The mfmea results of tbm hydraulic system engineering essay

PROBLEMLow output voltage from transformersCAUSESThis low output voltage has a Risk Priority Number of greater than acceptable level which needed to be modified. Power generator, short circuit in secondary windings of the transformer, high voltage drop along the power distribution line or getting high current from the system may lead to a low output voltage. EFFECTS AND SOLUTIONSThis failure can effect electric consuming subsystems or burn the transformer and finally stop the TBM. It can be prevented or discovered through applying voltage control relays, breakers sensitive to voltage in main circuit breakers, and phase controlling relays. The related expertise team suggested applying Programmable Logic Circuit (PLC) for design modification and controlling this failure mode. They believe that the application of PLC will reduce the RPN from 90 to an acceptable level of 60.

5. 4. 2 The MFMEA results of TBM Hydraulic System

PROBLEMSAll failure modes except the starting defect of pressure supplier (RPN= 93) were low risk failure modes. CAUSESThe high likelihood number of this failure means that the probability of its occurrence is relatively high. This failure mode that can stop the TBM may be caused mainly due to defective electromotor, defective circulation pump problems in main circuit or lose fittings. EFFECTS AND SOLUTIONSThe starting defect in the hydraulic system might even stop the whole TBM and might result in huge loss The related expertise team recommended an appropriate preventive maintenance program in order to control this failure. The application of an appropriate preventive maintenance is expected to reduce the likelihood number from 8 to 5 and the RPN from 93 to 40.

5. 4. 3 The MFMEA results of TBM Pneumatic system

PROBLEMSThe results show that, considering Risk Priority Numbers there is no much risk. The results also show that in the TBM pneumatic system 3 failure modes had severity numbers higher than 5. They included electric coil breakdown, starting defect of air supplier and opening defect of pressure tank. EFFECTS AND SOLUTIONS

Electric Coil Breakdown

If the electric coil of air supplier breaks down, it will not have any local effects but it will stop the compressor which will consequently stop the TBM. At present, PLC is applied to detect this failure. The expertise team believed that an appropriate preventive maintenance program will reduce its likelihood and detection numbers leading to a reduction of RPN from 56 to 14. The control actions will not reduce the severity number, thus modification of electric coil design seems to be essential.

Starting Defect In Air Supplier

Starting defect in air supplier will not have a local effect, but it will stop the compressor which will consequently stop the TBM. Any defects in PLC, burning of contactor blades, sulfating, dust and any electrical or mechanical defectives in electromotor may lead to this failure mode. Presently, PLC is used to detect this failure. Preventive maintenance is suggested to reduce RPN from 54 to 24, but it will not reduce the severity number. A modification of starting design is recommended to reduce severity number.

5. 4. 4 The MFMEA results of TBM Mechanic system

CUTTER HEAD STOPPROBLEMSCutter head stop is the most severe and highly risk failure mode in this system. High severity and likelihood numbers are the special characteristics of this failure mode. This failure leads to stop the TBM. EFFECTS, CAUSES AND SOLUTIONSBad rock condition is the main reason the cutter head stops. Core drilling is recommended to identify rock condition in advance. This will reduce the likelihood number from 8 to 6 and reduce the detection number from 3 to 2 which all together will reduce the RPN from 240 to 120. This suggestion was applied and reduced the cutter head stop due to rock condition from then on. CUTTER DISC WEARPROBLEMFailure mode with a high RPN and severity number. Cutter disc wear is also a major problem and it might result in many disadvantages. EFFECTS AND CAUSESIt may lead to TBM stop. Bad Rock condition and non-standard disc material are the main reasons for this failure. SOLUTIONSThe expertise team recommended using standard discs and periodical checks to prevent this failure. These actions will reduce the likelihood number from 4 to 2 and the detection number from 7 to 5 which will totally reduce the RPN from 160 to 60. SCRAPER DEFECTPROBLEMThe third failure mode with a RPN higher than 80 is scraper defect (break down and wear). Scraper defect is a very thypical failure which is not very critical but its hard to detect the failure. EFFECTS AND SOLUTIONSThis failure mode will stop the TBM. This failure has a relatively high detection number. Thus periodical checks may help to detect it easier. The team did not make any recommendations.

5. 4. 5 The MFMEA results of the ventilation system

HIGH PRESSURE IN THE DUCTPROBLEMThe most critical failure mode (e. g. high air pressure in duct) is related to this system. CAUSESThis failure is due several reasons but it is mainly due to duct blockage which will burst the duct and cause a huge emission. SOLUTIONSAt present, there is almost no controlling mechanism. Using dampers at the jet fan inlet, applying electro-motors with controllable rotation, as well as using standard duct material and proper duct mounting are recommended by the expertise team to prevent this failure. These actions will reduce likelihood number from 8 to 4 and detection number from 6 to 4 which will totally reduce the risk number from 415 to 160. This RPN will still be high. LOW PRESSURE IN THE DUCTPROBLEMLow air pressure in the ducts is the next failure with a high Risk Priority Number. EFFECTS AND CAUSESThis failure may be caused by low fan rotation, wrong ventilation design, duct leakage etc. It will lead to insufficient fresh air in the tunnel that can threat the human life in tunnel. SOLUTIONSPreventive maintenance, periodical checks, and the use of anemometers to measure air velocity at the duct exit are recommended by the expertise team. The application of these recommendations will reduce RPN of this failure from 232 to 60. INFERENCE FROM THE MFMEA ANALYSIS OF VENTIALATION SYSTEMSMost of the failure modes studied in the ventilation system had the highest severity number. 4 failure modes out of 6 failure modes in this system had the highest severity number. This shows the significant role of ventilation system in gassy and long tunnels such as the Alborz Tunnel. In a similar tunnel with H2S the same failure led to death of 4

people in the east of Iran in 2005. Losing ventilation system for 3 minutes in the Alborz Tunnel caused a fire incidence due to methane gas in tunnel.

5. 4. 6 MFMEA results of Rolling Stock

All failure modes studied in the Rolling Stock System are high risks (e. g. RPN higher than 80) with the highest severity numbers. HIGH RAIL WIDTHEFFECTS AND CAUSESHigh rail width has a RPN of 160. This failure is caused by moving the vehicle on it, defective traverses, poor material, construction and maintenance. This failure can lead to higher wearing of the rail, derailing of vehicles which will affect personnel safety, closing of the rail and finally stopping the TBM. SOLUTIONAt present monthly periodical checks and measurement of the width of the rail are the methods used to detect and prevent the failure. The expertise team recommended appropriate preventive maintenance, weekly measurement of rail width, supporting of traverses according to their bearing load, selection of the optimum cross section for wheel profile and mounting derailing mechanism to prevent traverse movement. These preventive actions will reduce the RPN from 160 to 40. The severity of the failure will not be reduced by the application of preventive actions. The likelihood and detection numbers will be reduced from 4 to 2. LOW RAIL WIDTHEFFECTS AND CAUSESLow rail width is the next high risk failure mode with a RPN of 172. This failure is caused by increasing road gradient, passing heavy duty vehicles such as loaders over the rail and ballast deficiency between traverses. The local effect of low rail width causes the wheel bandage to wear and finally derails the vehicle. This failure affects the personnel safety and may lead to road closure and stopping the TBM. SOLUTIONMonthly checks and rail width measurements are used to detect

the failure at present. Appropriate preventive maintenance, weekly rail width measurements, supporting the rail foundation between traverses, and mounting derailing mechanism to prevent traverse movement are the expertise recommendations. The application of these preventive actions is expected to reduce the RPN of this failure from 172 to 40. They will reduce likelihood number from 3 to 2 and the detection number from 4 to 2. These actions will not reduce severity number from 10. LATERAL UNLEVEWLLED TRAVERSEEFFECTS AND CAUSESLateral unleveled traverse with a RPN of 250 is the next high risk failure. Improper construction and maintenance, uneven foundation, inflation due to iced water, bent rails, old traverses and unstable ground are the main causes of this failure. This failure causes discomfort for commuters in vehicles and may lead to derailment of vehicles. It also affects personnel safety, road closure and stopping the TBM. SOLUTIONThe MFMEA team recommended an appropriate preventive maintenance program, weekly periodical checks, supporting the rail foundation with suitable soil, the mounting of a derailing mechanism to prevent traverse movement and using standard traverses. The application of these recommendations is expected to reduce the failures' RPN from 250 to 60. They will reduce the likelihood number of this failure from 5 to 3 and detection number from 5 to 2. The recommendations will not reduce the severity number. RAIL DEFECTEFFECTS AND CAUSESRail defect with a RPN of 192 is also a high risk failure. This failure is caused by improper construction and maintenance, uneven foundation, inflation due to iced water, bent rails, defected traverses and dirty ballast. Rail defect can move one rail with respect to the other rail, move a rail in any direction and derail the vehicle. The consequences of this

failure can affect personnel safety, close the rail road and stop the TBM. SOLUTIONMonthly periodical checks and rail measurements are the means of detecting the failure at present. The expertise team recommended correcting improper rail rotations in road bends, weekly periodical checks, adjusting rotation with proper equipment, the mounting of derailing mechanism to prevent traverse movement, using standard traverses and to tampon when the season changes. The application of recommendations is expected to reduce the failures' RPN from 192 to 60. The RPN will be reduced mainly due to likelihood and detection number reduction. LATERAL DEFLECTION OF LEVEREFFECTS AND CAUSESLateral deflection of lever with a RPN of 225 is the next high risk failure. This failure is caused by thermal variation of rails, improper bolts and connections or low resistance ballast. This failure may derail the vehicle which consequently will affect personnel safety, close the rail road and stop the TBM. At present, monthly periodical checks and rail measurements are the means of detecting this failure. SOLUTIONExpertise MFMEA team recommended an appropriate levering program, weekly periodical checks and lever adjustments according to guidelines. The application of these recommendations is expected to reduce the RPN of this failure from 225 to 40. LONGITUDINAL RAIL CRACKSEFFECTS AND CAUSESLongitudinal Rail Cracks with a RPN of 140 also constitute a high risk failure. Normal operation, passing heavy duty vehicles over the rail, old rails and corrosion are the main causes of this failure which can break the rail or its crown and derail the vehicle. Consequently this may affect the personnel safety, close the rail road and stop the TBM. SOLUTIONVisual checks are the only means to detect this failure at present. The MFMEA team

recommended using ultrasonic instrumentation to check the rail cracks. The application of this instrumentation is expected to reduce the RPN of this failure from 140 to 20. NO BLADE CONTACTSEFFECTS AND CAUSESNo blade contact with a RPN of 163 is another high risk failure. An unbalanced needle (laterally and longitudinally unbalanced rail guide), existence of metallic chips around the needle or a bent needle can cause this failure. This failure may derail the vehicle which will affect personnel safety, close the rail road and stop the TBM. Monthly periodical checks are the only means of investigating this failure. CAUSESThe expertise team recommended a daily preventive maintenance program to reduce the likelihood and detection numbers of this failure . The application of a daily preventive maintenance program will reduce the Risk Priority Number from 163 to 40. WHEEL WEAREFFECTS AND CAUSESWheel wear with a RPN of 157 is the last high risk failure in railway system. Mismatching between wheel and rail hardness, nonstandard profile, wrong rail geometry and reduction in bend radius can lead to wheel wear. This failure can derail the vehicle and affect personnel safety, close the rail road and stop the TBM. SOLUTIONDaily checks are the only means of detecting wheel wears. MFMEA team recommended appropriated preventive maintenance, selecting the optimum cross section and standard material for wheels, oiling the rails at bends, not applying extra width at bends and using automatic greasing instruments for better detection and likelihood parameter. The application of these recommendations is expected to reduce the RPN from 180 to 90. INFERENCE FROM ALL MFMEA ANALYSISA Risk Priority Number of 80 was considered as an acceptable level. According to this level, 18 failure modes with higher RPN

were categorized unacceptable failures. This shows these failure modes with their codes. The results show that even after modification and applying control measures, 3 failure modes will still have a RPN of higher than 80. These failure modes are high air pressure in ventilation duct, cutter head stop and locomotive wheel wear. In total 21 failure modes had severity numbers higher than 5. The accidents occurred in various positions were tracked. The results revealed that, modification of the process and equipment will reduce the accidents significantly. One small fire incident due to ventilation failure (for 1 minuet), 3 TBM stops due to bad rock condition and 3 derailing due to unleveled rails were the most major accidents occurred during . The consequences of these accidents were negligible.

5. 5 Failure Modes That Require Modifications Due To High Severity Number With Their New RPN

TABLE 11 : FAILURES THAT REQUIRE MODIFICATIONS

NO

MODES OF FAILURES

RISK PRIORITY NUMBER

SV

LN

DN

RPN

A1

High voltage51210

A2

HV leakage72228

C1

Missing dynamo layers81216

C2

Electric coil breakdown71214

C3

Starting defect62336

D1

Opening defect92354

D2

Electric tap breakdown62224

D2

Cutter head stop1062120

E1

Cutter disc wear62560

E1

Starting failure102120

E3

Low voltage102120

E3

Low air pressure102360

F1

High air pressure1044160

F1

High rail width102240

F1

Low rail width102240

F1

Lateral unleveled traverse1032120

F1

Rail defect103260

F1

Lever deflection102240

F1

Rail cracks101220

F1

No blades contact102240

F2

Wheel wear103390

5. 6 Risk Priority Number Of Critical Failure Modes After Control

TABLE 12 : CRITICAL FAILURES

NO

MODES OF FAILURES

RISK PRIORITY NUMBER

SV

LN

DN

RPN

D2
Cutter head stop1062120

E3
High air pressure1044160

F2
Wheel wear103390Risk priority number for all modes of failures were found out and then proper measures were taken for the failures having a RPN above 80 and dailures which are having severity number above 5 was also modified and given proper measure as much as possible. Then about the critical failures accidents occurred in various positions were tracked.. One small fire incident due to ventilation failure (for 1 minuet), 3 TBM stops due to bad rock condition and 3 derailing due to unleveled rails were the most

major accidents occurred during . The consequences of these accidents were

negligible.