EA04-009 (Fleetwood)
EA04-019 (Jayco)
PE04-051 (Thor Industries)

Enkei – ODI – VRTC Meeting Held on August 5, 2004

At Enkei's request, Mr. Ted Schorn, General Manager, Corporate Quality Systems at Enkei America, Inc visted ODI offices and provided the attached 40-page presentation.

Page 25 has been intentionally removed since Enkai intends to seek Confidential treatment for the information summarized on that page.

The information provided may be relevant to investigations EA04-009 (Fleetwood), EA04-019 (Jayco), and PE04-051 (Thor Industries).

This information may also be relevant to other manufacturers of towable recreational and commercial vehicles inasmuch as ODI plans to conduct additional inquires and investigations regarding the subject of "Trailer Hub/Wheel Retention Issues."

Attendees:

ODI: Tom Bowman, Richard Boyd,
NHTSA Office of General Counsel: Eric Ebenstein
VRTC (by video-conference): Jim Hague, Thad Gardner
Enkei: Ted Schorn
Crowell Moring (counsel for Enkei): Scott Winkelman, Leslie Epley

8/10/04

Trailer Hub/Wheel Retention Issues

Presented to the United States Department of Transportation: National Highway Traffic Safety Administration

Enkei Florida

August 5, 2004

ENKEI

Purpose

- Introduce Enkei
- Clarify Enkei's relationship to the parties and interests in this matter
- Present an initial warranty analysis
- Discuss what Enkei can do to help
- Encourage and listen to NHTSA/VRTC input

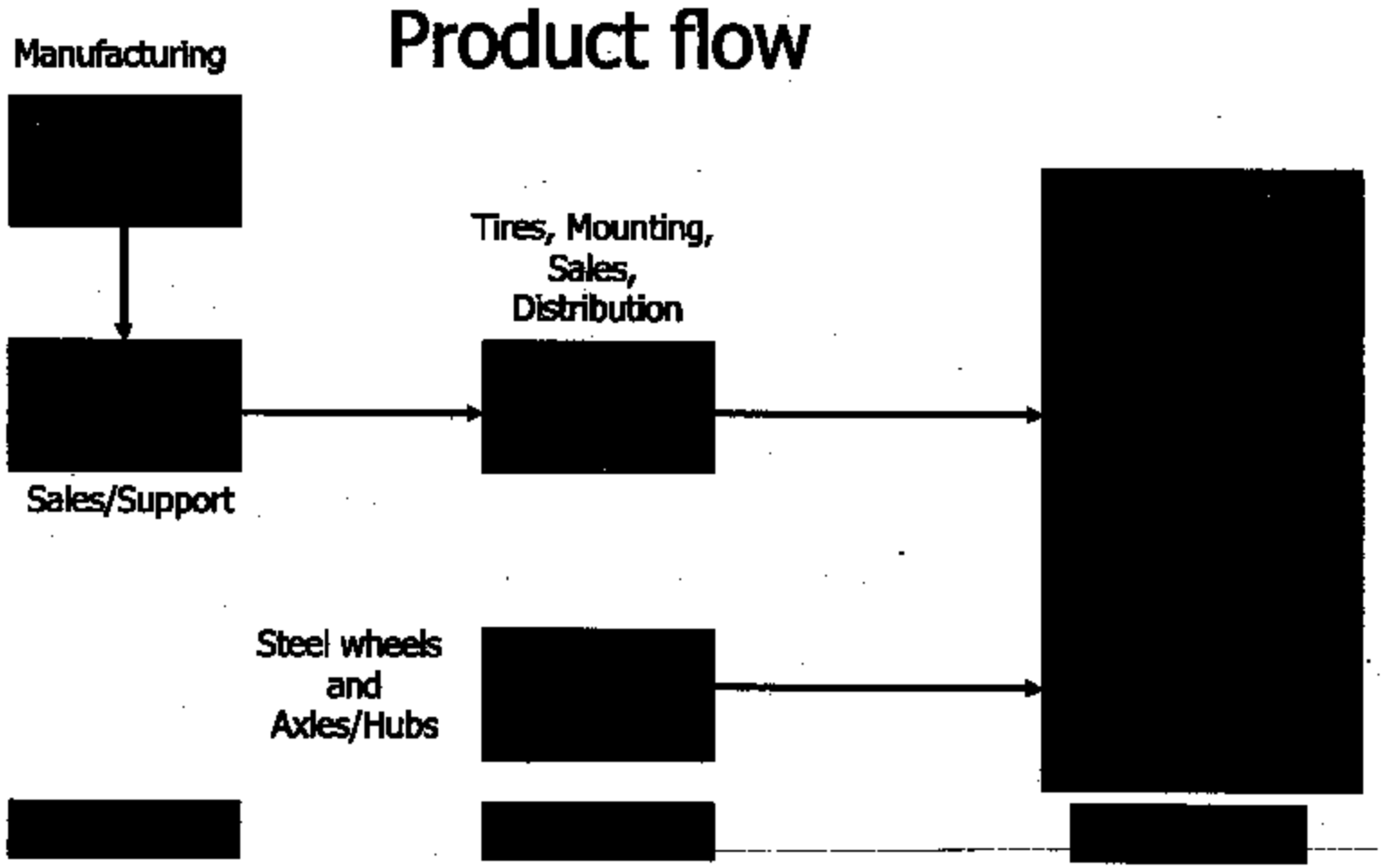
Who is Enkei?

- A privately held international corporation based in Hamamatsu, Japan
- ~5000 employees in 8 countries
- 2nd largest global wheel producer; 2W & 4W production, engine parts
- Globally system certified to ISO/TS 16949:2002 and ISO 9001:2000

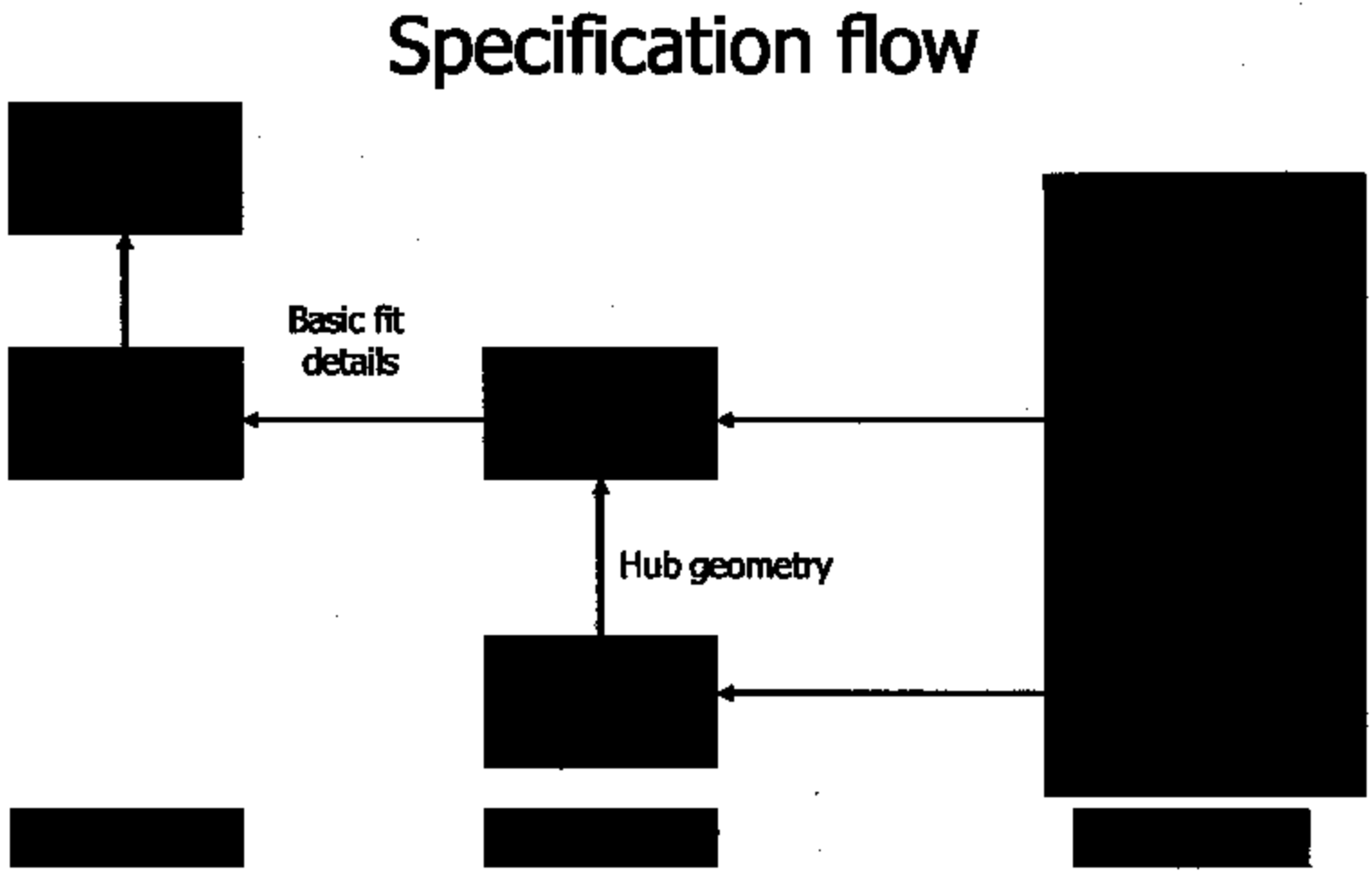
Enkei in America

- Enkei America, Inc. Columbus, IN
  - OEM automotive production
  - 2.5 million wheels annual production
  - Full lab and test facilities
  - 650 people
- Enkei Florida, Inc., Jacksonville, FL
  - OES automotive production and marketing
  - 100 people
  - 500,000 wheels annual production
- Enkei International, Dallas TX
  - Aftermarket Sales and Distribution
  - 30 people

Enkei's relation to the parties



Enkei's relation to the parties: a Tier II supplier



Enkei's interests here

- Enkei's reputation as a global, high-quality supplier compels us in this situation to
  - Regard the level of field reports of hub/wheel separation as completely unacceptable
  - Make this issue our #1 corporate concern
  - Play our part in an effective, science-driven investigation and industry-wide corrective action
  - Offer our resources to cooperate with the RV industry and NHTSA

Enkei's core position

- The field reports are disconcerting
- Corrective action is necessary
- Root cause analysis is essential
- "Quick fix" solutions are in fact not solutions, will not achieve safety goals, and should be avoided
- All of us in the industry should
  - Seize this opportunity to confirm and enhance quality
  - Take responsibility and lead
  - Embrace, and cooperate on, corrective action

Investigating warranty issues

- From the viewpoint of quality assurance, there are 6 points to consider:
  1. Component/System Design
  2. Materials
  3. Component Manufacture
  4. System Assembly
  5. Use/Abuse in Service
  6. Communications (warnings *et al.*)

1. Design

- Component Design
- System Design

1. Design: The Enkei Wheel

- Durability/overall design
- Nut seat geometry
- Mounting surface
- Hub- v. bolt-centricitry
- Paint/coatings

Durability/Overall Design

- No customer request for durability evaluation to any specification
- Enkei applied SAE J1204 as an industry standard for fatigue durability for trailer/RV application
- Enkei applied SAE J175 as an industry standard for impact resistance
- *NO* wheel design issues have been reported in the field or are otherwise known to Enkei
  - No fatigue or impact wheel failures have been reported to Enkei by any RV/trailer customer or distributor (Tredit)
  - No wheel cracking, bending, fatiguing, distorting, etc.

Nut seat geometry

- Initial design from prior supplier used conical lugs and nut seat
- Provides a generic fastening approach for flexible distribution through Tredit
- 60 degree included angle standard
- Construction follows familiar and common OEM and OES design

Mounting surface

- From ~ 1990 to 2002 used a flat mounting surface
- At Tredit's and Dexter's request, from 2002 design incorporated a 0.25 mm step: primary function is to ensure concavity of the contact area
- This design is similar to previous GM-NAO drawings

Mounting surface (2)

- Aluminum Wheel
  - Holds stress on the bolt by the incompressibility of the mating joint materials and friction at the lug seating surfaces and the lug/stud thread interfaces
- Steel Wheel
  - Holds stress on the bolt by the elastic forces inherent in the wrought wheel as it is pushed toward the hub by the lug and friction at the lug seating surfaces and the lug/stud thread interfaces

Bolt-centric Design

- Advantages
  - Robust design for use with a relatively unsophisticated market
  - Flexible application as fit errors are reduced
  - Simplified manufacturing at both axle and wheel maker
  - Allows simplified cap retention approach
- Disadvantages
  - Requires good control of drill operation to prevent concentricity errors that may lead to NVH or fit issues
  - Greater lateral movement can occur when fastening system fails

Hub-centric Design

Advantages

- Slip fit with axle reduces lateral forces on joints if torque is lost
- Potential NVH reduction due to better concentricity between axle and wheel

- Disadvantages
  - Slip fit requires high tolerance on both mating parts
  - Slip fit creates potential for interference or obstruction
  - Cap retention system increase in complexity
  - Mating parts must be designed together – loss of interchangeability
  - Increase in number of parts creates market confusion/errors

Hub v. Bolt summary

- Bolt-centric designs are generally used where a robust and flexible product is required in small volume applications or where there is high product diversity such as in the aftermarket, van conversion and trailer markets
- Hub-centric designs are generally used where systems are engineered for specific application, high volume and high performance such as in many OEM and OES markets

Paint coatings

- Enkei does not paint registration surfaces of its wheels
  - No paint is permitted on the conical nut seats, mounting surface or, in the case of hub-centric products, on the pilot diameter
- Paint, particularly on the nut seats and mounting surface, can create "bogus torque"
  - That is, torque that does not result in the planned prestress of the bolt but is merely a phenomenon of excessive friction at the lug

1. Design: Other Wheels

- Enkei cannot speak to other manufacturers' wheels

1. Design: Other Components

- The design of other components in the fastening system is not our area of expertise
- But we have observations based on:
  - General engineering principles
  - General review of some failed assemblies
  - Investigation and review of published materials

Hub/stud design

- ~~Paint on mounting surfaces generally is of concern~~
- Paint on the hub (measured > 200 µ) can, and often will, compromise joint function – the paint layer compresses and under plastic flow allows the stud and lug to relax
- Stud grade, length and diameter must be matched to joint requirements and wheel design
- Enkei receives the necessary hub profile information to permit interference-free wheel design

Lug design

- Lugs need to match the geometry on the wheel, including the angle and clearance for tools
- Lugs need to be hard – and at least as hard as the studs to properly put the stud in tension
- Lugs need to 'grab' enough threads to hold securely – and not 'bottom out'

Torque

- A key part of fastening system design
- Torque is a means to an end: the prestress of the bolt
- Many factors dictate what torque must be applied to ensure adequate tension exists in the bolt
  - Joint materials and mechanical properties
  - Presence of coatings, lubricants, contamination
  - Application and expected service loads/forces
  - Assembly practice

Torque (cont'd)

- Torque must be specified by one who
  - Has knowledge of the relevant factors
  - Has control over the relevant factors via specification or manufacture
  - This is not the wheel manufacturer
- Both over-torque (leading to elastic deformation of the bolt and premature failure) and under-torque (leading to bolt failure from lateral stress-induced fatigue) are bad

2. Materials

- ~~The Enkei wheel component is produced in A356-T6 aluminum alloy~~
- "A356 is [ ] the material of choice for cast aluminum automobile wheels in North America and has become the standard for most chassis and suspension castings as well"
  - *Aluminum Permanent Mold Handbook*, American Foundry Society (2001)
- A356 alloys "provide various combinations of tensile and physical properties that are attractive for many applications, including aircraft and automotive parts"
  - *Properties Of Commercial Casting Alloys* (ASM)

Materials (cont'd)

- This is the primary material used for virtually the entire North American automotive aluminum wheel market
- A356-T6 material
  - Good combination of strength (UTS > 210 MPa) and ductility (E > 7%); Yield > 130 MPa
  - Hardness variation typically 65 – 80 Brinell
- Aluminum is selected for the most intense, high-stress applications
  - racing vehicles
  - aircraft
  - heavy trucks

2. Materials (cont'd)

- Hardness is adequate for fastening
  - GM, Ford, Chrysler and Toyota OEM and OES use the same fastening system with our wheels
- Accelerated fatigue tests include torque loss as a failure criteria
  - No issues noted in testing
- No warranty issues for torque loss with Enkei's passenger car experience
- No indication of nut seat deformation in review of recovered wheels

3. Manufacture

- Enkei's wheels are produced under strict process controls
- The manufacturing site is 3rd party registered to IS0 9001:2000 and ISO/TS 16949:2002
- Every dimensional or mechanical test has passed – the wheels are in specification
- *No* part of any wheel has failed in service
  - No wheel cracking, bending, fatiguing, distorting, etc.

4. System assembly

- This is an area for others to evaluate
- Any root cause analysis must consider assembly/installation
- Records publicly available indicate the potential for
  - Process control issues?
  - Torque specification issues?
  - Inspection instruction issues?
  - Calibration/gauge control issues?
  - Nonconforming material control issues?

5. Use/Abuse in Service

- Others would know this best
- Owner abuse cannot alone be the cause
  - Proper system design and quality assurance must be sufficiently robust to anticipate foreseeable use/abuse
- Root cause analysis would consider, at a minimum:
  - The practices of vehicle haulers?
  - Initial dealer instructions to customers?
  - The relative experience/inexperience of new trailer owners to the conditions of trailering?

6. Communications

- Again, a Tier 2 supplier is far from this issue
- Torque is highlighted in owners' manuals, with recent upgrades
- Other techniques could be employed to facilitate consistency of customer torque checks

Warranty issue: summary

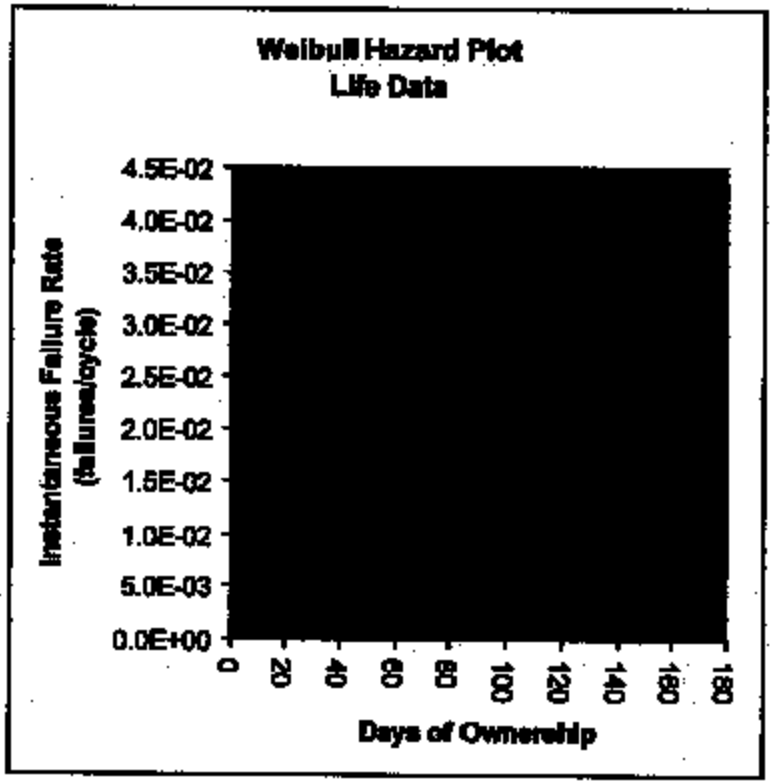
- The fastening system is underperforming
- There are potential scenarios where the wheel could negatively impact fastening, but not here. Enkei wheels
  - Follow standard, accepted design specifications and processes for trailer use
  - Use standard, accepted material
  - Don't themselves fail -- in the lab or in the field
  - Have been used for years without issue in this application
  - Succeed in other comparable applications
- Both assembly practices and system/hub component design merit investigation

Remedies

- An effective solution should
  - Be driven by analysis of these 6 elements, and by the search for root cause
  - Address "hard" and "soft" cause
  - Address *system* design responsibility
  - Be workable – i.e.,
    - lend itself to industry-wide implementation
    - reflect reasonable consumer expectations

Remedies: An Observation

- The (partial) warranty data available to Enkei appear to describe an "infant mortality" phenomenon; where the hazard function is initially high but drops substantially after 1 – 2 months of ownership (first big trip completed?)
- This is consistent with both initial torque at assembly and paint-related torque loss as root causes



THIS IS JUST AN ILLUSTRATION AND NOT BASED ON ACTUAL DATA

Remedies (cont'd)

- Paint removal, with appropriate care to provide a flat and contaminant-free joint, will protect those trailers that
  - Are sporadically or not yet used
  - Are using steel wheels and may subsequently change to aluminum
  - Have tire rotation or other opportunities to change the wheels

What Enkei can do

- Listen and learn: we know what we don't know
- Support the RV industry and NHTSA to develop long-term corrective actions
- Offer our
  - Quality assurance expertise
  - General engineering support
  - Testing, documentation and statistical analysis
  - Business/marketing support and industry training

What Enkei can't do

- The job of others
  - System design responsibility
  - Quality management
  - Configuration control
- Go it alone
  - Need industry-wide data
  - Need vehicle application engineering
  - Need fastener engineering
  - Need cooperation with industry and supply chain

Other considerations

- What does NHTSA think?
- What does the VRTC think?
- What other relevant information is available for us to study?
- How can we be of assistance?
- What is the next step?