# Crane Rehabilitation

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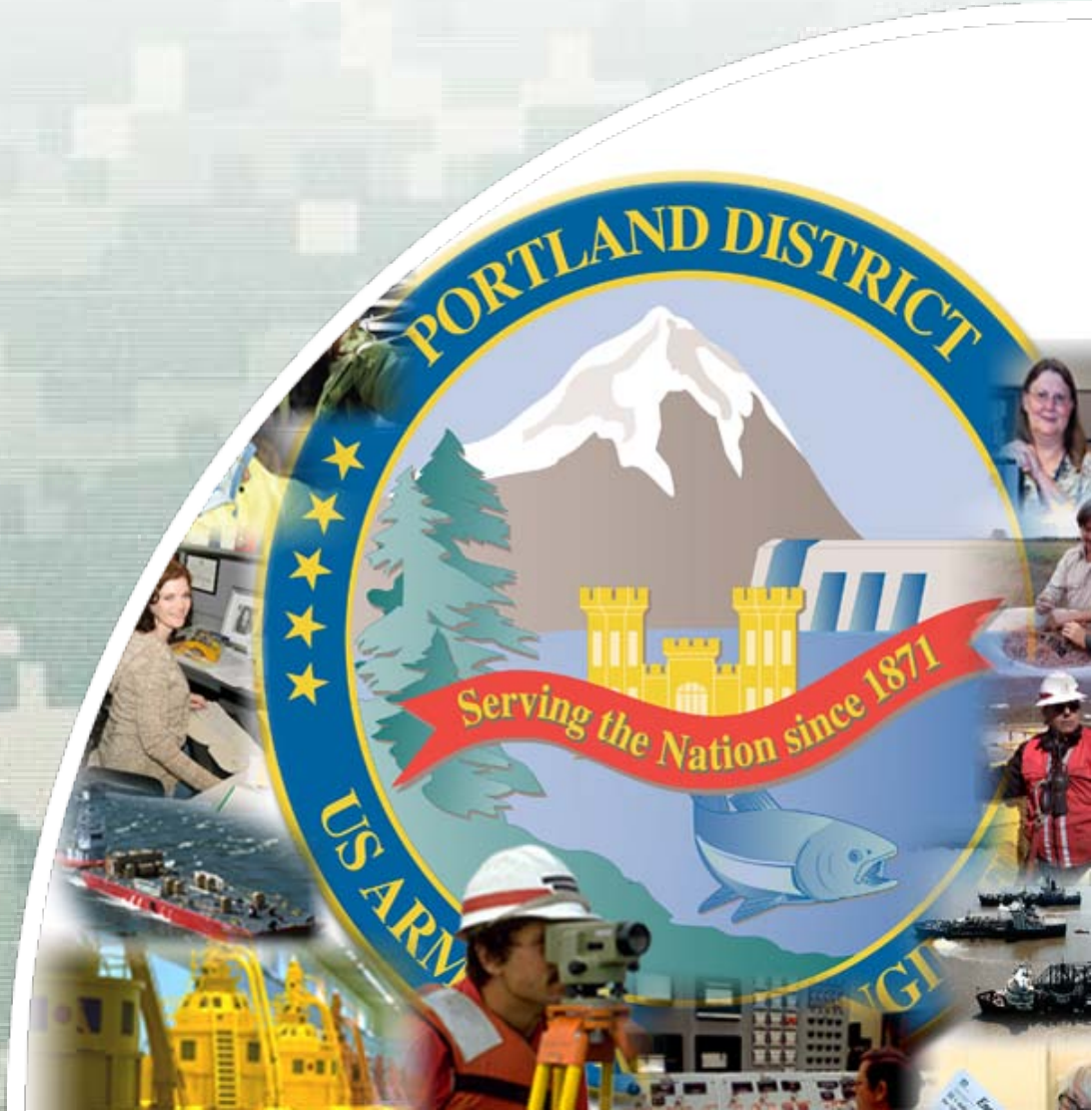
SWAPA Conference, 15 Jun 2011




US Army Corps of Engineers

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# Background

- Typical age of cranes at Corps plants is 60 yrs.
- Most wear occurred when plant was built. Rehab important before plant major rehab. Some cranes see much more severe duty cycle than others.
- Original criteria was to design the crane to be overloaded by 10% during heaviest lift. OSHA was not considered relevant. Not true anymore.
- Gantry cranes didn't usually include the weight of mud on the gates
- For a long time, we ignored the load issues since we didn't have load cells
- Fatigue was never considered in original design

# Risks

- Lots of discussion and some analysis is important to balance risks,  requirements, customer needs and available
- Bare minimum crane rehab just replaces electrical. When it suits the job, cost is much lower.
- Design build can increase risk for retrofit type work
- OSHA and ANSI/ASME don’t allow lifting more than rated load
  - Important to identify the lifted load and to the greatest extent possible what parts need to be replaced due to wear or inadequate load rating .
  - Can lift more than rated load with Engineered Lift, but this is only suitable for infrequent lifts.  2 times/year.

# Cost range

| | |
|---|---|
| Cougar 60 T bridge | $400,000 |
| Dexter 100 T bridge | $3,112,682 |
| Stockton 325 T bridge | $675,933 |
| JH Kerr 225 T Bridge | $1,013,563 |
| Ice Harbor 500T bridge | $1,455,759 |
| Lookout Point 200 T Bridge | $4,496,107 |
| Garrison Bridge 300 T bridge + 20 T gantry | $1,507,000 |
| New Ice Harbor 40 T tailrace | $1,757,000 |
| Bonneville PH1 2 x 300 T bridge | $ 3,109,335 |
| Hills Creek 60 T bridge | $2,895,685 |
| Big Cliff 100 T bridge | $3,523,720 |
| McNary 350 T bridge | $3,878,086 |
| New Lower Monumental/Lower Granite 2 x 130T gantry | $7,484,000 |

**This is a small sample of over 50 crane rehabs or replacements. Point: costs can vary widely based on the scope needed.**

# Electrical

- Includes complete replacement of electrical equipment.
- Old equipment is typically wound rotor, 2 speed squirrel cage or DC. Not typical practice in industry anymore.
- New equipment - AC Flux vector drives for hoist AC open loop VFD drives for everything else.
- PLC can integrate many functions and give the operator more information on the display. Useful for some cranes
- New conductors with 4$^{th}$ conductor ground and power supply updates sometimes needed.

# Mechanical and structural

- Mechanical and structural work is typically tailored to meet the needs of the job.  How worn is gearing? Fatigue cracks? Uprating needed?
- Structural design is often inadequate.  Usually more problematic for gantry cranes.
- Fall protection upgrades commonly part of the scope. Now requires a qualified person per revised EM 385-1-1 and ANSI Z 359
- Major components like gear boxes and drums sometimes less expensive to replace than fix
- Cab is often  replaced, depends on whether operators need significant changes.

# Mechanical and structural

- Structural inspection helps determine extent of corrosion by UT and identify significant problems early
- Structural analysis of crane, especially gantries is good to include at the start of the job
- Rails. Initial visual inspection is a good idea. May add a rail survey if problems are observed or known to pre-exist. Rails and or alignment are a high cost addition.
- When redesign is needed, fatigue analysis using realistic number of load cycles can allow the design to be sufficient without replacing equipment.
- Visual inspection sufficient for most mechanical equipment. NDT, thermal imaging or temp gun are useful tools for certain situations.

# Mechanical

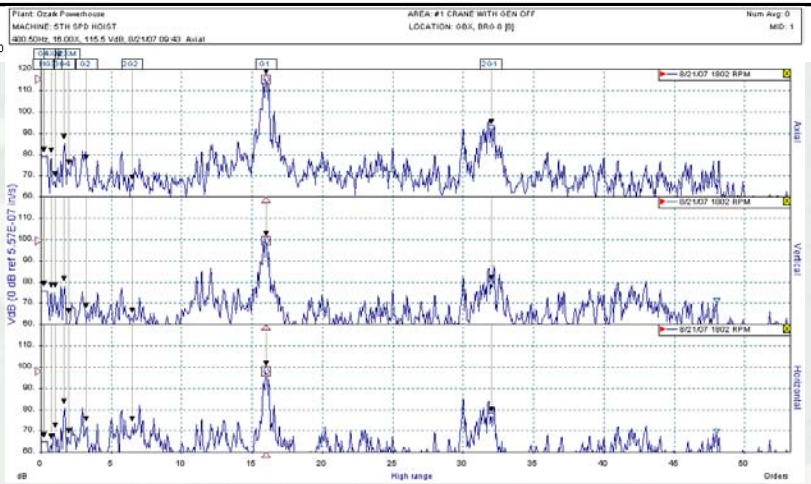
- Vibration analysis can be a good tool for some drive trains, especially where problems are suspected.

**McNary Bridge Crane - main hoist frequencies**

| | RATED rpm | rotational freq | gear ratio | # pinion | # gear | mesh freq | timken brg # | at rated speed | brg damage freqs (see timken website) f0 or f1 eccentricity or out of round rotating member | f2 ball or roller irregulatity | f2' ball or roller spin frequency | f3 inner race irregularity | f4 outer race irregularity | f5 ball or roller size variations rotating inner | f6 ball or roller size variations rotating outer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1st stage | 1800.0 | 30.00 | 4.0 | 22.0 | 87.0 | 660.0 | 32308 | | 30.000 | 177.480 | 88.740 | 277.800 | 202.200 | 12.630 | 17.370 |
| | 1800.0 | 30.00 | | | | | 32310 | | 30.000 | 157.32 | 78.66 | 248.01 | 171.99 | 12.3 | 17.73 |
| 2nd stage | 455.2 | 7.59 | 3.1 | 24.0 | 75.0 | 182.1 | 32311 | | 7.583 | 46.276 | 23.323 | 74.215 | 54.696 | 3.125 | 4.368 |
| 3rd stage | 145.7 | 2.43 | 3.9 | 22.0 | 86.0 | 53.4 | 32314 | | 2.433 | 12.807 | 6.404 | 22.977 | 15.951 | 0.998 | 1.435 |
| 4th stage | 37.3 | 0.62 | | | | | | | | | | | | | |

| | % rated speed | | actual rpm | gear ratio | # pinion | # gear | mesh freq | timken brg # | at actual speed | f0 or f1 eccentricity or out of round rotating member | f2 ball or roller irregulatity | f2' ball or roller spin frequency | f3 inner race irregularity | f4 outer race irregularity | f5 ball or roller size variations rotating inner | f6 ball or roller size variations rotating outer |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1st stage | 10.0% | 3.00 | 180.0 | 4.0 | 22.0 | 87.0 | 66.0 | 32308 | | 3 | 17.748 | 8.874 | 27.78 | 20.22 | 1.263 | 1.737 |
| | 10.0% | 3.00 | 180.0 | | | | | 32310 | | 3 | 15.732 | 7.866 | 24.801 | 17.199 | 1.23 | 1.773 |
| 2nd stage | 10.0% | 0.76 | 45.5 | 3.1 | 24.0 | 75.0 | 18.2 | 32311 | | 0.7583 | 4.6276 | 2.3323 | 7.4215 | 5.4696 | 0.3125 | 0.4368 |
| 3rd stage | 10.0% | 0.24 | 14.6 | 3.9 | 22.0 | 86.0 | 5.3 | 32314 | | 0.2433 | 1.2807 | 0.6404 | 2.2977 | 1.5951 | 0.0998 | 0.1435 |
| 4th stage | 10.0% | 0.06 | 3.7 | | | | | | | | | | | | | |

http://www.timken.com/en-us/Knowledge/engineers/Pages/BearingPerio



# Lessons Learned

- Communicate goals thoroughly, especially scope and cost
- The existing crane rating in tons is often inadequate.
- Important to define the scope of the job in detail, early. Formalize the details of the scope in writing so the whole team can agree.
- During design process, critical to get input from the right people, especially mechanics, electricians and operators
- Submittals – On time reviews are critical
- Important to have good QC plans for shop fabricated items. Good example is new drum fabrication and any repair of gear reducers.

# Lessons Learned

- When part of the scope, fall protection and crane cabs require lots of input and coordination to meet customer needs.
- Gantry cranes- structural inspection and weighing of crane and loads is important.
- Structural analysis of crane during design phase avoids unanticipated changes during contract.
- Detailed mechanical inspections but not  to point of significant disassembly
- If we’re doing significant replacements of mechanical equipment of the trolley, it can cost less to just replace it.

# Lessons Learned

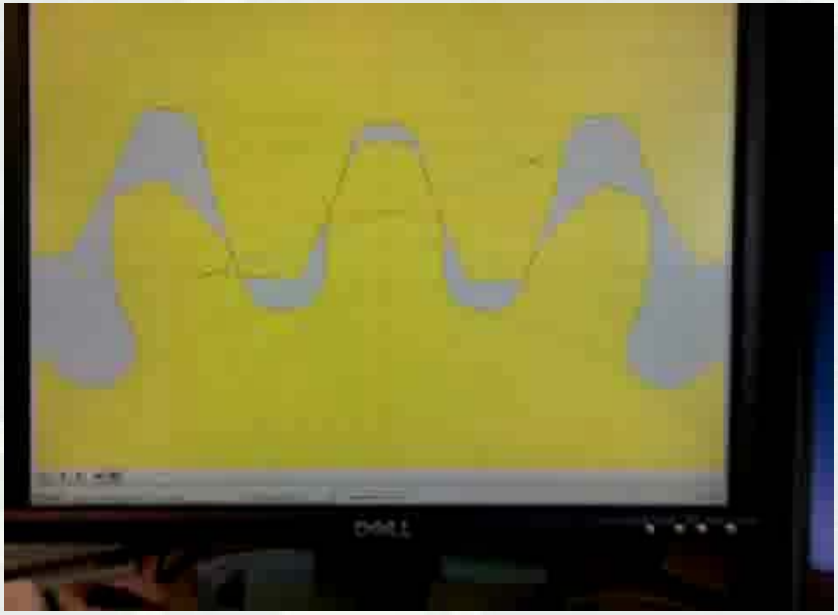
- Fewer problems with electrical, it's more like new construction
- Increased competition is important.  Some new contracts have been full and open competition to get adequate competition.
- RFP contracts, Best Value and LPTA have worked better than IFB (low bid). Past performance more important than experience.
- Get buy in on scope from the full team.  We've found detailed scope helpful in defining the features of the crane. Signed by all parties

# Lessons Learned

- Poorly qualified Contractors can cause big problems. Improper coupling installation led to this. Almost dropped a rotor.

# Open gears

- Lots of open gears have wear, lubrication and alignment  issues, , designs can be refined to fix this.  Initial visual inspections can help tell if there's a problem.

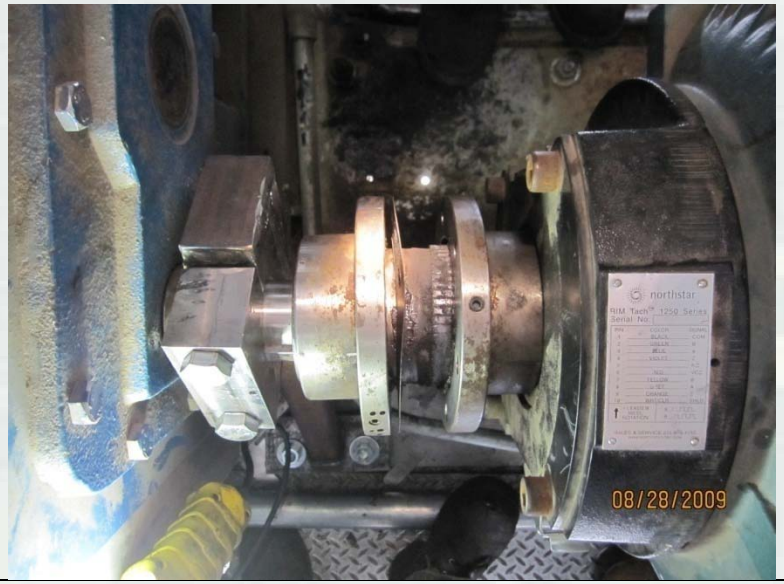


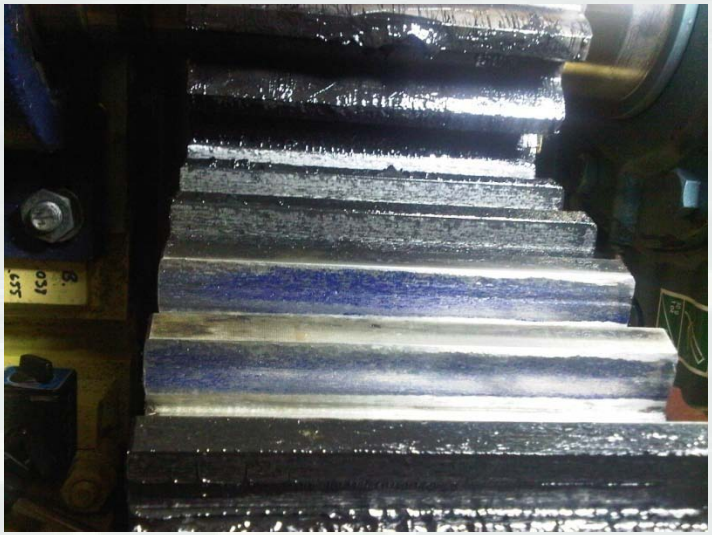
# Drum Cracks

- A very common occurrence, which could lead to dropping a load if not fixed.  Cracks occur in many drums of this design . Important to know before awarding contract.

# Alignment and Balancing

- Alignment and balancing
  - ISO 1940 G6.3 (low speed) G2.5 (high speed) Shop balance is preferred.
  - Inadequate alignment a common problem.
  - Laser or reverse indicator alignment of shafts, typically 2 mil offset and angular
  - Gear alignment crucial



# Summary

- Clear communication of project requirements and coming to full agreement on the details of the scope. This will help match the needs with the available budget.
- Important to identify critical problems ahead of time, like crane capacity issues, bad existing structural design, structural damage, drum or gear replacement, truck repair, rail surveys and repairs.
- Increased competition (sometimes large business), best value or LPTA contracts can be valuable tools