Main Landing Gear Wheel Tie Bolt Hole Corrosion

Presenter:
Mike Porter

Organization/Date:
Orbiter/10/18/01

Observation:

- Main landing gear (MLG) wheels at Goodrich for refurbishment show signs of corrosion in tie-bolt hole locations (this was discovered by visual inspection)

Concern:

- *Condition of the wheels on OV-105 is unknown*
  - If corrosion exists, it could lead to stress concentration points, causing formation of a fatigue crack with eventual failure during landing/roll out

Nasa spec. 1249
NDE POD

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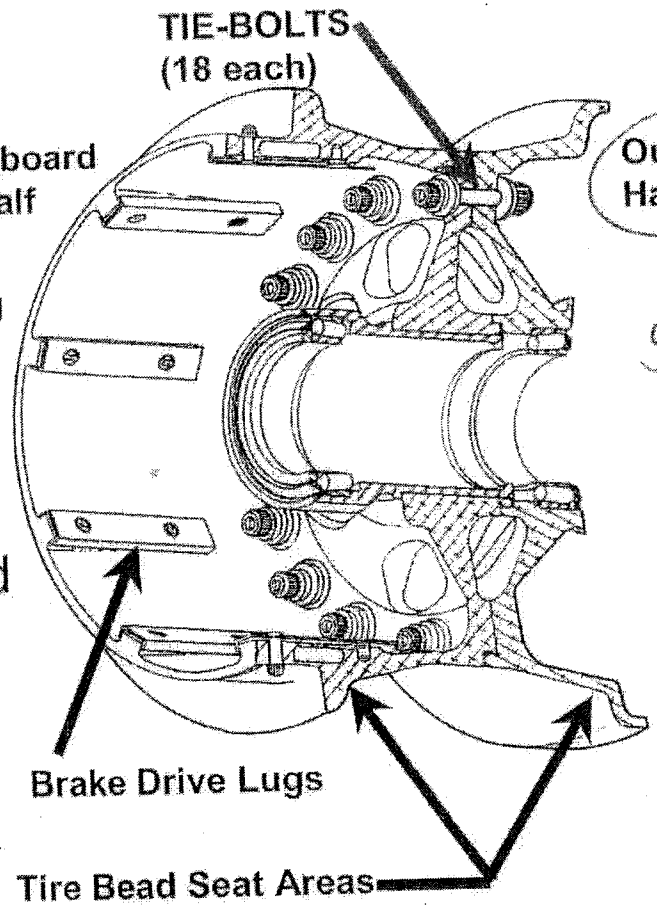
Main Landing Gear Wheel

- The Orbiter's MLG wheel is a typical aircraft split wheel design
  - Aluminum wheel halves
    - Chemical film coating and primer/top coat provide corrosion protection
    - Holes And Wheel Halves Mating Surfaces have chem film and primer only
  - High strength Multi-Phase tie-bolts assemble the inner and outer wheel halves together
- Wheels are disassembled and assembled every flow due to one flight use of MLG tire
  - Tie-bolts are used for 4 torquings and then replaced
  - Tie-bolt washers inspected at every wheel assembly



generally have more corrosion than inboard half

Outboard ~ 20 yrs. old
Inboard ~ 12 yrs. old

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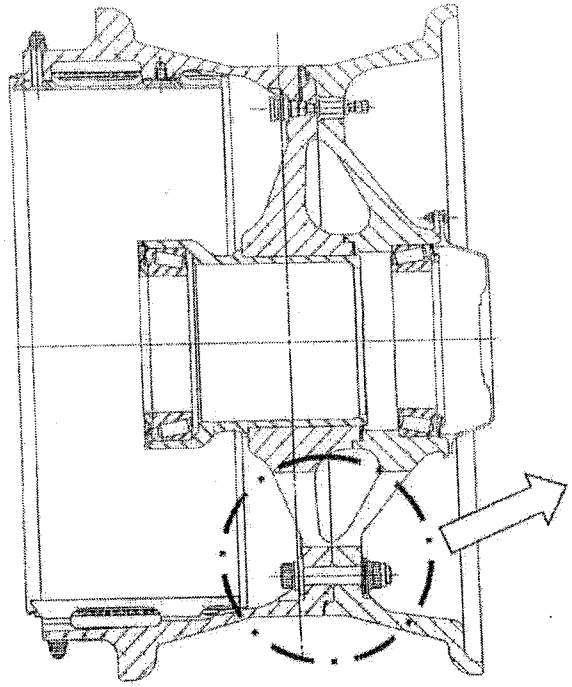
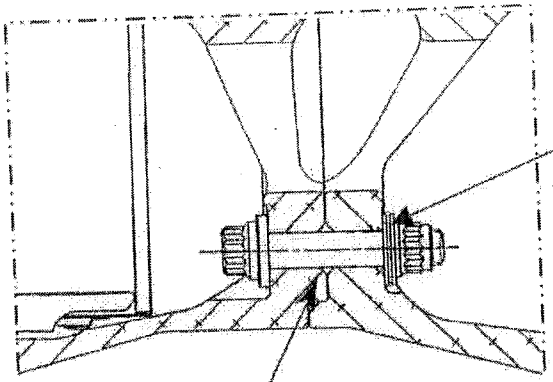


MLG Wheel

Typical Tie Bolt attachment



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Discussion:

- During the scheduled 10 flight refurbishment of six MLG wheels at Goodrich, visual inspection revealed signs of corrosion pits in tie-bolt hole areas
  - Corrosion on the edge radius of holes, washer bearing surfaces, and inside some holes
  - Corrosion seen on 1 – 4 of the 18 holes on all 12 wheel halves
  - Corrosion pits are estimated to be 0.020 inches deep
    - Plan to rework surfaces to remove corrosion which will determine actual depth (they took 0.010" off & some corrosion still exists)
  - No cracks or flaws were discovered during NDI inspection
    - Dye-penetrant standard NDI
    - Eddy current special NDI (detects very small flaw sizes)
      - Eddy Current pencil probe detects 0.05 " Long x 0.025 " deep Flaws

→ dye-pen suggests "no crack"; eddy current special NDI has not yet been done on the bolt hole radius.

only 2-3 outer halves have corrosion on the tie bolt radius

No flaw standard is available for use of special probe on wheel hole radius. → can't calibrate the probe yet.

BOEING

Preliminary version

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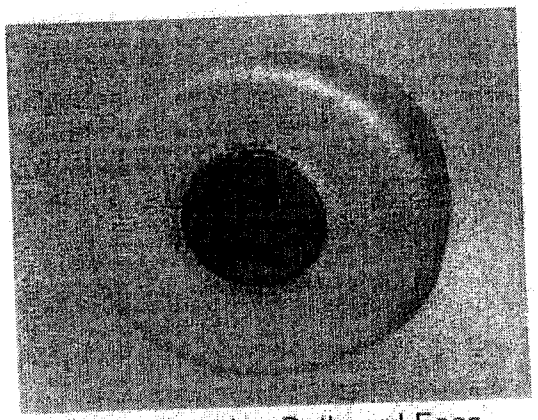
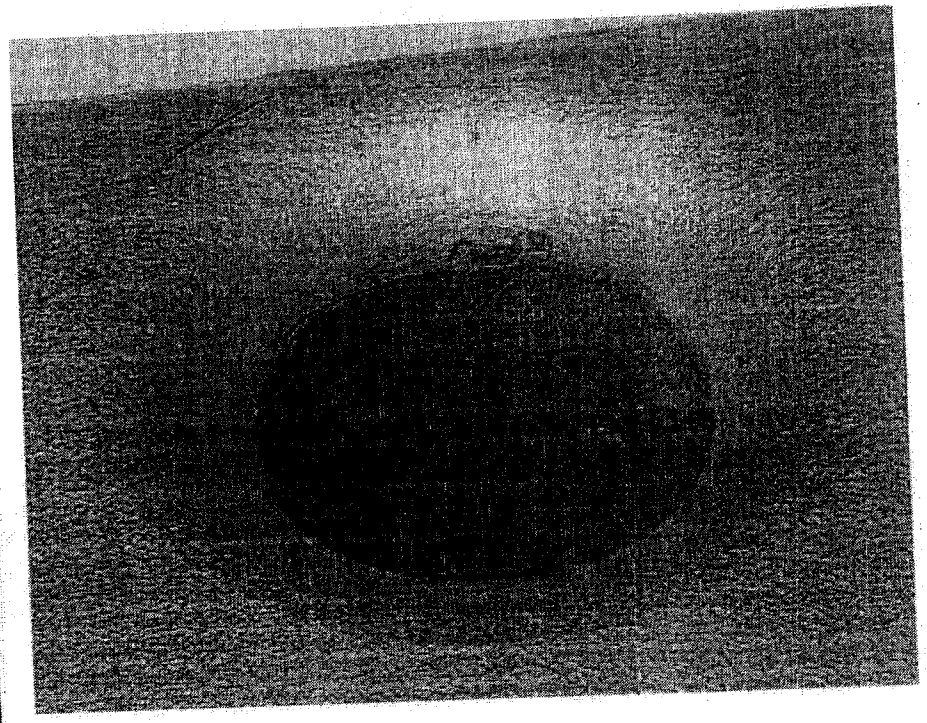
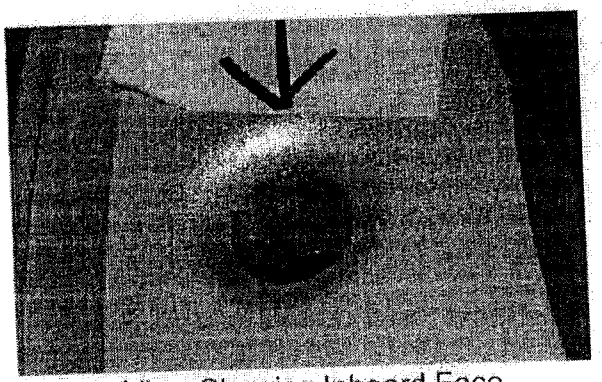
Tie Bolt Hole Corrosion



View Showing Outboard Face of Wheel Half





View Showing Inboard Face (Mating Surface) of Wheel Half

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Discussion:

- Fracture control analysis req't imposed on the MLG wheel during the carbon brake wheel CDR in 1988
  - No fracture analysis used on NLG wheel and MLG baseline beryllium wheel design
  - No fracture analysis used on other Goodrich design wheels - unique to orbiter carbon brake wheel (Goodrich to verify)
- Fracture analysis performed by Goodrich
  - Analysis assumed the existence of an initial flaw of 0.030 deep by 0.060 wide crack
  - Most critical area is tie bolt hole radius on outboard wheel half
  - Analysis indicates crack goes unstable during 6th mission resulting with crack between tie bolt holes –not necessarily loss of wheel but changes stresses
  - Inboard wheel half tie bolt holes are good for 62 missions

Airbus A320

Magnaflux Eddy current probe made for 11-14-89 bolt hole radii

2 of 6 wheels have corrosion on bolt hole radius of outboard half

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Discussion:

- 10 mission refurbishment requirement was carryover from beryllium brake wheel design
  - Same outboard wheel half used for both configurations
    - Outboard wheel half has fracture critical area
  - Inboard wheel half required redesign to accommodate the carbon brake
- Extensive fatigue life testing for carbon brake wheel similar to beryllium brake wheel testing
  - Completed 990 mile slow roll test
    - Same requirement as beryllium brake wheel
  - Completed 7 dynamic high speed landing profiles
    - Added another abort landing profile for carbon brake wheel qualification program
- Added special NDI to tie bolt hole because of fracture control requirement
- Based on successful fatigue testing and conservatisms in facture analysis – program stayed With 10 Flight for Refurbishment

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Actions Completed:

- OV-105 wheels and the 6 wheels at Goodrich were processed similarly at KSC

- KSC inspected one loose MLG wheel (2 wheel halves) currently available in the tire shop for signs of corrosion
  - **3 tie bolt holes on inboard wheel half has possible indications of corrosion pits,**
    - **White powder present, possibly Al oxide, but not enough to verify / sample**
  - **KSC will perform special NDI (eddy current) on tie bolt holes with suspected corrosion pits**
  - **Outboard wheel half ok**
  - **KSC inspected 6 loose nose wheel halves**
    - 1 wheel half has indications of possible corrosion pit

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Actions In Work/Actions Planned:

- Goodrich to rework all 12 wheel halves
  - Rework will determine the actual corrosion pit depth
    - Material will be machined until corrosion is no longer visible
    - If rework exceeds maximum allowable hole tolerance, than restricted flight usage MR may be required

- Seven additional wheels at the 10 flight limit are being expedited to Goodrich for inspection
- Goodrich to review procedures (KSC job cards) used during wheel processing at KSC
- Goodrich to visit KSC wheel tire shop November 7/8 for site and equipment review of wheel process

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Actions In Work/Actions Planned:

- **Corrosion can be the initiation of a fatigue crack**
  - Expect to find worst corrosion depth is < .030 inch fracture analysis flaw size
    - Visual approx 0.020 deep, Rework will determine actual depth
  - Then worst corrosion will still have full fracture life
    - Minimum of 6 Landings
  - Need to remove corrosion and blend area smooth
    - Corrosion will continue to grow
    - Need to know true depth of corrosion pits
- **Goodrich may make a second trip to KSC (post STS-108) to Review real time processing at the wheel and tire shop if needed to complete root cause investigation**
- **PRT to review/recommend future corrosion preventative options**

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Risk Assessment:

- No prior history of wheel corrosion reported
- No detrimental effects resulting from this condition are apparent on 6 wheels at Goodrich
  - No cracks found
- OV-105 wheels processed same as wheels at Goodrich
- No anomalies reported on OV-105 wheels

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Acceptable for STS 108 Rollout:

- If corrosion exists on OV-105 wheels, it is not expected to be worse than found on the 6 wheels at Goodrich
  - Wheels on OV-105 have been processed using the same procedures as the wheels at Goodrich
  - Wheels at Goodrich had reached their 10 flight limit
  - Wheels on OV-105 have a maximum of 8 flights usage
- No cracks detected by ~~"Special NDI"~~ Standard Dye Pen on 6 Wheels at Goodrich
- If cracks are small enough not to be detectible by Special NDI, fracture analysis predicts we are safe to fly STS-108
  - Minimum 6 flight life

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Back-up

Main Landing Gear Wheel Tie Bolt Hole Corrosion

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Organization/Date:
Orbiter/10/18/01

Wheel Assets:

- **30 Flight Wheels Total Plus 3 New Potential Spares**
  - 6 Wheels at Goodrich For Refurbishment (10 flights)
  - 7 Wheel With 10 Flights at KSC HDA
    - Sent to Goodrich 10/16/01 for Inspection
  - 4 Wheels on OV-105 (7-8 flights)
  - 4 Wheels on OV-103 (8-9 flights)
  - 4 Wheels on OV-102 (8-9 flights)
  - 4 Wheels in Wheel/tire Shop For OV-104 (6–9 flights)
  - 1 Loose Wheel in Wheel/tire Shop (10 Flights to be sent to Goodrich)
- **8 Spare Wheel Halves Available in Logistics Stores**
  - 3 Inner Halves and 5 Outer Halves (3 Potential Flight Assemblies)
  - Never Been Flown

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