APPENDIX A: CONSEQUENTIAL CUMULATIVE LOSS EFFECT WITH MACHINERY BREAKDOWNS

Table A.1 Breakdown Consequential Costs – Wheel Loader breakdowns

Breakdown of Wheel Loaders - Consequential Losses

S.No	Prime Activities	Actual BD hours	Delay Duration in hours	Delays/effects to follow on/related activities	Trades Manpower cost											Materials wastage/ other activities loses cost						Other Machinery /vehicles Idle charges						Effective loss	Repaired equipment Momentum gain losses	Penalty loss	Total Effective loss on project	BD equipment revenue loss	Equip. replacement cost		BD repair manpower charges			Effective loss for Equipment supplier (without spares)	Total loss to the organisation
					Supervisor		Operator		Driver		Technicians		Trdesman		Hlpers	Soil Test	Mun. Insp	conc. Wast	other	other	other	Trck	comp	vibr	Road roller	Other	Concrete Pump						Wheel loader	Mob&Demob	Supervisor	Mechanic	Helper		
					50.00		25.00		20.00		15.00		14.00		12.00		500.00	450.00				70.00			90.00		200.00		120.00			120.00	120.00	500.00	50.00	20.00	10.00		
1	Excavation			Leveling	3	50	2	25	4	20	2	15	4	14	10							4						766											
		1	1	Compacting	2	50	1	25		20	2	15	4	14	5										1			361	120	-	1,247	120	120	500	5	40	20	805	2,052
				PCC		50		25		20		15		14														-											
				Leveling	3	50	2	25	4	20	2	15	4	14	10							4						4,596											
		6	6	Compacting	2	50	1	25		20	2	15	4	14	5										1			2,166	120	50,000	65,902	720	720	500	30	240	120	2,330	68,232
				PCC	2	50		25		20		15		14	10		1	18									1	9,020											
				Leveling	3	50	2	25	4	20	2	15	4	14	10							4						7,660											
		10	10	Compacting	2	50	1	25		20	2	15	4	14	5										1			3,610	120	50,000	70,410	1,200	1,200	500	50	400	200	3,550	73,960
				PCC	2	50		25		20		15		14	10		1	18									1	9,020											
				Leveling	3	50	2	25	4	20	2	15	4	14	10							4						7,660											
		15	10	Compacting	2	50	1	25		20	2	15	4	14	5										1			3,610	120	50,000	70,410	1,800	1,800	500	75	600	300	5,075	75,485
				PCC	2	50		25		20		15		14	10		1	18									1	9,020											
				Leveling	3	50	2	25	4	20	2	15	4	14	10							4						7,660											
		17	10	Compacting	2	50	1	25		20	2	15	4	14	5										1			3,610	120	50,000	70,410	2,040	2,040	500	85	680	340	5,685	76,095
				PCC	2	50		25		20		15		14	10		1	18									1	9,020											
				Leveling	3	50	2	25	4	20	2	15	4	14	10							4						7,660											
		19	10	Compacting	2	50	1	25		20	2	15	4	14	5										1			3,610	120	50,000	70,410	2,280	2,280	500	95	760	380	6,295	76,705
				PCC	2	50		25		20		15		14	10		1	18									1	9,020											
				Leveling	3	50	2	25	4	20	2	15	4	14	10							4						7,660											
		20	10	Compacting	2	50	1	25		20	2	15	4	14	5										1			3,610	120	50,000	70,410	2,400	2,400	500	100	800	400	6,600	77,010
				PCC	2	50		25		20		15		14	10		1	18									1	9,020											
				Leveling	3	50	2	25	4	20	2	15	4	14	10							4						9,192											
		45	12	Compacting	2	50	1	25		20	2	15	4	14	5										1			4,332	120	50,000	72,664	5,400	5,400	500	225	1,800	900	14,225	86,889
				PCC	2	50		25		20		15		14	10		1	18									1	9,020											
				Leveling	3	50	2	25	4	20	2	15	4	14	10							4						9,192											
		48	12	Compacting	2	50	1	25		20	2	15	4	14	5										1			4,332	120	50,000	72,664	5,760	5,760	500	240	1,920	960	15,140	87,804
				PCC	2	50		25		20		15		14	10		1	18									1	9,020											
2	Rubbish removal	1	1	cleaning	1	50	1	25	10	20		15		14	4							10						1,023	120		1,143	120	120	500	5	40	20	805	1,948
		6	6	cleaning	1	50	1	25	10	20		15		14	4							10						6,138	120	10,000	16,258	720	720	500	30	240	120	2,330	18,588
		10	10	cleaning	1	50	1	25	10	20		15		14	4							10						10,230	120	10,000	20,350	1,200	1,200	500	50	400	200	3,550	23,900
		15	10	cleaning	1	50	1	25	10	20		15		14	4							10						10,230	120	10,000	20,350	1,800	1,800	500	75	600	300	5,075	25,425
		17	10	cleaning	1	50	1	25	10	20		15		14	4							10						10,230	120	10,000	20,350	2,040	2,040	500	85	680	340	5,685	26,035
		19	10	cleaning	1	50	1	25	10	20		15		14	4							10						10,230	120	10,000	20,350	2,280	2,280	500	95	760	380	6,295	26,645
		20	10	cleaning	1	50	1	25	10	20		15		14	4							10						10,230	120	10,000	20,350	2,400	2,400	500	100	800	400	6,600	26,950
		45	12	cleaning	1	50	1	25	10	20		15		14	4							10						12,276	120	10,000	22,396	5,400	5,400	500	225	1,800	900	14,225	36,621
		48	12	cleaning	1	50	1	25	10	20		15		14	4							10						12,276	120	10,000	22,396	5,760	5,760	500	240	1,920	960	15,140	37,536

Table A.2 Breakdown Consequential Costs – Generator breakdowns

Breakdown of Generator - Consequential Losses

S.No	Power supply for total site	Prime Activities	Actual BD hours	Delay Duration in hours	Delays/effects to follow on/related activities	Trades Manpower cost							Materials wastage/ other activities loses cost					Other Machinery /vehicles Idle charges						Effective loss	Repaired equipment Momentum gain losses	Penalty loss	Total Effective loss on project	BD equipment revenue loss	Equip. replacement cost		BD repair manpower charges			Effective loss for Equipment supplier (without spares)	Total loss to the organisation
						Supervisor	Operator	Driver	Technicians	Tradesman	Hipers		Soil Test	Mun. Insp	conc. Wast	other	other	other	Truck	comp	vibr	Road roller	Tower crane	Concrete Pump						Generator	MobDemob	Supervisor	Mechanic	Helper		
						50.00	25.00	20.00	15.00	14.00	12.00			500.00	450.00				70.00			90.00		200.00		40.00			40.00	40.00	500.00	50.00	20.00	10.00		
1					Steel	3	3			20	20												1		895				1,345	40	500	5	40	20	645	1,990
					Shuttering	3				10	10														410					40	500	5	40	20	645	
					PCC															2	5				-										
	1	1	1	1	Steel	3	3			20	20												1		1,790				2,650	80	500	10	80	40	790	3,440
					Shuttering	3				10	10														820					80	500	10	80	40	790	
					PCC															2	5				-										
	2	2	2	2	Steel	3	3			20	20												1		2,685				3,955	120	500	15	120	60	935	4,890
					Shuttering	3				10	10														1,230					120	500	15	120	60	935	
					PCC															2	5				-										
	3	3	3	3	Steel	3	3			20	20												1		3,580				5,260	160	500	20	160	80	1,080	6,340
					Shuttering	3				10	10														1,640					160	500	20	160	80	1,080	
					PCC															2	5				-										
	4	4	4	4	Steel	3	3			20	20												1		4,475				6,565	200	500	25	200	100	1,225	7,790
					Shuttering	3				10	10														2,050					200	500	25	200	100	1,225	
					PCC															2	5				-										
	5	5	5	5	Steel	3	3			20	20												1		5,370				7,870	240	500	30	240	120	1,370	9,240
					Shuttering	3				10	10														2,460					240	500	30	240	120	1,370	
					PCC															2	5				-										
	6	6	6	6	Steel	3	3			20	20												1		6,265				59,175	280	500	35	280	140	1,515	60,690
					Shuttering	3				10	10														2,870					280	500	35	280	140	1,515	
					PCC															2	5				-										
	7	7	7	7	Steel	3	3			20	20												1		7,160				60,480	320	500	40	320	160	1,660	62,140
					Shuttering	3				10	10														3,280					320	500	40	320	160	1,660	
					PCC															2	5				-										
	8	8	8	8	Steel	3	3			20	20												1		2,200	40	50,000	52,240	40	40	500	5	40	20	645	2,885
					Shuttering	5				75	75														4,400	40		4,440	80	80	500	10	80	40	790	5,230
					PCC																				6,600	40		6,640	120	120	500	15	120	60	935	7,575
	2	1	1	1	Site works	5				75	75														8,800	40	50,000	58,840	160	160	500	20	160	80	1,080	59,920
		2	2	2	Site works	5				75	75														11,000	40	50,000	61,040	200	200	500	25	200	100	1,225	62,265
		3	3	3	Site works	5				75	75														13,200	40	50,000	63,240	240	240	500	30	240	120	1,370	64,610
		4	4	4	Site works	5				75	75														15,400	40	50,000	65,440	280	280	500	35	280	140	1,515	66,955
		5	5	5	Site works	5				75	75														17,600	40	50,000	67,640	320	320	500	40	320	160	1,660	69,300

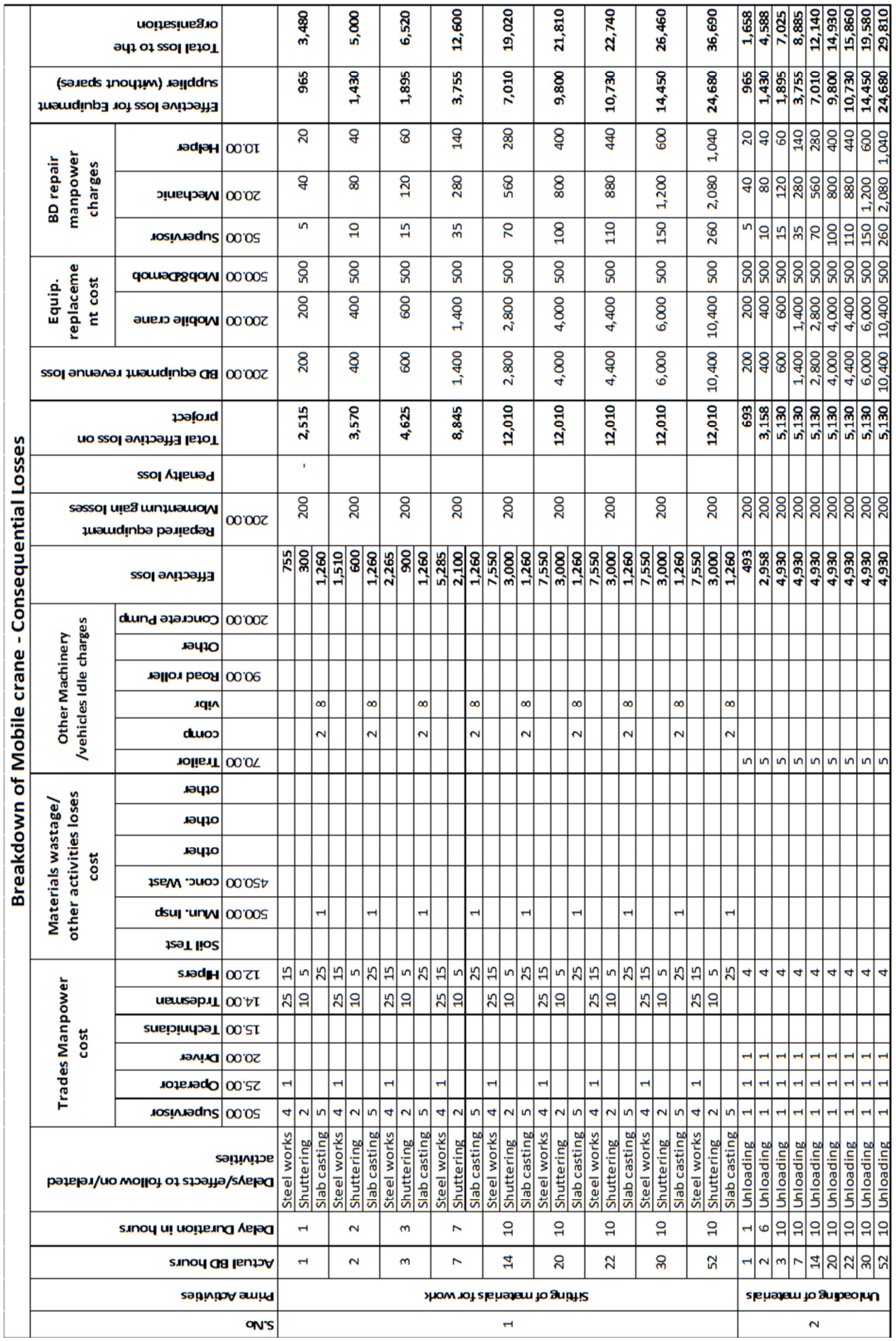
Table A.3 Breakdown Consequential Costs – Forklift breakdowns

Breakdown of Forklift - Consequential Losses																																		
S.No	Prime Activities	Actual BD hours	Delay Duration in hours	Delays/effects to follow on/related activities	Trades Manpower cost							Materials wastage/ other activities loses cost							Other Machinery /vehicles Idle charges							Effective loss	Repaired equipment Momentum gain losses	Penalty loss	Total Effective loss on project	BD equipment revenue loss	Equip. replacement cost		BD repair manpower charges			Effective loss for Equipment supplier (without spares)	Total loss to the organisation
					Supervisor	Operator	Driver	Technicians	Trdesman	Hlpers		Soil Test	Mun. Insp	conc. Wast	other	other	other	other	Trailor	comp	vibr	Road roller	Other	Concrete Pump						Forklift	Mob&Demob	Supervisor	Mechanic	Helper		
					50.00	25.00	20.00	15.00	14.00	12.00		500.00	450.00						70.00			90.00		200.00			100.00			100.00	500.00	50.00	20.00	10.00		
1	Unloading of materials	1	1	Unloading	1	1	1			4									5							493	100		593	100	100	500	5	40	20	765	1,358
		3	3	Unloading	1	1	1			4									5							1,479	100		1,579	300	300	500	15	120	60	1,295	2,874
		10	10	Unloading	1	1	1			4									5							4,930	100		5,030	1,000	1,000	500	50	400	200	3,150	8,180
		15	10	Unloading	1	1	1			4									5							4,930	100		5,030	1,500	1,500	500	75	600	300	4,475	9,505
		30	10	Unloading	1	1	1			4									5							4,930	100		5,030	3,000	3,000	500	150	1,200	600	8,450	13,480

Table A.4 Breakdown Consequential Costs – Compressor breakdowns

Breakdown of compressor - Consequential Losses																																				
S.No	Prime Activities	Actual BD hours	Delay Duration in hours	Delays/effects to follow on/related activities	Trades Manpower cost							Materials wastage/ other activities loses cost							Other Machinery /vehicles Idle charges							Effective lose	Repaired equipment Momentum gain losses	Penalty loss	Total Effective loss on project	BD equipment revenue loss	Equip. replacement cost		BD repair manpower charges			Effective loss for Equipment supplier (without spares)	Total loss to the organisation
					Supervisor	Operator	Driver	Technicians	Trdesman	Hlpers		Soil Test	Mun. Insp	conc. Wast	other	other	other	other	Trck	comp	vibr	Road roller	Other	Concrete Pump						Compressor	Mob&Demob	Supervisor	Mechanic	Helper		
					50.00	25.00	20.00	15.00	14.00	12.00		500.00	450.00						70.00			90.00		200.00			25.00			25.00	250.00	50.00	20.00	10.00		
1	Cleaning of slabs	1	1	Slab casting	1	1				50		1									5			1	1,475	25	-	1,500	25	25	250	5	40	20	365	1,865
	Breaking concrete	1	1	Rubbish	1	1				4													1		173	25		198	25	25	250	5	40	20	365	563
2	Cleaning of slabs	3	3	Slab casting	1	1				50		1									5			1	4,425	25	-	4,450	75	75	250	15	120	60	595	5,045
	Breaking concrete	3	3	Rubbish	1	1				4													1		519	25		544	75	75	250	15	120	60	595	1,139
3	Cleaning of slabs	7	7	Slab casting	1	1				50		1									5			1	10,325	25	-	10,350	175	175	250	35	280	140	1,055	11,405
	Breaking concrete	7	7	Rubbish	1	1				4													1		1,211	25		1,236	175	175	250	35	280	140	1,055	2,291
4	Cleaning of slabs	9	9	Slab casting	1	1				50		1									5			1	13,275	25	-	13,300	225	225	250	45	360	180	1,285	14,585
	Breaking concrete	9	9	Rubbish	1	1				4													1		1,557	25		1,582	225	225	250	45	360	180	1,285	2,867
5	Cleaning of slabs	11	10	Slab casting	1	1				50		1									5			1	14,750	25	-	14,775	275	275	250	55	440	220	1,515	16,290
	Breaking concrete	11	10	Rubbish	1	1				4													1		1,730	25		1,755	275	275	250	55	440	220	1,515	3,270
6	Cleaning of slabs	14	10	Slab casting	1	1				50		1									5			1	14,750	25	-	14,775	350	350	250	70	560	280	1,860	16,635
	Breaking concrete	14	10	Rubbish	1	1				4													1		1,730	25		1,755	350	350	250	70	560	280	1,860	3,615
7	Cleaning of slabs	17	10	Slab casting	1	1				50		1									5			1	14,750	25	-	14,775	425	425	250	85	680	340	2,205	16,980
	Breaking concrete	17	10	Rubbish	1	1				4													1		1,730	25		1,755	425	425	250	85	680	340	2,205	3,960
8	Cleaning of slabs	26	10	Slab casting	1	1				50		1									5			1	14,750	25	-	14,775	650	650	250	130	1,040	520	3,240	18,015
	Breaking concrete	26	10	Rubbish	1	1				4													1		1,730	25		1,755	650	650	250	130	1,040	520	3,240	4,995

Table A.5 Breakdown Consequential Costs – Mobile Crane breakdowns



Breakdown of Mobile crane - Consequential Losses

S.No	Prime Activities	Actual BD hours	Delay Duration in hours	Delays/effects to follow on/related activities	Trades Manpower cost							Materials wastage/ other activities loses cost					Other Machinery /vehicles Idle charges						Effective loss	Repaired equipment Momentum gain losses	Penalty loss	Total Effective loss on project	BD equipment revenue loss	Equip. replacement cost		BD repair manpower charges			Effective loss for Equipment supplier (without spares)	Total loss to the organisation
					50.00 Supervisor	25.00 Operator	20.00 Driver	15.00 Technicians	14.00 Tradesman	12.00 Hpers		Soil Test	500.00 Mun. Insp	450.00 conc. Wast	other	other	other	70.00 Trailor	comp	vibr	90.00 Road roller	Other	200.00 Concrete Pump		200.00			200.00 Mobile crane	500.00 Mob&Demob		50.00 Supervisor	20.00 Mechanic	10.00 Helper		
1	Sifting of materials for work	1	1	Steel works	4	1			25	15													755	200	-	2,515	200	200	500		5	40	20	965	3,480
				Shuttering	2				10	5													300												
				Slab casting	5					25			1						2	8				1,260												
		2	2	Steel works	4	1			25	15													1,510	200		3,570	400	400	500		10	80	40	1,430	5,000
				Shuttering	2				10	5													600												
				Slab casting	5					25			1						2	8				1,260												
		3	3	Steel works	4	1			25	15													2,265	200		4,625	600	600	500		15	120	60	1,895	6,520
				Shuttering	2				10	5													900												
				Slab casting	5					25			1						2	8				1,260												
		7	7	Steel works	4	1			25	15													5,285	200		8,845	1,400	1,400	500		35	280	140	3,755	12,600
				Shuttering	2				10	5													2,100												
				Slab casting	5					25			1						2	8				1,260												
		14	10	Steel works	4	1			25	15													7,550	200		12,010	2,800	2,800	500		70	560	280	7,010	19,020
				Shuttering	2				10	5													3,000												
				Slab casting	5					25			1						2	8				1,260												
		20	10	Steel works	4	1			25	15													7,550	200		12,010	4,000	4,000	500		100	800	400	9,800	21,810
				Shuttering	2				10	5													3,000												
				Slab casting	5					25			1						2	8				1,260												
		22	10	Steel works	4	1			25	15													7,550	200		12,010	4,400	4,400	500		110	880	440	10,730	22,740
				Shuttering	2				10	5													3,000												
				Slab casting	5					25			1						2	8				1,260												
		30	10	Steel works	4	1			25	15													7,550	200		12,010	6,000	6,000	500		150	1,200	600	14,450	26,460
				Shuttering	2				10	5													3,000												
				Slab casting	5					25			1						2	8				1,260												
		52	10	Steel works	4	1			25	15													7,550	200		12,010	10,400	10,400	500		260	2,080	1,040	24,680	36,690
				Shuttering	2				10	5													3,000												
				Slab casting	5					25			1						2	8				1,260												
2	Unloading of materials	1	1	Unloading	1	1	1			4								5					493	200		693	200	200	500		5	40	20	965	1,658
		2	6	Unloading	1	1	1			4								5					2,958	200		3,158	400	400	500		10	80	40	1,430	4,588
		3	10	Unloading	1	1	1			4								5					4,930	200		5,130	600	600	500		15	120	60	1,895	7,025
		7	10	Unloading	1	1	1			4								5					4,930	200		5,130	1,400	1,400	500		35	280	140	3,755	8,885
		14	10	Unloading	1	1	1			4								5					4,930	200		5,130	2,800	2,800	500		70	560	280	7,010	12,140
		20	10	Unloading	1	1	1			4								5					4,930	200		5,130	4,000	4,000	500		100	800	400	9,800	14,930
		22	10	Unloading	1	1	1			4								5					4,930	200		5,130	4,400	4,400	500		110	880	440	10,730	15,860
		30	10	Unloading	1	1	1			4								5					4,930	200		5,130	6,000	6,000	500		150	1,200	600	14,450	19,580
		52	10	Unloading	1	1	1			4								5					4,930	200		5,130	10,400	10,400	500		260	2,080	1,040	24,680	29,810

Table A.6 Breakdown Consequential Costs – Back Hoe Loader breakdowns

Breakdown of Back hoe loaders - Consequential Losses

S.No	Prime Activities	Actual BD hours	Delay Duration in hours	Delay/Affects to following/related activities	Trades Manpower cost										Materials wastage/ other activities loses cost					Other Machinery /vehicles idle charges						Effective loss	Repaired equipment	Maintenance/Margin loss	Penalty/ Gas	Total Effective loss on project	BD equipment revenue loss	Equip. replacement cost		BD repair manpower charges			Effective loss to equipment supplier (Without spares cost)	Total loss to the organisation
					Supervisor		Operator		Driver		Technicians		Tradesmn		Hpers	Soil Test	Mtn hrp	conc Matl	other	other	Truck	comp	Vibr	Roadroller	Other	Concrete Pump						Backhoe loader	Vib&Dtamb	Supervisor	Mechanic	Hlper		
					5000		2500		2000		1500		1400		1200		5000	4500			7000			9000		2000						1000	5000	5000	2000	1000		
1	Excavation	1	1	Leveling	3	50	2	25	4	20	2	15	4	14	10						4							766					100	100	500	5	40	20	765	1,992
				Compacting	2	50	1	25		20	2	15	4	14	5									1				361			-	1,227							
				PCC		50		25		20		15		14														-											
		2	2	Leveling	3	50	2	25	4	20	2	15	4	14	5						4							1,532					100	200	500	10	80	40	1,030	12,404
				Compacting	2	50	1	25		20	2	15	4	14	10									1				722			-	11,374	200						
				PCC		50		25		20		15	4	14	10		1	18								1		9,020											
		5	5	Leveling	3	50	2	25	4	20	2	15	4	14	10						4							3,830					100	500	500	25	200	100	1,825	16,580
				Compacting	2	50	1	25		20	2	15	4	14	5									1				1,805			-	14,755	500						
				PCC		50		25		20		15	4	14	10		1	18								1		9,020											
		6	6	Leveling	3	50	2	25	4	20	2	15	4	14	10						4							4,596					100	600	500	30	240	120	2,090	17,972
				Compacting	2	50	1	25		20	2	15	4	14	5									1				2,166			-	15,882							
				PCC		50		25		20		15	4	14	10		1	18								1		9,020											
		11	10	Leveling	3	50	2	25	4	20	2	15	4	14	10						4							7,660					100	1,100	500	55	440	220	3,415	73,805
				Compacting	2	50	1	25		20	2	15	4	14	5									1				3,610			50,000	70,390							
				PCC		50		25		20		15	4	14	10		1	18								1		9,020											
		25	10	Leveling	3	50	2	25	4	20	2	15	4	14	10						4							7,660					100	2,500	500	125	1,000	500	7,125	77,515
				Compacting	2	50	1	25		20	2	15	4	14	5									1				3,610			50,000	70,390							
				PCC		50		25		20		15	4	14	10		1	18								1		9,020											
		56	10	Leveling	3	50	2	25	4	20	2	15	4	14	10						4							7,660					100	5,600	500	280	2,240	1,120	15,340	85,730
				Compacting	2	50	1	25		20	2	15	4	14	5									1				3,610			50,000	70,390							
				PCC		50		25		20		15	4	14	10		1	18								1		9,020											
Refurbishment		1	1	cleaning	1	50	1	25	10	20		15		14	4						10							1,023				1,123	100	100	500	5	40	20	765	1,888
		2	2	cleaning	1	50	1	25	10	20		15		14	4						10							2,046			10,000	12,146	100	200	500	10	80	40	1,030	13,176
		5	5	cleaning	1	50	1	25	10	20		15		14	4						10							5,115			10,000	15,215	100	500	500	25	200	100	1,825	17,040
		6	6	cleaning	1	50	1	25	10	20		15		14	4						10							6,138			10,000	16,238	100	600	500	30	240	120	2,090	18,328
		11	10	cleaning	1	50	1	25	10	20		15		14	4						10							10,230			10,000	20,330	100	1,100	500	55	440	220	3,415	23,745
		25	10	cleaning	1	50	1	25	10	20		15		14	4						10							10,230			10,000	20,330	100	2,500	500	125	1,000	500	7,125	27,455
		56	10	cleaning	1	50	1	25	10	20		15		14	4						10							10,230			10,000	20,330	100	5,600	500	280	2,240	1,120	15,340	35,670
		1	1	pipe/cable	1	50	1	25		20	10	15	4	14														281				123							
				backfilling	1	50	1	25		20		15		14	4									1							10,000	10,667	100	100	500	5	40	20	765	11,432
				compaction		50	1	25		20	10	15	4	14														163											
Trench Excation		2	2	pipe/cable	1	50	1	25		20	10	15	4	14														562				246							
				backfilling	1	50	1	25		20		15		14	4									1							10,000	11,234	100	200	500	10	80	40	1,030	12,264
				compaction		50	1	25		20	10	15	4	14														326											
		5	5	pipe/cable	1	50	1	25		20	10	15	4	14														1,405				615							
				backfilling	1	50	1	25		20		15		14	4									1							10,000	12,935	100	500	500	25	200	100	1,825	14,760
				compaction		50	1	25		20		15		14														815											
		6	6	pipe/cable	1	50	1	25		20	10	15	4	14														1,686				738							
				backfilling	1	50	1	25		20		15		14	4									1							10,000	13,502	100	600	500	30	240	120	2,090	15,592
				compaction		50	1	25		20		15		14														978											
		11	10	pipe/cable	1	50	1	25		20	10	15	4	14														2,810				1,230							
				backfilling	1	50	1	25		20		15		14	4									1							10,000	15,770	100	1,100	500	55	440	220	3,415	19,185
				compaction		50	1	25		20		15		14														1,630											
		25	10	pipe/cable	1	50	1	25		20	10	15	4	14														2,810				1,230							
				backfilling	1	50	1	25		20		15		14	4									1							10,000	15,770	100	2,500	500	125	1,000	500	7,125	22,895
				compaction		50	1	25		20		15		14														1,630											
		56	10	pipe/cable	1	50	1	25		20	10	15	4	14														2,810				1,230							
				backfilling	1	50	1	25		20		15		14	4									1							10,000	15,770	100	5,600	500	280	2,240	1,120	15,340	31,110
				compaction		50	1	25		20		15		14														1,630											

Table A.7 Breakdown Consequential Costs – Skid Steer Loader breakdowns

Breakdown of Skid loaders - Consequential Losses

S.No	Prime Activities	Actual BD hours	Delay Duration in hours	Delays/effects to follow on/related activities	Trades Manpower cost						Materials wastage/ other activities loses cost						Other Machinery /vehicles idle charges						Effective lose	Repaired equipment Momentum gain losses	Penalty loss	Total Effective loss on project	BD equipment revenue loss	Equip. replacement cost		BD repair manpower charges			Effective loss for Equipment supplier (without spares)	Total loss to the organisation
					Supervisor	Operator	Driver	Technicians	Tradesman	Hipers	Soil Test	Mun. Insp	conc. Wast	other	other	other	Truck	comp	vibr	Road roller	Other	Concrete Pump						Skid loader	MobDemob	Supervisor	Mechanic	Helper		
					50.00	25.00	20.00	15.00	14.00	12.00		500.00	450.00				70.00			90.00		200.00		50.00			50.00	50.00	300.00	50.00	20.00	10.00		
1	Sand shifting	1	1	Leveling	1	1		2	4	5													221	50	-	582	50	50	300	5	40	20	465	1,047
				Compacting	1	1		2	4	5										1			311										
				PCC																			-										
2		2	2	Leveling	1	1		2	4	5													442	50	-	1,114	100	100	300	10	80	40	630	1,744
				Compacting	1	1		2	4	5										1			622										
				PCC																			-										
3		3	3	Leveling	1	1		2	4	5													663	50	-	1,646	150	150	300	15	120	60	795	2,441
				Compacting	1	1		2	4	5										1			933										
				PCC																			-										
4		4	4	Leveling	1	1		2	4	5													884	50	-	2,178	200	200	300	20	160	80	960	3,138
				Compacting	1	1		2	4	5										1			1,244										
				PCC																			-										
5		6	6	Leveling	1	1		2	4	5													1,326	50	-	3,242	300	300	300	30	240	120	1,290	4,532
				Compacting	1	1		2	4	5										1			1,866										
				PCC																			-										
6		11	10	Leveling	1	1		2	4	5													2,210	50	-	5,370	550	550	300	55	440	220	2,115	7,485
				Compacting	1	1		2	4	5										1			3,110										
				PCC																			-										
7		12	10	Leveling	1	1		2	4	5													2,210	50	-	5,370	600	600	300	60	480	240	2,280	7,650
				Compacting	1	1		2	4	5										1			3,110										
				PCC																			-										
1	Rubbish removal	1	1	cleaning	1	1				4													123	50		173	50	50	300	5	40	20	465	638
2		2	2	cleaning	1	1				4													246	50		296	100	100	300	10	80	40	630	926
3		3	3	cleaning	1	1				4													369	50		419	150	150	300	15	120	60	795	1,214
4		4	4	cleaning	1	1				4													492	50		542	200	200	300	20	160	80	960	1,502
5		6	6	cleaning	1	1				4													738	50		788	300	300	300	30	240	120	1,290	2,078
6		11	10	cleaning	1	1				4													1,230	50		1,280	550	550	300	55	440	220	2,115	3,395
7		12	10	cleaning	1	1				4													1,230	50		1,280	600	600	300	60	480	240	2,280	3,560

Table A.8 Breakdown Consequential Costs – Roller Compactor breakdowns

Breakdown of Roller compactor - Consequential Losses

S.No	Prime Activities	Actual BD hours	Delay Duration in hours	Delays/effects to follow on/related activities	Trades Manpower cost							Materials wastage/ other activities loses cost						Other Machinery /vehicles Idle charges						Effective loss	Repaired equipment Momentum gain losses	Penalty loss	Total Effective loss on project	BD equipment revenue loss	Equip. replacement cost		BD repair manpower charges			Effective loss for Equipment supplier (without spares)	Total loss to the organisation
					Supervisor	Operator	Driver	Technicians	Tradesman	Hipers		Soil Test	Mun. Insp	conc. Wast	other	other	other	Truck	comp	vibr	Road roller	Other	Concrete Pump						Roller compactor	MobDemob	Supervisor	Mechanic	Helper		
					50.00	25.00	20.00	15.00	14.00	12.00			500.00	450.00				70.00			90.00		200.00			25.00			25.00	300.00	50.00	20.00	10.00			
1	Compaction	2	2	Leveling	1	1		2	4	5														442	25	-	1,089	50	50	300	10	80	40	530	1,619
				Compacting	1	1		2	4	5											1			622											
				PCC																				-											
2		4	4	Leveling	1	1		2	4	5														884	25	-	2,153	100	100	300	20	160	80	760	2,913
				Compacting	1	1		2	4	5											1			1,244											
				PCC																				-											
3		5	5	Leveling	1	1		2	4	5														1,105	25	-	2,685	125	125	300	25	200	100	875	3,560
				Compacting	1	1		2	4	5											1			1,555											
				PCC																				-											
4		8	8	Leveling	1	1		2	4	5														1,768	25	-	4,281	200	200	300	40	320	160	1,220	5,501
				Compacting	1	1		2	4	5											1			2,488											
				PCC																				-											
5		10	10	Leveling	1	1		2	4	5														2,210	25	-	5,345	250	250	300	50	400	200	1,450	6,795
				Compacting	1	1		2	4	5											1			3,110											
				PCC																				-											
6		14	10	Leveling	1	1		2	4	5														2,210	25	-	5,345	350	350	300	70	560	280	1,910	7,255
				Compacting	1	1		2	4	5											1			3,110											
				PCC																				-											
7		15	10	Leveling	1	1		2	4	5														2,210	25	-	5,345	375	375	300	75	600	300	2,025	7,370
				Compacting	1	1		2	4	5											1			3,110											
				PCC																				-											
8		18	10	Leveling	1	1		2	4	5														2,210	25	-	5,345	450	450	300	90	720	360	2,370	7,715
				Compacting	1	1		2	4	5											1			3,110											
				PCC																				-											
9		22	10	Leveling	1	1		2	4	5														2,210	25	-	5,345	550	550	300	###	880	440	2,830	8,175
				Compacting	1	1		2	4	5											1			3,110											
				PCC																				-											

APPENDIX B: BREAKDOWN MAINTENANCE QUESTIONNAIRE AND SAMPLE FILLED IN FORMS

Table B.1 Breakdown Maintenance Questionnaire used for Survey

Name:							
Title/Designation:							
Company:							
Work Experience:							
Telephone:							
Mail:							
Questionaire on Breakdown Maintenance of Construction Plant and Equipment							
Sl. No.	**Question**	**Fully Agree**	**Agree**	**Partly Agree**	**Partly disagree**	**disagree**	**No comments**
		4	**3**	**2**	**1**	**0**	
Breakdown Maintenance Concepts / Beliefs							
1	Every Organization has ultimate goal of zero downtime due to equipment failures and breakdowns						
2	In construction industry generally breakdown in one equipment affects the follow on activities of other equipments/trades						
3	Even with the presence of preventive and planned maintenance, breakdowns and failures are unavoidable with construction equipment						
5	In construction industry generally a mix of old and new equipment work together in the projects						
6	Handling multiple brands for similar type of equipments is always a major hurdle due to availing resources to maintain all of them						
7	Generally breakdowns make loss of morale of the maintenance crew						
8	Breakdown Maintenance is not always an interesting work/activity to execute						
9	Time cannot be estimated generally for breakdown maintenance with conventional approach						
10	Competent level of technicians/mechanics is one of the key factors in reducing downtime						
11	New mechanics will always lack the knowledge of breakdowns maintenance						
Breakdown Maintenance Crew Stress Levels / Factors							
1	Maintenance crew gets panic situation whenever a breakdown information comes from the sources/projects						
2	Huge amount of pressure and responsibility remains with the maintenance crew during execution of breakdowns works						
3	Supervisor will be under extreme stress during breakdowns rectification with pressure and follow ups from projects and end users						
4	Mechanics attending the breakdown will always try to shift the works to the workshop/yard team due to indecisive situation prevailing with them						
5	The exact cause of the breakdowns are generally not ideintified immediately by the crew with conventional knowledge and methods						
Breakdown Maintenance Optimization							
1	An effective breakdown planning methodology for construction machineries will always serve good with good knowledge of breakdowns, resource back up and clear procedures						
2	Resources including following will not be generally available during breakdown rectification : Mechanics, Spare Parts, Supervisory Support, Special Tools, Hand Tools, Consumables						
3	Method of Rectification will help the mechanic to attend the breakdowns with ease						
4	* Breakdown Maintenance Protocol (BMP) will enable the crew to execute the breakdowns effectively						
	RATING SCORE						
* BMP is the Breakdown Maintenance Protocol which is an effective methodology to execute breakdown maintenance of construction equipment. A BMP Ruler which is developed with four tiers of breakdown codes printed on a circular rings (Breakdown Main Code, Breakdown Sub Code, Breakdown Symptom Code and Breakdown Reason Code) help the crew to identify the cause of the breakdowns to its closest route cause. The Breakdown Reason Code provide the resource requirement for the particular breakdown with the specific BMP number and also the associated resources and methods of rectification.							
Comments/Remarks/Additional Points, if any:							
You can also directly mail the filled in questionnaire to: pbahamed@gmail.com							

Name:	SIMON LESEIGNEUR
Title/Designation:	SUPERVISOR
Company:	GALLAGHER INTERNATIONAL
Work Experience:	19 YEARS
Telephone:	04-884 1102
Mail:	info@gallagher-uae.com

Questionaire on Breakdown Maintenance of Construction Plant and Equipment

Sl. No.	Question	Fully Agree	Agree	Partly Agree	Partly disagree	disagree	No comments
		4	3	2	1	0	
Breakdown Maintenance Concepts / Beliefs							
1	Every Organization has ultimate goal of zero downtime due to equipment failures and breakdowns		X				
2	In construction industry generally breakdown in one equipment affects the follow on activities of other equipments/trades	X					
3	Even with the presence of preventive and planned maintenance, breakdowns and failures are unavoidable with construction equipment	X					
5	In construction industry generally a mix of old and new equipment work together in the projects		X				
6	Handling multiple brands for similar type of equipments is always a major hurdle due to availing resources to maintain all of them			X			
7	Generally breakdowns make loss of morale of the maintenance crew				X		
8	Breakdown Maintenance is not always an interesting work/activity to execute		X				
9	Time cannot be estimated generally for breakdown maintenance with conventional approach		X				
10	Competent level of technicians/mechanics is one of the key factors in reducing downtime	X					
11	New mechanics will always lack the knowledge of breakdowns maintenance			X			
Breakdown Maintenance Crew Stress Levels / Factors							
1	Maintenance crew gets panic situation whenever a breakdown information comes from the sources/projects					X	
2	Huge amount of pressure and responsibility remains with the maintenance crew during execution of breakdowns works		X				
3	Supervisor will be under extreme stress during breakdowns rectification with pressure and follow ups from projects and end users	X					
4	Mechanics attending the breakdown will always try to shift the works to the workshop/yard team due to indecisive situation prevailing with them		X				
5	The exact cause of the breakdowns are generally not ideintified immediately by the crew with conventional knowledge and methods		X				
Breakdown Maintenance Optimization							
1	An effective breakdown planning methodology for construction machineries will always serve good with good knowledge of breakdowns, resource back up and clear procedures	X					
2	Resources including following will not be generally available during breakdown rectification - Mechanics, Spare Parts, Supervisory Support, Special Tools, Hand Tools, Consumables		X				
3	Method of Rectification will help the mechanic to attend the breakdowns with ease	X					
4	* Breakdown Maintenance Protocol (BMP) will enable the crew to execute the breakdowns effectively						X
	RATING SCORE						

* BMP is the Breakdown Maintenance Protocol which is an effective methodology to execute breakdown maintenance of construction equipment. A BMP Ruler which is developed with four tiers of breakdown codes printed on a circular rings (Breakdown Main Code, Breakdown Sub Code, Breakdown Symptom Code and Breakdown Reason Code) help the crew to identify the cause of the breakdowns to its closest route cause. The Breakdown Reason Code provide the resource requirement for the particular breakdown with the specific BMP number and also the associated resources and methods of rectification.

Comments/Remarks/Additional Points, if any:

You can also directly mail the filled in questionnaire to: pbahamed@gmail.com

Name: ANDREW WALLIS

Title/Designation: SERVICE MANAGER

Company: KANOO MACHINERY

Work Experience: 31 YEARS.

Telephone:

Mail:

Questionaire on Breakdown Maintenance of Construction Plant and Equipment

Sl. No.	Question	Fully Agree	Agree	Partly Agree	Partly disagree	disagree	No comments
		4	3	2	1	0	
Breakdown Maintenance Concepts / Beliefs							
1	Every Organization has ultimate goal of zero downtime due to equipment failures and breakdowns			✓			
2	In construction industry generally breakdown in one equipment affects the follow on activities of other equipments/trades			✓			
3	Even with the presence of preventive and planned maintenance, breakdowns and failures are unavoidable with construction equipment		✓				
5	In construction industry generally a mix of old and new equipment work together in the projects			✓			
6	Handling multiple brands for similar type of equipments is always a major hurdle due to availing resources to maintain all of them	✓					
7	Generally breakdowns make loss of morale of the maintenance crew			✓			*
8	Breakdown Maintenance is not always an interesting work/activity to execute						✓
9	Time cannot be estimated generally for breakdown maintenance with conventional approach					✓	
10	Competent level of technicians/mechanics is one of the key factors in reducing downtime	✓					
11	New mechanics will always lack the knowledge of breakdowns maintenance			✓			
Breakdown Maintenance Crew Stress Levels / Factors							
1	Maintenance crew gets panic situation whenever a breakdown information comes from the sources/projects						✓
2	Huge amount of pressure and responsibility remains with the maintenance crew during execution of breakdowns works			✓			
3	Supervisor will be under extreme stress during breakdowns rectification with pressure and follow ups from projects and end users	✓					
4	Mechanics attending the breakdown will always try to shift the works to the workshop/yard team due to indecisive situation prevailing with them			✓			
5	The exact cause of the breakdowns are generally not ideintified immediately by the crew with conventional knowledge and methods			✓			
Breakdown Maintenance Optimization							
1	An effective breakdown planning methodology for construction machineries will always serve good with good knowledge of breakdowns, resource back up and clear procedures			✓			
2	Resources including following will not be generally available during breakdown rectification : Mechanics, Spare Parts, Supervisory Support, Special Tools, Hand Tools, Consumables			✓			
3	Method of Rectification will help the mechanic to attend the breakdowns with ease		✓				
4	* Breakdown Maintenance Protocol (BMP) will enable the crew to execute the breakdowns effectively			✓			
	RATING SCORE						

* BMP is the Breakdown Maintenance Protocol which is an effective methodology to execute breakdown maintenance of construction equipment. A BMP Ruler which is developed with four tiers of breakdown codes printed on a circular rings (Breakdown Main Code, Breakdown Sub Code, Breakdown Symptom Code and Breakdown Reason Code) help the crew to identify the cause of the breakdowns to its closest route cause. The Breakdown Reason Code provide the resource requirement for the particular breakdown with the specific BMP number and also the associated resources and methods of rectification.

Comments/Remarks/Additional Points, if any:

1

You can also directly mail the filled in questionnaire to: pbahamed@gmail.com

Name:	Basim Hassoon Juhi
Title/Designation:	Maintenance Engineer/(Mechanical Engineer)
Company:	AL-Jaber Leasing Services LLC
Work Experience:	25 Years
Telephone:	02-5020573, 056-1991857
Mail:	bassim.hassoon@aje.ae

Questionaire on Breakdown Maintenance of Construction Plant and Equipment

Sl. No.	Question	Fully Agree	Agree	Partly Agree	Partly disagree	disagree	No comments
		4	3	2	1	0	
Breakdown Maintenance Concepts / Beliefs							
1	Every Organization has ultimate goal of zero downtime due to equipment failures and breakdowns	✓					
2	In construction industry generally breakdown in one equipment affects the follow on activities of other equipments/trades						✓
3	Even with the presence of preventive and planned maintenance, breakdowns and failures are unavoidable with construction equipment	✓					
5	In construction industry generally a mix of old and new equipment work together in the projects	✓					
6	Handling multiple brands for similar type of equipments is always a major hurdle due to availing resources to maintain all of them					✓	
7	Generally breakdowns make loss of morale of the maintenance crew					✓	
8	Breakdown Maintenance is not always an interesting work/activity to execute					✓	
9	Time cannot be estimated generally for breakdown maintenance with conventional approach	✓					
10	Competent level of technicians/mechanics is one of the key factors in reducing downtime			✓			
11	New mechanics will always lack the knowledge of breakdowns maintenance	✓					
Breakdown Maintenance Crew Stress Levels / Factors							
1	Maintenance crew gets panic situation whenever a breakdown information comes from the sources/projects					✓	
2	Huge amount of pressure and responsibility remains with the maintenance crew during execution of breakdowns works		✓				
3	Supervisor will be under extreme stress during breakdowns rectification with pressure and follow ups from projects and end users	✓					
4	Mechanics attending the breakdown will always try to shift the works to the workshop/yard team due to indecisive situation prevailing with them					✓	
5	The exact cause of the breakdowns are generally not identified immediately by the crew with conventional knowledge and methods					✓	
Breakdown Maintenance Optimization							
1	An effective breakdown planning methodology for construction machineries will always serve good with good knowledge of breakdowns, resource back up and clear procedures	✓					
2	Resources including following will not be generally available during breakdown rectification : Mechanics, Spare Parts, Supervisory Support, Special Tools, Hand Tools, Consumables			✓			
3	Method of Rectification will help the mechanic to attend the breakdowns with ease	✓					
4	* Breakdown Maintenance Protocol (BMP) will enable the crew to execute the breakdowns effectively						✓
	RATING SCORE						

* BMP is the Breakdown Maintenance Protocol which is an effective methodology to execute breakdown maintenance of construction equipment. A BMP Ruler which is developed with four bars of breakdown codes printed on a circular rings (Breakdown Main Code, Breakdown Sub Code, Breakdown Symptom Code and Breakdown Reason Code) help the crew to identify the cause of the breakdowns to its closest route cause. The Breakdown Reason Code provide the resource requirement for the particular breakdown with the specific BMP number and also the associated resources and methods of rectification.

Comments/Remarks/Additional Points, if any:

WS-Admin
01 AUG 2012
Bassem Hassoun

You can also directly mail the filled in questionnaire to: phaha...@gmail.com

Name: Rajesh Sukala

Title/Designation: Foreman

Company: DOdsal

Work Experience: ~14 years

Telephone:

Mail:

Questionaire on Breakdown Maintenance of Construction Plant and Equipment

Sl. No.	Question	Fully Agree	Agree	Partly Agree	Partly disagree	disagree	No comments
		4	3	2	1	0	
Breakdown Maintenance Concepts / Beliefs							
1	Every Organization has ultimate goal of zero downtime due to equipment failures and breakdowns	✓					
2	In construction industry generally breakdown in one equipment affects the follow on activities of other equipments/trades			✓			
3	Even with the presence of preventive and planned maintenance, breakdowns and failures are unavoidable with construction equipment		✓				
5	In construction industry generally a mix of old and new equipment work together in the projects		✓				
6	Handling multiple brands for similar type of equipments is always a major hurdle due to availing resources to maintain all of them		✓				
7	Generally breakdowns make loss of morale of the maintenance crew		✓				
8	Breakdown Maintenance is not always an interesting work/activity to execute			✓			
9	Time cannot be estimated generally for breakdown maintenance with conventional approach		✓				
10	Competent level of technicians/mechanics is one of the key factors in reducing downtime		✓				
11	New mechanics will always lack the knowledge of breakdowns maintenance		✓				
Breakdown Maintenance Crew Stress Levels / Factors							
1	Maintenance crew gets panic situation whenever a breakdown information comes from the sources/projects				✓		
2	Huge amount of pressure and responsibility remains with the maintenance crew during execution of breakdowns works		✓				
3	Supervisor will be under extreme stress during breakdowns rectification with pressure and follow ups from projects and end users		✓				
4	Mechanics attending the breakdown will always try to shift the works to the workshop/yard team due to indecisive situation prevailing with them		✓	✓			
5	The exact cause of the breakdowns are generally not ideintified immediately by the crew with conventional knowledge and methods				✓		
Breakdown Maintenance Optimization							
1	An effective breakdown planning methodology for construction machineries will always serve good with good knowledge of breakdowns, resource back up and clear procedures		✓				
2	Resources including following will not be generally available during breakdown rectification : Mechanics, Spare Parts, Supervisory Support, Special Tools, Hand Tools, Consumables		✓				
3	Method of Rectification will help the mechanic to attend the breakdowns with ease		✓				
4	* Breakdown Maintenance Protocol (BMP) will enable the crew to execute the breakdowns effectively			✓			
	RATING SCORE						

* BMP is the Breakdown Maintenance Protocol which is an effective methodology to execute breakdown maintenance of construction equipment. A BMP Ruler which is developed with four tiers of breakdown codes printed on a circular rings (Breakdown Main Code, Breakdown Sub Code, Breakdown Symptom Code and Breakdown Reason Code) help the crew to identify the cause of the breakdowns to its closest route cause. The Breakdown Reason Code provide the resource requirement for the particular breakdown with the specific BMP number and also the associated resources and methods of rectification.

Comments/Remarks/Additional Points, if any:

You can also directly mail the filled in questionnaire to: pbahamed@gmail.com

Name: Naveen Dsouza

Title/Designation: Workshop manager

Company: Al Faris Group.

Work Experience: 5 years Maintenance Manager. (21 years in Dubai) (BP, Nabors Drilling, Murghan Gas Plant.) (4 years for Al Faris)

Telephone: 04-3477225

Mail: naveen@alfarisuae.com

Questionaire on Breakdown Maintenance of Construction Plant and Equipment

Sl. No.	Question	Fully Agree	Agree	Partly Agree	Partly disagree	disagree	No comments
		4	3	2	1	0	
Breakdown Maintenance Concepts / Beliefs							
1	Every Organization has ultimate goal of zero downtime due to equipment failures and breakdowns	✓					
2	In construction industry generally breakdown in one equipment affects the follow on activities of other equipments/trades	✓					
3	Even with the presence of preventive and planned maintenance, breakdowns and failures are unavoidable with construction equipment				✓		
5	In construction industry generally a mix of old and new equipment work together in the projects		✓				
6	Handling multiple brands for similar type of equipments is always a major hurdle due to availing resources to maintain all of them			✓			
7	Generally breakdowns make loss of morale of the maintenance crew	✓					
8	Breakdown Maintenance is not always an interesting work/activity to execute	✓					
9	Time cannot be estimated generally for breakdown maintenance with conventional approach	✓					
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11	New mechanics will always lack the knowledge of breakdowns maintenance		✓				
Breakdown Maintenance Crew Stress Levels / Factors							
1	Maintenance crew gets panic situation whenever a breakdown information comes from the sources/projects				✓		
2	Huge amount of pressure and responsibility remains with the maintenance crew during execution of breakdowns works		✓				
3	Supervisor will be under extreme stress during breakdowns rectification with pressure and follow ups from projects and end users		✓				
4	Mechanics attending the breakdown will always try to shift the works to the workshop/yard team due to indecisive situation prevailing with them		✓				
5	The exact cause of the breakdowns are generally not ideintified immediately by the crew with conventional knowledge and methods		✓				
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1	An effective breakdown planning methodology for construction machineries will always serve good with good knowledge of breakdowns, resource back up and clear procedures	✓					
2	Resources including following will not be generally available during breakdown rectification : Mechanics, Spare Parts, Supervisory Support, Special Tools, Hand Tools, Consumables	✓					
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Comments/Remarks/Additional Points, if any:

Control measures, line of control and Command along with "Maintenance Capability plot" in place. Nothing is impossible. 'If it isn't broken don't fix it'. 'Prevention is better than Cure'. In Al Faris Proactive measures, Such as Preventive & Predictive maintenance are given absolute weightage, than waiting for Corrective and breakdown maintenance. This approach helps us to reduce downtime to ZERO.

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This policy is in Conjuction with AFER. H&S policy as per requirements of OHSAS 18001 : 2007.

Name: Nilesh S. Bacchuwar

Title/Designation: Product Support Manager - SE.

Company: Kanoo Machinery

Work Experience: 19 Years

Telephone: 02 - 8119046

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Questionaire on Breakdown Maintenance of Construction Plant and Equipment

Sl. No.	Question	Fully Agree	Agree	Partly Agree	Partly disagree	disagree	No comments
		4	3	2	1	0	
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2	In construction industry generally breakdown in one equipment affects the follow on activities of other equipments/trades	✓					
3	Even with the presence of preventive and planned maintenance, breakdowns and failures are unavoidable with construction equipment	✓					
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6	Handling multiple brands for similar type of equipments is always a major hurdle due to availing resources to maintain all of them		✓				
7	Generally breakdowns make loss of morale of the maintenance crew			✓			
8	Breakdown Maintenance is not always an interesting work/activity to execute				✓		
9	Time cannot be estimated generally for breakdown maintenance with conventional approach		✓				
10	Competent level of technicians/mechanics is one of the key factors in reducing downtime		✓				
11	New mechanics will always lack the knowledge of breakdowns maintenance	✓					
Breakdown Maintenance Crew Stress Levels / Factors							
1	Maintenance crew gets panic situation whenever a breakdown information comes from the sources/projects				✓		
2	Huge amount of pressure and responsibility remains with the maintenance crew during execution of breakdowns works		✓				
3	Supervisor will be under extreme stress during breakdowns rectification with pressure and follow ups from projects and end users		✓				
4	Mechanics attending the breakdown will always try to shift the works to the workshop/yard team due to indecisive situation prevailing with them		✓				
5	The exact cause of the breakdowns are generally not ideintified immediately by the crew with conventional knowledge and methods		✓				
Breakdown Maintenance Optimization							
1	An effective breakdown planning methodology for construction machineries will always serve good with good knowledge of breakdowns, resource back up and clear procedures		✓				
2	Resources including following will not be generally available during breakdown rectification : Mechanics, Spare Parts, Supervisory Support, Special Tools, Hand Tools, Consumables			✓			
3	Method of Rectification will help the mechanic to attend the breakdowns with ease		✓				
4	* Breakdown Maintenance Protocol (BMP) will enable the crew to execute the breakdowns effectively		✓				
	RATING SCORE						

* BMP is the Breakdown Maintenance Protocol which is an effective methodology to execute breakdown maintenance of construction equipment. A BMP Ruler which is developed with four tiers of breakdown codes printed on a circular rings (Breakdown Main Code, Breakdown Sub Code, Breakdown Symptom Code and Breakdown Reason Code) help the crew to identify the cause of the breakdowns to its closest route cause. The Breakdown Reason Code provide the resource requirement for the particular breakdown with the specific BMP number and also the associated resources and methods of rectification.

Comments/Remarks/Additional Points, if any:

You can also directly mail the filled in questionnaire to: pbahamed@gmail.com

APPENDIX C - WORKING HOURS AND BREAKDOWN HOURS OF 9 SELECTED MACHINERY OF TARGET COMPANY

Table A.1 Breakdown Details of Machinery 2007

Working Hours VS Breakdown Hours - 2007														
Equipment Details		Mobile Crane	Wheel Loader	Back Hoe loader	Air Compressor	Dumper	Skidsteer	Genset	Roller Compactor	Fork lift	Sub total of selected Equipment	Sub total of selected Equipment	Total of overall Equipment	Total of overall Equipment
Jan-07	W.Hrs	1363	450	870	2144	4952	1045	11521	2075	1290	25710	0.99%	67711	1.31%
	B.D.Hrs	6.5	70	0	126	248	6	11	200	0	667.5		884	
Feb-07	W.Hrs	1297	512	777	2067	5190	1018	10406	2400	1300	24967	0.42%	63270	1.03%
	B.D.Hrs	3	8	0	13	10	22	10	200	0	266		654	
Mar-07	W.Hrs	1450	520	810	2265	5139	1054	11524	2805	1448	27015	0.33%	70136	0.70%
	B.D.Hrs	0	0	0	55	61	11	8	95	2	232		493	
Apr-07	W.Hrs	1360	515	550	1925	4885	1100	11145	2700	1375	25555	1.03%	65787	1.22%
	B.D.Hrs	15	5	0	275	315	0	15	50	0	675		804	
May-07	W.Hrs	1450	520	580	2130	5200	1160	11387	2295	1450	26172	0.91%	67496	1.30%
	B.D.Hrs	0	0	0	200	0	0	122	291	0	613		875.5	
Jun-07	W.Hrs	1171	520	500	3465	5194	1120	10504	2492	1360	26326	0.46%	65120	1.20%
	B.D.Hrs	4	0	55	160	6	0	7	28	40	300		782	
Jul-07	W.Hrs	1285	516	570	3485	4950	1123	9608	2280	1425	25242	1.16%	65881.5	1.63%
	B.D.Hrs	65	4	0	200	250	12	174.5	60	0	765.5		1072.5	
Aug-07	W.Hrs	1020	513	290	3920	5192	1160	9013	2605	1450	25163	0.83%	65705	1.84%
	B.D.Hrs	0	7	0	130	8	0	403	0	0	548		1208	
Sep-07	W.Hrs	817	520	275	3315	5194	1100	8923	1925	1375	23444	1.31%	61122	1.81%
	B.D.Hrs	8	0	0	500	6	8	278	0	0	800		1107	
Oct-07	W.Hrs	721	516	290	3402	5183	1160	9279	1845	1450	23846	0.75%	65236.5	0.92%
	B.D.Hrs	9	4	0	273	17	0	17	170	0	490		598	
Nov-07	W.Hrs	848	520	260	3360	5020	930	9212	1720	1400	23270	1.12%	64011	1.78%
	B.D.Hrs	102	0	20	200	180	0	42	170	0	714		1140.5	
Dec-07	W.Hrs	1140	520	570	3280	5120	1145	9096	1585	1425	23881	1.06%	64802	1.85%
	B.D.Hrs	0	0	0	330	80	0	160	120	0	690		1200	
Total W.Hrs		13922	6142	6342	34758	61219	13115	121618	26727	16748	300591	0.86%	786278	1.38%
Total B.D.Hrs		212.5	98	75	2462	1181	59	1247.5	1384	42	6761		10818.5	
BD % of Individual Equipment		1.5%	1.6%	1.2%	7.1%	1.9%	0.4%	1.0%	5.2%	0.3%	1.7%			
Over all breakdown %		0.03%	0.01%	0.01%	0.31%	0.15%	0.01%	0.16%	0.18%	0.01%	0.9%			
Contribution to total BD by All Equipment		2.0%	0.9%	0.7%	22.6%	10.9%	0.5%	11.5%	12.7%	0.4%	62.2%			

Table A.2 Breakdown Details of Machinery 2008

Working Hours VS Breakdown Hours - 2008														
Equipment Details		Mobile Crane	Wheel Loader	Back Hoe loader	Air Compressor	Dumper	Skidsteer	Genset	Roller Compactor	Fork lift	Sub total of selected Equipment	Sub total of selected Equipment	Total of overall Equipment	Total of overall Equipment
Jan-08	W.Hrs	1065	498	400	3000	5184	1036	9096	1814	1300	23393	1.58%	59329	1.87%
	B.D.Hrs	130	22	100	170	16	6	486	6	0	936		1112	
Feb-08	W.Hrs	1085	520	325	3375	5190	1195	7932	1812	1300	22734	1.33%	59844	1.99%
	B.D.Hrs	100	0	80	205	10	0	390	8	0	793		1192	
Mar-08	W.Hrs	1195	520	470	3700	5022	1255	9478	1710	1300	24650	0.97%	59648	2.07%
	B.D.Hrs	20	0	5	200	178	0	138	0	40	581		1233	
Apr-08	W.Hrs	1116	515	552	3856	5141	1378	8904	1605	1370	24437	0.50%	58843	1.52%
	B.D.Hrs	4	5	12	50	59	22	83	60	0	295		892	
May-08	W.Hrs	1146	502	561	3460	5200	1432	9295	1320	1420	24336	0.62%	67552	1.13%
	B.D.Hrs	10	18	19	14	0	18	343	0	0	422		760	
Jun-08	W.Hrs	1043	260	492	1637	5175	1365	9388	1220	1353	21933	0.78%	64835	1.25%
	B.D.Hrs	22	260	18	17	25	10	132	0	22	506		812	
Jul-08	W.Hrs	870	300	570	4055	4987	1450	10326	1450	1443	25451	1.22%	71145.5	1.43%
	B.D.Hrs	0	220	10	25	213	0	392	0	7	867		1016.5	
Aug-08	W.Hrs	921	510	574	4562	4907	2867	10642	2320	1151	28454	0.76%	73582	0.88%
	B.D.Hrs	9	10	6	78	293	28	123	0	9	556		645	
Sep-08	W.Hrs	1080	511	481	4370	5195	3011	10431	2105	1100	28284	0.35%	72129	0.96%
	B.D.Hrs	21	9	69	30	5	14	9	94	0	251		693	
Oct-08	W.Hrs	940	498	475	4936	5114	2898	9665	2150	1100	27776	0.53%	72999	0.98%
	B.D.Hrs	0	22	70	14	66	137	29	50	0	388		719	
Nov-08	W.Hrs	1120	516	558	4943	5184	3080	10892	2005	1118	29416	0.52%	74351	0.90%
	B.D.Hrs	0	4	2	92	16	0	160	110	2	386		667	
Dec-08	W.Hrs	1025	503	440	4737	5100	2892	11128	2160	1072	29057	0.47%	74971	0.82%
	B.D.Hrs	55	17	0	118	100	28	26	0	8	352		615.5	
Total W.Hrs		12606	5653	5898	46631	61399	23859	117177	21671	15027	309921	0.78%	809228.5	1.32%
Total B.D.Hrs		371	587	391	1013	981	263	2311	328	88	6333		10357	
BD % of Individual Equipment		2.9%	10.4%	6.6%	2.2%	1.6%	1.1%	2.0%	1.5%	0.6%	2.4%			
Over all breakdown %		0.05%	0.07%	0.05%	0.13%	0.12%	0.03%	0.29%	0.04%	0.01%	0.8%			
Contribution to total BD by All Equipment		3.5%	5.5%	3.7%	9.5%	9.2%	2.5%	21.7%	3.1%	0.8%	59.5%			

Table A.3 Breakdown Details of Machinery 2009

Working Hours VS Breakdown Hours - 2009														
Equipment Details		Mobile Crane	Wheel Loader	Back Hoe loader	Air Compressor	Dumper	Skidsteer	Genset	Roller Compactor	Fork lift	Sub total of selected Equipment	Sub total of selected Equipment	Total of overall Equipment	Total of overall Equipment
Jan-09	W.Hrs	1113	763	480	4835	4637	2975	11046	1982	1120	28951	0.79%	76737	1.30%
	B.D.Hrs	17	17	0	205	43	0	84	243	0	609		1001	
Feb-09	W.Hrs	958	777	520	4557	4612	2582.5	10126	1805	902	26839.5	0.79%	70114.5	1.19%
	B.D.Hrs	62	3	0	118	68	32.5	256	15	0	554.5		835.5	
Mar-09	W.Hrs	952	776	485	4945	4670	2947	10524	1925	1050	28274	0.83%	75861	1.30%
	B.D.Hrs	68	4	0	5	10	13	478	0	50	628		987	
Apr-09	W.Hrs	1104	766	540	5040	4660	3002	10976	1960	1120	29168	0.24%	75649	0.91%
	B.D.Hrs	16	14	0	0	20	3	132	0	0	185		688.5	
May-09	W.Hrs	1115	761	572	4905	4674	3142	11083	1890	1156	29298	0.78%	77388	1.26%
	B.D.Hrs	45	19	8	20	6	44	325	130	4	601		977	
Jun-09	W.Hrs	1059	767	550	4427	4653	3015	10563	1910	1100	28044	0.99%	73577	1.26%
	B.D.Hrs	36	13	0	213	27	10	416	10	0	725		925.5	
Jul-09	W.Hrs	1153	660	568	4882	4553	2952	11205	2020	4565	32558	0.74%	81671	0.79%
	B.D.Hrs	7	120	12	48	127	53	231	10	0	608		643.5	
Aug-09	W.Hrs	905.5	725	570	4773	4680	2428	11453	1995	958	28487.5	0.27%	76776	0.83%
	B.D.Hrs	14.5	55	0	63	0	7	67	0	0	206.5		635.5	
Sep-09	W.Hrs	527	589	560	4744	4658	2180	10447	1950	1029	26684	0.73%	76672.5	1.20%
	B.D.Hrs	28	191	0	16	22	0	265	10	26	558		919.5	
Oct-09	W.Hrs	545	485	580	4930	4546	3081	10910	1687	1152	27916	1.21%	80604.5	1.60%
	B.D.Hrs	35	295	0	0	134	24	182	297	8	975		1287	
Nov-09	W.Hrs	964	731	417	4675	4644	3026	11031.5	1650	1098	28236.5	0.25%	77689.5	0.75%
	B.D.Hrs	17	49	0	0	36	0	88	0	2	192		583	
Dec-09	W.Hrs	1009	709	510	4638	4641	3080	10336	1650	1120	27693	1.11%	79604	1.41%
	B.D.Hrs	76	71	0	117	39	0	580	0	0	883		1121	
Total W.Hrs		11404.5	8509	6352	57351	55628	34410.5	129701	22424	16370	342149.5	0.73%	922344	1.15%
Total B.D.Hrs		421.5	851	20	805	532	186.5	3104	715	90	6725		10604	
BD % of Individual Equipment		3.7%	10.0%	0.3%	1.4%	1.0%	0.5%	2.4%	3.2%	0.5%	1.9%			
Over all breakdown %		0.05%	0.09%	0.00%	0.09%	0.06%	0.02%	0.34%	0.08%	0.01%	0.7%			
Contribution to total BD by All Equipment		4.0%	8.0%	0.2%	7.6%	5.0%	1.8%	29.3%	6.7%	0.8%	63.4%			

Table A.4 Breakdown Details of Machinery 2010

Working Hours VS Breakdown Hours - 2010														
Equipment Details		Mobile Crane	Wheel Loader	Back Hoe loader	Air Compressor	Dumper	Skidsteer	Genset	Roller Compactor	Fork lift	Sub total of selected Equipment	Sub total of selected Equipment	Total of overall Equipment	Total of overall Equipment
Jan-10	W.Hrs	1417	756	1147	4823.5	4399	3990	24911	2252	1140	44835.5	0.34%	107451.5	1.01%
	B.D.Hrs	3	24	0	16.5	21	0	273	28	0	365.5		1085.5	
Feb-10	W.Hrs	1293	766	1309	4501	4134	3680	25081	2120	1052	43936	1.01%	96195	1.20%
	B.D.Hrs	32	14	16	4	546	30	323	0	8	973		1159	
Mar-10	W.Hrs	1550	765	1550	4960	4960	4340	27208	2790	1240	49363	0.79%	124930	1.17%
	B.D.Hrs	109	15	16	271	240	6	231	55	46	989		1465	
Apr-10	W.Hrs	1325	628	1400	4415	5020	3920	26431	2504	1120	46763	0.57%	112775.5	1.47%
	B.D.Hrs	70	152	0	60	180	0	161	16	0	639		1659	
May-10	W.Hrs	1418	780	1425	4412	5200	3650	27295	2555	1140	47875	0.47%	117421	1.27%
	B.D.Hrs	7	0	0	138	0	0	151	260	0	556		1495	
Jun-10	W.Hrs	1387	777	1394	4417	5072	3640	25769	2235	1120	45811	0.73%	115820.5	1.49%
	B.D.Hrs	13	3	6	58	128	0	373	260	0	841		1725	
Jul-10	W.Hrs	1437	774	1410	4470	5020	3750	26822	2300	1160	47143	0.54%	120631.5	1.43%
	B.D.Hrs	13	6	30	160	180	20	242	0	0	651		1723	
Aug-10	W.Hrs	1267	740	1421.5	4560	5147	3810	26922	2000	1045	46912.5	0.67%	118674	1.68%
	B.D.Hrs	148	40	3.5	0	53	8	178	330	30	790.5		1990.5	
Sep-10	W.Hrs	840	703	1369	4466	5073	3840	26230	2520	1065	46106	0.50%	116851.5	1.29%
	B.D.Hrs	260	77	31	14	127	30	40	0	0	579		1508.5	
Oct-10	W.Hrs	1025	551	1425	4168	4940	3931.5	26230	2480	1140	45890.5	1.23%	116330.5	1.43%
	B.D.Hrs	100	229	0	337	260	3.5	425	80	0	1434.5		1665.5	
Nov-10	W.Hrs	822	612	1345	4190	5110	3849	26072	2370	1110	45480	0.90%	113618.5	1.53%
	B.D.Hrs	148	168	0	270	90	36	158	140	10	1020		1744	
Dec-10	W.Hrs	1455	780	1181.5	5455	5200	3271	32954	2738	945	53979.5	0.67%	127338	1.36%
	B.D.Hrs	0	0	3.5	0	0	334	324	100	90	851.5		1727.5	
Total W.Hrs		15236	8632	16377	54837.5	59275	45671.5	321925	28864	13277	564095	0.70%	1388037.5	1.36%
Total B.D.Hrs		903	728	106	1328.5	1825	467.5	2879	1269	184	9690		18947.5	
BD % of Individual Equipment		5.9%	8.4%	0.6%	2.4%	3.1%	1.0%	0.9%	4.4%	1.4%	2.4%			
Over all breakdown %		0.07%	0.05%	0.01%	0.10%	0.13%	0.03%	0.21%	0.09%	0.01%	0.7%			
Contribution to total BD by All Equipment		4.8%	3.9%	0.6%	7.0%	9.7%	2.5%	15.2%	6.7%	1.0%	51.3%			

Table A.5 Breakdown Details of Machinery 2011

Working Hours VS Breakdown Hours - 2011														
Equipment Details		Mobile Crane	Wheel Loader	Back Hoe loader	Air Compressor	Dumper	Skidsteer	Genset	Roller Compactor	Fork lift	Sub total of selected Equipment	Sub total of selected Equipment	Total of overall Equipment	Total of overall Equipment
Jan-11	W.Hrs	1522	582	1243	5634	4940	3913	34776	2994	1120	56724	1.28%	107451.5	1.01%
	B.D.Hrs	50	198	127	226	0	7	683	86	0	1377		1085.5	
Feb-11	W.Hrs	1235	774	1289.5	5179	4917	3287	31561	2792	971.5	52006	1.06%	96195	1.20%
	B.D.Hrs	60	6	10.5	238	23	83	513	68	13.5	1015		1159	
Mar-11	W.Hrs	1472	721	1156	5790	4885	4060	31561	3105	1055	53805	0.73%	124930	1.17%
	B.D.Hrs	18	59	4	297	55	0	402	80	0	915		1465	
Apr-11	W.Hrs	1141	687	1120	5783	4556	3589	34247	2661	1113	54897	1.11%	112775.5	1.47%
	B.D.Hrs	9	93	0	92	384	26	245	394	7	1250		1659	
May-11	W.Hrs	1298	729	1395	5981	4880	3935	34723	2760	1110	56811	1.03%	117421	1.27%
	B.D.Hrs	122	51	30	4	60	55	523	330	30	1205		1495	
Jun-11	W.Hrs	1316	744	1396	5817	4919	3735	33337	2847	1120	55231	0.90%	115820.5	1.49%
	B.D.Hrs	84	36	4	63	21	170	635	25	0	1038		1725	
Jul-11	W.Hrs	1135	770	1394	4875	4872	3455	34609	2782	1040	54932	1.12%	120631.5	1.43%
	B.D.Hrs	240	10	6	360	68	150	253	268	0	1355		1723	
Aug-11	W.Hrs	1290	691	1140	5999	4876	3558	34751.5	2766.5	1160	56232	0.88%	118674	1.68%
	B.D.Hrs	150	89	280	86	64	32	166.5	178.5	0	1046		1990.5	
Sep-11	W.Hrs	1310	780	1375	5510	4920	3525	33371	2750	1100	54641	0.24%	116851.5	1.29%
	B.D.Hrs	0	0	0	0	20	0	13	250	0	283		1508.5	
Oct-11	W.Hrs	1419	572	1401	5401	4940	3705	32093	2850	1140	53521	0.46%	116330.5	1.43%
	B.D.Hrs	6	208	24	14	0	0	19	260	0	531		1665.5	
Nov-11	W.Hrs	1070	771	1221	5127	4940	3682	30209	2430	970	50420	0.35%	113618.5	1.53%
	B.D.Hrs	0	9	54	3	0	18	53	260	0	397		1744	
Dec-11	W.Hrs	1440	766	1450	5606	4871	4035	32873.5	3040	1160	55241.5	0.37%	127338	1.36%
	B.D.Hrs	10	14	0	183.5	69	20	38.5	140	0	475		1727.5	
Total W.Hrs		15648	8587	15580.5	66702	58516	44479	398112	33777.5	13059.5	654461.5	0.78%	1388037.5	1.36%
Total B.D.Hrs		749	773	539.5	1566.5	764	561	3544	2339.5	50.5	10887		18947.5	
BD % of Individual Equipment		4.8%	9.0%	3.5%	2.3%	1.3%	1.3%	0.9%	6.9%	0.4%	2.5%			
Over all breakdown %		0.05%	0.06%	0.04%	0.11%	0.06%	0.04%	0.26%	0.17%	0.00%	0.8%			
Contribution to total BD by All Equipment		4.0%	4.1%	2.9%	8.3%	4.0%	3.0%	18.7%	12.4%	0.3%	57.6%			

APPENDIX D – BREAKDOWN DETAILS OF DUMPER AND WHEEL LOADER (2007 – 2011)

Table D.1 Breakdown Details Dumper - 2007

Sl. No	Equipment Name	PNM	January-07	February-07	March-07	April-07	May-07	June-07	July-07	August-07	September-07	October-07	November-07	December-07	Total	Breakdown Hours	No. of Breakdowns
1	Dumper	49	260	245	235	260	260	260	260	260	260	260	260	260	3080	40.0	2
2	Dumper	50	260	260	260	260	260	260	260	252	260	260	260	260	3112	8.0	1
3	Dumper	51	260	250	260	0	260	260	260	260	260	260	260	260	2850	338.5	3
4	Dumper	52	252	260	260	260	260	260	260	260	260	260	260	220	3072	48.0	2
5	Dumper	53	260	260	260	260	260	260	260	260	254	260	260	260	3114	6.0	1
6	Dumper	54	260	260	260	260	260	260	260	260	260	260	149	260	3009	116.0	1
7	Dumper	56	260	260	260	260	260	260	260	260	260	260	260	260	3120	0.0	
8	Dumper	57	20	260	260	260	260	260	260	260	260	260	260	260	2880	240.0	1
9	Dumper	58	260	260	219	260	260	260	160	260	260	243	260	260	2962	158.0	4
10	Dumper	59	260	260	260	260	260	260	110	260	260	260	223	260	2933	187.0	2
11	Dumper	60	260	260	260	215	260	260	260	260	260	260	228	260	3043	77.5	2
12	Dumper	61	260	260	260	260	260	260	260	260	260	260	260	220	3080	40.0	1
13	Dumper	323	260	260	260	250	260	260	260	260	260	260	260	260	3110	10.0	1
14	Dumper	517	260	260	260	260	260	254	260	260	260	260	260	260	3114	6.0	1
15	Dumper	518	260	260	260	260	260	260	260	260	260	260	260	260	3120	0.0	
16	Dumper	520	260	260	240	260	260	260	260	260	260	260	260	260	3100	20.0	1
17	Dumper	1013	260	260	260	260	260	260	260	260	260	260	260	260	3120	0.0	
18	Dumper	1014	260	260	260	260	260	260	260	260	260	260	260	260	3120	0.0	
19	Dumper	3172	260	260	260	260	260	260	260	260	260	260	260	260	3120	0.0	
20	Dumper	3177	260	260	260	260	260	260	260	260	260	260	260	260	3120	0.0	
21	Dumper	17769	260	260	260	260	260	260	260	260	260	260	260	260	3120	0.0	
	Total		4952	5190	5139	4885	5200	5194	4950	5192	5194	5183	5020	5120	61219	1255.0	23

Table D.2 Breakdown Details Dumper - 2008

Sl. No.	Equipment name	PNM	January-08	February-08	March-08	April-08	May-08	June-08	July-08	August-08	September-08	October-08	November-08	December-08	Total	Breakdown Hours	No. of Breakdowns
1	Dumper	49	260	250	260	260	260	260	260	260	260	260	260	260	3110	10	1
2	Dumper	50	260	260	220	260	260	260	260	0	260	260	260	220	2780	342	3
3	Dumper	51	260	260	260	204	260	260	260	260	260	260	260	260	3064	56	1
4	Dumper	52	260	260	260	260	260	260	260	260	255	260	260	260	3115	5	1
5	Dumper	53	260	260	260	260	260	260	254	253	260	260	260	260	3107	13	2
6	Dumper	54	260	260	260	260	260	260	256	260	260	212	260	260	3068	52	2
7	Dumper	56	260	260	220	260	260	260	57	260	260	260	255	260	2872	248	3
8	Dumper	57	260	260	260	260	260	260	260	260	260	222	260	200	3022	98	3
9	Dumper	58	260	260	260	260	260	260	260	260	260	260	260	260	3120	0	0
10	Dumper	61	260	260	260	260	260	260	260	260	260	260	260	260	3120	0	0
11	Dumper	62	260	260	260	260	260	245	260	260	260	260	260	260	3105	15	1
12	Dumper	323	256	260	260	260	260	260	260	260	260	260	260	260	3116	4	1
13	Dumper	517	260	260	260	260	260	260	260	234	260	260	260	260	3094	26	1
14	Dumper	518	248	260	252	260	260	260	260	260	260	260	249	260	3089	31	3
15	Dumper	520	260	260	170	260	260	256	260	260	260	260	260	260	3026	94	2
16	Dumper	1013	260	260	260	257	260	260	260	260	260	260	260	260	3117	3	1
17	Dumper	1014	260	260	260	260	260	254	260	260	260	260	260	260	3114	6	1
18	Dumper	3172	260	260	260	260	260	260	260	260	260	260	260	260	3120	0	0
19	Dumper	3177	260	260	260	260	260	260	260	260	260	260	260	260	3120	0	0
20	Dumper	17769	260	260	260	260	260	260	260	260	260	260	260	260	3120	0	0
	Total		5184	5190	5022	5141	5200	5175	4987	4907	5195	5114	5184	5100	61399	1003	26

Table D.3 Breakdown Details Dumper 2009

Sl. No.	Equipment name	PNM	January-09	February-09	March-09	April-09	May-09	June-09	July-09	August-09	September-09	October-09	November-09	December-09	Total	Breakdown Hours	No. of Breakdowns
1	Dumper	**50**	260	**260**	**260**	260	260	251	260	260	260	252	260	260	3103	17	2
2	Dumper	**51**	260	260	260	260	260	260	190	**260**	260	260	260	260	3050	70	1
3	Dumper	**52**	260	**260**	260	**250**	260	260	260	260	260	260	260	260	3110	10	1
4	Dumper	**53**	**260**	260	260	260	260	260	203	260	260	260	260	**260**	3063	57	1
5	Dumper	**54**	260	260	256	250	260	260	260	260	**260**	254	260	260	3100	**20**	3
6	Dumper	**56**	260	252	260	260	260	260	260	260	256	260	**260**	245	3093	27	3
7	Dumper	**57**	260	260	260	260	260	260	260	260	260	200	260	236	3036	84	2
8	Dumper	**58**	**260**	260	260	260	260	260	260	260	260	260	260	260	3120	0	0
9	Dumper	**60**	260	260	**260**	260	260	260	**260**	260	260	**260**	260	260	3120	0	**0**
10	Dumper	**61**	260	260	260	260	260	260	**260**	260	260	260	**260**	260	3120	0	0
11	Dumper	**517**	217	260	260	**260**	260	260	260	260	260	260	**260**	260	3077	43	1
12	Dumper	**518**	260	200	260	260	260	260	260	260	260	260	224	**260**	3024	96	3
13	Dumper	**520**	260	260	260	**260**	260	260	260	260	242	260	260	260	3102	18	1
14	Dumper	**1013**	260	260	260	260	260	**245**	260	260	260	260	260	260	3105	15	1
15	Dumper	**1014**	260	260	254	260	254	260	260	260	260	260	260	260	3108	12	2
16	Dumper	**3172**	260	260	**260**	260	260	257	260	260	260	260	260	260	3117	3	1
17	Dumper	**3177**	260	260	260	260	260	260	260	260	260	260	260	260	3120	0	0
18	Dumper	**17769**	260	260	260	260	260	260	260	260	260	200	260	260	3060	60	1
	Total		4637	4612	4670	4660	4674	4653	4553	4680	4658	4546	4644	4641	55628	532	23

Table D.4 Breakdown Details Dumper - 2010

Sl. No.	Equipment name	PNM No.	January-10	February-10	March-10	April-10	May-10	June-10	July-10	August-10	September-10	October-10	November-10	December-10	Total	Breakdown Hours	No. of Breakdowns
1	Dumper	**50**	260	**260**	**260**	260	260	260	260	260	260	260	260	260	3120	0	0
2	Dumper	**51**	260	0	260	260	260	260	260	**260**	260	0	260	260	2600	524	3
3	Dumper	**52**	260	**260**	50	**260**	260	210	260	260	260	260	260	260	2860	260	2
4	Dumper	**53**	**260**	218	260	260	260	260	260	210	260	260	260	**260**	3028	92	2
5	Dumper	**54**	260	260	260	260	260	260	260	260	**140**	260	260	260	3000	120	1
6	Dumper	**56**	260	260	260	260	260	260	260	257	260	260	**260**	260	3117	3	1
7	Dumper	**57**	260	260	260	80	260	192	80	260	260	260	260	260	2692	428	3
8	Dumper	**58**	**260**	260	260	260	260	260	260	260	260	260	260	260	3120	0	0
9	Dumper	**61**	260	260	**230**	260	260	260	**260**	260	260	**260**	260	260	3090	**30**	1
10	Dumper	**517**	260	260	260	260	260	260	**260**	260	260	260	**170**	260	3030	90	2
11	Dumper	**518**	260	260	260	**260**	260	260	260	260	253	260	**260**	260	3113	7	1
12	Dumper	**520**	260	16	260	260	260	260	260	260	260	260	260	**260**	2876	244	1
13	Dumper	**1013**	242	260	260	**260**	260	260	260	260	260	260	260	260	3102	18	1
14	Dumper	**1014**	260	260	260	260	260	**250**	260	260	260	260	260	260	3110	10	1
15	Dumper	**3172**	260	260	260	260	260	260	260	260	260	260	260	260	3120	0	0
16	Dumper	**3177**	256.5	260	**260**	260	260	260	260	260	260	260	260	260	3117	3.5	1
17	Dumper	**16942**	0	260	260	260	260	260	260	260	260	260	260	260	2860	0	0
18	Dumper	**16943**	0	0	260	260	260	260	260	260	260	260	260	260	2600	0	0
19	Dumper	**17768**	0	0	260	260	260	260	260	260	260	260	260	260	2600	0	0
20	Dumper	**17769**	260	260	260	260	260	260	260	260	260	260	260	260	3120	0	0
	Total		4399	**4134**	**4960**	5020	5200	5072	5020	5147	5073	4940	5110	5200	59275	1830	20

Table D.5 Breakdown Details Dumper - 2011

Sl. No.	Equipment name	PNM No.	January-11	February-11	March-11	April-11	May-11	June-11	July-11	August-11	September-11	October-11	November-11	December-11	Total	Breakdown Hours	No. of Breakdowns
1	Dumper	**51**	260	260	260	256	260	260	260	234	240	260	260	260	3070	50	3
2	Dumper	**52**	260	260	260	80	260	255	260	240	260	260	260	260	2915	205	3
2	Dumper	**53**	260	260	260	260	260	260	260	260	260	260	260	260	3120		
4	Dumper	**54**	260	260	246	260	230	260	240	260	260	260	260	260	3056	64	4
5	Dumper	**56**	260	260	225	260	260	260	260	260	260	260	260	260	3085	35	2
6	Dumper	**57**	260	260	260	260	260	260	257	260	260	260	260	260	3117	3	1
7	Dumper	**58**	260	260	260	60	260	260	260	260	260	260	260	260	2920	200	1
8	Dumper	**61**	260	260	260	260	260	260	260	260	260	260	260	260	3120		
9	Dumper	**517**	260	260	260	260	260	260	260	247	260	260	260	260	3107	13	1
10	Dumper	**518**	260	260	260	260	260	260	215	260	260	260	260	260	3075	45	1
11	Dumper	**520**	260	260	260	260	260	260	260	260	260	260	260	260	3120		
12	Dumper	**1013**	260	260	260	260	260	260	260	260	260	260	260	260	3120		
13	Dumper	**1014**	260	260	260	260	260	260	260	260	260	260	260	198	3058	62	1
14	Dumper	**3172**	260	260	254	260	260	260	260	260	260	260	260	260	3114	6	1
15	Dumper	**3177**	260	255	260	260	260	260	260	260	260	260	260	260	3115	5	1
16	Dumper	**16942**	260	242	260	260	260	260	260	260	260	260	260	260	3102	18	1
17	Dumper	**16943**	260	260	260	260	260	244	260	255	260	260	260	253	3092	28	3
18	Dumper	**17768**	260	260	260	260	230	260	260	260	260	260	260	260	3090	30	1
19	Dumper	**17769**	260	260	260	260	260	260	260	260	260	260	260	260	3120		
20	Dumper	**19994**	260	260	260	260	200	260	260	260	260	260	257	260	3057	63	2
	Total		4940	4917	4885	4556	4880	4919	4872	4876	4920	4940	4940	4871	58516	827	24

Table D.6 Breakdown Details Wheel Loader - 2007

Sl. No.	Equipment name	PNM No.	January-07	February-07	March-07	April-07	May-07	June-07	July-07	August-07	September-07	October-07	November-07	December-07	Total	Breakdown Hours	No. of Breakdowns
1	Wheel Loader	67	194	254	260	260	260	260	256	253	260	260	260	260	3103.5	81.5	5
2	Wheel Loader	68	256	258	260	255	260	260	260	260	260	256	260	260	3172.5	15	4
	Total		450	512	520	515	520	520	516	513	520	516	520	520	**6276**	96.5	9

Table D.7 Breakdown Details of Wheel Loader 2008

Sl. No.	Equipment name	PNM No.	January-08	February-08	March-08	April-08	May-08	June-08	July-08	August-08	September-08	October-08	November-08	December-08	Total	Breakdown Hours	No. of Breakdowns
1	Wheel Loader	67	260	260	260	260	242	0	40	256	255	258	256	249	2595.5	524.5	11
2	Wheel Loader	68	238	260	260	255	260	260	260	254	256	240	260	254	3056.5	63.5	7
	Total		498	520	520	515	502	260	300	510	511	498	516	503	**5652**	588	18

Table D.8 Breakdown Details of Wheel Loader 2009

Sl. No.	Equipment name	PNM No.	January-09	February-09	March-09	April-09	May-09	June-09	July-09	August-09	September-09	October-09	November-09	December-09	Total	Breakdown Hours	No. of Breakdowns
1	Wheel Loader	67	260	257	260	250	251	253	243	248	255	252	254	255	3038	82	21
2	Wheel Loader	68	243	260	256	256	250	254	157	256	254	233	241	214	2874	246	16
3	Wheel Loader	17500	260	260	260	260	260	260	260	221	80	0	236	240	2597	523	7
	Total		763	777	776	766	761	767	660	725	589	485	731	709	**8509**	851	44

Table D.9 Breakdown Details of Wheel Loader 2010

Sl. No.	Equipment name	PNM No.	January-10	February-10	March-10	April-10	May-10	June-10	July-10	August-10	September-10	October-10	November-10	December-10	Total	Breakdown Hours	No. of Breakdowns
1	Wheel Loader	67	248	256	256	258	260	260	254	260	256	260	110	260	2938	182	7
2	Wheel Loader	68	252	254	249	260	260	257	260	257	187	251	247	260	2994	126	8
3	Wheel Loader	17500	256	256	260	110	260	260	260	223	260	40	255	260	2700	420	6
	Total		756	766	765	628	780	777	774	740	703	551	612	780	**8632**	728	21

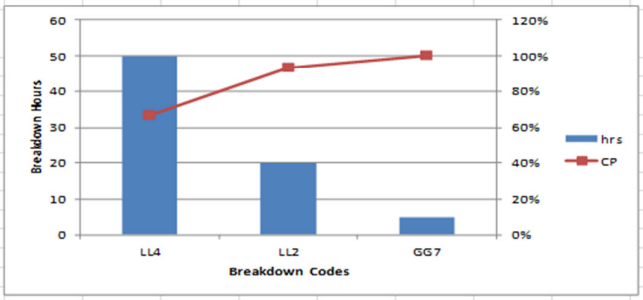
Table D.10 Breakdown Details of Wheel Loader 2011

Sl. No.	Equipment name	PNM No.	January-11	February-11	March-11	April-11	May-11	June-11	July-11	August-11	September-11	October-11	November-11	December-11	Total	Breakdown Hours	No. of Breakdowns
1	Wheel Loader	67	254	260	248	255	260	237	255	260	260	242	257	255	3043	72	12
2	Wheel Loader	68	248	254	213	252	260	247	260	256	260	260	260	260	3030	88	11
3	Wheel Loader	17500	80	260	260	180	209	260	255	175	260	70	254	251	2514	606	11
	Total		582	774	721	687	729	744	770	691	780	572	771	766	**8587**	766	34

APPENDIX E – PARETO ANALYSIS FOR SELECTED MACHINERY OF THE TARGET COMPANY

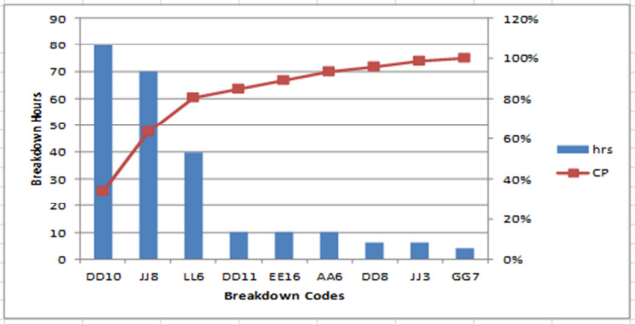
Backhoe Loader 2007

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
LL4	50	67%	67%
LL2	20	27%	93%
GG7	5	7%	100%



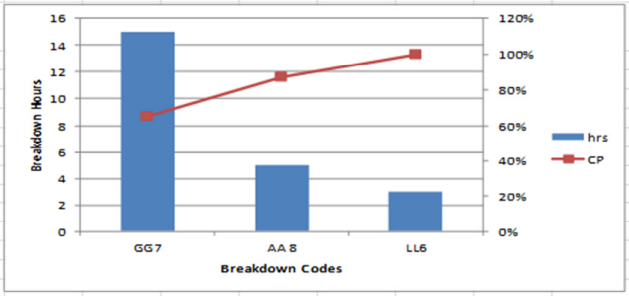
Backhoe Loader 2008

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
DD10	80	34%	34%
JJ8	70	30%	64%
LL6	40	17%	81%
DD11	10	4%	85%
EE16	10	4%	89%
AA6	10	4%	93%
DD8	6	3%	96%
JJ3	6	3%	98%
GG7	4	2%	100%



Backhoe Loader 2009

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
GG7	15	65%	65%
AA 8	5	22%	87%
LL6	3	13%	100%



Backhoe Loader 2010

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
GG7	52	41%	41%
LL8	26	21%	62%
BB3	20	16%	78%
CC11	16	13%	90%
AA2	8	6%	97%
EE16	4	3%	100%

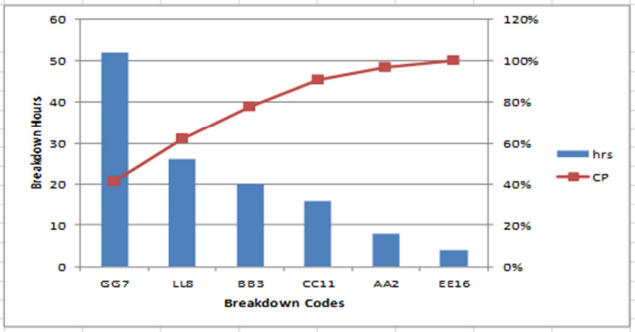
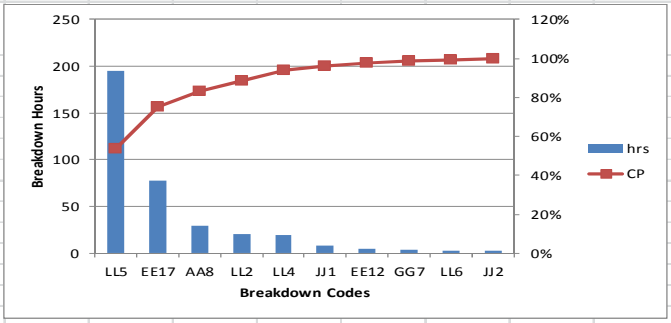


Figure E.1 Pareto Analysis of Back Hoe Loader

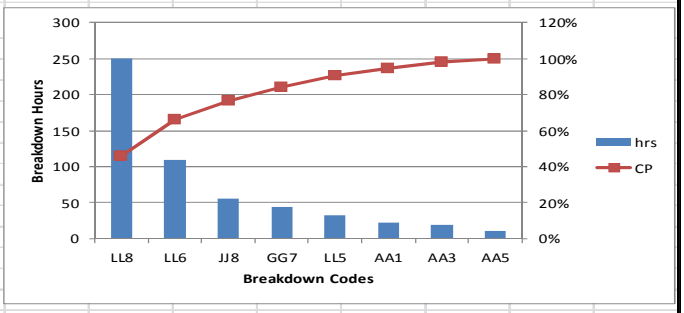
MOBILE CRANE 2007

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
LL5	195	54%	54%
EE17	77	21%	75%
AA8	30	8%	83%
LL2	20	6%	89%
LL4	19	5%	94%
JJ1	8	2%	96%
EE12	4.5	1%	97%
GG7	4	1%	98%
LL6	3	1%	99%
JJ2	2.5	1%	100%



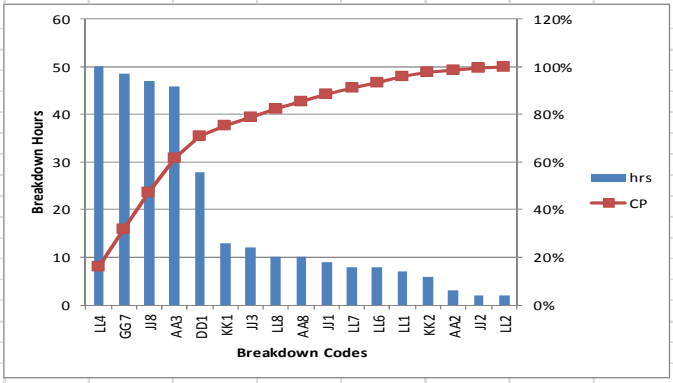
MOBILE CRANE 2008

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
LL8	250	46%	46%
LL6	109	20%	66%
JJ8	55	10%	76%
GG7	44	8%	84%
LL5	32.5	6%	90%
AA1	22	4%	94%
AA3	20	4%	98%
AA5	10	2%	100%



MOBILE CRANE 2009

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
LL4	50	16%	16%
GG7	48.5	16%	32%
JJ8	47	15%	47%
AA3	46	15%	62%
DD1	28	9%	71%
KK1	13	4%	75%
JJ3	12	4%	79%
LL8	10	3%	82%
AA8	10	3%	85%
JJ1	9	3%	88%
LL7	8	3%	91%
LL6	8	3%	94%
LL1	7	2%	96%
KK2	6	2%	98%
AA2	3	1%	99%
JJ2	2	1%	99%
LL2	2	1%	100%



MOBILE CRANE 2010

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
AA4	350	39%	39%
JJ8	150	17%	55%
DD5	104	11%	67%
AA1	75	8%	75%
LL5	73	8%	83%
JJ1	56	6%	89%
GG7	29	3%	92%
AA8	25	3%	95%
GG4	13	1%	97%
JJ2	12	1%	98%
DD8	10	1%	99%
LL6	8	1%	100%

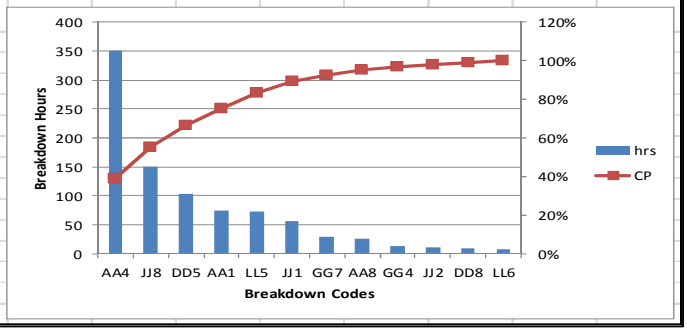
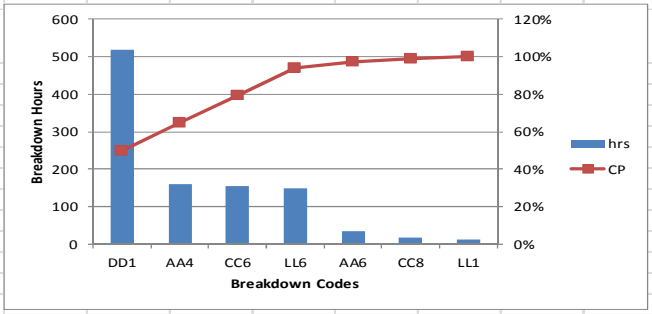


Figure E.2 Pareto Analysis of Mobile Crane

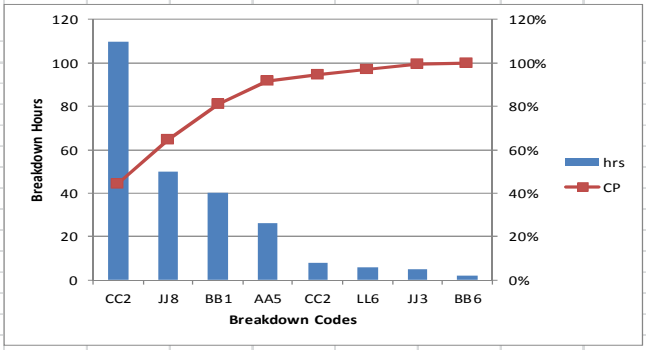
Roller Compactor 2007

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
DD1	518	49%	49%
AA4	160	15%	65%
CC6	154	15%	79%
LL6	150	14%	94%
AA6	35	3%	97%
CC8	18	2%	99%
LL1	12	1%	100%



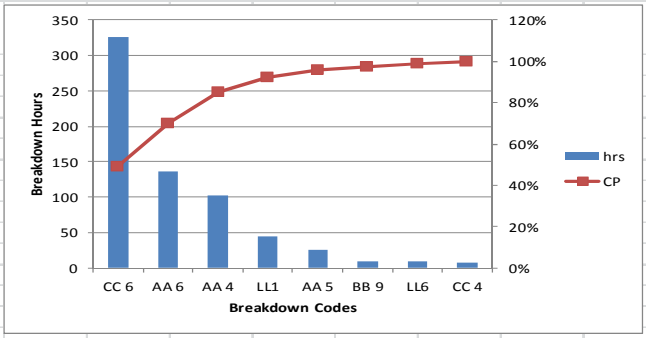
Roller Compactor 2008

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
CC2	110	45%	45%
JJ8	50	20%	65%
BB1	40	16%	81%
AA5	26	11%	91%
CC2	8	3%	95%
LL6	6	2%	97%
JJ3	5	2%	99%
BB6	2	1%	100%



Roller Compactor 2009

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
CC 6	325.5	49%	49%
AA 6	137	21%	70%
AA 4	103	16%	85%
LL1	45	7%	92%
AA 5	25	4%	96%
BB 9	10	2%	97%
LL6	10	2%	99%
CC 4	8	1%	100%



Roller Compactor 2010

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
CC11	458	57%	57%
AA1	260	32%	89%
LL6	70	9%	98%
BB3	16	2%	100%

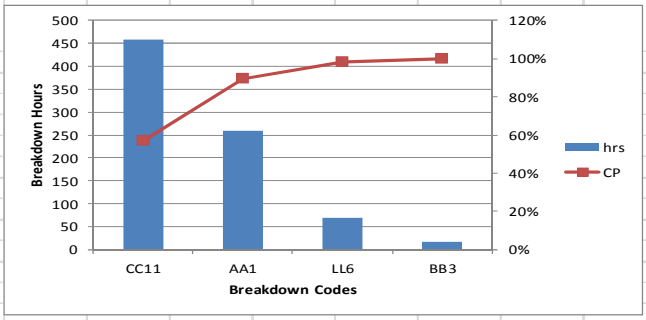
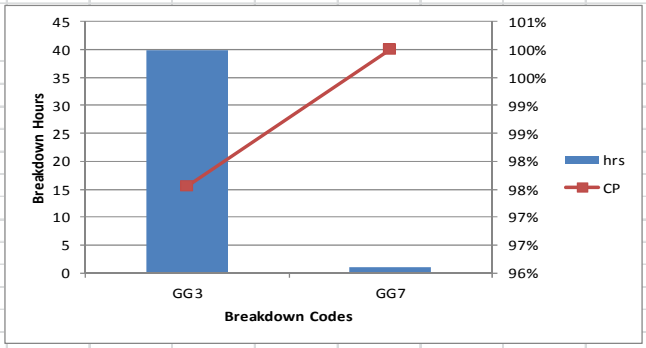


Figure E.3 Pareto Analysis of Roller Compactor

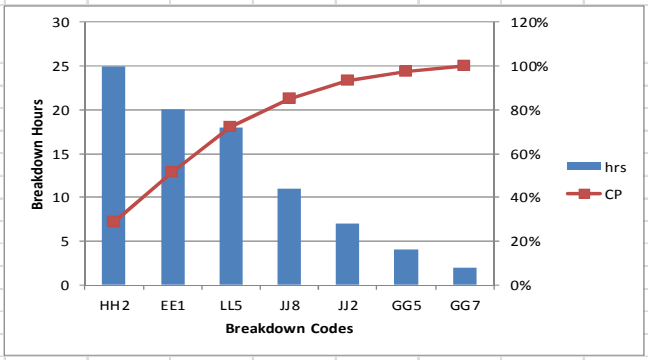
Forklift 2007

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
GG3	40	98%	98%
GG7	1	2%	100%



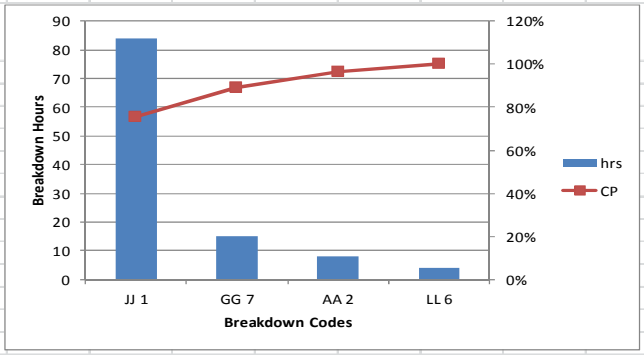
Forklift 2008

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
HH2	25	29%	29%
EE1	20	23%	52%
LL5	18	21%	72%
JJ8	11	13%	85%
JJ2	7	8%	93%
GG5	4	5%	98%
GG7	2	2%	100%



Forklift 2009

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
JJ 1	84	76%	76%
GG 7	15	14%	89%
AA 2	8	7%	96%
LL 6	4	4%	100%



Forklift 2010

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
AA2	46	71%	71%
EE16	10	16%	87%
GG8	8.5	13%	100%

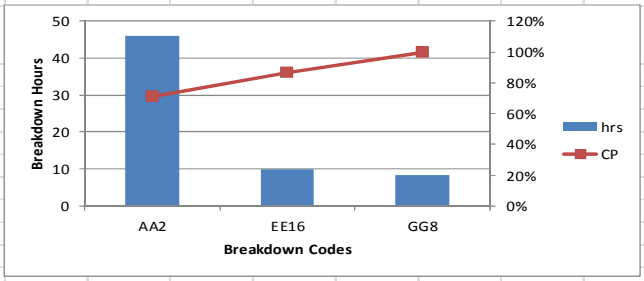
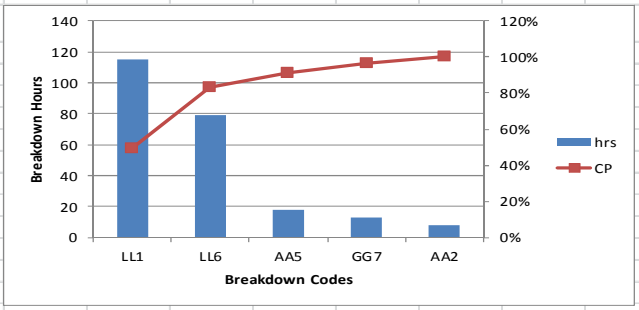


Figure E.4 Pareto Analysis of Forklift

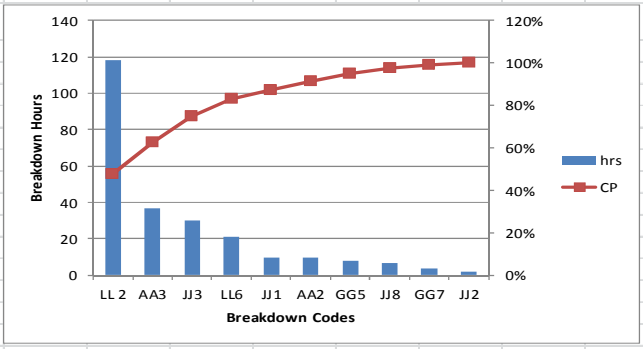
Skidsteer 2007 (Bobcat)

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
LL1	115	49%	49%
LL6	79.5	34%	83%
AA5	18	8%	91%
GG7	13	6%	97%
AA2	8	3%	100%



Skidsteer 2008 (Bobcat)

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
LL 2	118	48%	48%
AA3	37	15%	63%
JJ3	30	12%	75%
LL6	21	9%	83%
JJ1	10	4%	87%
AA2	10	4%	91%
GG5	8	3%	95%
JJ8	7	3%	98%
GG7	4	2%	99%
JJ2	2	1%	100%



Skidsteer 2009 (Bobcat)

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
LL 2	53	28%	28%
LL 6	39	21%	49%
AA 5	33	18%	67%
JJ 1	28	15%	82%
JJ 3	15.5	8%	91%
LL 1	11	6%	97%
GG 7	3.5	2%	98%
JJ 4	3	2%	100%

Skidsteer 2010 (Bobcat)

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
HH8	56	57%	57%
LL5	20	20%	78%
LL6	12	12%	90%
AA2	6	6%	96%
JJ1	4	4%	100%

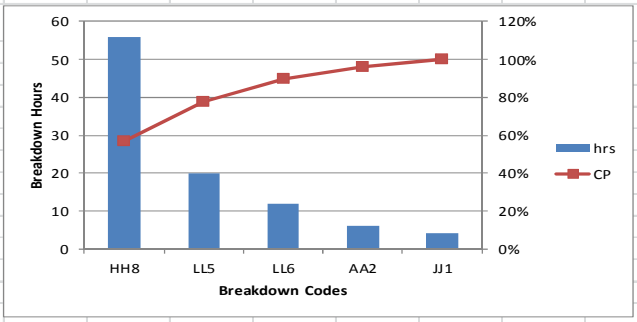
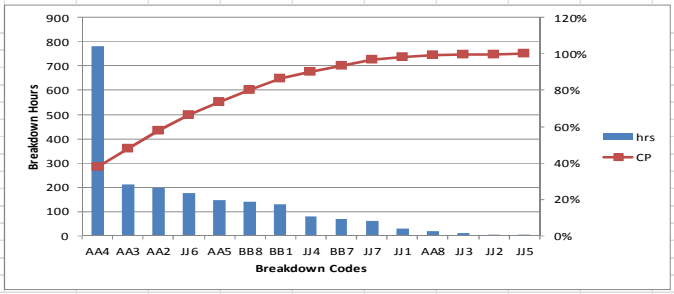


Figure E.5 Pareto Analysis of Skid Steer Loader

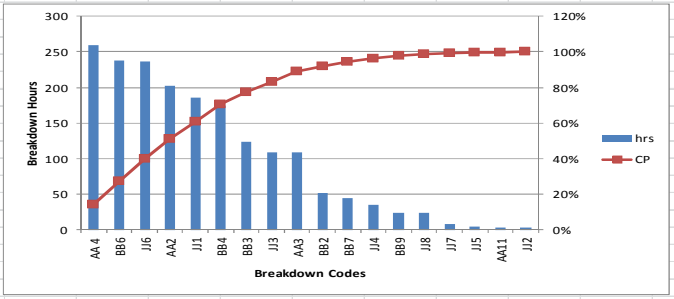
Generator 2007

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
AA4	780	38%	38%
AA3	210	10%	48%
AA2	198	10%	58%
JJ6	175	9%	66%
AA5	146	7%	73%
BB8	140	7%	80%
BB1	130	6%	86%
JJ4	80	4%	90%
BB7	70	3%	94%
JJ7	61	3%	97%
JJ1	30	1%	98%
AA8	20	1%	99%
JJ3	11	1%	100%
JJ2	4.5	0%	100%
JJ5	2	0%	100%



Generator 2008

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
AA 4	260	14%	14%
BB6	238	13%	27%
JJ6	237	13%	40%
AA2	202.5	11%	51%
JJ1	185	10%	61%
BB4	175	10%	71%
BB3	124	7%	77%
JJ3	109.5	6%	83%
AA3	109	6%	89%
BB2	52	3%	92%
BB7	44	2%	94%
JJ4	35	2%	96%
BB9	24	1%	98%
JJ8	24	1%	99%
JJ7	8	0%	99%
JJ5	5	0%	100%
AA11	3	0%	100%
JJ2	3	0%	100%



Generator 2009

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
AA 4	732	27%	27%
JJ 6	574	21%	48%
AA 2	527	19%	67%
JJ 4	283	10%	77%
BB 8	180	7%	84%
JJ 2	119	4%	88%
AA 3	99	4%	92%
BB 3	80	3%	95%
JJ 1	37	1%	96%
BB 5	34	1%	97%
BB 7	25	1%	98%
LL 7	18	1%	99%
JJ3	17	1%	99%
AA 8	5	0%	99%
BB 2	5	0%	100%
JJ 5	5	0%	100%
BB 9	4	0%	100%

Generator 2010

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
AA 4	541	20%	20%
AA5	491	18%	37%
JJ1	349	13%	50%
LL 6	320	12%	61%
JJ 6	235	8%	70%
AA 2	217	8%	78%
BB 3	171	6%	84%
BB 7	100	4%	87%
AA 3	67	2%	90%
BB 2	52	2%	92%
JJ 2	51	2%	94%
BB 1	48	2%	95%
JJ 3	43	2%	97%
AA 9	40	1%	98%
JJ 4	25	1%	99%
BB 5	20	1%	100%
JJ 5	3	0%	100%

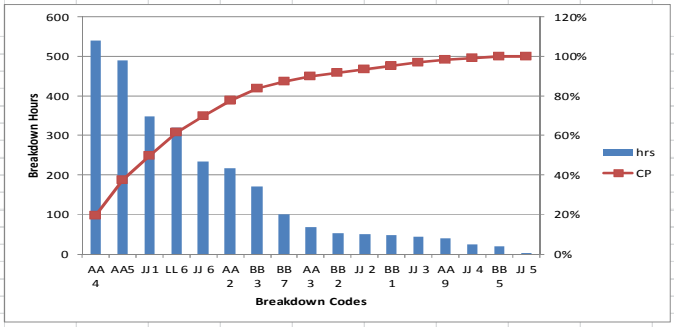


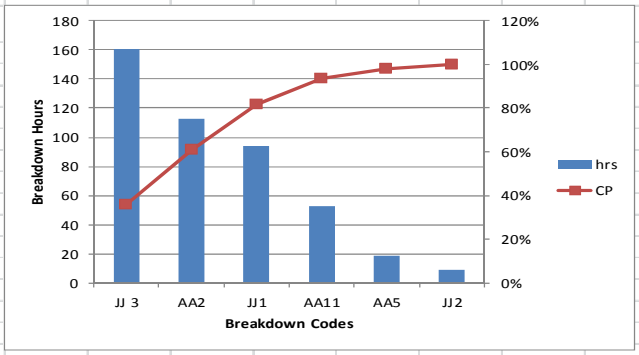
Figure E.6 Pareto Analysis of Generator

Compressor 2007

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
AA11	443	44%	44%
AA7	245	24%	68%
JJ1	120	12%	80%
AA2	70	7%	86%
BB3	50	5%	91%
AA4	40	4%	95%
AA8	23	2%	98%
AA5	15	1%	99%
AA3	10	1%	100%

Compressor 2008

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
JJ 3	161	36%	36%
AA2	112.5	25%	61%
JJ1	94	21%	82%
AA11	53	12%	94%
AA5	19	4%	98%
JJ2	9	2%	100%



Compressor 2009

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
JJ 3	294	37%	37%
JJ 1	163	20%	57%
AA 7	111	14%	71%
AA 1	100	12%	83%
AA 3	60	7%	90%
BB 3	39	5%	95%
DD 9	20	2%	98%
AA 11	18	2%	100%

Compressor 2010

Breakdown Codes	Hours	Percentage	Cumulative Percentage (CP)
DD9	404	36%	36%
AA4	350	31%	68%
JJ1	251	22%	90%
AA7	75	7%	97%
JJ3	15	1%	98%
AA11	12	1%	99%
BB9	6	1%	100%
JJ2	3.5	0%	100%

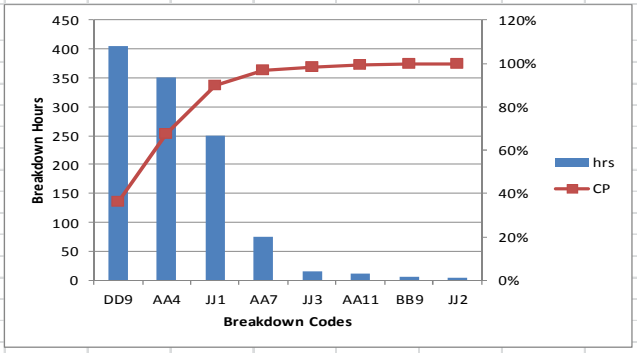
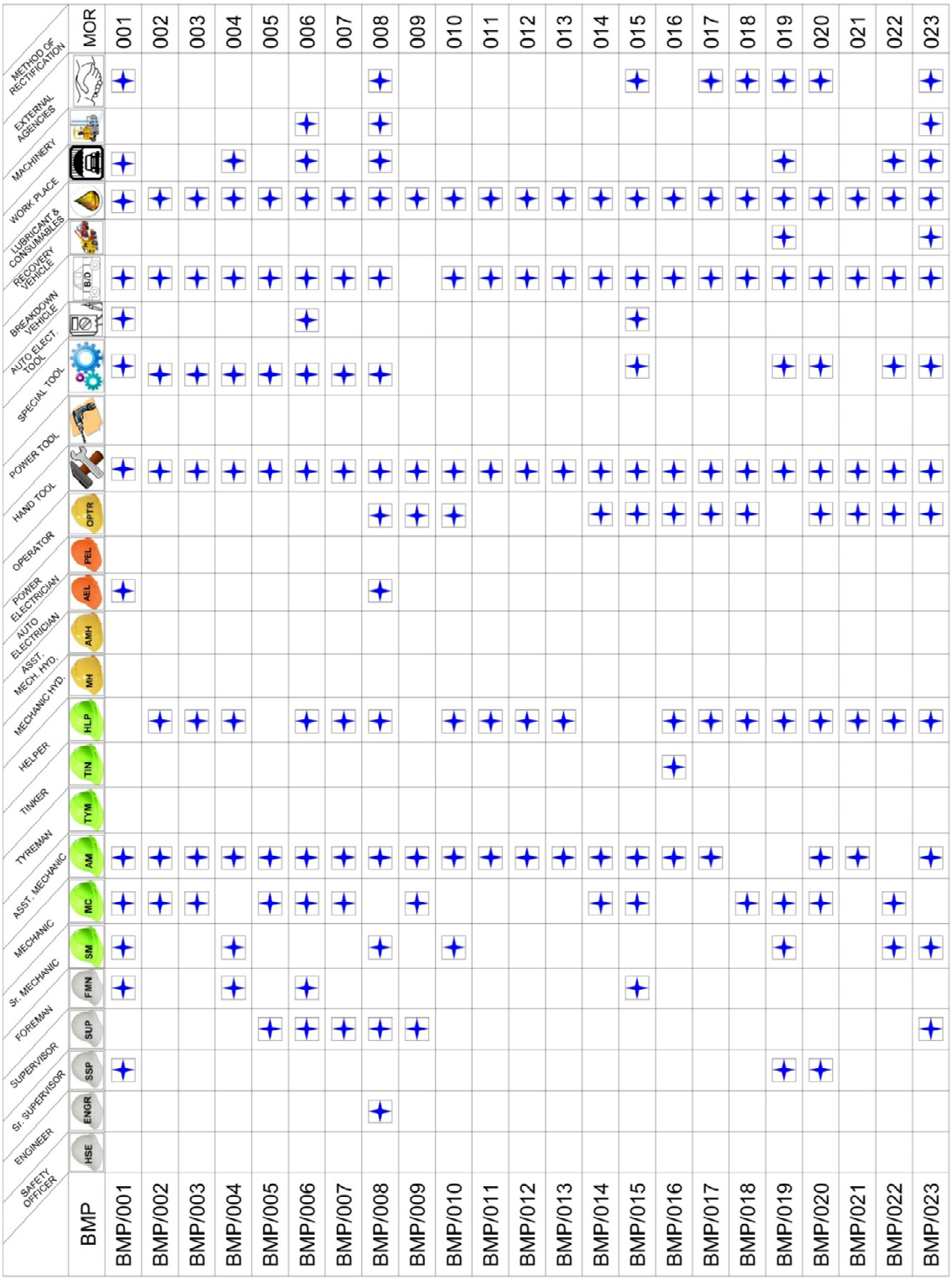
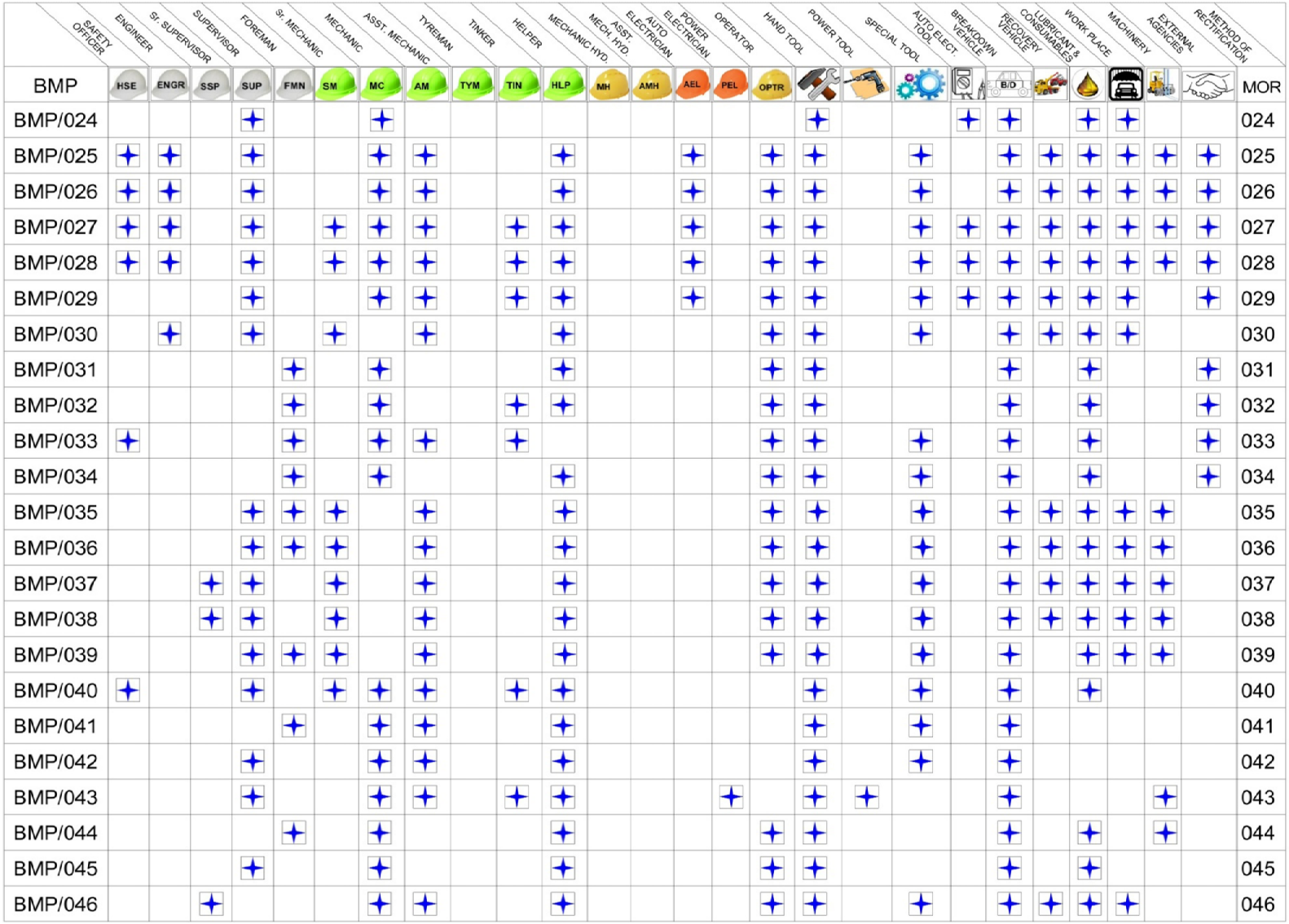


Figure E.7 Pareto Analysis of Compressor

APPENDIX F: BREAKDOWN MAINTENANCE PROTOCOL (BMP) LIST - (BMP 01 to BMP 195)




SAFETY OFFICER
ENGINEER
Sr. SUPERVISOR
SUPERVISOR
FOREMAN
Sr. MECHANIC
MECHANIC
ASST. MECHANIC
TYREMAN
TINKER
HELPER
MECHANIC HYD.
ASST. MECH. HYD.
AUTO ELECTRICIAN
POWER ELECTRICIAN
OPERATOR
HAND TOOL
POWER TOOL
SPECIAL TOOL
AUTO ELECT. TOOL
BREAKDOWN VEHICLE
RECOVERY VEHICLE
LUBRICANT & CONSUMABLES
WORK PLACE
MACHINERY
EXTERNAL AGENCIES
METHOD OF RECTIFICATION
BMP
HSE
ENGR
SSP
SUP
FMN
SM
MC
AM
TYM
TIN
HLP
MH
AMH
AEL
PEL
OPTR
B/D
MOR
BMP/024 024
BMP/025 025
BMP/026 026
BMP/027 027
BMP/028 028
BMP/029 029
BMP/030 030
BMP/031 031
BMP/032 032
BMP/033 033
BMP/034 034
BMP/035 035
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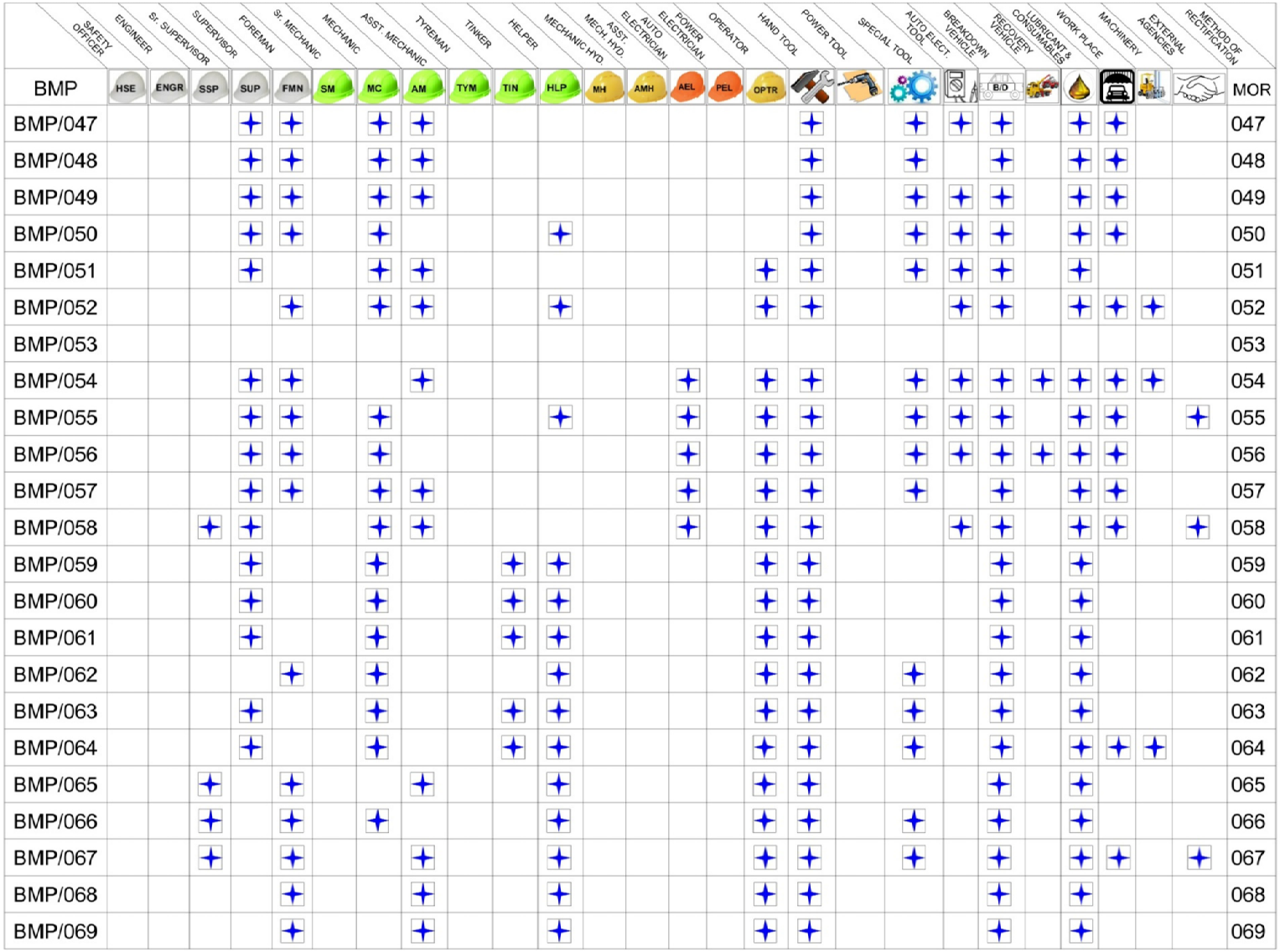
BMP/044 044
BMP/045 045
BMP/046 046


SAFETY OFFICER
ENGINEER
Sr. SUPERVISOR
SUPERVISOR
FOREMAN
Sr. MECHANIC
MECHANIC
ASST. MECHANIC
TYREMAN
TINKER
HELPER
MECHANIC HYD.
ASST. MECH. HYD.
AUTO ELECTRICIAN
POWER ELECTRICIAN
OPERATOR
HAND TOOL
POWER TOOL
SPECIAL TOOL
AUTO ELECT. TOOL
BREAKDOWN VEHICLE
RECOVERY VEHICLE
LUBRICANT & CONSUMABLES
WORK PLACE
MACHINERY
EXTERNAL AGENCIES
METHOD OF RECTIFICATION
BMP
HSE
ENGR
SSP
SUP
FMN
SM
MC
AM
TYM
TIN
HLP
MH
AMH
AEL
PEL
OPTR
B/D
MOR
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BMP/062 062
BMP/063 063
BMP/064 064
BMP/065 065
BMP/066 066
BMP/067 067
BMP/068 068
BMP/069 069

BMP	SAFETY OFFICER	ENGINEER	Sr. SUPERVISOR	SUPERVISOR	FOREMAN	Sr. MECHANIC	MECHANIC	ASST. MECHANIC	TYREMAN	TINKER	HELPER	MECHANIC HYD.	ASST. MECH. HYD.	AUTO ELECTRICIAN	POWER ELECTRICIAN	OPERATOR	POWER TOOL	HAND TOOL	SPECIAL TOOL	AUTO ELECT. TOOL	BREAKDOWN VEHICLE	RECOVERY VEHICLE	LUBRICANT & CONSUMABLES	WORK PLACE	MACHINERY	EXTERNAL AGENCIES	METHOD OF RECTIFICATION	MOR
BMP/070																												070
BMP/071																												071
BMP/072																												072
BMP/073																												073
BMP/074																												074
BMP/075																												075
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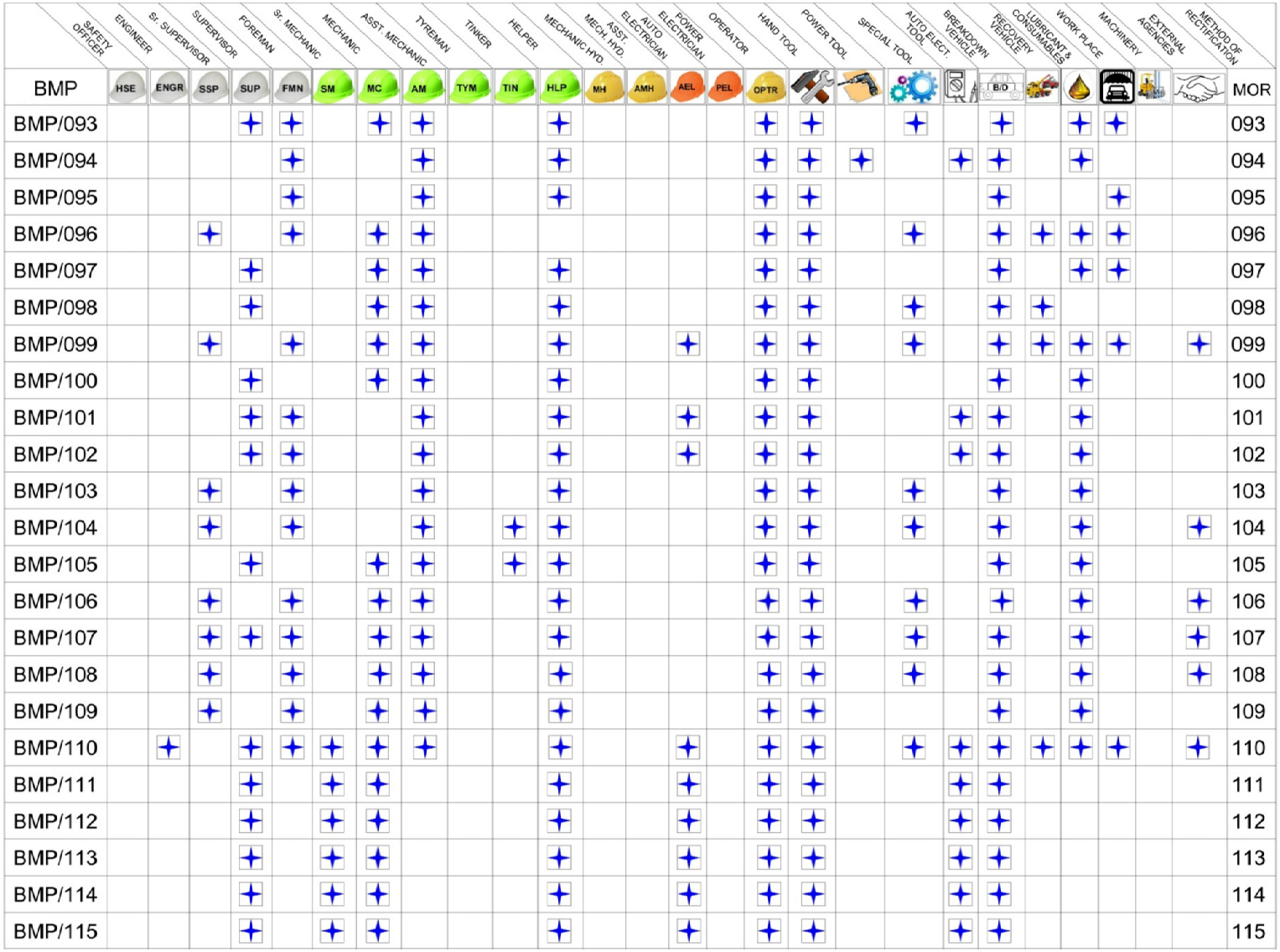
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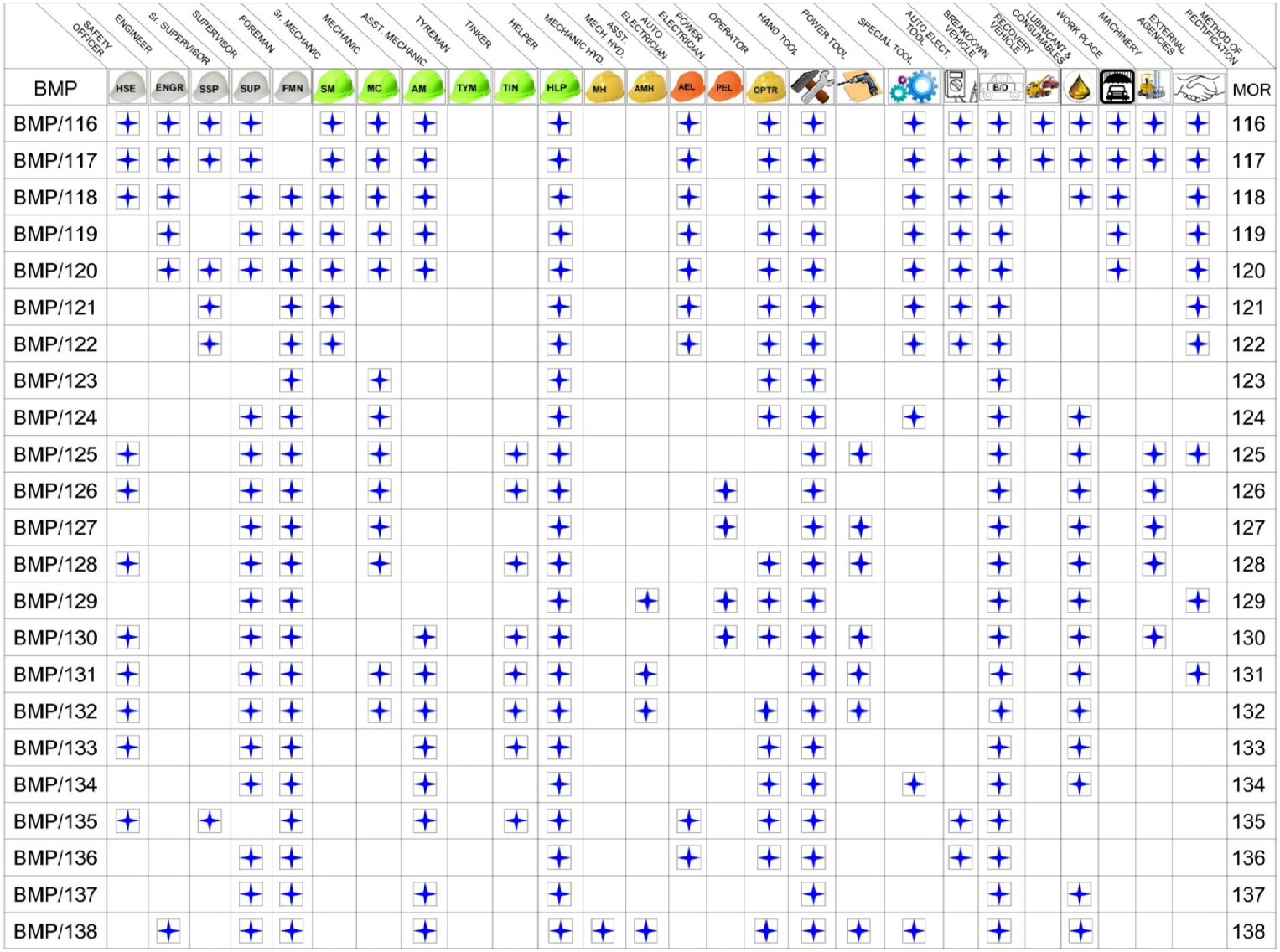
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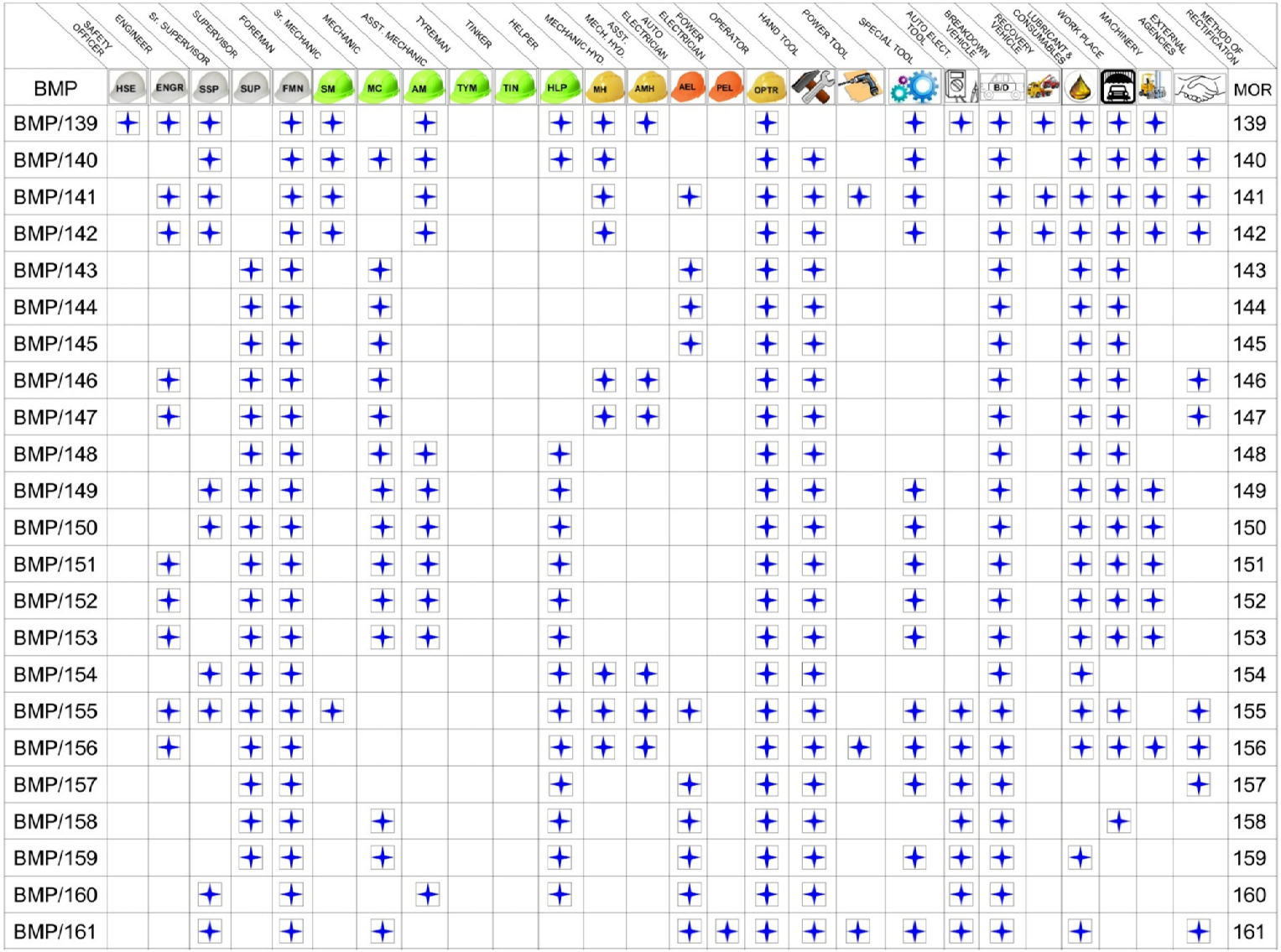
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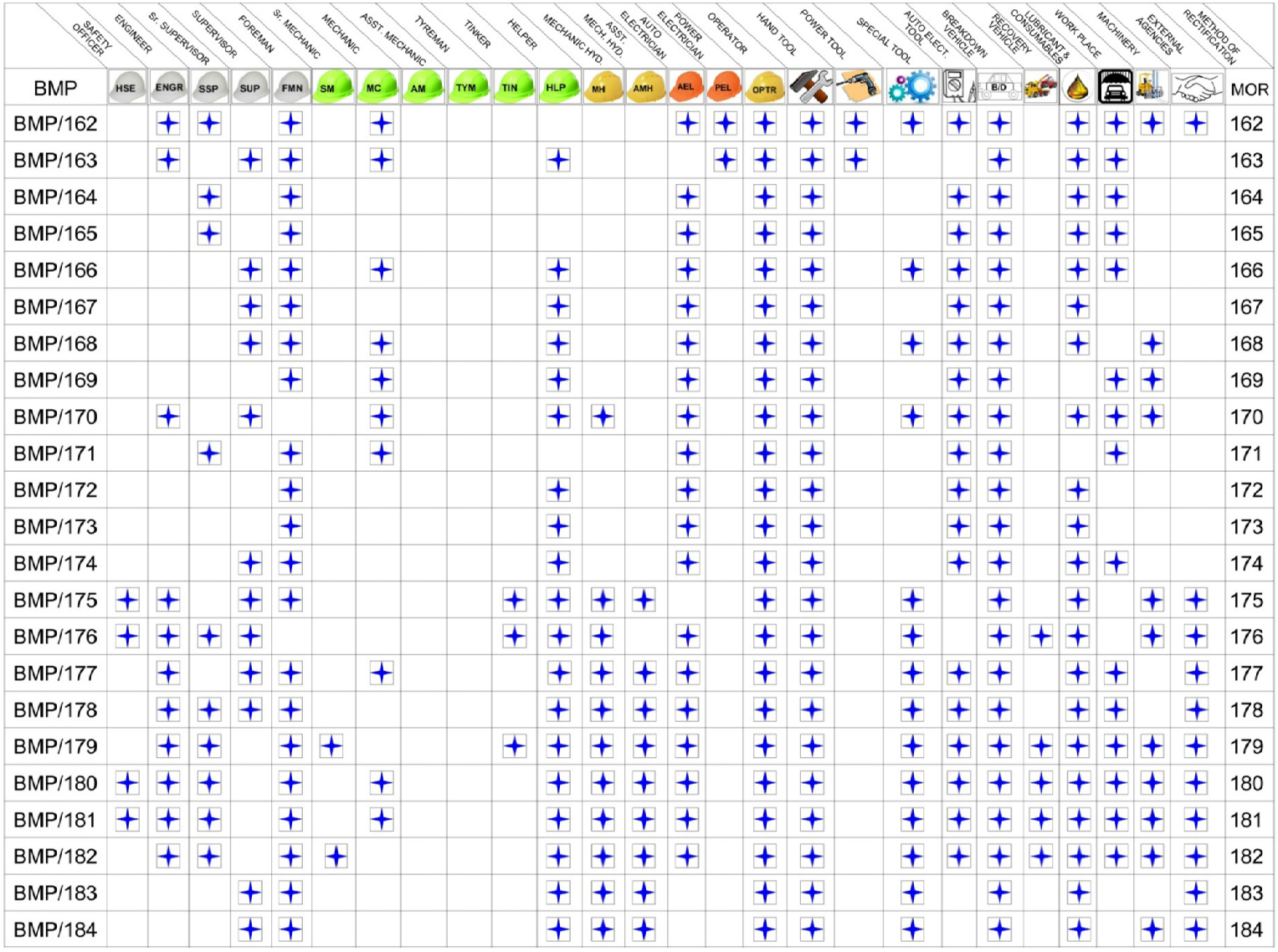
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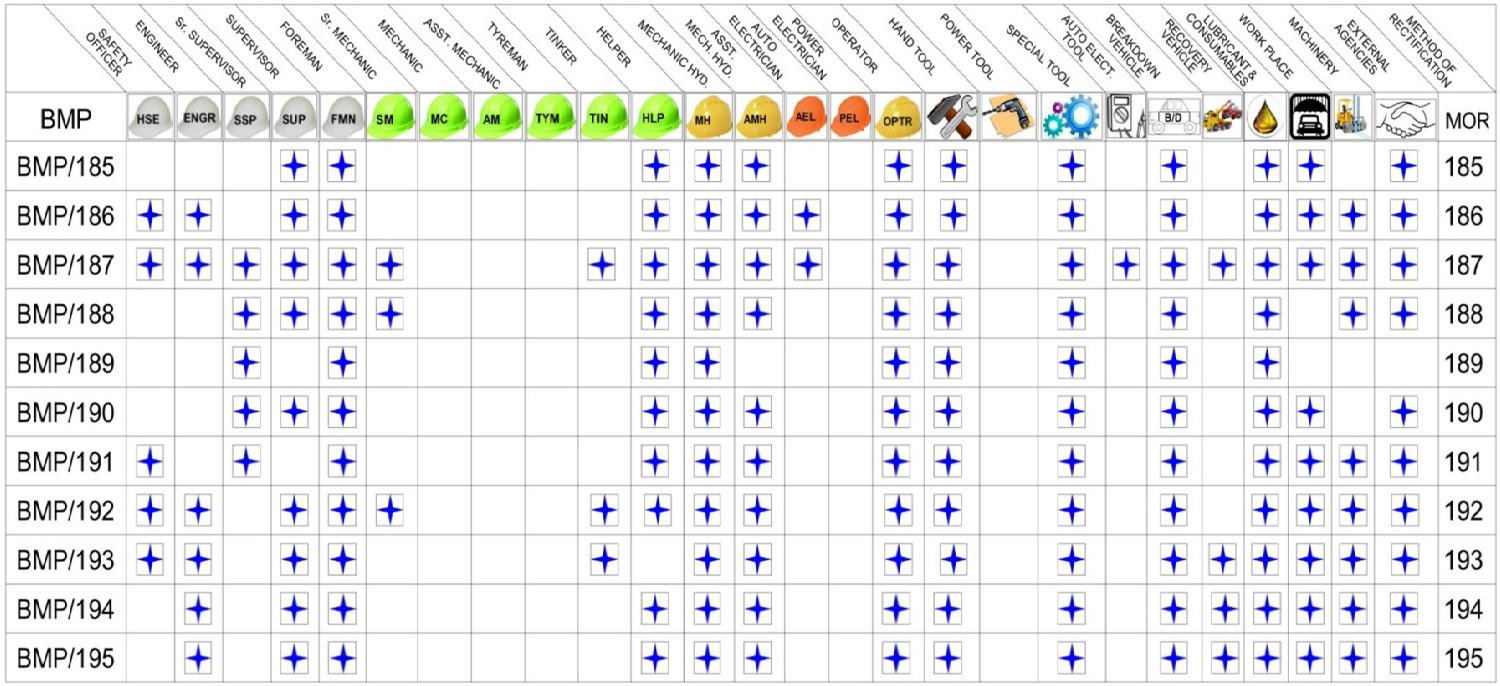
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APPENDIX G – LIST OF METHOD OF RECTIFICATION SHEETS

Method of Rectification: BMP 49 (A17R3)

- To check the engine temperature, if it is heated do not remove the water pump.
- To reduce the pressure and drain the coolant water from the radiator.
- To loose the radiator top hose, bottom hose clips and radiator mountings after remove the radiator from the engine.
- To remove the fan belt, radiator cover and fan leaf.
- Remove the water pump from the engine.
- To clean thoroughly water pump seating place.
- Apply packing paste on seating place.
- To fix gasket and new water pump on engine.
- To re-fix fan belt radiator and fan assy.
- To tight the drain plug and fill up the coolant water at required level.
- To start the engine and check the leakages.

Method of Rectification:BMP 50 (A17R4)

- To check the engine temperature, if it is heated do not remove the water pump.
- To reduce the pressure and drain the coolant water from the radiator.
- To loose the radiator top hose, bottom hose clips and radiator mountings after remove the radiator from the engine.
- To remove the fan belt, radiator cover and fan leaf.
- Remove the water pump from the engine.
- To clean thoroughly water pump seating place.
- Apply packing paste on seating place.
- To fix new gasket on water pump.
- To re-fix fan belt radiator and fan assy.
- To tight the drain plug and fill up the coolant water at required level.
- To start the engine and check the leakages.

Method of Rectification: BMP 51 (A17R5)

- To check the engine temperature, if it is heated do not remove the water pump.
- To reduce the pressure and drain the coolant water from the radiator.
- To loose the radiator top hose, bottom hose clips and radiator mountings after remove the radiator from the engine.
- To remove the fan belt, radiator cover and fan leaf.
- Remove the water pump from the engine.
- To clean thoroughly water pump seating place.
- To check & correct the seating place.
- Apply packing paste on seating place.
- To fix new gasket on water pump.
- To re-fix fan belt radiator and fan assy.
- To tight the drain plug and fill up the coolant water at required level.
- To start the engine and check the leakages.

Method of Rectification:BMP52 (A17R6)

- To check the engine temperature, if it is heated do not remove the water pump.
- To reduce the pressure and drain the coolant water from the radiator.
- To loose the radiator top hose, bottom hose clips and radiator mountings after remove the radiator from the engine.
- To remove the fan belt, radiator cover and fan leaf.
- Remove the water pump from the engine.
- To clean thoroughly water pump seating place.
- To check & correct the seating place.
- Apply packing paste on seating place.
- To fix new gasket on water pump.
- To re-fix fan belt radiator and fan assy.
- To tight the drain plug and fill up the coolant water at required level.
- To start the engine and check the leakages.

Method of Rectification: BMP 54 (A19R1)

- To disconnect the battery connection / Off the master switch.
- To loose the belt adjuster and remove the alternator and belt from the engine.
- To dismantle the alternator and remove the bearing from the alternator.
- To change the new bearing and reassemble alternator.
- To fit the alternator assembly and new fan belt.
- To check the belt tight at required level.
- To connect the battery connection & ON master switch.
- To check coolant level, if required to top-up.
- To start the engine, check the engine temperature and battery charging.

Method of Rectification:BMP 55 (A19R2)

- To disconnect the battery connection / Off the master switch.
- To loose the belt adjuster and remove the alternator and belt from the engine.
- To remove the broken radiator cover.
- To change the new radiator cover and new belt.
- To fit the alternator assembly and new fan belt.
- To check the belt tight at required level.
- To connect the battery connection & ON master switch.
- To check coolant level, if required to top-up.
- To start the engine, check the engine temperature and battery charging.

Method of Rectification: BMP 57 (A19R4)

- To disconnect the battery connection / Off the master switch.
- To loose the belt adjuster and remove the alternator and belt from the engine.
- To remove the radiator fan and clutch assembly..
- To fix the new radiator cover.
- To fit the alternator assembly and new fan belt.
- To check the belt tight at required level.
- To connect the battery connection & ON master switch.
- To check coolant level, if required to top-up.
- To start the engine, check the engine temperature and battery charging.

Method of Rectification: BMP 58 (A24R1)

- To reduce the pressure and drain the coolant water from the radiator.
- To loose the radiator top hose, bottom hose clips and radiator mountings after remove the radiator from the engine.
- To repair and service the radiator.
- Pressure tested on radiator.
- To fit the radiator and all accessories simultaneous.
- To start the engine and check the leakages and engine temperature

Method of Rectification: BMP 86 (A38R5)

- To check the engine temperature, if it is heated do not remove the water pump.
- To reduce the pressure and drain the coolant water from the radiator.
- To loose the radiator top hose, bottom hose clips and radiator mountings after remove the radiator from the engine.
- To remove the fan belt, radiator cover and fan leaf.
- Remove the water pump from the engine.
- To clean thoroughly water pump seating place.
- Apply packing paste on seating place.
- To fix new gasket on water pump.
- To re-fix fan belt radiator and fan assy.
- To tight the drain plug and fill up the coolant water at required level.
- To start the engine and check the leakages.

Method of Rectification: BMP 87 (A38R6)

- To drain the engine oil from the engine.
- To remove all injector pipes, valve door cover, rocker arm, push rods from the cylinder head.
- To drain the coolant oil from the radiator.
- To loosen the radiator top hose, bottom hose clips and radiator mountings and remove the radiator from the engine.
- To remove the fan belt, radiator cover and fan leaf.
- Remove the water pump from the engine.
- To loosen and remove the cylinder head bolt.
- To remove the exhaust and inlet manifolds from the head.
- To remove the cylinder head assmebly from the engine.
- To remove the head gasket.
- To change the new head assembly with inlet and exhaust valve, seat & guide.
- To clean head surface area.
- To change the new head gasket.
- To inspect the push rod, rocker arm, cylinder bore. If it is ok, re-assmeble as same.
- To fix the radiator, water pump, fan leaf, hoses.
- To tight the drain plug and fill up the coolant water at required level.
- To tight the drain plug and fill up the engine oli (Specificed Grade) at required level.
- To start the engine, check the head pressure and find any leakages.

APPENDIX H: GENERAL CONSTRUCTION MACHINERY USED IN CONSTRUCTION INDUSTRY

Table H.1 Types of construction equipment and machinery

Heavy Equipment	Vibrator Roller / Small
Mobile Crane	Road Cleaning Machine
Wheel Loader	**Utilities and Equipment**
Boom Loader	Compressor – Air
Excavator	Generators
Back Hoe Loader	Concrete Pump
Grader	Asphalt Mixer
Single Drum Vibration Roller	Wet Mixer
Double Drum Vibration Roller	Mobile Light Tower
Dozer	Grade Rail Machine
Pneumatic tired Roller	Dewatering Pump
Milling Machine	Jetting Pump
Piling Machine	**Small Equipment**
Drilling Machine	Compactor - Plate/ Roller
Tele-handler	Power floats
Crawler Crane	Bar Bending Machine
Dump Truck	Bar Cutting Machine
Heavy Plant	Tile Cutting Machine
Power Machines	Block Cutting Machine
Tower Cranes	Mixer Machine
Hoists	Scabbler
Cradles	Concrete Vibrators
Concrete Placer Booms	Wood saw / Planner
Batching Plant	Floor Polishing Machine
Asphalt Plant	Screwed Machine
Wet Mix Plant	Plaster Machine
Medium Equipment	Water Jet Pump
Skid steer	Road Cutting Machine
Dumper	Interlock Cutting Machine
Mini Excavator	Industrial Vacuum Cleaner
Fork Lift	Jack Hammer
Spray Plaster	Mosaic Polish Machine
Scissor Lift	Road Marking Machine

Construction Machinery Selection

The first principle of construction machinery selection that must be understood is the fact that each item of machinery is a tool designed for certain specific purposes. In construction work, a contractor cannot ordinarily afford to have the piece of construction machinery best adapted to each operation that may ever be required during a construction project so it's necessary to select the best machinery available for the job.

In general, the best strategy is to consider the most commons tasks and select construction machinery that will accomplish those tasks. When the need arises, the construction engineer will use his ingenuity in an effort to adapt the machinery available in such a manner to complete the task without putting either the machinery or the construction site personnel in a perilous situation.

It is always possible to avoid the high cost of purchasing a specific piece of construction machinery by renting it for the short term. The expenses for that specific construction project will be increased but at least the job will be done correctly using construction machinery designed for that specific purpose and moreover it will be done safely. Renting construction machinery also saves the enormous cost of having to purchase the machinery for just one job.

The second principle in selecting construction machinery is the fact that cost per unit of production, and not initial investment or even ownership cost per hour of an individual piece of construction machinery is the true criterion of economical selection.

For example, when a shovel breaks down, it is not only running up repair costs, but the ownership and labor costs of a whole fleet of trucks will continue to increase while the trucks produce nothing, waiting for the shovel to be repaired or replaced.

The third principle of construction machinery selection is that of utilizing standardized machinery as far as practicable. Standardized parts are readily available and can be stocked so as to minimize replacement delays. They are almost always considerably cheaper than specially made parts. In addition, standardized construction machinery is generally readily convertible to various other uses by addition or substitution of other standardized parts which minimized the initial investment in construction machinery.

The fourth and final principle of construction machinery selection is to not use machinery too large of too powerful for the job. Large heavy machinery running at a fraction of its capacity is generally less economical than smaller machinery running at capacity.

This principle must be applied in accordance with construction machinery available which may have been selected on a basis of the majority of operations to be performed versus that of any single operation. In addition, the transport of heavy machinery from one job site to another may be challenging when you consider such things as bridge capacity and clearance, overhead wires, and highway load limits.

While selecting the type of construction machinery to employ, one must consider the nature of work involved. For instance in Dam construction, the required machines would be dozers, excavators and wheel loaders, while in road construction one would require compactors motor graders and backhoe loaders among others. In addition, the size of the project must be put into consideration. For instance in case of a new road construction, one would require a powerful 140H Motor grader because it can rip more virgin ground compared to 120h which is more suitable for maintenance work. In the highly competitive demolition field, a contractor is most concerned with machine versatility, durability and dependability. All machines working at site are often needed to perform multiple tasks. Various work tools properly applied are the key to success. According to automobile experts, as far as durability and reliability is concerned, machines and work tool designs must afford the maximum time when utilized in harsher environments. With this information in mind, selecting among the variety of wheel loaders, skid steers and backhoe loaders available, should be a bit easier though each machine offers different strength that may be more suitable for a given job.

Failure to adhere with proper maintenance intervals and procedures may result in diminished performance of the product and or accelerated wear of components. Some of the challenges facing the sector include the high initial cost especially when the economy is not good, hence most companies or individuals cannot afford to purchase the right machinery. Unfair competitions from inferior products being sold at throw away prices without support. To deal with the above challenges, respective governments should set standards for the type of machinery to be used by contractors undertaking funded government projects. Creating awareness of the range of machinery and support available in the region and what value they bring.

WHEEL LOADER

Volvo L120E front loader

Caterpillar 988 adapted for log handling

A track loader

A loader is an engineering vehicle (often used in construction) that is primarily used to "load" material (asphalt, demolition debris, dirt, feed, gravel, logs, raw minerals, recycled material, rock, sand, wood chips, etc.) into or onto another type of machinery (dump truck, conveyor belt, feed-hopper, rail-car, etc.). A loader (also known as: bucket loader, front loader, front end loader, pay loader, scoop loader, shovel, skip loader, and/or wheel loader) is a type of tractor, usually wheeled, sometimes on tracks, that has a front mounted square wide bucket connected to the end of two booms (arms) to scoop up loose material from the ground, such as dirt, sand or gravel, and move it from one place to another without pushing the material across the ground. A loader is commonly used to move a stockpiled material from ground level and deposit it into an awaiting dump truck or into an open trench excavation.

Loaders are used mainly for uploading materials into trucks, laying pipe, clearing rubble, and digging. A loader is not the most efficient machine for digging as it cannot dig very deep below the level of its wheels, like a backhoe can. Their deep bucket can usually store about 3-

6 cubic meters (exact number varies with the model) of earth. The front loader's bucket capacity is much bigger than a bucket capacity of a backhoe loader. Loaders are not classified as earthmoving machinery, as their primary purpose is other than earthmoving.

Unlike most bulldozers, most loaders are wheeled and not tracked, although track loaders are common. They are successful where sharp edged materials in construction debris would damage rubber wheels, or where the ground is soft and muddy. Wheels provide better mobility and speed and do not damage paved roads as much as tracks but provide less traction. In construction areas loaders are also used to transport building materials – such as bricks, pipe, metal bars, and digging tools – over short distances.

Loaders are also used for snow removal, using their bucket or a snow basket, but usually using a snowplow attachment. They clear snow from streets, highways and parking lots. They sometimes load snow into dump trucks for transport. High-tip buckets are suitable for light materials such as chip, peat and light gravel and when the bucket is emptied from a height.

Skid loaders & track loaders

A skid loader is a small loader utilizing four wheels with hydraulic drive that directs power to either, or both, sides of the vehicle. Very similar in appearance and design is the track loader, which utilizes a continuous track on either side of the vehicle instead of the wheels. Since the expiration of Bobcat's patent on its quick-connect system, newer tractor models are standardizing on that popular format for front end attachments.

Backhoe loader

Backhoe loader, also called a loader backhoe, and commonly shortened to backhoe, is an engineering vehicle, which consists of a tractor, fitted with a shovel/bucket on the front and a small backhoe on the back. Due to its (relatively) small size and versatility, backhoe loaders are very common in urban engineering and small construction projects (such as building a small house, fixing city roads etc.).

Back Hoe Loader

Backhoe loaders are very common and can be used for a wide variety of tasks: construction, small demolitions and light transportation of building materials, powering building machinery, digging holes/excavation, landscaping, breaking asphalt, and paving roads.

A backhoe, also called a rear actor or back actor, is a piece of excavating machinery or digger consisting of a digging bucket on the end of a two-part articulated arm. They are typically mounted on the back of a tractor or front loader. The section of the arm closest to the vehicle is known as the boom, and the section which carries the bucket is known as the dipper or dipper stick (the terms 'boom' and 'dipper' having been used previously on steam shovels). The boom is attached to the vehicle through a pivot known as the kingpost, which allows the arm to slew left and right, usually through a total of around 200 degrees. Modern backhoes are powered by hydraulics.

A backhoe loader is a tractor-like vehicle with an arm and bucket mounted on the back and a front loader mounted on the front. This type of vehicle is often known colloquially as a **JCB** in Europe and simply a Backhoe or a Tractor Loader Backhoe, or TLB, in North America. In North American terms, a Backhoe includes both a front bucket and a rear hoe, on a chassis originally derived from farm tractors. A dedicated hoe on its own chassis is more properly referred to as an excavator.

Mini Dumpers

Mini Dumpers are versatile construction machinery that really punches above its weight and used in most of the building construction sites where material movement is at large. The actual lifting system in a mini dumper is very simple, and relies on the staple of most of the construction vehicles: which is the principle of hydraulics. One or more hydraulic pistons or

actuators are used to raise the 'dump box' containing the material. These rams raise one end of the box high enough to allow the driver to dump its contents. On high tip models this is enough to load into a high sided vehicle.

Hydraulics are used instead of pneumatic rams, as pneumatics by their nature use liquid that could be compressed by the weight of the load, causing the dump box to lower unintentionally. Hydraulic liquids cannot be compressed, hence their common use in construction. With hydraulic pistons, the operator can lower the dump box gradually by slowly releasing the hydraulic fluid, which brings it back to its original position.

The hydraulic system uses power which is generally drawn from the dumper's transmission through engine, like on larger dumpers. This means that unless the vehicle is running on its engine it won't be able to lift anything. On larger dump trucks the power is transferred from the transmission to the pistons by way of the Power Take Off, similar to what we find on a tractor.

A PTO is a separate splined driveshaft which is connected to the main transmission. This provides power to the pump that feeds fluid into the hydraulics, but on a mini dumper this system is integrated into the machine itself and as such does not require a PTO like its bigger brothers.

As with any piece of construction machinery, a mini dumper is built with limits to its ability. Aside from its maximum load weight, the actual distribution of this weight in the dump box can affect the true height that the box can be lifted to, so it is always best to play it safe and never overload the vehicle. The size of the hydraulics is also the main limit to the power of the mini dumper, as the pistons must fit inside these cylinders.

Like other dumper trucks, mini dumpers should be treated with the right care, and not neglected because of their size. Dumpers are statistically the most likely vehicle to be involved in an accident on a construction site, so always ensure that all safety precautions are followed and that users and operators are fully trained. Mini dumpers are a great investment, and due to the wide range of models available, there is a machine to suit every job. From 300kg to over 6 tons, mini dumpers are a great way to save time and effort on the construction site.

Mini Dumper Activities

Roller Compactor

A **compactor** is a machine or mechanism used to reduce the size of waste material or soil through compaction. A trash compactor is often used by homes and businesses to reduce the volume of trash. Normally powered by hydraulics, compactors take many shapes and sizes. In landfill sites for example, a large bulldozer with spiked wheels called a landfill compactor is used to drive over waste deposited by waste collection vehicles (WCVs).

Increasing the density of soil, along with its side effects of increased strength and decreased permeability, is usually desirable in earthwork constructions and below the building foundations. Compaction is accomplished by use of heavy machinery. In sands and gravels, the machinery usually vibrates, to cause re-orientation of the soil particles into a denser configuration. In silts and clays, a sheep's foot roller is frequently used, to create small zones of intense shearing, which drives air out of the soil. The result of soil compaction is measured by determining the bulk density of the compacted soil and comparing it to a maximum density, for example, obtained from a Proctor compaction test, to determine the relative compaction.

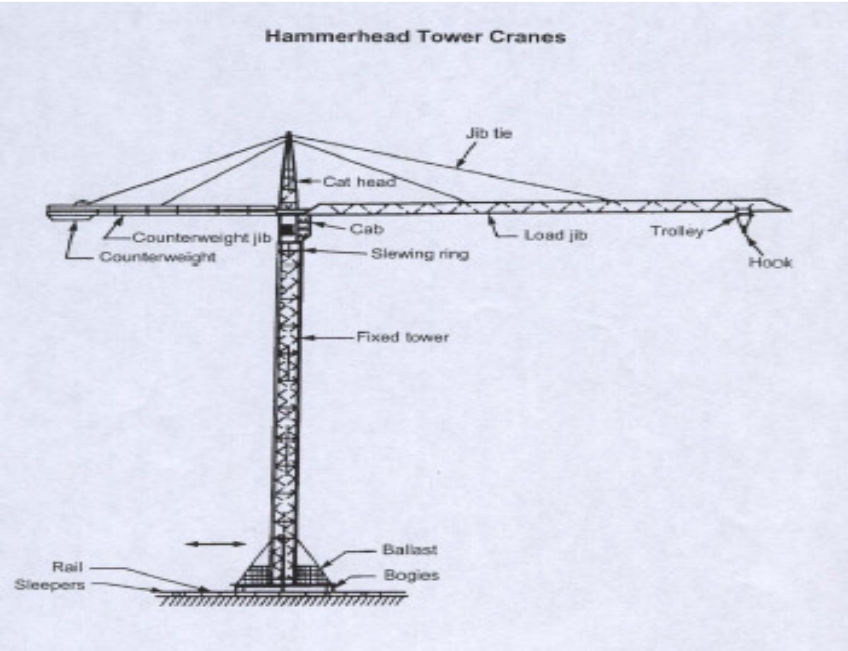
Roller Compactor at road formation

Tower Cranes:

Tower cranes are a common fixture at any major construction site. They're pretty hard to miss -- they often rise hundreds of feet into the air, and can reach out just as far. The construction crew uses the tower crane to lift steel, concrete, large tools like acetylene torches and generators, and a wide variety of other building materials. A typical tower crane has the following specifications:

- Unsupported height – (40 to 90 meters) / the crane can have a total height much greater than this height if it is tied laterally to the building as the building rises around the crane.
- Maximum reach - (90 meters) / maximum lifting power – up to 24 tons, but the maximum moment is limited with the capacity at the tip.
- For example, the maximum load that the crane can lift is 18 metric tons, but the crane cannot lift that much weight if the load is positioned at the end of the jib. The closer the load positioned to the mast, the more weight the crane can lift safely.
- The 300 ton -meter rating can explain the relationship. For example, if the operator positions the load at 30 meters (100 feet) from the mast, the crane can lift a maximum of 10.1 tons. (This very much depends on load chart provided by the crane manufacturer)
- Counterweights - 20 tons to 30 tons / the crane uses two limit switches to make sure that the operator does not overload the crane:

- The maximum load switch monitors the pull on the cable and makes sure that the load does not exceed 18 tons.
- The load moment switch makes sure that the operator does not exceed the ton-meter rating of the crane as the load moves out on the jib.
- A cat head assembly in the slewing unit can measure the amount of collapse in the jib and sense when an overload condition occurs.
- The base is bolted to a large concrete pad that supports the crane. The base connects to the mast (or tower), which gives the tower crane its height.
- Attached to the top of the mast is the slewing unit -- the gear and motor -- that allows the crane to rotate:
- The long horizontal jib (or working arm), which is the portion of the crane that carries the load.
- A trolley runs along the jib to move the load in and out from the crane's center:
- The shorter horizontal machinery arm, which contains the crane's motors and electronics as well as the large concrete counter weights:
- The operator's cab: The machinery arm contains the motor that lifts the load, along with the control electronics that drive it and the cable drum
- The motors that drive the slewing unit are located above the unit's large gear.



Tower Crane with labeled parts

APPENDIX I: MAINTENANCE TERMINOLOGIES

Asset Management - the systematic planning and control of a physical resource throughout its life. This may include the specification, design, and construction of the asset, its operation, maintenance and modification while in use, and its disposal when no longer required.

Availability - the proportion of total time that an item of machinery is capable of performing its specified functions, normally expressed as a percentage. It can be calculated by dividing the machinery available hours by the total number of hours in any given period. One of the major sources of disagreement over the definition of availability is whether downtime should be divided by total hours, or by Scheduled Operating Time.

Average Life - how long, on average, a component will last before it suffers a failure. Commonly measured by Mean Time Between Failures.

Benchmarking - the process of comparing performance with other organizations, identifying comparatively high performance organizations, and learning what it is they do that allows them to achieve that high level of performance.

Breakdown - a specific type of failure, where an item of plant or machinery is completely unable to function.

Component - a subassembly of an Asset, usually removable in one piece and interchangeable with other, standard components (eg. Truck engine).

Computerized Maintenance Management System – is a computerized system to assist with the effective and efficient management of maintenance activities through the application of computer technology. It generally includes elements such as a computerized Work Order system, as well as facilities for scheduling Routine Maintenance Tasks, and recording and storing Standard Jobs, Bills of Materials and Applications Parts Lists, as well as numerous other features.

Condition Based Maintenance - Machinery maintenance strategy based on measuring the condition of machinery in order to assess whether it will fail during some future period, and then taking appropriate action to avoid the consequences of that failure. The condition of machinery could be monitored using Condition Monitoring, Statistical Process Control

techniques, by monitoring machinery performance, or through the use of the Human Senses. The terms Condition Based Maintenance, On-Condition Maintenance and Predictive Maintenance can be used interchangeably.

Condition Monitoring – is the use of specialist machinery to measure the condition of machinery. Vibration Analysis, Tribology and Thermography are all examples of Condition Monitoring techniques.

Corrective Maintenance – is the maintenance activity which is required to correct a failure that has occurred or is in the process of occurring. This activity may consist of repair, restoration or replacement of components.

Criticality - The priority rank of a failure mode based on some assessment criteria.

Downtime - the time that an item of machinery is out of service, as a result of machinery failure. The time that an item of machinery is available, but not utilized is generally not included in the calculation of downtime.

Economic Life - the total length of time that an asset is expected to remain actively in service before it is expected that it would be cheaper to replace the machinery rather than continuing to maintain it. In practice, machinery is more often replaced for other reasons, including: because it no longer meets operational requirements for efficiency, product quality, comfort etc., or because newer machinery can provide the same quality and quantity of output more efficiently.

Machinery Maintenance Strategies - the choice of routine maintenance tasks and the timing of those tasks, designed to ensure that an item of machinery continues to fulfill its intended functions.

Failure - an item of machinery has suffered a failure when it is no longer capable of fulfilling one or more of its intended functions. Note that an item does not need to be completely unable to function to have suffered a failure. For example, a pump that is still operating, but is not capable of pumping the required flow rate, has failed. In Reliability Centered Maintenance terminology, a failure is often called a Functional Failure.

Failure Code - a code typically entered against a Work Order in a CMMS which indicates the cause of failure (eg. lack of lubrication, metal fatigue etc.)

Failure Effect - a description of the events that occur after a failure has occurred as a result of a specific Failure Mode. It is used in Reliability Centered Maintenance, FMEA and FMECA analyses.

Failure Mode – is any event which causes a failure.

Failure Modes, Effects and Criticality Analysis – this is a structured method of assessing the causes of failures and their effect on production, safety, cost, quality etc.

Failure Modes and Effects Analysis - a structured method of determining machinery functions, functional failures, assessing the causes of failures and their failure effects. The first part of a Reliability Centered Maintenance analysis is a Failure Modes and Effects Analysis.

Failure Pattern – it is the relationship between the Conditional Probability of Failure of an item, and its age. Failure patterns are generally applied to Failure Modes. Research in the airline industry established that there are six distinct failure patterns. The type of failure pattern that applies to any given failure mode is of vital importance in determining the most appropriate machinery maintenance strategy. This fact is one of the key principles underlying Reliability Centered Maintenance.

FTA - Fault Tree Analysis

Infant Mortality - The relatively high conditional probability of failure during the period immediately after an item returns to service.

Inherent Reliability - A measure of the reliability of an item, in its present operating context, assuming adherence to ideal machinery maintenance strategies.

Inspection - Any task undertaken to determine the condition of machinery, and/or to determine the tools, labor, materials, and machinery required to repair the item.

Key Performance Indicators - A select number of key measures that enable performance against targets to be monitored.

Life Cycle Costing – is a process of estimating and assessing the total costs of ownership, operation and maintenance of an item of machinery during its projected machinery life. This is typically used in comparing alternative machinery design or purchase options in order to select the most appropriate option.

Maintainability - the ease and speed with which any maintenance activity can be carried out on an item of machinery. It may be measured by Mean Time to Repair. Is a function of machinery design, and maintenance task design (including use of appropriate tools, jigs, work platforms etc.).

Maintainability Engineering - The set of technical processes that apply maintainability theory to establish system maintainability requirements, allocate these requirements down to system elements and predict and verify system maintainability performance.

Maintenance - any activity carried out on an asset in order to ensure that the asset continues to perform its intended functions, or to repair the machinery. Note that modifications are not maintenance, even though they may be carried out by maintenance personnel.

Maintenance Policy - a statement of principle used to guide Maintenance Management decision making

Maintenance Schedule - a list of planned maintenance tasks to be performed during a given time period, together with the expected start times and durations of each of these tasks. Schedules can apply to different time periods (i.e. Daily Schedule, Weekly Schedule etc.)

Maintenance Strategy – it is a long-term plan, covering all aspects of maintenance management which sets the direction for maintenance management, and contains firm action plans for achieving a desired future state for the maintenance function.

Mean Time Between Failures - a measure of machinery reliability. It is equal to the number of failures in a given time period, divided by the total machinery uptime in that period.

Mean Time To Repair - a measure of maintainability. It is equal to the total machinery downtime in a given time period, divided by the number of failures in that period.

Operating Context - the operational situation within which an asset operates. For example, is it a stand-alone piece of plant, or is it one of a duty-standby pair? Is it part of a batch manufacturing process or a continuous production process? What is the impact of failure of this item of machinery on the remainder of the production process? The operating context has enormous influence over the choice of appropriate machinery maintenance strategies for any asset.

Overall Machinery Effectiveness - a term initially coined in connection with Total Productive Maintenance. It provides a measure of overall asset productivity. Is generally expressed as a percentage, and can be calculated by multiplying Availability by Utilization by Operational Efficiency by Quality Rate.

Overhaul - a comprehensive examination and restoration of an asset to an acceptable condition.

Planned Maintenance - any maintenance activity for which a pre-determined job procedure has been documented, for which all labor, materials, tools, and machinery required to carry out the task have been estimated, and their availability assured before commencement of the task.

Potential Failure - a term used in Reliability Centered Maintenance. It is an identifiable condition which indicates that a functional failure is either about to occur, or in the process of occurring.

Predictive Maintenance - An machinery maintenance strategy based on measuring the condition of machinery in order to assess whether it will fail during some future period, and then taking appropriate action to avoid the consequences of that failure. The condition of machinery could be monitored using Condition Monitoring, Statistical Process Control techniques, by monitoring machinery performance, or through the use of the Human Senses. The terms Condition Based Maintenance, On-Condition Maintenance and Predictive Maintenance can be used interchangeably.

Preventive Maintenance – It is a machinery maintenance strategy based on replacing, overhauling or remanufacturing an item at a fixed interval, regardless of its condition at the

time. Scheduled Restoration tasks and Scheduled Discard tasks are both examples of Preventive Maintenance tasks.

Proactive Maintenance - Any tasks used to predict or prevent machinery failures.

Reliability - the capability of an asset to continue to perform its intended functions. Normally measured by Mean Time Between Failures

Reliability, Availability, and Maintainability - RAM modeling can simulate the configuration, operation, failure, repair and maintenance of machinery. The inputs to RAM modeling will include the physical components and maintenance schedules in a system and the outputs can determine how productive the system can be over the plant life. RAM studies will generate sufficient data to base decisions for possible systems changes that may increase system efficiency and hence project profits.

Reliability Centered Maintenance - A structured process, originally developed in the airline industry, but now commonly used in all industries to determine the machinery maintenance strategies required for any physical asset to ensure that it continues to fulfill its intended functions in its present operating context. A number of books have been written on the subject, but none better than Moubray's book, RCM II.

Reliability Engineering - - a staff function whose prime responsibility is to ensure that maintenance techniques are effective, that machinery is designed and modified to improve maintainability, that ongoing maintenance technical problems are investigated, and appropriate corrective and improvement actions are taken. Used interchangeably with Plant Engineering and Maintenance Engineering.

Run-to-Failure - No Scheduled Maintenance - a Machinery Maintenance Strategy, where no routine maintenance tasks are performed on the machinery. The only maintenance performed on the machinery is Corrective Maintenance, and then only after the machinery has suffered a failure. This is also described as a No Scheduled Maintenance strategy.

Scheduled Maintenance – implies any maintenance work that has been planned and included on an approved Maintenance Schedule.

Shutdown - that period of time when machinery is out of service.

Shutdown Maintenance - Maintenance that can only be performed while machinery is shutdown

Terotechnology - the application of managerial, financial, engineering and other skills to extend the operational life of, and increase the efficiency of, machinery and machinery.

Thermography - the process of monitoring the condition of machinery through the measurement and analysis of heat. Typically conducted through the use of infra-red cameras and associated software. Commonly used for monitoring the condition of high voltage insulators and electrical connections, as well as for monitoring the condition of refractory in furnaces and boilers, amongst other applications.

Total Asset Management - an integrated approach to Asset Management which incorporates elements such as Reliability Centered Maintenance, Total Productive Maintenance, Design for Maintainability, Design for Reliability, Value Engineering, Life Cycle Costing, Probabilistic Risk Assessment and others, to arrive at the optimum Cost-Benefit-Risk asset solution to meet any given production requirements.

Tribology - the process of monitoring the condition of machinery through the analysis of properties of its lubricating and other oils. This is typically conducted through the measurement of particulates in the oil, or the measurement of the chemical composition of the oil (Spectrographic Oil Analysis). Commonly used for monitoring the condition of large gearboxes, engines and transformers, amongst other applications.

Total Productive Maintenance – It is a company-wide machinery management program, with its origins in Japan, emphasizing production operator involvement in machinery maintenance, and continuous improvement approaches. Numerous books have been written on the subject, including Nakajima's authoritative introduction, and a more recent Western hemisphere update by Wilmot.

Unscheduled Maintenance denotes any maintenance work that has **not** been included on an approved Maintenance Schedule prior to its commencement.

Useful Life – is the maximum length of time that a component can be left in service, before it will start to experience a rapidly increasing probability of failure. The Useful Life determines the frequency with which a Scheduled Restoration or a Scheduled Discard task should be

performed. The concept of the Useful Life of a component to hold true, components must, at some consistent point in time, experience a rapidly increasing probability of failure. Research in the airline industry showed that, in this industry at least, this was only true for 11% of the components in modern aircraft.

Vibration Analysis - - the process of monitoring the condition of machinery, and the diagnosis of faults in machinery through the measurement and analysis of vibration within that machinery, typically conducted through hand-held or permanently positioned accelerometers placed on key measurement points on the machinery. It is commonly used on most large items of rotating machinery, such as turbines, centrifugal pumps, motors, gearboxes etc.

List of Publications

1. P.B. Ahamed Mohideen, M. Ramachandran, Rajam Ramasamy Narasimmalu, (2011) "Construction plant breakdown criticality analysis – part 1:UAE perspective", Benchmarking: An International Journal, 18(4), 472 – 489

2. P. B. Ahamed Mohideen, M. Ramachandran (2012) “Strategic Approach to Breakdown Maintenance on Construction Plant – UAE Perspective” (Accepted for Publication by Benchmarking: An International Journal – Scheduled for Vol.21 Iss: 2

3. P. B. Ahamed Mohideen, M. Ramachandran (2012) “Systematic Breakdown Maintenance Protocol (BMP) for Breakdown Maintenance execution to Construction Machinery - United Arab Emirates Perspective” (Under review with the International Journal of Maintenance Management)

4. P. B. Ahamed Mohideen, M. Ramachandran (2012) "Cumulative Consequential Cost Analysis for Construction Machinery Breakdowns - United Arab Emirates Perspective" (Under review with the International Journal of Construction Education and Research).

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