



*Handwritten:*  
2/12/07

February 9, 2007

Kathleen C. DeMeter, Director  
Office of Defects Investigation  
NHTSA Enforcement  
Room #5326  
400 Seventh Street, S.W.  
Washington, D.C. 20590

GM-671C

EA05-017  
NVS-214pk

Dear Ms. DeMeter:

This letter is General Motors' (GM) response to your information request (IR), dated December 21, 2006, regarding allegations of steering knuckle fracture for MY 2003 through 2006 Hummer H2 vehicles.

GM is responding to the following questions with updated and additional information since responding to prior NHTSA inquiries for this investigation. Additionally, GM's overall conclusion of this issue begins on page 7.

Your questions and our corresponding replies are as follows:

1. **State the number and provide copies of all of the following information that relates or potentially relates to the subject condition in the subject vehicles. This should include all information in GM's possession or control or of which it is otherwise aware.**
  - a. owner complaints;
  - b. repair shop claims;
  - c. field reports;
  - d. crash/injury incident reports;
  - e. subrogation claims;
  - f. lawsuits; and
  - g. third-party arbitration proceedings where GM is a party to the arbitration.

List and collate your response separately for each category ("a" through "g") by date the incident was filed with GM. Provide for each item in this response the incident date, model, model year, wheel size, engine, owner name, owner address, owner phone number, zone, dealer code, problem code, vehicle identification number, build date, vehicle in-service date, repair date, repair mileage, repair order number, part numbers of subject components replaced, property damage, injuries, and the current status of GM's response to the incident.

For "d," identify all crashes by date, location, and names of parties involved. For "f," identify all the lawsuits by caption, court, and docket number. Provide a separate analysis and description of each item "e" through "g" identifying the vehicle (by model year, build date, and VIN) and the vehicle owner (by name, address, and telephone number). Include all police reports that relate to the subject condition known to GM. Clearly describe the sequence of events leading up to any accident(s), the approximate vehicle speed, approximate vehicle mileage, and any personal injuries, vehicle damage, or property damage that may have occurred.

Provide all related material and information that relate to the subject condition even if GM has not verified it. Indicate if no information exists for any category.



Table 1-1 below summarizes the records for the subject vehicles that could relate to the subject condition. GM has identified no additional reports.

TYPE OF REPORT	GM REPORTS	SUBCATEGORIES			
		CORRESPONDING TO NHTSA REPORTS	NUMBER WITH PROPERTY DAMAGE	NUMBER WITH CRASH	NUMBER WITH INJURIES/FATALITIES
Owner Reports	0	0	0	0	0
Field Reports	0	0	0	0	0
Not-In-Suit Claims	0	0	0	0	0
Subrogation Claims	0	0	0	0	0
Third Party Arbitration Proceedings	0	0	0	0	0
Product Liability Lawsuits	0	0	0	0	0
Total Reports (Including Duplicates)	0	0	0	0	0
Total Vehicles with Reports (Unique VIN)	0	0	0	0	0

TABLE 1-1: SUBJECT H2 VEHICLE REPORT BREAKDOWN  
 N/A NOT APPLICABLE

The data sources searched are shown in Table 1-2.

SOURCE SYSTEM	LAST DATE GATHERED
Customer Assistance Center	1/10/2007
Technical Assistance Center	1/8/2007
Early Quality Feedback (EQF)	1/5/2007
Field Information Network Database (FIND)	1/4/2007
Field Product Report Database (FPRD)	1/4/2007
Company Vehicle Evaluation Program (CVEP)	1/5/2007
Captured Test Fleet (CTF)	1/5/2007
Legal / Employee Self Insured Services (ESIS)	1/4/2007

TABLE 1-2: DATA SOURCES

2. State, by model and model year, a total count for all of the following categories of claims, collectively, that have been paid by GM to date that relate to, or may relate to, the alleged defect for the subject vehicles: warranty claims; extended warranty claims; claims for good will services that were provided; field, zone, or similar adjustments and reimbursements; and warranty claims or repairs made in accordance with a procedure specified in a technical service bulletin or customer satisfaction campaign.

Separately, for each such claim, state the following information:

- a. GM's claim number;
- b. Vehicle owner or fleet name (and fleet contact person) and telephone number;
- c. VIN;
- d. Repair date;
- e. Vehicle mileage at time of repair;
- f. Repairing dealer's or facility's name, telephone number, city and state or ZIP code;

- g. Labor operation number;
- h. Problem code;
- i. Replacement part number(s) and description(s);
- j. Whether the vehicle was towed to the dealer for the repair (y/n);
- k. Secondary component damage (y/n) - Whether there were coincident repairs to secondary components that can be damaged when steering knuckle fracture occurs. For example, repairs to the following components at the same front wheel position as the subject component on or about the same date as the subject component repair ( $\pm$  2 days): brake rotor, brake hose, axle (four-wheel drive), body damage, tie rod, etc. (state the specific criteria used by GM);
- l. Concern stated by customer;
- m. Comment, if any, by dealer/technician relating to claim and/or repair; and
- n. If good will or any other GM good faith payment was received to the owner in an accordance to fix the subject vehicle.

Provide this information in Microsoft Access 2000, or a compatible format, entitled "WARRANTY DATA." See Enclosure 1, Data Collection Disc, for a pre-formatted table which provides further details regarding this submission.

No additional regular warranty and goodwill claims were reported to GM. There were no additional Motors Insurance Corporation (MIC—extended warranty) and Universal Warranty Corporation (UWC—extended warranty) claims. The warranty data was last gathered on January 22, 2007.

The regular and extended warranty data were collected using the same criteria used in response to EA05-017 IR on March 31, 2006 and update on October 25, 2006.

3. State, by model and model year, a total count for all of the following categories of claims, collectively, that have been paid by GM to date that relate to, or may relate to, inner and/or outer tie rod failures for the subject vehicles: warranty claims; extended warranty claims; claims for good will services that were provided; field, zone, or similar adjustments and reimbursements; and warranty claims or repairs made in accordance with a procedure specified in a technical service bulletin or customer satisfaction campaign.

Separately, for each such claim, state the following information:

- a. GM's claim number;
- b. Vehicle owner or fleet name (and fleet contact person) and telephone number;
- c. VIN;
- d. Repair date;
- e. Vehicle mileage at time of repair;
- f. Repairing dealer's or facility's name, telephone number, city and state or ZIP code;
- g. Labor operation number;
- h. Problem code;
- i. Replacement part number(s) and description(s);
- j. Whether the vehicle was towed to the dealer for the repair (y/n);
- k. Secondary component damage (y/n) - Whether there were coincident repairs to secondary components that can be damaged when steering knuckle fracture occurs. For example, repairs to the following components at the same front wheel position as the subject component on or about the same date as the subject component

**repair ( $\pm$  2 days): brake rotor, brake hose, axle (four-wheel drive), body damage, tie rod, etc. (state the specific criteria used by GM);**

- i. Concern stated by customer;**
- m. Comment, if any, by dealer/technician relating to claim and/or repair; and**
- n. If good will or any other GM good faith payment was received to the owner in an accordance to fix the subject vehicle.**

**Provide this information in Microsoft Access 2000, or a compatible format, entitled "WARRANTY DATA." See Enclosure 1, Data Collection Disc, for a pre-formatted table which provides further details regarding this submission.**

NHTSA and GM agreed on January 3, 2007 that GM would search for reports of steering knuckle fracture that contained information indicating inner and/or outer tie rod fractures. Please see GM's responses to prior NHTSA inquiries: question 6 on March 31, 2006 and question 2 on October 25, 2006.

- 4. Please provide all studies, reports, and analyses related to Hummer H2 field incidents involving fractured knuckles that GM has: 1) conducted on its own using in-house GM personnel; 2) had conducted on its behalf by outside consultants; or 3) received during the course of litigation, arbitration or any other alternative dispute resolution processes, including those that were prepared by outside consultants not under contract by GM.**

**For each of the above reports, please indicate whether a tie rod failure (e.g., broken, bent, cracked, deformed, etc.) was involved.**

GM submitted these records in responses to Preliminary Evaluation (PE04-080) Information Request (IR) on February 28, 2005, GM671 Supplement 3 PE04-080-IR on July 22, 2005, Engineering Analysis (EA05-017) IR on GM March 31, 2006, GM671B EA-IR update on October 25, 2006 and the non privileged presentation documents submitted on December 18, 2006.

GM is providing additional information on one incident that was submitted to NHTSA on October 25, 2006. This report is in ATT\_1\_GM disc in folder "Q\_04."

GM is submitting a list of field reports to indicate the condition of the tie rods associated with alleged Hummer H2 knuckle fractures. This confirmation is based on photos that were available to GM. This summary is also in ATT\_1\_GM disc in folder "Q\_04."

Please see response to question 8 for additional information that relates to H2 field incidents.

- 5. Please provide all studies, reports, and analyses related to Hummer H2 field incidents involving tie rod failures that GM has: 1) conducted on its own using in-house GM personnel; 2) had conducted on its behalf by outside consultants; or 3) received during the course of litigation, arbitration or any other alternative dispute resolution process, including those that were prepared by outside consultants not under contract by GM.**

**For each of the above reports, please indicate whether a knuckle failure (e.g. broken, fractured, cracked, bent, deformed, etc.) was involved.**

There were no additional reports of steering knuckle fracture that contain information indicating inner and/or outer tie rod fractures since the October 25, 2006 update.

6. Describe all modifications or changes made by, or on behalf of, GM in the design, material composition, manufacture, quality control, supply, or installation of the tie rods from the start of production to date, in the subject vehicles. For each such modification or change, provide the following information:
- The date or approximate date on which the modification or change was incorporated into vehicle production;
  - A detailed description of the modification or change;
  - The reason(s) for the modification or change;
  - The part numbers (service and engineering) of the original component;
  - The part number (service and engineering) of the modified component;
  - Whether the original unmodified component was withdrawn from production and/or sale, and if so, when;
  - When the modified component was made available as a service component; and
  - Whether the modified component can be interchanged with earlier production components.

Also, provide the above information for any modification or change of which GM is aware that may be incorporated into vehicle production within the next 180 days.

See GM's March 31, 2006 response to EA05-017 in question 10.

GM identified no additional modifications or changes to the tie rods since GM's March 31, 2006 response and that may be incorporated into vehicle production within the next 180 days.

7. State the total number of knuckles produced at Grede Foundries' Saint Cloud and Reedsburg facilities for use on the subject vehicles and peer GMT 800 (i.e., C/K light truck) platform vehicles covering the same model years. Provide a breakdown of how many steering knuckles were produced at each plant and, separately, state how many knuckles from each facility were installed on a) H2 vehicles and b) GMT 800 platform vehicles.

See ATT\_1\_GM disc in folder "Q\_07" for the matrix of Grede knuckle production counts for Saint Cloud and Reedsburg casting facilities. GM is also providing US vehicle production by assembly plant for H2 and GMT800 vehicles.

8. Describe and provide all supporting documentation related to any analysis employed by GM to assess the H2's performance when striking another object, including, but not limited to breakaway base-mounted light poles.

The H2 vehicle in the New Jersey incident was reported to have struck a traffic light pole. The police report indicated property damage to the light pole. The subject light pole was mounted on a breakaway transformer base manufactured by Pfaff and Kendall (P&K Pole Products) of Newark, New Jersey.

The US Department of Transportation Federal Highway Administration sent a letter (labeled LS-41) to P&K Pole Products dated August 30, 1995. In this letter, they stated: "Therefore, the tested aluminum breakaway base described above is acceptable for use on Federal-aid highway projects, within the range of conditions tested, if proposed by a State." Drawings accompanying the letter match the geometry of the breakaway transformer base involved in the

New Jersey incident. This letter also provided a summary of the test conditions, with references to AASHTO<sup>1</sup> Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals and the NCHRP<sup>2</sup> Report 350. See ATT\_1\_GM disc in folder "Q\_08\_A" for the letter and drawings.

The test conditions provided with the acceptance letter indicate that a test vehicle with a mass of 820 kg (1,808 pounds) and a test speed of 35.28 km/h (21.9 mph) was used. Among the criteria for passing, the base would need to give way under the test conditions. The impact severity (as defined in NCHRP report 350) is the kinetic energy of the impacting vehicle, and can be calculated for a head-on impact as  $E = \frac{1}{2}mV^2$ , or 39,376 Joules. An H2 weighing 3,000 kg (6,613 pounds) which is 6,400 pounds curb weight plus 213 pounds for passengers and cargo) would need to be traveling at 18 km/h (11.4 mph) to achieve this energy level. The actual speed of the New Jersey H2 just prior to wheel failure is unknown. However, other incidents of knuckle fracture have occurred at impact speeds lower than 11 mph. For example, Event Data Record (EDR) data downloaded from other incidents showed speeds at impact of 9 mph for H2 California case and 7 mph for Massachusetts case. Therefore, the energy level required to fracture the knuckle is lower than the energy level to fracture the P&K pole base.

A review of the New Jersey traffic crash records database at the intersection where the New Jersey incident occurred uncovered numerous crashes involving traffic sign posts or light standards. A summary of those incidents from calendar years 2001 to 2005 are provided in ATT\_1\_GM disc in folder "Q\_08\_B".

A recent inspection of the subject light pole provided data that suggested that the base of the pole had been repaired. The data includes photographs of the bolt-to-collar area showing evidence of a collar movement, bolt replacement, different bolts being used in the collar. See ATT\_1\_GM disc in folder "Q\_08\_B" for the photographs.

9. **Provide an analysis including static and impact calculations and an assessment of the effects on the "early knuckle" lower ball joint strength from the lack of surface contact at the top of the frustum hole of the knuckle lower ball joint to ball joint stud interface using the following assumptions:**
- a. **The minimum allowable surface contact per GM specification of 75%, with the contact concentrated entirely at the bottom of the frustum hole; and**
  - b. **The air gap at the top of the hole is 0.020 inches (radial).**

**State all failure modes by which this gap could be formed and what measures are taken to prevent the occurrence of the failure modes. Vary the surface contact to a level of 50%, concentrated entirely at the bottom of the hole and vary the air gap to 0.035 inches (radial) and include these parameters in the calculations and assessment.**

GM has not performed the type of hypothetical and unrealistic calculations indicated here. The ball stud and taper are manufactured to ensure that contact will occur at the top of the hole both prior to and after draw-in. A review of all knuckle fracture incidents where photographic data are available show a consistent pattern of deformation that includes unidirectional gross ductile deformation on the top inside surface of the knuckle consistent with an overload event. Where

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<sup>1</sup> American Association of State Highway and Transportation Officials

<sup>2</sup> National Cooperative Highway Research Program

$E = \frac{1}{2}mV^2$  E = Energy, m = mass, V = Velocity

metallurgical analyses have been performed on the fracture surfaces, these analyses have conclusively determined that the knuckle fracture was caused by a single massive overload event with fracture initiation on the outside surface of the boss.

The hypothetical situation proposed in Question 9 contradicts how the knuckle and ball stud are designed and manufactured, and do not match the evidence gathered from the incidents. Furthermore, theoretical analyses of the type envisioned by Question 9 are so complex that any attempt to model them without undergoing an extensive program of calibration and testing would result in unreliable and possibly misleading results.

Servo-hydraulic testing, where a ball stud installed in a knuckle was repeatedly subjected to increasingly massive overloads sufficient to cause progressively larger gross plastic deformation, found that forces in excess of 20,000 pounds were needed to cause knuckle fracture – an amount comparable to that of an undamaged knuckle subjected to a single, monotonically increasing load.

- 10. State whether the early arm knuckles, ball joints, and/or outer tie rod ends were withdrawn from production at any of the casting, manufacturing, or assembly facilities. If any of these components were withdrawn, provide manufacturing non-conformance containment documentation and the reason(s) for doing so.**

See GM's March 31, 2006 response to EA05-017 in question 10 for engineering changes. GM is not aware that any of these components were withdrawn for manufacturing non-conformance containment actions.

In its March 31, 2006 response to EA05-017 in question 10, GM indicated the lower ball joint was withdrawn from production and/or dealer sales. This characterization of disposition was in error. GM is now providing an updated table that indicates none of these components were withdrawn from production and/or dealer sales. See ATT\_1\_GM disc in folder "Q\_10."

- 11. Provide all studies, reports, and related documents in GM's possession involving the testing, analysis, and evaluation of the "early arm" knuckle, inner tie rods, and outer tie rods as they were adapted to the H2 application with the 315 X 70 R17 tire and wheel package.**

See response to GM671 PE04-080-IR on February 28, 2005 in question 13 for the Gross Vehicle Weight Rating (GVWR) and wheel sizes spreadsheet and GM671A EA05-017 IR on March 31, 2006 in question 9 for the engineering study, reports, and documents, and question 27 for the wheelbase and turning radius spreadsheet.

### **Conclusion**

NHTSA began this investigation on December 2, 2004. In our investigation of this matter we have conclusively established that the component failures we have been able to inspect exhibit ductile deformation consequent to a single event overload. Our conclusion is that the reported part failures are a result of collision events overloading the tire and wheel assembly and causing fracture of the steering knuckle. GM has discovered no evidence of defect related to motor vehicle safety.

GM's risk assessment is summarized below. As to the existence of a design or engineering defect, NHTSA agreed at a meeting on December 7 and December 15, 2006, that "the original

knuckle design is probably sufficient for the H2 application if the manufacturing processes are entirely in conformance.”

The qualification in that NHTSA's statement regarding manufacturing implicates three processes: assembly, casting and machining. Quality control plans, processes and audit torque data for the front suspension assembly, including the knuckle assembly, verified by a GM Product Investigations team visit to the H2 vehicle assembly plant in February 2005, have been provided to NHTSA on February 28, 2005 (response to question 9) and November 11, 2005 (response to questions 3 & 5) and on March 31, 2006 (response to question 32). Additional audit torque measurement charts responsive to this information request appear in ATT\_2\_GM\_CONF disc in the folder labeled "Q\_11\_A\_Audit." GM requests that this information, which has been stamped "GM Confidential" be afforded confidential treatment by NHTSA.

The casting process and associated metallurgical evaluation has been reviewed in detail with NHTSA staff by means of failure analysis of steering knuckles fractured in field incidents involving H2 and GMT800 vehicles, exemplar knuckle testing and examination of pearlite content and material properties. As demonstrated by GM's PhD consultant in metallurgy at our meeting with NHTSA on December 15, 2006, analysis of field and test specimens exhibit identical fracture morphology: gross plastic deformation from unidirectional overloading, accompanied by a consistent pattern of Brinell marks in the boss from overload events. There is no evidence of low-energy, brittle fracture initiation. As amplified during this discussion, GM's November 11, 2005 response and March 31, 2006 response (question 31), applicable specifications for pearlite content and mechanical properties, including hardness and elongation requirements were consistently met and there is no pearlite level trend observable for knuckles fractured in field incidents.

The machining control plan and Potential Failure Mode Effect Analyses were submitted on February 28, 2005 (response to question 9). An updated PFMEA responsive to this information request appears in ATT\_4\_SPLR\_CONF Disc in the folder labeled "Q\_11\_B\_PFMEA." Supplier Eagle Picher requests that this information, which has been stamped "Confidential" be afforded confidential treatment by NHTSA.

GM conducted a rigorous analysis of field performance, reviewing all data available from the incident reports, including photographs of vehicles, parts and crash scenes; police reports; vehicle inspection reports; event data recorder downloads; eyewitness accounts and other relevant information. GM also purchased a field incident vehicle and provided NHTSA with a detailed physical review of the physical evidence as well as making the vehicle available for a subsequent inspection by NHTSA. Data from the event data recorder (EDR) and physical evidence on the vehicle show that a collision event preceded knuckle failure and that the single event overload was consequent to the collision event, not the reverse.

During the December 15, 2006 meeting, GM enumerated 9 conclusions from the incidents for which sufficient supporting data could be assembled. In each of these incidents, the ultimate conclusion was always that the crash caused the knuckle separation – not the other way around. None of the physical facts leading to these conclusions is open to dispute.

Finally, there is no safety defect. There has been only one reported incident of an H2 steering knuckle fracture in the past 16 months.

The investigative record is complete and clearly sufficient to conclude that no defect exists.



\* \* \*

General Motors requested assistance and documents from suppliers in responding to item 7. This response includes those documents received from suppliers.

GM claims that certain information, in documents that are part of lawsuit and claims files maintained by the GM Legal Staff, is attorney work product and/or privileged. That information includes notes, memos, reports, photographs, and evaluations by attorneys (and by consultants, claims analysts, investigators, and engineers working at the request of attorneys). GM is producing responsive documents from claims files that are neither attorney work product nor privileged, and withholding those that are attorney work product and/or privileged.

This response is based on searches of General Motors Corporation (GM) locations where documents determined to be responsive to your request would ordinarily be found. As a result, the scope of this search did not include, nor could it reasonably include, "all of its divisions, subsidiaries (whether or not incorporated) and affiliated enterprises and all of their headquarters, regional, zone and other offices and their employees, and all agents, contractors, consultants, attorneys and law firms and other persons engaged directly or indirectly (e.g., employee of a consultant) by or under the control of GM (including all business units and persons previously referred to), who are or, in or after 1993, were involved in any way with any of the following related to the subject condition in the subject vehicles:

- (a) Design, engineering, analysis, modification or production (e.g. quality control);
- (b) testing, assessment or evaluation;
- (c) consideration, or recognition of potential or actual defects, reporting, record-keeping and information management, (e.g., complaints, field reports, warranty information, part sales), analysis, claims, or lawsuits; or
- (d) communication to, from or intended for zone representatives, fleets, dealers, or other field locations, including but not limited to people who have the capacity to obtain information from dealers."

This response was compiled and prepared by this office upon review of the documents produced by various GM locations, and does not include documents generated or received at those GM locations subsequent to their searches.

Please contact me if you require further information about this response or the nature or scope of our searches.

Sincerely,



Gay P. Kent  
Director

Product Investigations

Attachments

**GM671C  
EA05-017**

**GM CONFIDENTIALITY LETTER**

**GM CONFIDENTIALITY LETTER  
HAS BEEN REMOVED FROM THIS  
ATTACHMENT AND SUPPLIED TO  
THE OFFICE OF THE CHIEF COUNSEL**

**GM671C  
EA05-017**

**SUPPLIER CONFIDENTIAL LETTER**

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HAS BEEN REMOVED FROM THIS  
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THE OFFICE OF THE CHIEF COUNSEL**

**GM671C  
EA05-017**

**ATTACHMENT "1"**

**GM NON-CONFIDENTIAL MATERIAL**

**GM671C  
EA05-017**

**ATTACHMENT "2"**

**GM CONFIDENTIAL MATERIAL**

**GM CONFIDENTIAL MATERIAL  
HAS BEEN REMOVED FROM THIS  
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THE OFFICE OF THE CHIEF COUNSEL**

**GM671C  
EA05-017**

**ATTACHMENT "3"  
DOES NOT EXIST**

**GM671C  
EA05-017**

**ATTACHMENT "4"**

**SUPPLIER CONFIDENTIAL MATERIAL**

**SUPPLIER CONFIDENTIAL MATERIAL  
HAS BEEN REMOVED FROM THIS  
ATTACHMENT AND SUPPLIED TO  
THE OFFICE OF THE CHIEF COUNSEL**