even clearer and more self-explanatory, but Xtek's lawyers and the district judge all had opportunities to ask Dr. Hutter to explain his calculations. Based on the written submissions, the district judge here did not feel the need to question Dr. Hutter directly, and Xtek did not request that he hold a hearing to do so.

The page of notes that was selected by Xtek as an example of Dr. Hutter's scientific "Sanskrit" is reproduced below:

$$10{,}550^{\#} \qquad 0.37''$$

$$\text{Energy} = \frac{10{,}550 \times 0.37}{12} = 325.3 \text{ ft-lbs}$$

$$E = \tfrac{1}{2} m v^2 \qquad v^2 = \frac{E}{m\,(.5)}$$

$$V = \left[\frac{E}{m\,(.5)}\right]^{1/2} = \left[\frac{325.3 \text{ ft-lbs}}{\frac{1 \text{ lbs}}{32.4 \text{ ft/sec}^2}\,(.5)}\right]^{1/2} \qquad \frac{\text{ft-lbs}\,\frac{\text{ft}}{\text{sec}^2}}{\text{lbs}} \quad \left(\frac{\text{ft}^2}{\text{sec}^2}\right)^{1/2}$$

$$= \left(\frac{325.3 \text{ ft-lbs}}{0.0154}\right)^{1/2} = \left(21123.3\right)^{1/2}$$

$$= 145.3 \frac{\text{ft}}{\text{sec}} \qquad = \boxed{145.3 \frac{\text{ft}}{\text{sec}}}$$

$$145.3 \frac{\text{ft}}{\text{sec}} \cdot \frac{12 \text{ in}}{1 \text{ ft}} = \boxed{1744 \frac{\text{in}}{\text{sec}}}$$

$$145.3 \frac{\text{ft}}{\text{sec}} \cdot \frac{3600 \text{ sec}}{5280 \text{ ft/mi}} = \boxed{99 \frac{\text{mi}}{\text{hr}}}$$

Really Pressure

$$P = \tfrac{1}{2} \rho V^2 \qquad P = (0.5) \frac{62.4 \frac{\text{lb}}{\text{ft}^3}}{32.4 \text{ ft/sec}^2} V^2 \leftarrow \text{in } \frac{\text{ft}}{\text{sec}}$$

$$P = \frac{(0.5)(62.4)(145)^2}{32.4} = 20246 \frac{\text{lb}}{\text{ft}^2}$$

$$20246 \frac{\text{lb}}{\text{ft}^2} \times \frac{1 \text{ ft}^2}{144 \text{ in}^2}$$

$$\boxed{\approx 140 \text{ psi}}$$

The basic equations of classical mechanics used in this case by both sides' experts were first published in 1687 by Sir Isaac Newton in his *Philosophiæ Naturalis*

Principia Mathematica.[2] The *Principia*, which built on the work of Galileo and Descartes, and on Newton's own development of calculus, is often described as the most significant scientific publication of the Western world. It contains Newton's Second Law of Motion, relating the force (F) on an object to the product of its mass (m) and acceleration (a). This equation is commonly expressed as: F = ma. Acceleration is defined as the rate of change (or derivative in calculus terms) of the velocity (v) over time (t). These relationships, discovered by Newton, led to the derivation of equations like the kinetic energy equation, which in turn allows the determination of velocity when force, distance, and mass are known.[3]

Kinetic energy is the energy stored in an object that is in motion. Gottfried Leibniz and Johann Bernoulli developed the principle, building on Newton's mechanics. The

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[2] For the curious, Newton's personally annotated copy of the *Principia* first edition has been digitized by the Cambridge Digital Library and is available online at http://cudl.lib.cam.ac.uk/collections/newton (last visited July 24, 2012). The original text is in Latin, but innumerable explanations and translations are available in libraries and online.

[3] In the centuries since publication of the *Principa*, only a few exceptions have been found for Newton's Second Law. Einstein discovered that as velocity nears the speed of light, corrections need to be made to account for effects of special relativity. Also, there are complications at the extremely small scale of quantum mechanics. Newtonian physics still provides a reliable and workable description for the mechanical systems of a steel mill.

best known equation for kinetic energy (E) is expressed as one-half the product of the mass (m) and the square of the velocity (v): $E = \frac{1}{2} mv^2$. This equation appears on the "Sanskrit" example page of Dr. Hutter's calculations and is a direct application of Newton's Second Law. First Dr. Hutter calculated the assumed Energy from the spring — that is, the work done by the spring exerting 10,550 pounds (#) of force over an assumed distance of 0.37 inches ("). Because the fundamental law of conservation of energy tells us that total energy is conserved (neither gained nor lost) in a closed system, Dr. Hutter could treat the work done by the spring at one end of the mechanism as the eventual kinetic energy imparted to the grease that exited the spindle.[4] Inputting that known energy, and the mass of the grease thought to be involved, the kinetic energy equation yielded a theoretical grease velocity of 145.3 feet per second, which Dr. Hutter also converted to 1744 inches per second and 99 miles per hour.

Another important equation on the "Sanskrit" page, $P = \frac{1}{2} \rho v^2$, relates the dynamic pressure (P) to one-half

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[4] In fact, some small amount of energy was certainly lost to heat from friction and to turbulence in the grease as it moved inside the mechanism. As is common and acceptable in mathematical modeling and estimation, Dr. Hutter assumed that these effects were so small in relation to the total energy that they could be ignored without compromising the end result. If Xtek believed the effects of friction were actually significant, it could have cross-examined Dr. Hutter on that point or introduced its own evidence to counter his estimates.

the product of the fluid density (ρ) and the square of the fluid velocity (v). This is one form of Bernoulli's equation, a fundamental principle of fluid dynamics first published by mathematician Daniel Bernoulli (son of Johann) in 1738 in his book *Hydrodynamica*. Bernoulli's equation in its various forms has innumerable applications in aerodynamics (it describes how the shape of an airplane's wing lifts the plane or an inverted wing keeps a race car on the track in a high-speed turn) and in hydraulics. Dr. Hutter used the equation here to convert the velocity of the grease, which he had derived from the kinetic energy equation, into a pressure value of approximately 140 pounds per square inch (psi). Published results of experiments with jets of fluid taught that pressures above 100 psi could pierce clothing and human flesh.

So, starting from the assumed values (which were reasonable estimates from the information available) for the force of the spring, the distance it may have traveled, and the density and mass of the grease, Dr. Hutter was able to confirm the theoretical possibility that a sudden release of tension in the spring could produce a high velocity jet of grease at the other end of the mechanism — one moving with sufficient energy to create sufficient pressure to cause Lapsley's wounds. Dr. Hutter concluded, and testified, that the spring probably caused the accident, suddenly ramming the spindle into the full grease reservoir with enough force to create the dangerous jet of grease. This conclusion was based in large part on Dr. Hutter's conclusion that there was no other viable explanation for Lapsley's injuries, including specifically that the available evidence was not consistent with the steel mill's internal grease distribution system causing the accident.

Dr. Hutter could not say exactly how the spring got bound up or cocked and then released. From this gap, Xtek argues that his theory is incomplete and therefore amounts to impermissible conjecture. Dr. Hutter was cross-examined on this point and testified that the accident itself — other sources of great pressure having been excluded — was evidence that the spring was the cause. He testified that the spring could have become cocked in the spindle assembly or installation process. However it got bound up, Dr. Hutter's calculations showed that the release of the spring, traveling as little as 0.37 inches, could have created the necessary force. Rule 702 asks whether Dr. Hutter's causation hypothesis was reliably supported and applied to the known facts, such that it rises above speculation and becomes a presentable probability. See *Smith v. Ford Motor Co.*, 215 F.3d 713, 718-19 (7th Cir. 2000) (hypothetical explanations of probable causes permitted where they have "analytically sound bases" beyond mere speculation). Even when judging sufficiency of all the evidence, Indiana design defect law does not require absolute certainty on every aspect of causation. The plaintiff need only present "evidence of probative value based on facts, or inferences to be drawn from the facts" that rises above "supposition or speculation." *Smith v. Beaty*, 639 N.E.2d 1029, 1033-34 (Ind. App. 1994) (expert opinion that something is "possible" may be sufficient to sustain verdict in conjunction with totality of other circumstantial evidence). The district court did not abuse its discretion in concluding that the proposed causation testimony was reliable.[5]

Dr. Hutter's report, calculations, and deposition testimony available to the district court at the time of Xtek's *Daubert* motion were clear and understandable, at least on their face. When the relevant question on appeal is whether the district court reasonably found the proposed evidence reliable, we need not further evaluate Dr. Hutter's math for all possible substantive errors. That is what the adversary process, including cross-examination at trial, is for. Throughout this litigation, no one has attacked or questioned the calculations we described above, and we see no fault in them. If there were pertinent attacks to be made, the proper time to have done so was no later than trial.

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[5] Xtek makes several arguments on appeal going to the weight and ultimate truth of the evidence rather than its Rule 702 reliability. For instance, Xtek argues that its engineer, Mohammed Daher gave "uncontradicted" testimony that if the spring were to be bound up, the rollers could not have been installed because they would "fall out." The diagrams that Xtek showed the jury seem to belie the possibility that a half-inch play in the internal spring would be enough to allow the heavy mechanism, which per Daher is externally supported during installation, to fall to pieces. Daher also testified that installation of the rollers can cause the spring to be pushed in. If we were examining sufficiency, we could say that the jury may have reasonably concluded, as Dr. Hutter opined, that this was when the spring probably became cocked.

III. *Alternative Design*

Just before the accident, after many years of using thrust plates with grease grooves around their outside edges, Xtek substituted a new thrust plate design that omitted those grooves. As Xtek's engineer Daher testified, the grooves were designed to facilitate grease flow throughout the end pod mechanism when filling it with grease from outside the pod, as Lapsley was doing. Daher testified that the grooves were removed in the new design because they were not needed to spread grease when using the new method of filling the pod through the spindle itself. Several months after the accident, Xtek went back to the thrust plates with grooves. According to Daher, this was done in case millwrights continued to grease through the outside port, as they had always done before the design change.

Dr. Hutter employed simple calculations using the areas of the corresponding exit paths to show that the grooves would have significantly lessened the grease exit velocity and pressure by providing more alternate paths for the grease to escape. Dr. Hutter started from calculations similar to those discussed above to estimate the energy and velocity of the shifting spindle, which acted across a wide area of the internal grease reservoir. He then computed: (1) the much higher velocity of the displaced grease if it had all exited through the small area of the grease port, (2) the somewhat lower velocity if the additional exit area of the available relief valves and Glyd seal were considered, and (3) the much lower velocity if the additional exit area of the grease grooves were available. Again employing Bernoulli's equation, the calculations yielded corresponding pressures in the thousands of pounds per square inch without the grease grooves, and less than a hundred pounds per square inch with them. For reference, Dr. Hutter cited medical journal articles about water-jet scalpels used to perform surgeries, which operate in the range of several hundred to two thousand pounds per square inch of water jet pressure. He concluded that the grease grooves could have reduced the jet of grease from the port from a surgical pressure to a much safer one.

Indiana law requires that proposed alternative designs be shown to be cost-effective and able to reduce the injury. See *Pries v. Honda Motor Co.*, 31 F.3d 543, 545-46 (7th Cir. 1994), citing *Miller v. Todd*, 551 N.E.2d 1139, 1141-42 (Ind. 1990). Expert testimony is not needed to show the cost-effectiveness of a design actually used by the defendant both before and after the accident. With regard to reducing or preventing injury, Dr. Hutter's calculations modeled the effectiveness of the grooves at reducing the grease velocities below skin-penetrating pressures. Xtek raises the same arguments concerning failure to explain and lack of absolute certainty that we discussed above with regard to causation. They fail here for the same reasons.

Xtek also faults Dr. Hutter for failing to do physical tests of his theories with regard to causation (the effect of the spring releasing) and alternate design (the reduction in pressure from the grease grooves). Xtek calls

Dr. Hutter's mathematical models the simulation of science, not science. Testing is certainly one of the most common and useful reliability guideposts for a district court when contemplating proposed Rule 702 evidence. But physical re-creations of industrial accidents are not always feasible or prudent. See *Schmude v. Tricam Industries, Inc.*, 556 F.3d 624, 626 (7th Cir. 2009) (discussing a failed and potentially dangerous attempt to recreate a ladder fall for a jury). Xtek's argument also overlooks the fact that simulation is one of the most common of scientific and engineering tools. Around the world, computers simulate nuclear explosions, quantum mechanical interactions, atmospheric weather patterns, and innumerable other systems that are difficult or impossible to observe directly. A mathematical or computer model is a perfectly acceptable form of test.

We do not require experts to drop a proverbial apple each time they wish to use Newton's gravitational constant in an equation. Similarly here, the burden of proof at trial, and certainly the guideposts of reliability attached to the *Daubert* inquiry, did not require Dr. Hutter to try to recreate the binding up of a ten thousand pound spring to produce a potentially deadly jet of industrial grease. Xtek was free to raise the lack of physical tests of the accident with the jury, and to attack any aspect of the mathematical model that was used in place of physical re-creations. The district court, however, did not abuse its discretion by allowing Dr. Hutter to testify to the results of his mathematical simulations.

IV. *Foreseeability*

Xtek argues most strenuously on appeal that Dr. Hutter's opinion about reasonable care in design (which includes an element of foreseeability under Indiana law) is merely conclusory and therefore should not have been allowed before the jury. Among all of Dr. Hutter's opinions, this one certainly had the least support from data, but it was also completely unchallenged by Xtek during the trial. On appeal, Xtek now seeks to exclude what it did not challenge at trial. We do not find an abuse of discretion in allowing Dr. Hutter to opine about foreseeability.

In addition to proving causation in fact and demonstrating a reasonable alternative design, Indiana design defect law requires plaintiff to show that the defendant failed to exercise reasonable care in designing the product. Ind. Code § 34-20-2-2; *TRW Vehicle Safety Systems, Inc. v. Moore*, 936 N.E.2d 201, 209 (Ind. 2010). This reasonable care standard imports "general negligence principles." See *Pries*, 31 F.3d at 545; *Whitted v. General Motors Corp.*, 58 F.3d 1200, 1206 (7th Cir. 1995). Those principles include an element of proximate cause, which "turns largely on whether the injury 'is a natural and probable consequence, which in the light of the circumstances, should have been foreseen or anticipated.' " *City of Gary ex rel. King v. Smith & Wesson Corp.*, 801 N.E.2d 1222, 1244 (Ind. 2003), quoting *Bader v. Johnson*, 732 N.E.2d 1212, 1218 (Ind. 2000).

Before trial, Dr. Hutter's report asserted his opinion, based on his calculations and observations of the various thrust plates, that a safer design existed. He also asserted that Xtek, as the mechanism's sole designer and manufacturer, should have known of the defective condition created by the thrust plate redesign. The district court, in its denial of Xtek's initial *Daubert* motion, found this evidence "relevant in establishing that alternative designs existed and that the Defendant should have used them." Xtek had objected, in the separate context of the failure-to-warn claim, that Dr. Hutter provided no reports or evidence of similar accidents that could have informed Xtek of a potential grease ejection hazard. But reports of prior incidents are only one way to establish that a defendant in a design defect case should have known of a hazard. If prior events were the only possible basis, defendants could escape liability for genuine defects by pointing to the unusual and thus arguably unforeseeable features present in every accident. Dr. Hutter, a highly qualified mechanical engineer with a career focused on safety in design, testified in essence that a reasonable designer would have thought about the possibility of the powerful internal spring pushing the spindle — and would have considered the consequences that would arise. His assertions about what a reasonable thrust plate designer should contemplate might be vulnerable to criticism, but Xtek did not lay a glove on that opinion in the adversarial testing of the jury trial. The district court found the opinion was relevant and reliable enough to pass Rule 702, and we see no abuse of discretion in that finding.

Dr. Hutter testified that designers of equipment like this possess the knowledge and expertise to identify hazards, and that the presence of a spring with over ten thousand pounds of force should have led Xtek's engineers to evaluate this particular kind of hazard. Expert testimony by engineers concerning what an ordinary engineer would understand and do is commonplace in patent law. It is naturally relevant to the foreseeability question here as well. See *Vaughn v. Daniels Co.* (*West Virginia*), *Inc.*, 841 N.E.2d 1133, 1137 (Ind. 2006) (applying Indiana evidence rules and allowing expert to opine about reasonable care based on his "engineering and construction management expertise"). As the district court noted in its *Daubert* ruling, Xtek did not dispute Dr. Hutter's engineering qualifications. Those qualifications provide the primary basis for his testimony about what a similarly qualified design engineer might anticipate.

Unlike the opinions discussed above, no one needs to understand physics to counter design evidence effectively or to criticize it as dependent on hindsight bias. "Vigorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof are the traditional and appropriate means of attacking shaky but admissible evidence." *Daubert*, 509 U.S. at 596. "These conventional devices, rather than wholesale exclusion under an uncompromising 'general acceptance' test, are the appropriate safeguards where the basis of scientific testimony meets the standards of Rule 702." *Id.*

Xtek failed to counter Dr. Hutter's brief but admissible testimony on the question of whether grease ejection was foreseeable to designers of the spindle assembly. In fact, the only people who used the words "foresee" or "foreseeable" in front of the jury during trial were plaintiffs' lawyer, when asking Dr. Hutter if he thought the designers could have foreseen a dangerous condition (he said yes), and the judge, when properly instructing the jury on Indiana law concerning design defects. Dr. Hutter was not even cross-examined on his opinion about the reasonable care of the designers. Xtek's engineer and expert both testified. Neither provided even a contrary opinion on the issue, and Xtek opted not to remind the jury of the issue during its closing argument. We see no persuasive reason to hold now that Dr. Hutter's evidence on the issue should have been excluded.[6]

[6] Xtek suggests that if we were to agree that Dr. Hutter's testimony should have been excluded, the proper remedy would be an outright dismissal for insufficiency of the evidence rather than a remand for a new trial. Other circuits have remanded for retrial in analogous circumstances, leaving district judges substantial discretion in reaching a fair solution when a party presented his case at trial relying on a decision to admit evidence that turned out to be erroneous. See, *e.g.*, *Tamraz v. Lincoln Elec. Co.*, 620 F.3d 665, 677 (6th Cir. 2010); *Dodge v. Cotter Corp.*, 328 F.3d 1212, 1229 (10th Cir. 2003). Defendant's proposed dismissal remedy could be manifestly unfair to parties who based their trial strategy on the district court's pre-trial evidentiary rulings — particularly in cases where the defendant failed to attack the sufficiency of the evidence during trial. Plaintiffs who seemed to have met their evidentiary burden might have found other ways to meet that burden if they had known (continued...)

* * *

The accident that disabled Leonard Lapsley appears to have been unprecedented, and fortunately it has not been repeated with other millwrights. The uniqueness of an accident can weigh against jury findings of foreseeability and lack of reasonable care in design, but that is a matter for the jury to decide. The jury here accepted Dr. Hutter's uncontradicted expert opinion that a reasonable designer would have considered the danger of the powerful spring being bound up unexpectedly and releasing its energy so as to act like a ram on the grease in the spindle assembly. Rule 702 provides a test of reliability, not of ultimate merit. District courts acting as gatekeepers of scientific, technical, or specialized knowledge evidence retain significant discretion under the flexible *Daubert* inquiry. The district court here did not misapply *Daubert*, and Xtek has identified no compelling reason to disturb the court's exercise of its discretion.

The judgment of the district court is AFFIRMED.

[6] (...continued)
they would not be allowed to present key part of the testimony of their chosen expert witness. We need not and do not decide this question, just as we declined to decide it in *Fuesting v. Zimmer*, 448 F.3d 936, 939 n.1 (7th Cir. 2006).