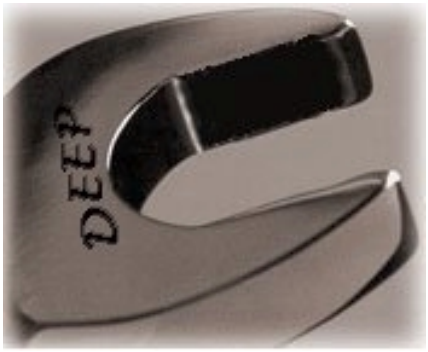
Diesel Engine Maintenance

Audit Plan

For The DEEP Research Project

“Maintenance and Diesel Exhaust Emissions”



Disclaimer

This plan has been established for the sole purpose of evaluating potential sites in their maintenance of diesel engines, and determining the most suitable candidate for the success of this research project

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Diesel Engine Maintenance Review Plan

Introduction

The purpose of this document is to set the framework and provide working papers to perform a review of diesel engine maintenance processes. A brief description of the major components of the review process, key areas of the review protocol, process for conducting an interview and finally a timetable, resource participation and working papers are included.

The review plan is only a guideline to facilitate information gathering. Improvising may be required depending on the situation. If improvising is required, documentation of the motivation and results should be performed.

Overview

Goal of Diesel Engine Maintenance Review
"To identify a site to undertake the maintenance project and assess the strengths, weaknesses, opportunities, and threats (SWOTs) that will impact on this".

The major components that will comprise the review **will be:**

- **Pre Visit – Communicate scope of the** review **to the site and acquire background materials required before arriving on site**
- **Opening Meeting – Introduce the project and** review **process to all stakeholders**
- **Orientation Tour – Introduction to physical layout of** review **site**
- **Timetable – Schedule of one week** review **process**
- **Resource Participation – Outline of the** review **schedule and who is involved in each step**
- **Working Papers – Key areas of the** review **protocol are outlined with specific points under each. The points are addressed through a combination of interviews and verification.**
- **Evaluation and Consolidation – Summary and conclusions drawn from** review **process**
- **Closing Meeting – Present findings from evaluation**
- **Final Report – Detailed formal report explaining results from evaluation**

The key areas of the review protocol are documented in detail in the working papers. They will be implemented through interviews, inspection, and verification. The key areas outlined are:

- **Roles and Responsibilities**
- **Operational Issues**
- **Training**
- **Tools**
- **Maintenance Practices**
- **Detail of Maintenance Process**
  - **Preventive Mtce**
  - **Predictive Mtce**
  - **Reliability Based Mtce**
  - **Quality Based Mtce**
  - **Breakdown Mtce**
- **Engine Subsystems**
  - **Intake**
  - **Exhaust**
  - **Fuel Injection**
  - **Cooling**

- **Fuel Quality and Handling**
- **Lubrication**

- **Housekeeping and Organization**

Diesel Engine Maintenance Review – Pre Visit

A letter of introduction will be sent to each of the two sites identified for the review. The purpose of this letter will be communication of the objectives and a description of the project. The description will include:

- Scope of project and what will be done
- Outputs and deliverables
- Scheduling and timeline
- Roles and responsibilities
- Map of the review process and site requirements
- Distribution list

There will also be a request for background material described in the letter. This material will ensure that the review team is prepared in advance of arrival on site to avoid delays in conducting the review. The site will be asked to provide:

- Description of management structure
- Description of PMs and written procedures relevant to diesel engine maintenance
- Sample of typical work orders (planned and emergency blanks)
- Archive of maintenance data specific to diesel engines (optional prior – mandatory during)

Diesel Engine Maintenance Audit – Opening Meeting

To kick off the review process at the site an opening meeting will take place with all stakeholders in the process in attendance. A package will be presented describing the background of DEEP, the maintenance project, and the actual review process being conducted.

It will be the responsibility of the site to select the mechanics and operators to be present for the opening meeting and formal interviews. Informal interviews will take place with random selection of people during the verification stage of the review. All representatives of underground operations from JHSC and union should be included in the opening and closing meetings.

The oral presentation will consist of a review of the project objectives, a review of the scope and reference period, why the individuals at the site are involved in the review, and what they will receive from it.

Diesel Engine Maintenance Review – U/G Orientation Tour

The tour will ideally be led by a maintenance foreman from the U/G shops. There will not be any interviews or evaluations made at this time although the review team will be taking notes to highlight areas that may have otherwise been overlooked in the interviews and verification

process. The tour will also give the audit team a clearer understanding of the maintenance process at the site pertaining to locations, roles, and responsibilities. The tour should include both maintenance and production areas specific to the maintenance of diesel engines.

Review Schedule

Hour	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 am	Opening Meeting				
9:00 am		Interviews 1 Mechanic 1 Operator (Formal)	Verification (Informal)	Evaluate Review Results	Closing Meeting Present Findings
10:00 am	U/G Orientation Tour				
11:00 am					
12:00 pm	Lunch	Lunch Update Meeting	Lunch Update Meeting	Lunch Update Meeting	Lunch
1:00 pm					
2:00 pm	Interviews Mtce Planner Mtce Sup't			Consolidate And Prepare Written Findings	
3:00 pm	Union/OH&S	Interviews 1 Mechanic 1 Operator	Verification (Informal)		
4:00 pm	(Formal)	(Formal)			
5:00 pm	team meeting	team meeting	team meeting	team meeting	

Resource Participation

Events / People Involved	Pre Audit Correspondence	Opening Meeting	U/G Tour	Formal Interviews	Verification	Update Meetings (Informal)	Closing Meeting	Final Report
Mine Manager	**Cc**	**O**				**O**	**O**	**Cc**
Maintenance Superintendent	**Cc**	**X**		**X**	**X**	**X**	**X**	**Cc**
Maintenance Planner		**X**		**X**	**X**		**X**	
Maintenance Foreman		**X**	**X** (1)	**X**	**X**		**X**	
Mechanics		**X**	**X**	**X** (2)	**X**		**X**	
Operators				**X** (3)	**X**			
Production Foreman/Captain		**O**			**X**		**X**	
JHSC Union Reps		**X**		**X**	**X**		**X**	
Ventilation Technician		**O**			**X**		**O**	
Site Champion	**X**	**X**			**X**	**X**	**X**	**X**

Legend

X	**Strongly Recommended**
O	**Optional**
CC	**Carbon Copy**

1) Maintenance Foreman suggested leader for U/G orientation tour
2) Recommendation of 3-4 mechanics for formal interviews
3) Recommendation of 2-3 operators for formal interviews

Working Papers

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
1.0	**Roles and Responsibilities**
1.1	Produce a flow chart of responsibilities in the mtce process
1.2	What is the relationship between production and mtce Are there "teamwork" practices in place and if so describe? Outline the responsibilities of each toward engine mtce individually and as a team.
1.3	Describe the formal and informal mechanisms for accountability
1.4	Describe the shop locations, facilities, and responsibilities using notes, flow charts, etc. Describe the structure of mechanics, work areas, and shifts Describe the structure of vehicles and operators with respect to each shop
1.5	What are the responsibilities of operators with respect to equipment maintenance? What are the responsibilities of mechanics with respect to equipment maintenance? Do these responsibilities fall short or overlap in combined maintenance? Describe the relationship between operators<>mechanics<>supervision Describe the working relationship between operators and mechanics in maintaining equipment [Outline the successes and conflicts in the operator<>mechanic work relationship]

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
2.0	**Operational Issues**
2.1	Evaluate proactive vs reactive practices When is equipment brought in for emergency repairs and planned / preventative work? What is the ratio of emergency vs planned work?
2.2	[Operator Empowerment – What is their level of decision making responsibility?] Describe the degree of responsibility for equipment and maintaining it properly How do they gauge when repairs and maintenance are required? Are operators hard on equipment? How and why? Are operators bringing equipment in for repair when they should be?
2.3	Mechanic Empowerment – How are mechanic's responsibilities assigned in shop activities? Do they respect and LISTEN to operators? Are repairs done to the satisfaction of operators? If not explain why? What is the level of motivation or "buy in" towards maintaining engines? Do the mechanics feel that they are being allowed to maintain engines as effectively as they would like?

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
3.0	**Training and Support**
3.1	Describe formal mechanisms for training mechanics and operators What previous training/certification is required of mechanics/operators who are hired at the mine today? When were these requirements introduced and what percentage of mechanics/operators meet them?
3.2	What is the criteria upon which training is based? What kind of ongoing training/upgrading occurs for mechanics/operators in relation to maintenance of diesel vehicles and control of emissions? What is the content and length of the training and how often is it offered?
3.3	Who gives the training? Is the training mandatory for mechanics/operators?
3.4	How is service and technical information managed – is it up to date? Is it complete and in legible condition? Do the operators share in access to this technical information? Operators manuals, etc

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
4.0	**Workplace and Tools**
4.1	Is the space available for maintenance activities poor, adequate or good? Please explain. Are maintenance shops well-located? Is there adequate lighting? Ventilation? Power? Is there adequate storage for tools?
4.2	What tools are in place for diagnosing and repairing diesel engines? Are they sufficient? What condition are they in? How well are they being used?
4.3	What is the condition of basic shop equipment? (hoisting, rigging, grinders, benches, etc.)

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
5.0	**Maintenance Practices**
5.1	Preventive Maintenance
5.11	Describe the PM program. Are PMs recorded? What is the actual vs target PM schedule?
5.12	What is the frequency of filter changes? What are the criteria?
5.13	Describe and verify written PM procedure
5.14	How are PMs recorded and archived and where?
5.15	How are filters stored and handled prior to installation?
5.16	Describe procedure for replacement of filters. Clean, consistent, etc?
5.17	What is the consistency of practice between mechanics and shifts?
5.18	Describe the program in place for performing tune ups?
5.19	What is the criteria for performing tune ups?
5.20	Is there a written procedure?
5.21	What training has been done for doing tune ups?
5.23	What is the procedure for archiving tune up history and what is archived?
5.24	Describe the mechanism for creation and management of planned work orders.
5.25	Are back logged W/Os sent out with PMs?
5.26	How and when are back logged and current planned W/O's evaluated and completed?

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
5.3	**Predictive Maintenance**
5.31	What criteria is used for determining diagnostics on engines – emergency only?
5.32	Describe the procedure(s) used for diagnosing engines.
5.33	What is the recording and archiving mechanism for diagnosing engines?
5.34	How is recorded and archived diagnostic data used or is it used at all?

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
5.4	**Reliability Based Maintenance**
5.41	How are statistics and historical data for engines maintained?
5.42	Are they being used for maintenance decisions and how, by who?
5.43	What is the mechanism for replacing engines and overhauling, major repairs, etc.? What are the critical factors used in making these decisions?

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
5.5	**Quality Based Maintenance**
5.51	What teamwork, quality assurance, incentive processes are in place? Describe
5.52	Are mechanics and operators made stakeholders in the maintenance of the equipment? How are stakeholders (mechanics, operators) encouraged to pursue higher quality maintenance?
5.53	Evaluate the effectiveness of the quality programs

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
5.6	**Breakdown Maintenance**
5.61	What is the ratio of emergency vs planned work orders?
5.62	Is this ratio monitored? If so, has the monitoring reduced emergency repair work?
5.63	Determine where the emergency repairs are being done (shop, drift, etc.)
5.64	How adequate is the equipment (tools, etc.) for working outside the shop?

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
6.0	**Engine Sub Systems**
6.1	**Intake System**
6.10	How are they tested for integrity and sealing?
6.11	Describe the ducting system (hoses, clamps, welding, etc.)
6.12	Evaluate the location of the filters and ducting (proximity to heat source, serviceability, etc)
6.13	Describe the filter system (double stage, radial seal?) Correctly sized?
6.14	Are OEM or jobber filters being used? Why? Whose decision?
6.15	Are restriction indicators used and what kind?
6.16	How often are they (complete systems) serviced, on what criteria, by who?

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
6.2	**Exhaust System**
6.21	What procedures are in place for diagnosing and maintaining aftertreatment systems?
6.22	What procedures are in place for diagnosing and maintaining turbos ?(Operators also)
6.23	Can and do they measure gases, backpressure, etc.? How?
6.24	Is there any mechanism in place for regular interval service on exhaust systems? Detail?
6.25	Evaluate condition of exhaust systems – efficiency, damage, leaks, # of elbows, proper size.

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
6.3	**Fuel Injection System**
6.31	What mechanisms are in place for regular service on fuel injection systems? Detail.
6.32	What type of filters are being used – OEM or jobber? Why?
6.33	What type of service practices are performed on FI system? What criteria?
6.34	Inspect FI system – Water separators, warranty seals, filtered vent, condition of lines, etc

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
6.4	**Cooling System**
6.41	Describe maintenance procedures for cooling system. How, when?
6.42	Describe cleaning procedures. Air & water cooled, How and when, what criteria?
6.43	Cooling system tests? Equipment used, How and when?
6.44	Inspect cooling systems – Leaks, plugged with dirt, belts, proper components?
6.45	How is coolant stored, mixed, checked?
6.46	Shrouds installed and in good condition?
6.47	Hoses and clamps – type and condition?
6.48	Conditioner – type, filter element?

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
6.5	**Fuel Quality and Handling**
6.51	What type of fuel is being used?
6.52	How is it checked and how often?
6.53	Map process of how fuel moves from supplier to vehicle
6.54	Who maintains storage tanks, how, how often, what criteria?
6.55	Tanks on vehicle – are they maintained, how, how often?
6.56	Inspect and evaluate storage tanks (surface & U/G – water separators, filtered vents, clean?)
6.57	Inspect and evaluate vehicle tanks (fill system, filtered vent, cleaned, water separator?)

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
6.6	**Lubrication**
6.61	What type of filters are being used – OEM or jobber, criteria?
6.62	Detail of oils used, criteria
6.63	Describe oil sampling procedure and points tested.
6.64	Engine oil temperature monitored? Alarmed?
6.65	Describe handling and fill systems.
6.66	Describe change interval – criteria?

Site:		
	Name	Date
Interviewee:		
Evaluated by:		

Step	Description / Comments
7.0	**Housekeeping and Organization**
7.1	Describe the state of the shop floors – oil, floor dry, mud, dust, etc.
7.2	Describe the state of work benches and surrounding area – cluttered, neat, clean,
7.3	Describe the state of shop equipment – hoses, brooms, electrical cords, - neat and put away?
7.4	What processes are in place for regular scheduled cleanups? Criteria?

Opening Meeting Sign-Up Sheet

Company Name: _____
Audit Dates: _____
Meeting Date: _____
Audit Team: _____

Name	Job Title

Closing Meeting Sign-Up Sheet

Company Name: _____
Audit Dates: _____
Meeting Date: _____
Audit Team: _____

Name	Job Title

PRE-AUDIT PREPARATION

COMPANY:	DATE:

STEP	SITE RESOURCE PERSON NUMBER 1	SITE RESOURCE PERSON NUMBER 2	REVIEWER
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Deliverables

On the final day of the review at the site a closing meeting and presentation of findings will be conducted. At this time a draft report of the strengths, weaknesses, opportunities, and threats will be presented as well as a map of the maintenance process developed over the review that week. All persons having participated through the week in the review will be encouraged to attend the closing meeting.

A post review formal report will be produced outlining in greater detail the results of the review process. A numerical scoring system will be used to rank the site using individual scores for each of the primary categories. The primary categories will each have an individual significance weighting which will be used in tallying a final score. An explanation of the SWOTs for each category will also be included in the final report. The site champion, Maintenance Superintendent, and Mine Manager from each review will receive copies of the final report from their site.

Evaluation Grid Example

Category	Weight Factor	weakest									Strongest	Score
Roles & Responsibilities	B							X				80%
Training	C							X				60%
Tools	C								X			75%
Housekeeping	B									X		80%
Intake System	A								X			70%
Exhaust System	A								X			70%

A presentation will be made to the DEEP Technical Committee once final reports for both sites have been drawn. The final ranking for each site will be presented as well as an outline of the specific strengths and weaknesses to affect the successful implementation of the maintenance project at each site. The DEEP Technical Committee will be asked to select the test site for the project based on the presentation of these findings.