KEY PERFORMANCE INDICATOR (KPI)

Periode Jan-08

	EQUIP. NO	MODEL	DOWN TIME					TOTAL DOWN TIME	FREQ OF DT	SHM TOTAL
			I	II	III	IV	V			
1	A11DT01	773B/D	0	36	24	1	0	61	4	550
2	A11DT02	773B/D	126	126	126	39	0	417	5	238
3	A11DT03	773B/D	1	1	0	0	3	5	3	254
4	A11DT04	773B/D	20	8	3	8	0	39	5	424
5	A11DT05	769C	2	2	0	10	12	26	6	180
6	A11DT06	769C	0	0	0	0	0	0	0	119
7	A11DT07	769C	7	0	0	0	1	8	2	223
8	A11DT08	769C	0	0	0	0	0	0	0	244
9	A11DT10	773B/D	126	126	126	126	72	576	5	94
10	A11DT11	773B/D	30	84	1	1	8	124	7	619
11	A11DT12	773B/D	0	1	0	1	12	14	3	716
12	A11DT13	777D	0	0	2	28	0	30	3	479
13	A11DT14	777D	0	12	1	0	2	15	3	230
14	A11DT15	777D	0	108	0	3	2	113	5	508
15	A11DT16	777D	0	4	0	2	15	21	3	463

KEY PERFORMANCE INDICATOR (KPI)

Periode : Februari 2008

EQUIP. NO	MODEL	DOWN TIME					TOTAL DOWN TIME	FREQ OF DT	SHM TOTAL
		I	II	III	IV	V			
A11DT01	773B/D	0	0	0	0	0	0	0	186
A11DT02	773B/D	0	0	0	0	0	0	0	132
A11DT03	773B/D	0	0	0	1	1	2	2	128
A11DT04	773B/D	1	12	1	8	2	24	6	184
A11DT05	769C	0	82	44	1	0	127	4	51
A11DT06	769C	0	0	0	3	0	3	1	59
A11DT07	769C	0	3	0	0	0	3	2	88
A11DT08	769C	0	0	0	0	1	1	1	133
A11DT10	773B/D	54	126	126	21	13	340	6	108
A11DT11	773B/D	1	0	0	11	5	17	6	278
A11DT12	773B/D	0	0	0	3	35	38	4	314
A11DT13	777D	0	0	2	28	2	32	3	197
A11DT14	777D	0	0	1	0	0	1	1	69
A11DT15	777D	0	0	0	0	0	0	0	246
A11DT16	777D	0	0	0	0	0	0	0	198

Lampiran 1 : Data Pemeliharaan Alat Berat (Lanjutan)

KEY PERFORMANCE INDICATOR (KPI)

Periode : Maret 2008

	EQUIP. NO	MODEL	DOWN TIME						TOTAL DOWN TIME	FREQ OF DT	SHM TOTAL
			I	II	III	IV	V	VI			
1	A11DT01	773B/D	0	4	2	2	0	0	8	6	294
2	A11DT02	773B/D	0	0	0	0	0	0	0	0	0
3	A11DT03	773B/D	0	0	2	12	98	18	130	4	186
4	A11DT04	773B/D	0	16	2	102	37	0	157	6	174
5	A11DT05	769C	14	0	2	62	40	0	118	4	100
6	A11DT06	769C	0	0	0	0	0	0	0	0	0
7	A11DT07	769C	0	0	1	0	0	0	1	1	187
8	A11DT08	769C	0	0	0	0	0	0	0	0	206
9	A11DT10	773B/D	0	51	1	7	1	0	60	5	382
10	A11DT11	773B/D	0	1	9	1	1	0	12	4	443
11	A11DT12	773B/D	0	12	0	9	1	18	40	5	425
12	A11DT13	777D	0	19	3	6	80	18	126	5	296
13	A11DT14	777D	0	2	0	44	48	0	94	3	154
14	A11DT15	777D	0	0	0	4	0	0	4	1	441
15	A11DT16	777D	0	102	62	2	0	0	166	3	274

KEY PERFORMANCE INDICATOR (KPI)

Periode : April

	EQUIP. NO	MODEL	DOWN TIME					TOTAL DOWN TIME	FREQ OF DT	SHM TOTAL
			I	II	III	IV	V			
1	A11DT01	773B/D	65	126	126	126	54	497	6	37
2	A11DT02	773B/D	0	0	7	2	0	9	3	274
3	A11DT03	773B/D	94	0	0	0	0	94	2	137
4	A11DT04	773B/D	1	1	2	7	30	41	7	268
5	A11DT05	769C	0	0	0	116	36	152	2	143
6	A11DT06	769C	0	0	0	0	0	0	0	45
7	A11DT07	769C	2	0	0	2	2	6	3	255
8	A11DT08	769C	0	0	90	100	0	190	2	172
9	A11DT10	773B/D	0	0	1	72	0	73	2	351
10	A11DT11	773B/D	0	0	0	0	0	0	0	397
11	A11DT12	773B/D	108	126	54	0	0	288	3	197
12	A11DT13	777D	30	0	0	0	2	32	2	315
13	A11DT14	777D	0	12	0	0	0	12	1	138
14	A11DT15	777D	0	1	0	0	0	1	1	362
15	A11DT16	777D	12	32	26	0	2	72	4	291

Lampiran 1 : Data Pemeliharaan Alat Berat (Lanjutan)

KEY PERFORMANCE INDICATOR (KPI)

Periode : Mei

	EQUIP. NO	MODEL	DOWN TIME					TOTAL DOWN TIME	FREQ OF DT	SHM TOTAL
			I	II	III	IV	V			
1	A11DT01	773B/D	0	0	0	0	0	0	0	0
2	A11DT02	773B/D	0	24	0	0	0	24	1	409
3	A11DT03	773B/D	0	0	0	0	0	0	0	245
4	A11DT04	773B/D	72	0	20	4	40	136	9	220
5	A11DT05	769C	0	0	0	0	0	0	0	183
6	A11DT06	769C	0	3	0	0	0	3	1	88
7	A11DT07	769C	48	26	0	0	0	74	3	173
8	A11DT08	769C	0	0	0	0	0	0	0	193
9	A11DT10	773B/D	0	25	11	18	0	54	4	200
10	A11DT11	773B/D	0	0	2	2	9	13	4	409
11	A11DT12	773B/D	0	24	5	10	10	49	7	351
12	A11DT13	777D	0	5	0	0	2	7	3	407
13	A11DT14	777D	0	0	0	0	0	0	0	0
14	A11DT15	777D	0	10	0	6	1	17	3	429
15	A11DT16	777D	0	0	0	2	0	2	1	426

KEY PERFORMANCE INDICATOR (KPI)

Periode : June

EQUIP. NO	MODEL	DOWN TIME				TOTAL DOWN TIME	FREQ OF DT	SHM TOTAL
		I	II	III	IV			
A11DT01	773B/D	0	0	0	5	5	2	31
A11DT02	773B/D	0	0	0	1	1	1	327
A11DT03	773B/D	21	102	3	36	162	5	118
A11DT04	773B/D	0	0	12	126	138	2	242
A11DT05	769C	0	0	0	126	126	1	119
A11DT06	769C	0	0	1	0	1	1	104
A11DT07	769C	0	0	0	0	0	0	124
A11DT08	769C	0	0	0	0	0	0	129
A11DT10	773B/D	0	0	0	0	0	0	0
A11DT11	773B/D	5	12	0	7	24	4	307
A11DT12	773B/D	0	0	3	0	3	1	305
A11DT13	777D	2	9	30	0	41	4	103
A11DT14	777D	0	0	0	0	0	0	71
A11DT15	777D	2	1	0	0	3	2	291
A11DT16	777D	3	3	10	0	16	3	296

KEY PERFORMANCE INDICATOR (KPI)

Periode : July 2008

	EQUIP. NO	MODEL	DOWN TIME					TOTAL DOWN TIME	FREQ OF DT	SHM TOTAL
			I	II	III	IV	V			
1	A11DT01	773B/D	0	5	9	36	54	104	6	526
2	A11DT02	773B/D	5	0	6	0	0	11	2	619
3	A11DT03	773B/D	0	2	4	8	0	14	4	616
4	A11DT04	773B/D	126	126	90	8	0	350	3	280
5	A11DT05	769C	126	126	94	0	0	346	1	284
6	A11DT06	769C	0	0	0	0	9	9	1	621
7	A11DT07	769C	0	0	0	0	0	0	0	630
8	A11DT08	769C	0	0	7	13	0	20	2	610
9	A11DT10	773B/D	90	0	0	0	0	90	1	540
10	A11DT11	773B/D	7	8	2	0	28	45	5	585
11	A11DT12	773B/D	0	3	9	102	72	186	4	444
12	A11DT13	777D	90	0	0	0	0	90	1	540
13	A11DT14	777D	0	3	2	0	3	8	3	622
14	A11DT15	777D	0	17	3	0	0	20	3	610
15	A11DT16	777D	4	5	0	0	0	9	2	621

KEY PERFORMANCE INDICATOR (KPI)

Periode : Agustus 2008

	EQUIP. NO	MODEL	DOWN TIME					TOTAL DOWN TIME	FREQ OF DT	SHM TOTAL
			I	II	III	IV	V			
1	A11DT01	773B	54	126	126	126	37	469	1	33
2	A11DT02	773B	0	4	0	13	0	17	3	394
3	A11DT03	773B	0	120	18	0	0	138	1	95
4	A11DT04	773B	2	2	39	4	0	47	4	230
5	A11DT05	769C	0	0	0	3	0	3	1	125
6	A11DT06	769C	0	0	4	0	44	48	2	134
7	A11DT07	769C	0	0	18	2	0	20	3	263
8	A11DT08	769C	0	6	0	9	14	29	5	214
9	A11DT10	773D	1	0	0	3	3	7	3	381
10	A11DT11	773D	12	0	5	10	2	29	6	371
11	A11DT12	773D	2	0	0	0	14	16	3	441
12	A11DT13	777D	0	0	0	8	0	8	1	141
13	A11DT14	777D	22	0	0	0	3	25	2	340
14	A11DT15	777D	0	4	1	0	18	23	5	324
15	A11DT16	777D	2	2	2	0	0	6	3	341

Lampiran 1 : Data Pemeliharaan Alat Berat (Lanjutan)

KEY PERFORMANCE INDICATOR (KPI)

Periode : September 2008

	EQUIP. NO	MODEL	DOWN TIME					TOTAL DOWN TIME	FREQ OF DT	SHM TOTAL
			I	II	III	IV	V			
1	A11DT01	773B	10	5	24	0	0	39	6	39
2	A11DT02	773B	2	20	16	1	30	69	8	69
3	A11DT03	773B	0	0	50	1	0	51	3	51
4	A11DT04	773B	0	2	12	32	4	50	10	50
5	A11DT05	769C	12	0	0	7	0	19	2	19
6	A11DT06	769C	0	0.5	5	0	0	5.5	4	6
7	A11DT07	769C	6	0	1	2	0	9	5	9
8	A11DT08	769C	0	23	44	0	2	69	3	69
9	A11DT10	773D	10	7	0	4	0	21	6	21
10	A11DT11	773D	0	0	2	0	4	6	2	6
11	A11DT12	773D	4	116	126	126	18	390	3	390
12	A11DT13	777D	8	2	8	1	1	20	8	20
13	A11DT14	777D	2	0	13	0	0	15	3	15
14	A11DT15	777D	4	0	3	6	0	13	5	13
15	A11DT16	777D	8	12	12	6	2	40	6	40

KEY PERFORMANCE INDICATOR (KPI)

Periode : Oktober

	EQUIP. NO	MODEL	DOWN TIME					TOTAL DOWN TIME	FREQ OF DT	SHM TOTAL
			I	II	III	IV	V			
1	A11DT01	773B	1	9	0	10	4	24	5	24
2	A11DT02	773B	90	14	3	2	48	157	4	157
3	A11DT03	773B	40	126	72	48	18	304	3	304
4	A11DT04	773B	0	1	1	0	10	12	4	12
5	A11DT05	769C	0	1	9	0	4	14	4	14
6	A11DT06	769C	0	2	0	0	5	7	3	7
7	A11DT07	769C	0	2	0	0	0	2	1	2
8	A11DT08	769C	10	58	0	0	0	68	4	68
9	A11DT10	773D	0	2	0	10	40	52	4	52
10	A11DT11	773D	2	4	10	4	0	20	5	20
11	A11DT12	773D	2	0	1	8	2	13	4	13
12	A11DT13	777D	3	0	0	0	11	14	3	14
13	A11DT14	777D	0	1	3	0	0	4	2	4
14	A11DT15	777D	0	10	15	0	1	26	4	26
15	A11DT16	777D	0	2	90	126	90	308	2	308

Lampiran 1 : Data Pemeliharaan Alat Berat (Lanjutan)

KEY PERFORMANCE INDICATOR (KPI)

Periode : November

	EQUIP. NO	MODEL	DOWN TIME					TOTAL DOWN TIME	FREQ OF DT	SHM TOTAL
			I	II	III	IV	V			
1	A11DT01	773B	0	8	18	9	36	71	7	71
2	A11DT02	773B	2	0	4	2	1	9	5	9
3	A11DT03	773B	0	0	64	1	0	65	2	65
4	A11DT04	773B	2	8	14	126	126	276	5	276
5	A11DT05	769C	0	0	12	3	0	15	3	15
6	A11DT06	769C	0	0	0	0	0	0	0	0
7	A11DT07	769C	0	1	4	0	0	5	2	5
8	A11DT08	769C	0	0	0	8	0	8	1	8
9	A11DT10	773D	22	102	97	50	0	271	3	271
10	A11DT11	773D	0	3	20	14	4	41	5	41
11	A11DT12	773D	0	2	0	0	8	10	2	10
12	A11DT13	777D	1	4	10	0	6	21	6	21
13	A11DT14	777D	0	0	0	0	0	0	0	0
14	A11DT15	777D	0	9	8	1	0	18	4	18
15	A11DT16	777D	36	126	126	126	126	540	2	540

KEY PERFORMANCE INDICATOR (KPI)

Periode : December

	EQUIP. NO	MODEL	DOWN TIME				TOTAL DOWN TIME	FREQ OF DT	SHM TOTAL
			I	II	III	IV			
1	A11DT01	773B	30	0	0	4	34	2	34
2	A11DT02	773B	0	8	0	0	8	1	8
3	A11DT03	773B	12	0	22	10	44	4	44
4	A11DT04	773B	126	126	126	126	504	0	504
5	A11DT05	769C	0	0	0	0	0	0	0
6	A11DT06	769C	0	80	0	0	80	2	80
7	A11DT07	769C	0	0	0	2	2	1	2
8	A11DT08	769C	5	2	44	72	123	3	123
9	A11DT10	773D	0	0	8	8	16	2	16
10	A11DT11	773D	4	6	0	0	10	2	10
11	A11DT12	773D	29	0	0	7	36	4	36
12	A11DT13	777D	0	0	0	12	12	1	12
13	A11DT14	777D	0	4	0	0	4	1	4
14	A11DT15	777D	0	0	5	0	5	1	5
15	A11DT16	777D	126	126	126	126	504	0	504

Lampiran 2 : Kuesioner Tingkat Kepentingan

DATA RESPONDEN

1. Nama:
   ____
2. Umur:
   ____
3. Pendidikan Formal Terakhir:
   ____
4. Pengalaman Kerja (dalam tahun):
   ____
5. Jenis alat berat yang dioperasikan (truck/loader/grader/dozer):
   ____
6. No unit alat berat yang dioperasikan :
   ____

Citeureup, …...April 2009

Tanda Tangan Responden

(____________________)

PETUNJUK PENGISIAN KUESIONER

Berilah nilai skor yang paling Bapak anggap penting terkait dengan pemeliharaan alat berat yang dilaksanakan di workshop berdasarkan skala berikut ini:

5 = Kondisi yang ada dianggap **Sangat Penting**.

4 = Kondisi yang ada dianggap **Penting.**

3 = Kondisi yang ada dianggap **Sedang**.

2 = Kondisi yang ada dianggap **Kurang Penting**.

1 = Kondisi yang ada dianggap **Tidak Penting**.

CONTOH PENGISIAN KUESIONER

No.	**PENILAIAN TERHADAP TINGKAT KEPENTINGAN PEMELIHARAAN ALAT BERAT**	**Nilai Skor: 5 = Sangat Penting 4 = Penting 3 = Sedang 2 = Kurang Penting 1 = Tidak Penting**				
1	Kondisi tempat duduk operator	~~5~~	4	3	2	1
2	Kenyamanan berkendara	5	~~4~~	3	2	1
3	Respons dari teknisi terhadap laporan kerusakan	5	4	3	2	~~1~~

Kondisi tempat duduk operator terkait dengan kualitas pemeliharaannya. dianggap **Sangat Penting**

Kenyamanan berkendara terkait dengan kualitas pemeliharaannya dianggap **Penting**
.

Respons dari teknisi terhadap laporan kerusakan dari operator dianggap **Tidak Penting**.

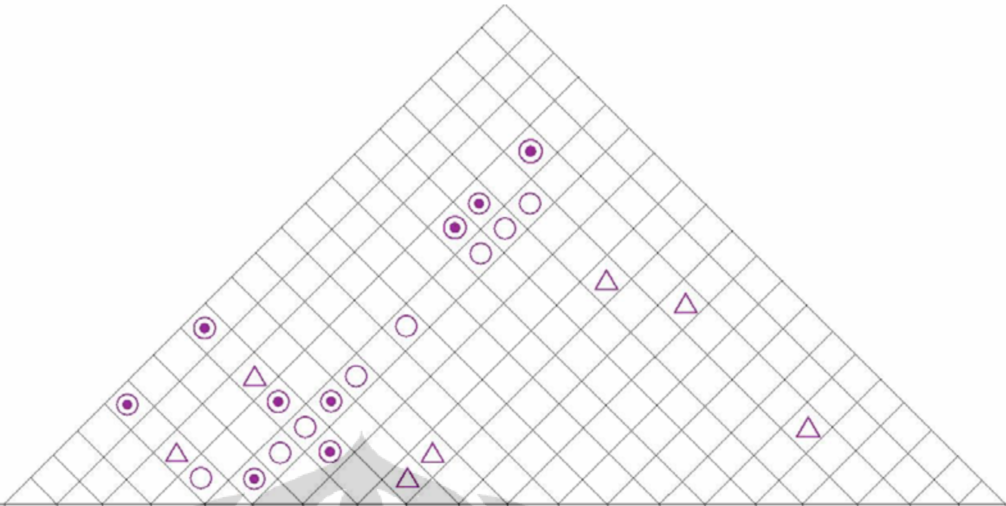
Lampiran 2 : Kuesioner Tingkat Kepentingan (Lanjutan)

No.	PENILAIAN TERHADAP TINGKAT KEPENTINGAN PEMELIHARAAN ALAT BERAT	Nilai Skor: 5 = Sangat Penting 4 = Penting 3 = Sedang 2 = Kurang Penting 1 = Tidak Penting				
1	Kondisi tempat duduk operator	5	4	3	2	1
2	Kondisi cermin / mirror	5	4	3	2	1
3	Kondisi lampu	5	4	3	2	1
4	Kondisi AC	5	4	3	2	1
5	Kondisi panel-panel di kabin operator	5	4	3	2	1
6	Kondisi gauge di kabin operator	5	4	3	2	1
7	Kondisi engine	5	4	3	2	1
8	Kondisi transmisi	5	4	3	2	1
9	Kondisi suspensi	5	4	3	2	1
10	Kondisi komponen hydraulic	5	4	3	2	1
11	Kondisi final drive	5	4	3	2	1
12	Kondisi ban	5	4	3	2	1
13	Kondisi steering	5	4	3	2	1
14	Kondisi rem	5	4	3	2	1
15	Kondisi klakson	5	4	3	2	1
16	Kondisi wiper	5	4	3	2	1
17	Kondisi emergency shutdown switch	5	4	3	2	1
18	Kondisi Alat Pemadam Api Ringan (APAR)	5	4	3	2	1
19	Penangan terhadap bolt / nut yang kendur	5	4	3	2	1
20	Penanganan terhadap adanya oli yang bocor	5	4	3	2	1
21	Kenyamanan saat berkendara	5	4	3	2	1
22	Penggunaan bahan bakar	5	4	3	2	1
23	Service (PM) secara teratur	5	4	3	2	1
24	Respon teknisi terhadap laporan kerusakan	5	4	3	2	1
25	Tingkat keahlian teknisi	5	4	3	2	1
26	Penanggulangan terhadap kerusakan yang sering terjadi / berulang - ulang.	5	4	3	2	1
27	Lainnya……….	5	4	3	2	1
28		5	4	3	2	1
29		5	4	3	2	1
30		5	4	3	2	1
31		5	4	3	2	1

Lampiran 3 : Kuesioner Tingkat Kepentingan dan Kepuasan

No.	Atribut Keinginan Pelanggan	Tingkat Kepuasan					Tingkat Kepentingan				
		TB	KB	CB	B	SB	TP	KP	CP	P	SP
1	Kondisi tempat duduk operator										
2	Kondisi cermin / mirror										
3	Kondisi lampu										
4	Kondisi AC										
5	Kondisi panel-panel di kabin operator										
6	Kondisi gauge di kabin operator										
7	Kondisi engine										
8	Kondisi transmisi										
9	Kondisi suspensi										
10	Kondisi komponen hydraulic										
11	Kondisi final drive										
12	Kondisi ban										
13	Kondisi steering										
14	Kondisi rem										
15	Kondisi klakson										
16	Kondisi wiper										
17	Kondisi emergency shutdown switch										
18	Kondisi Alat Pemadam Api Ringan (APAR)										
19	Penangan terhadap bolt / nut yang kendur										
20	Penanganan terhadap adanya oli yang bocor										
21	Kenyamanan saat berkendara										
22	Penggunaan bahan bakar										
23	Service (PM) secara teratur										
24	Respon teknisi terhadap laporan kerusakan										
25	Tingkat keahlian teknisi										
26	Penanggulangan terhadap kerusakan yang sering terjadi / berulang - ulang.										

Lampiran 4 : *House of Quality* (HOQ)



MAINTENANCE QUALITY FUNCTION DEPLOYMENT (MQFD)	Pelaksanaan pemeliharaan pencegahan	Pelaksanaan test operasional	Pelaksanaan program overhaul	Memperbaiki Proses Pemeliharaan	Melatih staff pemeliharaan	Pelaksanaan pemeriksaan harian	Pengunduhan Electronic Technician (ET)	Membersihkan mesin secara teratur	Pelaksanaan Technical Analysis (TA)	Memeriksa sample oli	Penggunaan suku cadang asli	Pelaksanaan program PCR	Pengunduhan Payload Management System	Penyetelan suspensi	Penyetelan valve engine	Pelaksanaan preload bearing	Memeriksa sample coolan radiator	Penggunaan bahan bakar yang berkualitas	Penggunaan tempat duduk yang ergonomis	Pengunaan lampu halloger	TINGKAT KEPUASAN PELANGGAN
Nilai Korelasi Teknis	88	22	35	147	58	42	38	34	56	36	14	21	19	23	27	20	33	11	0	0	
	HOWs																				
	OEE																				
WHATs																					
Tempat duduk yang rusak	⊙	⊙	△	△															⊙		44
Cermin yang rusak / pecah	⊙	⊙	△	△																	45
Lampu yang kurang terang / tidak berfungsi	⊙	⊙	△	○	○				△		△	△								⊙	41
AC yang rusak / tidak dingin	⊙	⊙	△	○	○				△		△	△									42
Panel yang tidak berfungsi	⊙	⊙	△	○	○				△		△	△									47
Gauge yang tidak berfungsi	⊙	⊙	△	○	○				△		△	△									41
Engine yang bermasalah	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙		⊙		⊙	⊙			33
Transmisi yang bermasalah	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙								37
Suspensi yang bermasalah	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	⊙	⊙	○	⊙	⊙							43
Komponen hydraulic yang rusak	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙									34
Final drive yang bermasalah	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	⊙	⊙	○				⊙					40
Ban yang bermasalah	⊙	⊙	⊙	⊙	⊙	⊙		○	△		△		⊙								45
Steering yang bermasalah	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙									35
Rem yang tidak berfungsi	⊙	⊙	⊙	⊙	⊙		⊙	○	⊙	⊙	⊙	⊙	⊙								38
Klakson yang tidak berfungsi	⊙	⊙	⊙	○	○				△		△	△									44
Wiper yang kurang baik	⊙	⊙	⊙	○	○			○	△		△	△									48
Saklar darurat yang tidak berfungsi	⊙	⊙	⊙	○	○		⊙		△		△	△									44
APAR yang rusak / tidak tersedia	⊙	⊙	⊙	○	○	⊙					△	△									37
Bolt / nut sering kendur / hilang	⊙	⊙	⊙	⊙	○	⊙		○	△			△									38
Oli yang bocor	⊙	⊙	⊙	⊙	○	⊙		○	○			△									47
Punggung yang sakit jika mengoperasikan al terus-menerus														⊙					⊙		47
Penggunaan bahan bakar yang boros	⊙		⊙	⊙	○	○	⊙		○	○	○	○	⊙		⊙		○	⊙			33
Tidak melasanakan PM secara teratur	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙		⊙	⊙	⊙	⊙	⊙	⊙				32
Respon yang lama terhadap adanya laporan kerusakan	○			⊙	○	⊙															40
Memerlukan waktu yang lama untuk memperbaiki kerusakan	○			⊙	⊙	○	○	○	○	○		△	○	○	○	○	○				34
Sering memperbaiki kerusakan yang sama secara berulang-ulang	⊙	△	⊙	⊙	⊙	⊙	○	○	⊙	△	△	△	○	○	○	○	△	△			44
Nilai Customer Technical Interactive (CTI)	8610	7739	6308	6278	5241	4746	3555	3168	3156	3014	2872	2736	2583	1332	1116	882	877	638	819	369	

The Implementation of Maintenance Quality Function Deployment (MQFD) for Improving Maintenance Quality at Mining Industry

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Abstract

The heavy equipment has an important role to support the mining industry activity. The heavy equipment will operating well if maintained properly. Good maintenance relate with the election of the maintenance strategy. Maintenance Quality Function Deployment (MQFD) is a model that introduced by Pramod et. al. to improve maintenance quality through the strategic decision development. The strategic decision developed based on the voice of customer, eight pillars of Total Productive Maintenance (TPM) and the maintenance parameters on TPM. The voice of customer is gathered by spreading the survey and used to determine the priority of the maintenance quality aspect. The prioritized voice of customer then translated into technical language which will be implemented by the workshop to improve the maintenance quality based on eight pillars of TPM. Both of maintenance quality aspect and technical language are generated by the development of House of Quality (HOQ) that usually used in Quality Function Deployment (QFD) method. The TPM's maintenance parameters used as an indicator to measure the performance of the strategy implementation. The indicator make the MQFD model has the ability to develop the maintenance quality continuous improvement.

***Key Words** : Heavy equipment, maintenance strategy, Maintenance Quality Function Deployment (MQFD), Total Productive Maintenance (TPM), House of Quality (HOQ)*

1. Introduction

At mining industry, maintenance is an important issue. It's due to the majority of mining industry activities using mechanical devices to support it, so that the production activity depend on the availability of the mechanical devices. One of the important mechanical device at the mining industry is the heavy equipment. Most of the activity at mining industry using the heavy equipment.

To guarantee the availability of the heavy equipment, good maintenance strategy is a must. But it's not an easy matter to have good maintenance practise at mining industry due to its high utilization & mobilitation. Beside that, heavy equipment has high sensitivity to operational abuse so that the operator skill has big influence to determine the heavy equipment condition. That's why the responsibility to the heavy equipment health not only on the maintenance crew, but also on the operator that using the heavy equipment.

By the developing of the industrial world, the organizations choosing to focus on its core business and outsourcing another area outscope their core business. It's also happened at the mining industry. This condition force the company to have good communication and coorperation between all organization involved on their business.

The implementation of Maintenance Quality Function Deployment (MQFD) model at the mining industry expected can improve the quality of maintenance and also the coorperation and communication between the maintenance crew and the heavy equipment operator through the existing customer voice.

The objective of this research is to get the maintenance strategy that can improve the maintenance quality and the productivity of heavy equipment based on voice of customer by implementing the Maintenance Quality Function Deployment (MQFD) model.

2. Basic Theory

The MQFD model was introduced at the first time by Pramod, Devadasan, Muthu, Jagathyraj & Moorthy on 2006 through a journal

"*Integrating TPM and QFD for improving quality in maintenance engineering*". The MQFD model is an integrating method of QFD and TPM. The integration of these two method expected can improve the maintenance quality and also accomadate the VOC both of internal and external customer comparing the existing maintenance method. Figure 1 is a MQFD model that introduced by Pramod et.al.

From the MQFD model at figure 1, the company performance can be known from the customer voice. The customer voice is used to develop the house of quality (HOQ). The result of QFD is the technical language that will be delivered to top management to make the strategic decision. The technical languages which are concerned with enhancing maintenance quality are strategically directed by the top management for progressing through the eight TPM pillars. The TPM characteristics developed through the development of eight pillars are fed into the production system. This implementation shall be focussed on the increasing of the maintenance quality parameters' values that are availability, Mean Time To Repair (MTTR), Mean Time Between Failure (MTBF), Mean Down Time (MDT) dan Overall Equipment Effectiveness (OEE).

The results of this implementation then used to develop another HOQ by comparing it with the decided target. This process will form the new cycle of MQFD model.

3. Data Collection and Calculation

The data was collected at a mining company on Bogor, West Java. The data consist of production data, heavy equipment maintenance history and the respondent's satisfaction level of maintenance quality at workshop.

The maintenance history data calculated based on the maintenance parameters of Total Productive Maintenance (TPM).

Availabilty is a measure of what percentage of the total time the heavy equipment is available for used. *Availabilty* (A) calculated using the formula:

$$A = \frac{ScheduledRunningTime - Downtime}{ScheduledRunningTime} x100\%$$

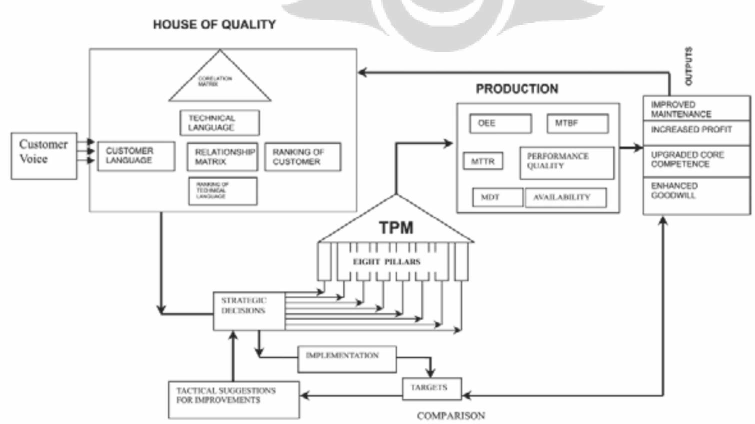
Mean Down Time (MDT) is the average down time of the heavy equipment. MDT calculated using the formula:

$$MDT = \frac{TotalDowntime}{FrekuensiDownTime}$$

Mean Time Beetween Failures (MTBF) is the average time a heavy equipment would run trouble-free before experiencing any sort of failure. MTBF calculated using the formula:

$$MTBF = \frac{TimeBetweenFailure}{NumberofFailure}$$

Mean Time To Repair (MTTR) is the average time taken to repair once it is brought into service.



Source : *Journal of Quality in Maintenance Engineering*,Vol. 13 No.4, 2007, p. 340 – 343

Figure 1.
MQFD Model

MTTR calculated using the formula:

$$MTTR = \frac{Total\ Repair\ Time}{Number\ of\ Repair}$$

At the workshop which this research took place, *Mean Time To Repair* (MTTR) equal to *Mean Down Time* (MDT).

OEE is the important parameter to measure the success of TPM implementation. To get OEE, it's need to calculate the *Availability* (A), *Performance Efficiency* (P) and *Rate of Quality* (Q) first. OEE calculated using the formula:

OEE = A x P x Q

where :

$$A = \frac{Scheduled Running Time - Downtime}{Scheduled Running Time} x100\%$$

$$P = \frac{Processed Amount}{Operating Time / Theoritical Cycle Time} x100\%$$

$$Q = \frac{Processed Amount - Defect Amount}{Processed Amount} x100\%$$

4. The Result of Research

Maintenance Quality Function Deployment (MQFD) model consist of two big step of design. The design of HOQ started by determining the priority of the attributes. The maintenance quality attributes were obtained from the direct interviewing of workshop superintendent and dealer maintenance supervisor. The determining of attribute priority calculated based on the weighting of 15 operators' assessment to the maintenance quality aspects on the workshop. The total score is obtained from the answer of each maintenance quality aspects that calculated using the formula:

Total Score = *(N1 x 5) + (N2 x 4) + (N3 x 3) + (N4 x 2) + (N5 x 1)*

where :

N1 = Number of "not good " answer
N2 = Number of "little not good "
N3 = Number of "fair"
N4 = Number of "good "
N5 = Number of "very good "

As a sample, the priority score of "the operator seat condition" is:

The operator seat condition = (0x5) + (6x4) + (3x3) + (5x2) + (1x1) = 44.

With the same way, it can be determined the priority score for the other aspects which can be seen in table 1.

Table 1. The Priority Score of Maintenance Aspects

No.	Suara Pelanggan	Score	Urutan Prioritas
1	Kondisi tempat duduk operator	44	4
2	Kondisi cermin / mirror	45	3
3	Kondisi lampu	41	7
4	Kondisi AC	42	6
5	Kondisi panel-panel di kabin operator	47	2
6	Kondisi gauge di kabin operator	41	7
7	Kondisi engine	33	13
8	Kondisi transmisi	37	10
9	Kondisi suspensi	43	5
10	Kondisi komponen hydraulic	34	12
11	Kondisi final drive	40	8
12	Kondisi ban	45	3
13	Kondisi steering	35	11
14	Kondisi rem	38	9
15	Kondisi klakson	44	4
16	Kondisi wiper	48	1
17	Kondisi emergency shutdown switch	44	4
18	Kondisi Alat Pemadam Api Ringan (APAR)	37	10
19	Penangan terhadap bolt / nut yang kendur	38	9
20	Penanganan terhadap adanya oli yang bocor	47	2
21	Kenyamanan saat berkendara	47	2
22	Penggunaan bahan bakar	33	13
23	Service (PM) secara teratur	32	14
24	Respon teknisi terhadap laporan kerusakan	40	8
25	Tingkat keahlian teknisi	34	12
26	Penanggulangan terhadap kerusakan yang sering terjadi / berulang - ulang.	44	4

Based on the calculation result that can be seen in table 1, the maintenance quality aspects with the score ≥ 47 are:

1. Wiper condition
2. Panels on operator cabin condition
3. The oil leaking handling
4. The driving comfortable

The next step of the HOQ design is to determine the technical language at the vertical side of House of Quality. The technical language is a planning action or activity that will be implement to improve the maintenance quality of heavy equipment at the workshop. The technical language were determined based on the data that obtained from the interviewing of workshop superintendent, recommendation from the heavy equipment dealer maintenance supervisor and some reference. This technical language also considering the eight pillars of TPM.

List of the technical languages are:

1. The Technical Analysis (TA)
   Technical Analysis (TA) is an inspection and measurement program to asses the pressure, temperature, cycle time and components speed.
2. Using the original spare parts
   Always buy the original spare parts like filter, oil and another component only from the heavy equipment dealer.
3. Using the quality of fuel
   Fuel that will used has a recommendation from the heavy equipment dealer.
4. Daily Inspection
   Perform daily inspection to check the oil leaking, loosen bolt, condition of components visually, tyre pressure, greasing and oil level checking.
5. Oil Sampling
   Oil sampling performed at 100 hours before the preventive maintenance execution.
6. Coolant Radiator Sampling
   Coolant radiator sampling is to detect the possibility of damage on engine or cooling system.
7. Operational Test
   Before operating the heavy equipment, the operator must check the condition of panels on the dashboard, gauges indicator, AC, wiper, klakson performance, operator seat, mirror, lamp, emergency shutdown switch and braking performance.
8. Usage of Hallogen lamp
   The usage of Hallogen lamp is meant to make operator can see clearer at night, so that the potency of accident during working smaller.
9. Train the maintenance staff
   Every six month or when buying the new aqquipment, heavy equipment dealer have to give training about procedure of heavy equipment maintenance and also introduction to the new heavy equipment operational system, especially for the main activator components.
10. Execution of PCR (*Planned Component Replacement*) Program.
    PCR program executed when the age of component reach a half of the life time usage of equipment, which is 6.000 hours..
11. Usage of ergonomis seat
    Usage of ergonomis seat is intended to make operator do not be tired quickly and more comfortable when operating the heavy equipment.
12. Cleaning machine regularly
    Cleaning machine conducted regularly by operator shift 1 so that the risk of dirt contamination come in to the heavy equipment system and destroy heavy equipment become lower.
13. Execution of *overhaul* program
    Overhaul program is maintenance program at the time heavy equipment has entered its one life cycle that is 12.000 hours.
14. Execution of *preventive maintenance*
    Execution of PM conducted after equipment have operated for 250 hours. oli replacement, filter and repairement that have been scheduled in backlog are conducted when doing preventive maintanance.
15. Downloading *Electronic Technician* (ET)
    Electronic Technician (ET) is a software that available to record the healthy parameter of heavy equipment during its operation.
16. Improvement maintenance process
    Every 6 months, maintenance process that have been conducted is reviewed. This review conducted after the training that has been given by heavy equipment dealer.
17. Downloading *truck payload management system* (TPMS)
    In heavy equipment there is a software called *truck payload management system* (TPMS). the function of TPMS is to record burden level brought by heavy equipment, therefore we know whether it is overload or not
18. Suspension setting
    Suspension setting conducted every heavy equipment has operated for 1000 hours to avoid suspension damage.

19. Execution of *preload bearing*

Preload bearing is setting conducted every 2000 hours heavy equipment operation at final drive component to avoid earlier wear caused by friction occurred at gear and others component in final drive.

20. Valve engine setting

Valve engine setting conducted every 2000 hours heavy equipment operation.

After obtaining technical language, the next step is determine the relationship matrix between technical language and customer desire, correlation matrix among technical language, and assess total normalization value. nilai normalisasi total. *Relationship matrix* is calculated to obtain the *Customer Technical Interactive* (CTI) value, while *correlation matrix* is calculated to obtain *Technical Correlation Value* (TCV). To get this values, the existing relationship divided in to three type that is :

1. Strong relationship (Θ)
   In its calculation is given by value 9.
2. Moderate relationship (O)
   In its calculation is given by value 3.
3. Weak relationship (Δ)
   In its calculation is given by value 1.

CTI score is a measurement to know the relationship between technical language and customer desire. CTI value calculation used as follow :

CTI value = $\sum_{i=1}^{n}$ Relationship value x customer desire value

where n : amount of customer

For example, CTI value for "good quality of fuel usage"
= (9X33) + (9x33) + (1x44) = 638

In order to obtain relative weight of CTI value, the calculation used is as follow :

$$\text{Relative weight of CTI} = \frac{CTIvalue}{\sum CTIvalue} x100\%$$

For example, CTI relative weight for technical languange "good quality of fuel usage" = (638 / 66039) x 100 % = 0,97 %

TCV value is assessment of correlation matrix among technical language. TVC calculation used is as follow :

TCV value = $\sum_{i=1}^{n}$ Correlation value

Where n : amount of technical languange

For example, TCV value for "good quality of fuel usage"
= 1 + 9 + 1 = 11

To obtain relative weight of TVC value, calculation used is as follow :

$$\text{TCV relative weight} = \frac{Technicalcorrelationvalue}{\sum Technicalcorrelationvalue} x100\%$$

For example, relative weight of TCV for technical language " good quality of fuel usage"
= (11 / 724) x 100 % = 1,52 %

Total normalization value is sum of relative weight of CTI and relative weight of TCV. This value will be utilized to arrange priority of technical language that will be implemented in order to fulfill customer desire. For example, total normalization value to technical language "good quality of fuel usage"
= 0,97 % + 1,52 % = 2,49 %

By the same calculatiuon can be obtained CTI value, TCV and total normalization value for other technical language, as seen in table 2. Then these value are input in to the *House of Quality* (HoQ) as seen in Figure 2.

From table 2 can be known the technical language that very influencing the attribute based on total normalization value sequences, that is :

1. Improvement of maintenance process
2. Execution of preventive maintenance
3. Train maintenance staff
4. Execute operational test
5. Execute overhaul program

In order to measure efficacy of technical language implementation as a strategic decision hence in MQFD model measurement is focused at improvement of maintenance quality parameter in TPM, that is *availability*, *Mean Time To Repair* (MTTR), *Mean Time Between Failure* (MTBF), *Mean Down Time* (MDT) and *Overall Equipment Effectiveness* (OEE). From maintenance data processing result that has been done previously, the parameters as seen in table 3 obtained.

Table 2. Technical information value

No.	Deskripsi Bahasa Teknis	Nilai CTI	Bobot Relatif CTI	Nilai TCV	Bobot Relatif TCV	Nlai Normalisasi Total
1	Pelaksanaan Technical Analysis (TA)	3156	20.04%	56	20.44%	40.48%
2	Penggunaan suku cadang asli	2872	18.24%	14	5.11%	23.35%
3	Penggunaan bahan bakar yang berkualitas	638	4.05%	11	4.01%	8.07%
4	Pelaksanaan pemeriksaan harian	4746	30.14%	42	15.33%	45.47%
5	Memeriksa sampel oli	3014	19.14%	36	13.14%	32.28%
6	Memeriksa sampel coolant radiator	877	5.57%	33	12.04%	17.61%
7	Pelaksanaan test operasional	7739	49.15%	22	8.03%	57.18%
8	Pengunaan lampu hallogen	369	2.34%	0	0.00%	2.34%
9	Melatih staff pemeliharaan	5241	33.28%	58	21.17%	54.45%
10	Pelaksanaan program PCR	2736	17.38%	21	7.66%	25.04%
11	Penggunaan tempat duduk yang ergonomis	819	5.20%	0	0.00%	5.20%
12	Membersihkan mesin secara teratur	3168	20.12%	34	12.41%	32.53%
13	Pelaksanaan program overhaul	6308	40.06%	35	12.77%	52.83%
14	Pelaksanaan pemeliharaan pencegahan	8610	54.68%	88	32.12%	86.80%
15	Pengunduhan Electronic Technician (ET)	3555	22.58%	38	13.87%	36.45%
16	Memperbaiki Proses Pemeliharaan	6278	39.87%	147	53.65%	93.52%
17	Pengunduhan TPMS	2583	16.40%	19	6.93%	23.34%
18	Penyetelan suspensi	1332	8.46%	23	8.39%	16.85%
19	Pelaksanaan preload bearing	882	5.60%	20	7.30%	12.90%
20	Penyetelan valve engine	1116	7.09%	27	9.85%	16.94%

Table 3. Equipment Maintenance Performace

No. Alat	Model	% *Availability*	MDT (jam)	MTBF (jam)	% OEE
A11DT01	773B/D	80,16	24,09	97,30	28,91
A11DT02	773B/D	88,57	20,63	159,81	31,95
A11DT03	773B/D	80,75	29,68	124,52	29,13
A11DT04	773B/D	70,16	29,08	68,37	25,31
A11DT05	769C	77,44	32,62	111,96	22,82
A11DT06	769C	96,96	9,21	293,91	28,57
A11DT07	769C	96,19	5,65	142,89	28,35
A11DT08	769C	90,91	22,09	220,93	26,79
A11DT10	773B/D	75,12	35,85	108,25	23,60
A11DT11	773B/D	94,78	6,69	121,51	29,78
A11DT12	773B/D	83,18	25,19	124,59	26,13
A11DT13	777D	91,31	8,58	90,08	37,07
A11DT14	777D	94,41	8,90	150,32	38,33
A11DT15	777D	96,59	6,94	196,81	39,22
A11DT16	777D	70,41	34,43	81,91	28,58

From table 3 can be seen that each equipment has OEE value relatively lower therefore by implementing technical language which has been formulated previously, expected maintenance quality parameters can be increased. This parameters will be evaluated continuously and in this evaluation process, the new HoQs will be made till wanted parameter value are obtained. This is the benefit of MQFD model which able to be made as continuous improvement tool and involve all the existing stake holder.

5. Conclusion

Based on análisis resolt of maintenance parameter in TPM, known that heavy equipment performance in Workshops still need to be increased. By paying attention at *voice of customer* known that there are 26 attribute of *customer requirement* for effort of heavy equipment maintenance quality improvement in Workshops.

Maintenance quality aspect which must become priority alternately is wiper condition, panels in operator cabin condition, handling to existence of leaky oil, freshment Turing driving. While technical languange which very influencing attribute base on total normalisation value alternately is improvement of maintenance process, Execution of maintenance preventive, train maintenance staff, execute operacional test, and execute overhaul program.

Analysis result of MQFD model can be implemented as activity plan where its implementation in order to improvè maintenance quality and company benefits (reduction in maintenance cost) and improvè the competency of involved employer, have to be made as a priority.

Reference:

[1] Pramod et al. (2006). Integrating TPM and QFD for improving quality in maintenance engineering. *Journal of Quality in Maintenance Engineering*, Vol. 12 No.2, p. 151.

[2] Ahmed, S., Hassan, M.H. and Taha, Z. (2005). TPM can go beyond maintenance : except from a case implementation. *Journal of Quality in Maintenance Engineering*, Vol. 11 No.1, p.19-42.

[3] Seth,D. and Tripathi, D. (2005). Relationship between TQM and TPM

implementation factors and business performance of manufacturing industry in Indian contrast. *International Journal of Quality & Reliability Management*, Vol.22 No.3, p.256-277.

[4] Fung, R.Y.K., Law, D.S.T. and Ip, W.H. (1999). Design targets determination for inter-department product attributes in QFD using fuzzy interference. *Integrated Manufacturing Systems*, Vol.10 No.6, p.376-387.

[5] Zairi, M. and Youssef, M.A. (1998). Quality Function Deployment : a main pillar for successful total quality management and product development. *International Journal of Quality & Reliability Management*, Vol.12 No.6, p.9-23.

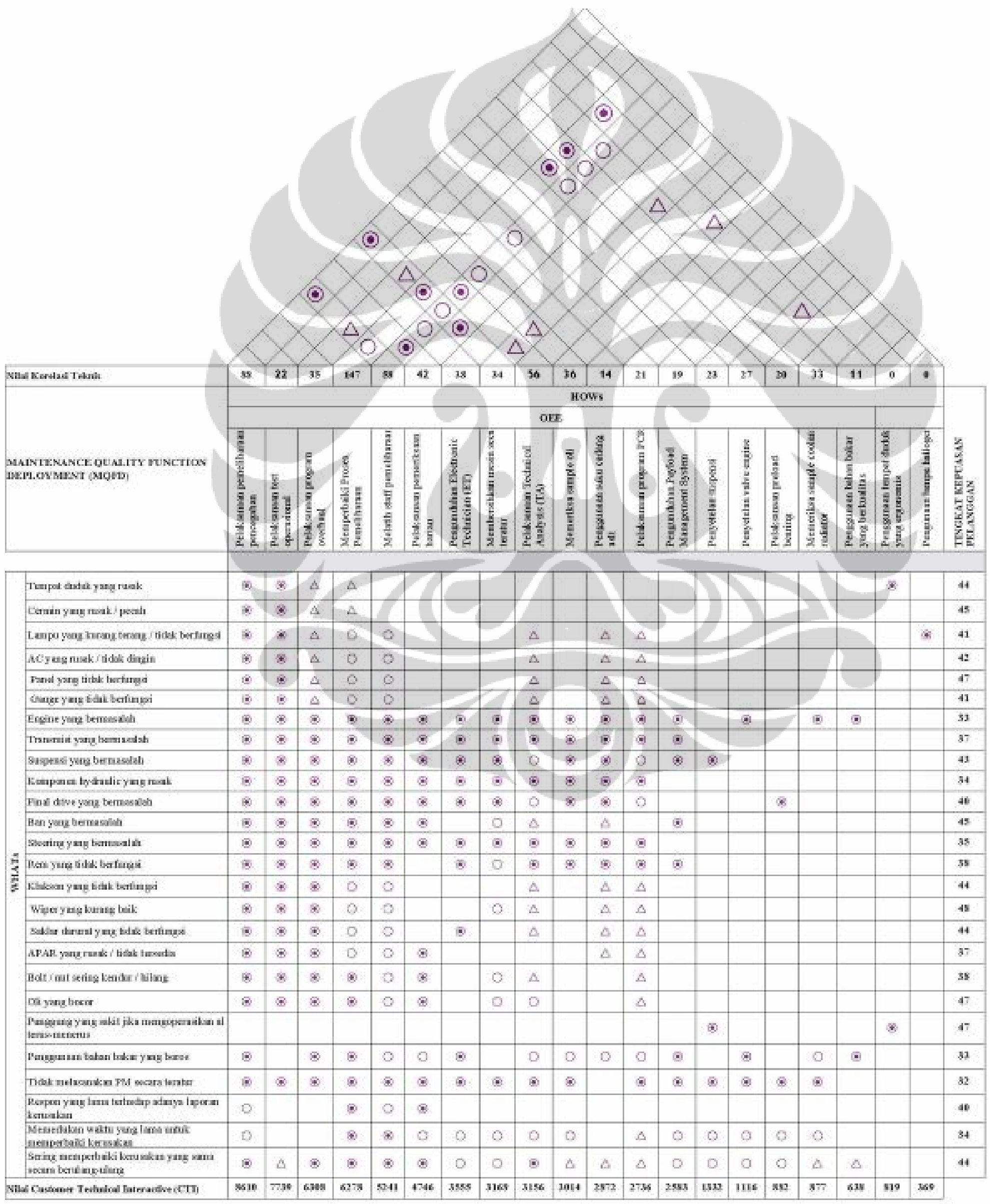


Figure 2.
House of Quality (HoQ)