Dietrich Haeseler writes:

> If that (dynamic overshoot) is so dangerous as claimed by AbuTaha, why then did it never cause a problem, not necessarily fatal, since STS-26?

Hansen and McDonald echoed the same sentiment earlier:

> If it (AbuTaha's failure scenario) had been correct, these same excessive loads would have occurred on every flight of the Shuttle, not just Challenger…

Anyone who read my "shuttlfactor" report that "astroborg" found on the net can find the answer there. Let me, as Mr. Pearlman suggests, give a direct synopsis myself.

First, the "dynamic overshoot" produces a transient effect of 70% or more at start-up, throttle-up or throttle-down of rocket engines and more than 90% for the start-up of solid rocket motors. For the Shuttle, with yield and ultimate safety margins of 25% and 40% respectively, this should indeed cause major failures, if not disasters, in most launches. Why didn't that happen?

Had the dynamic overshoot problem not been partially corrected for, albeit fortuitously, then fatal accidents would have been the rule, rather than the exception. Consider the following Commission or media documented facts, and my comments:

1. The first biggest story relating to Shuttle loads was the tiles problem in the late 1970's, which delayed the program. The old timers remember that. The tiles "*failed at about 50% the load at which a failure would have been expected*," said Maxim Faget in 1980 (Faget, The Space Shuttle, 27$^{th}$ AAS, p. 5887). A 100% error in measuring the strength of materials in laboratories is unheard of. If any of us, who tested aerospace materials in the 1970's made such a massive mistake, then we would (or should) have been fired on the spot. In the late 70's, Aaron Cohen said, "*so there we were with the tiles half the strength we originally thought and the actual loads involved <u>very hard to calculate…</u>*" and "*Densified tiles have <u>twice</u> the strength of undensified tiles,*" (Shuttle, Macknight, 1984, my emphasis).

   I have been saying that the "dynamic overshoot" loads caused the 100% tiles' problem. The loads were "*very hard to calculate*" because the start-up transient effect was not included in the original 1972 JSC 07700 specification at all. Had the strength of the tiles not been corrected, serious accidents would have happened frequently. "Minimum material properties" requirement and other standard conservative design practices would have been the only line of defense against disasters.

2. The SRB segments are connected together with 180 1-inch diameter pins around the circumference. The initial design spacing between the pins is just at the minimum allowable by any Standard (1-inch holes spaced at 1½-inches). In 1986, I discovered that the Forward Skirt Clevis Joints had extra 1-inch holes drilled in between the original holes, i.e., in the 1½ spacing. This violated any and all design Standards. We all see the rivets pattern in airplanes before we board. If I see rivets spaced as above, I

would simply not board the plane. The extra holes doubled the number of pins in a specific sector of the segments. That sector is just below the forward struts, which bears the brunt of the "dynamic overshoot" lift-off loads from the SRBs' start-up transient. As I write in my report, "*The Shuttle engineers doubled the number of pins to double the load carrying capacity of the SRB sections involved.*"

Had the above reckless doubling of the number of pins not been done, serious and deadly accidents would have happened more frequently before and after Challenger. McDonald and Hansen should be familiar with the above correction as it was included in the massive Commission record in the Archives as a Morton Thiokol, Inc. Document – and should perhaps be part of the research for their book. There, Thiokol describes the doubling of the number of the pins in 1984 as a measure to counter *"thrust peaking loads."* What "thrust peaking loads"? Wasn't that correctly calculated and measured before? In my first post here, I mentioned the "26 SRM Thrust-Time Traces During Ignition" that McDonald presented in a major Propulsion Conference for rocket scientists in 1985 – after the above Thiokol Document. I pointed out that the 26 traces do not show the "dynamic overshoot" because Allan was using "non-overshooting pressure" measurements and presenting them as "force" measurements, which overshoot.

3. The number of "stiffener rings" in the Aft Segments of the SRBs was about doubled in number and strength after STS-1 (just look at your photos of Shuttle launches). Obviously, that was not done for decoration, but to counter serious damage observed from mission to mission.

   Blaming splashdown into the ocean for the observed damage is wrong. I analyzed that with actual splashdown data. Also, Goddard's rockets parachute-landed in the fields and he would recover them, hammer them back into shape and reuse them.

4. Then came Challenger. Failure occurred in the Aft Stiffener Segment near the Aft ET/SRB Attach Ring. The half-ring was doubled to full-ring.

   Some make a big deal out of whether NASA doubled the ring because of AbuTaha or if the agency did it on their own. That is completely irrelevant. The ring was going to be doubled with, or without, me. Without this change, everyone will agree that the Shuttle would have remained vulnerable to catastrophic failure – even after the changes to the joints and O-rings.

Look at the following sequence, which can be put together from the Commission, Flight International, Aviation Week, etc.:

On STS-1, long cracks (20 feet long!) were found on the MLP 1-inch blast deck. This is a serious failure. The MLPs were strengthened. Then serious damage was observed in the Aft Skirts, and those were strengthened. Then the number of stiffener rings in the SRB Aft Segments was about doubled to counter observed damage after flights. Then after Challenger, the Half-Attach-Ring was doubled to a Full-Ring. Can you follow the sequence in space and time? The "dynamic overshoot" excessive forces have been chasing the engineers up the stack, who wrote about loads difficult to calculate and loads of mysterious origin. I don't believe in magical forces. Design optimization was well developed and well taught in the 1960's. The initial Shuttle design was supposed to be an optimum design. This means, to this aerospace engineer, that only minor tweaking was necessary on the first roll to the launch pad – Not 100% changes, or changes that exceeded the built-in safety margins. If I translate the above changes to your car, you wouldn't want to own it.

Had all the "doubling" and "strengthening" mentioned above and others not been done over the years, almost every other mission would have been a disaster.

The strengthening of the stack from the bottom up just drove the "dynamic overshoot" effect further up the stack. What was next? How about the segments above the doubled Aft Attach Ring? The mid- and upper-segments? No way, everyone says there are no excessive forces acting on the Shuttle.

Mr. Haeseler writes, *"I have never heard that a damage was observed which might have been caused by "dynamic overshoot."* Tim Furniss writes in his Challenger chapter, *"In January 1992, the Washington Post space reporter, Kathy Sawyer, wrote, "After launches of Atlantis in April and November (1991), NASA found that the forward section of one booster had buckled irreparably and that the forward part of another booster had cracked open halfway around and three of its four main segments had buckled."* Ten years after the first flight and five years after Challenger, we still had steel "buckled irreparably" and "cracked open halfway around" in the SRBs? Someone is not doing his or her job right. NASA blamed the damage on "splashdown," and I insisted (and insist today) that it was the "dynamic overshoot" forces moving up the stack. I should point out that before 1983, NASA did extensive analyses and concluded that the splashdown loads *"were generally not sufficient to cause the observed damage."* Well, if the excessive loads did not originate in splashdown, where did the excessive loads come from?

You don't chase a problem like the "dynamic overshoot." You solve it. What do you suppose would happen after the SRBs and the Orbiters were strengthened and the payload went from about 65,000 to what, 40,000 lbs? Either we are chasing the dynamic overshoot, or it is chasing us. How about the most reliable part of the Space Shuttle for years becoming the most vulnerable – the weakest, the ET, the External Tank?

The historians of science and technology should take the dynamic overshoot mistake to its roots in history. It's a long journey from von Braun and Goddard to Boltzmann and Mach to Newton and Leibniz.

Let me add that as part of my Challenger work, I studied the scant literature on Soviet rocketry up to the 1980's and I discovered that the Soviets had observed and reported "dynamic overshoot" data without recognizing the source of the effect. The same is true of others.

During 1970-72, I did a lot of work on the dynamic overshoot effect, analytically and experimentally, and I documented that work. Though I lost my massive library, I kept some of those papers. Around that time, I attended a talk by von Braun at a neighboring company or agency. I was fascinated, but I hardly remember a word of it now. One thing that stuck in my mind, which I distinctly remembered after starting this dynamic overshoot work in 1986, was von Braun's comments in the Q/A session. His words were distinct: You cannot include the transient loads in design because of the prohibitive penalty in payload capacity. Talk about a great lesson from a great teacher. And this is why I attribute the 90%

Apollo and initial-Shuttle liftoff thrust specification to him. Are there any old-timers around who might remember from direct contact with von Braun how he handled the issue?

As to the O-rings, I will address the issue in response to questions and comments by Bob, which I hope to post soon.

Ali AbuTaha