

NTSB

RRD21LR007

Mechanical Working Group

Union Pacific Track Maintenance Machine (TMT) TMT-1602 Inspection Protocol

The purpose of the Mechanical Working Group is to determine the overall (mechanical, pneumatic, hydraulic, and electrical) condition of Track Maintenance Tamper TMT-1602. The purpose is not to analyze or otherwise make claims about how the conditions found at the time of the inspection may have, or may not have, contributed to the accident in Vail, AZ on January 31, 2021.

Post-accident factual information received through interviews, photographs, and prior testing will assist the group in the determination of an inspection protocol.

First Draft for team review	2/24/21	*First Draft
Second Draft after initial review	3/2/21	*Modified inspections *Moved inspection protocol to new spreadsheet document.
Third Draft after 3/4/21 review	3/15/21	
Final Draft after 3/24/21 inspection activities	3/26/21	Items in red are removed since 3/15/21 draft Items in blue are added since 3/15/21 draft
Completed document after Mechanical Working Group review	5/1/21	

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Participants

Name	Title	Phone	eMail
John Manutes	Investigator, NTSB	[REDACTED]	[REDACTED]
Ryan Frigo	Investigator, NTSB	[REDACTED]	[REDACTED]
Rick Bruce	Specialist, FRA	[REDACTED]	[REDACTED]
Shane Mapes	Inspector, FRA	[REDACTED]	[REDACTED]
JT Zimmerman	Inspector, FRA	[REDACTED]	[REDACTED]
Robert Hill	Director, UP	[REDACTED]	[REDACTED]
Tony Bernhard	Director, UP	[REDACTED]	[REDACTED]
Drew Bokenkamp	Director, UP	[REDACTED]	[REDACTED]
Brian Cumbridge	Director, Nordco	[REDACTED]	[REDACTED]
John Gobert	Manager, Nordco	[REDACTED]	[REDACTED]
Adam Allen	BMWED	[REDACTED]	[REDACTED]

Key Facts

- The accident occurred January 31, 2021 near Vail, Arizona at 12:40pm
- Weather at the time of the accident was described as good. It was 62 degrees, very light wind, no precipitation.
- The machine is manufactured by Nordco and is similar to equipment known to them as a Hydraulic Switch Tamper <https://www.nordco.com/products-catalog/roadway-work-equipment/ballast-tamping/hydraulic-switch-tamper-hst.htm>
 - Specifically, this machine is known as an HSTX, and was manufactured new by Nordco
 - Serial Number 220114
- The machine is known to Union Pacific as Track Maintenance Tamper 1602 (TMT-1602).
 - The [Working Group](#) will use this designation.
- It was manufactured November 2016
- Stenciled Dimensions are L21' x W8'6" x H11'6"; Weight 31,500lbs.
- On the day of the accident:
 - The speed gauge and speed sensor were inoperative and had been for several days, a part was on order
 - The rear hydraulic travel motor was disconnected from the drive axle, and its hydraulic hoses were removed. A motor at this location failed two days prior to the accident and was replaced with a remanufactured unit. One day prior to the accident the remanufactured motor failed after working just two ties. The motor was disconnected, and work was completed. The day of the accident the motor remained disconnected prior to the start of work and during the work day.
- Work began at 9:28am
- Approximately 100-150 ties were tamped
- The operator stated:
 - He worked the last tie then "indexed" (his term) the machine forward to skip 5 old ties that did not need tamping
 - He stated that he let go of joystick expecting the machine to stop, "it didn't stop".
 - Estimated speed was 3-5 mph
 - He said, "Panic set in"
 - He stated that he tried, but failed, to blow horn. The failure was on account of "missing" the cable or otherwise not activating the horn. No implication was made that the horn was in any way inoperative.
 - Did not use emergency stop button
 - "Pulled the joystick to put work heads in the ground"
 - Operator was injured when he hit windshield with head, hit other windshield with knee, breaking the glass.
 - [The operator was taken to a hospital, where he was released without treatment.](#)
 - [The UP seat belt matrix did not require the operator to use the seat belt.](#)
- A broken hydraulic hose leading to work heads are consistent with failures found during the rapid deceleration in the accident sequence. The damage and leaking oil is consistent with a sudden lowering of the work heads while in motion. The oil that sprayed from these hose failures is seen in Pima County Sheriff images (Accellion). Union Pacific replaced the hoses and tested the work-head system post-accident.
 - [Further discussions with an experienced mechanic working to assist the working group indicated that the amount of damage to the tamper when the work heads drop is a function of speed and the object they hit. Higher speeds and more rigid objects often cause additional damage to the vertical guide rods that allow work head travel, the pistons that cant the work heads, the yoke holding the work head assembly, or other parts. These parts were not damaged in the accident. This is consistent with impacting a tie and ballast which absorbed some energy and "gave" a little before stopping the machine.](#)
- The normal minimum distance between this machine and other equipment is 50ft. The normal minimum distance between this machine and people is 70 feet. The normal distance between this machine and other

equipment in travel mode is 300 feet. See rules 136.7.4, 136.7.5, and 136.7.15. Also see this gang's job briefing sheet.

- The operator had operated this machine about 6-days
- The prior operator operated the machine about 16-days. After the accident he was asked to try “every way to operate the machine” (His term). He reported no anomalies before or after the accident. However, he thought it was strange, “The foot pedal didn’t do anything in work mode”
- The accident occurred on the Lordsburg Subdivision at Mile Post 1015.55. The gang was working eastward, in the direction of increasing mile post numbers.
- At this location there is a 0.97% grade, uphill in the direction of work. The accident occurred in the exit spiral of a 2-degree left hand curve.

Key Facts – Switch positions

The following switch positions were noted in the Pima County Sherriff “First on scene” photographs

- Right control panel
 - Joystick – Neutral
 - Left Traverse – Extend
 - Mode – Inner Cylinder
 - Right Traverse – Extend
 - Mode – Outer Cylinder
 - Workhead Select – Both
 - Index Select – Manual



- Left control panel
 - Left vibrator – Off
 - Right vibrator – Off
 - Left Workhead lock – unlock
 - Right workhead lock – unlock

- Main panel
 - Double tamp – off
 - Warm up – off
 - Mode – Work
 - Traction Delay – Off
 - Propel Direction – Forward
 - Propel Speed – Low



- Overhead panel
 - Perimeter lights – on(up)
 - Front lights – on (up)
 - Rear lights – off (down)
 - Work lights – on (up)
 - Engine speed – low
 - Ignition – off

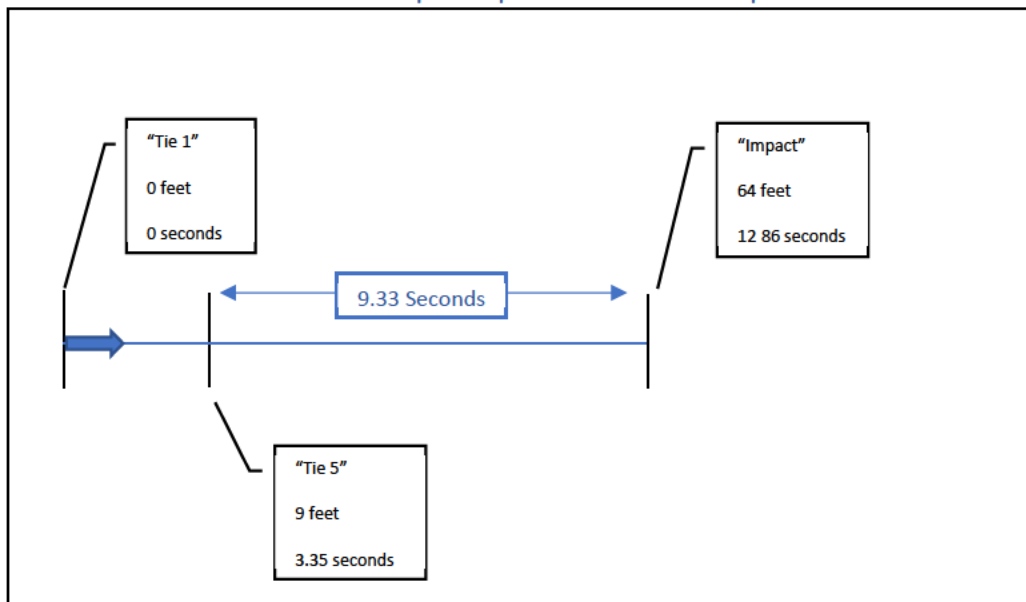


Safety: Rules and instructions from Union Pacific must be followed. Ensure an operator is always at the controls, or as directed by Union Pacific SMEs. Wear all PPE, including the machine safety belt, as needed. Be wary of broken glass, loose components, or other items that may have shifted during the accident. The number of people in the cab during movement is limited to the number of seats/seat belts and these devices should be inspected prior to use. Adjustment, replacement, removal, or manipulation of components must be done by UP or under the direct supervision of UP. This machine has been in an accident and should be assumed to be possibly damaged or operating in an unintended manner and treated accordingly. When in doubt, take the safe course. Report any near misses or safety concerns to Union Pacific and NTSB representatives.

Previously Conducted Tests:

During the investigation activities the group discussed testing that the UP conducted in Arizona in the days following the accident. The UP had previously supplied the group with notes regarding the testing, but more detail was given, therefore the notes and discussion are summarized here.

- Testing was conducted on February 1 and 2, 2021.
- Union Pacific and Nordco were present
- There were 5,332 hours on the machine
- The inspection was conducted on the Lordsburg Subdivision, near the Marsh Siding at Mile Post 1012.5. The tests were conducted on the main line. The rail in this area is the same size as at the accident location. The grade in this area is 0.73%, which is more conservative than the 0.97% grade at the accident site. Tests were conducted uphill.
- Before the team could start, the team needed to make two repairs due to the events in the accident.
 - Right front workhead hydraulic hose had ruptured due to workhead being lowered while the machine was in motion. It was a #12 hose approximately 5' long.
 - Left lower step had been removed to extract the injured employee. Step was returned to service.
 - Middle lower window broken during incident. No window replacement on hand.
- Braking Tests
 - The machine was operated in [Work] mode until a top speed of 9 mph was reached
 - The emergency stop button was pressed and the machine stopped in 23 feet
 - The test was repeated and braking was accomplished by simply removing a hand from the joystick. The machine stopped in 21 feet.
- Time and Distance Tests
 - The machine was operated from a stand-still at "Tie 1", representing the location of the last tie worked by the operator.
 - The machine reached "Tie 5" in 3.53 seconds
 - The machine continued to the "impact" spot and reached this point in 12.86 seconds from the start.



- The "impact" location was determined by evidence collected at the accident site and was approximately 17 feet west of the injured employee's post-accident location.
- The test was repeated with an emergency stop application at "Tie 5". The machine stopped 11 feet past "Tie 5"

- Top Speed Stop Testing
 - The machine's top speed is achieved in [Travel] mode.
 - Using Low travel mode, a top speed of 14 mph was accomplished in approximately 1/8th mile. After traveling approximately ¼ mile, a stop was accomplished in 55-feet
 - Using High travel mode, the top speed of 17 mph was accomplished in approximately 1/8th mile. After traveling approximately ¼ mile, a stop was accomplished in 59-feet.

Of particular note, the inspection notes that "Foot pedal for workhead cycle was inoperative – bad switch in the pedal". During the working group's tests on March 24, described in this protocol, it was determined that this is not an accurate statement. The foot pedal works as intended and the function is described below.

The Mechanical Working Group agreed to use the test results above and not repeat the tests. The basis for this decision was the more accurate rail profile, grade, and environmental conditions found near the accident scene in February as compared to the environment in Denver in late March. Adding to the decision was the quality of the record keeping maintained by Nordco/UP and the participation of the testing personnel in the working group.

Agenda:

Meeting Date/ Time: 0900	Wed. March 24, 2021	Meeting Location/ Address:	UPRR 5929 Pecos Street, Denver, CO, 80221
Meeting access point instructions:	Meet in parking lot, proceed to "Main Entrance", then 2 nd floor conference room		
Meeting Contact Person/ Number:	Tina Gonzales (303) 405-5225		
Day 1: Wednesday, Mar. 24, 2021 :			
Item	Led By		
Job Briefing	UPRR		
Introductions	All		
Housekeeping	NTSB		
Review of Events/Facts	NTSB/All		
Review of test protocol, additions, deletions, etc.	NTSB/All		
Break			
Review Prior UP Tests			
Break - Lunch			
Inspection Safety/Questions/Job Brief	UPRR		
Tamper Familiarization, Walk-around	UPRR/Nordco		
Routine inspection items (Daily, Weekly, Quarterly, etc. as req'd) [Inspection Activities, Section 1]	UPRR/Nordco		
Cab Set up and Sight distance testing [New Section]	NTSB		
Normal Ops./Dynamic Tests [Inspection Activities, Section 2]	NTSB		
Inspection Activities, Section 3			
Investigative Situational testing			These would require an operator and a length of track long enough to reach 5mph and stop safely. Space to exercise the work heads would be ideal also.
Inspection Activities, Section 4			Removal of parts discussion
Discussion – are we done with all possible testing? Should we remove any components for additional lab testing?			
Component removal, inspection, and tagging as necessary.			
Discussion – follow up activities, next steps.			
Day 2 –			
The only activity completed was the capturing of hydraulic oil samples and shipping to the lab. The group did not meet formally.			

Housekeeping: Photographs are allowed for party members. Photos and notes should be uploaded to Accellion for party review by April 24. Photos, and investigative information in general, should not be shared outside of the party. Always remember, we are gathering facts, not forming opinions or analysis. Most of all, we are not trying to assign blame, fault or liability.

Familiarization: UP/Nordco to provide walk-around familiarization with machine off. Opportunity for general photographs and ‘big picture’ questions. Estimate 15-minutes.

Specialized Tools:

Items below are suggestions for discussion:

Hydraulic Pressure Gauges		Speed tracking – Fix speed sensor/gage? Radar? GPS/Phone app (Cell policy?)	
Pneumatic Pressure Gauges		Cones for distance visualization	
Mechanical Force Gauges		Chalk/Paint Stick	
Used hydraulic fluid basin		Dry Erase Board/ Marker	
Hydraulic fluid filter/screener		Camera	
Collection area for debris from hydraulic fluid		Stopwatch	
Multimeter			
Manuals (operation, mechanical, electrical, hydraulic, parts, etc)			
Speedometer/ Radar gun			
Measuring tape			
Distance wheel			


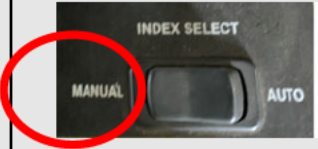
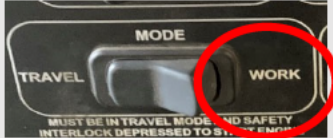


Inspection Activities:

See Spreadsheet: "TMT 1602 Inspection Protocol.xlsx"

Additional Inspection Activity: "Foot pedal operation"

There was significant discussion and observational testing regarding the operation of the foot pedal and the note from prior testing that indicated an inoperative foot pedal may have been present. This was bolstered by the prior operator's interview statement that he didn't understand why the foot pedal wasn't working.

The mechanical working group reviewed the design of the foot pedal and conducted tests to verify the various modes the foot pedal can operate under. These are described below.

	Auto	Manual	N/A
			
Work 	Foot pedal cycles the work heads down, vibrates the ballast, raises the work heads, and travels the vehicle forward until the pedal is released.	Foot pedal does not function, by design	
Travel 			Foot pedal moves the vehicle in the direction indicated by the [Forward/Reverse] switch 

For further review:

- Three hydraulic oil samples taken. Oil analysis expected within one week.
- The Mechanical Working Group expects to release the tamper to the UP two weeks after the oil samples are uploaded to Accellion