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APPENDICES

APPENDIX A

SUGGESTED PFMEA SEVERITY EVALUATION CRITERIA TABLE

PROCESS FMEA

Table 6. Suggested PFMEA Severity Evaluation Criteria

Effect	Criteria: Severity of Effect This ranking results when a potential failure mode results in a final customer and/or a manufacturing/assembly plant defect. The final customer should always be considered first. If both occur, use the higher of the two severities. (Customer Effect)	Criteria: Severity of Effect This ranking results when a potential failure mode results in a final customer and/or a manufacturing/assembly plant defect. The final customer should always be considered first. If both occur, use the higher of the two severities. (Manufacturing/ Assembly Effect)	Ranking
Hazardous without warning	Very high severity ranking when a potential failure mode affects safe vehicle operation and/or involves noncompliance with government regulation without warning.	Or may endanger operator (machine or assembly) without warning.	10
Hazardous with warning	Very high severity ranking when a potential failure mode affects safe vehicle operation and/or involves noncompliance with government regulation with warning.	Or may endanger operator (machine or assembly) with warning.	9
Very High	Vehicle/Item inoperable (loss of primary function).	Or 100% of product may have to be scrapped, or vehicle/item repaired in repair department with a repair time greater than one hour.	8
High	Vehicle/Item operable but at a reduced level of performance. Customer very dissatisfied.	Or product may have to be sorted and a portion (less than 100%) scrapped, or vehicle/item repaired in repair department with a repair time between a half-hour and an hour.	7
Moderate	Vehicle/item operable but Comfort/ Convenience item(s) inoperable. Customer dissatisfied.	Or a portion (less than 100%) of the product may have to scrapped with no sorting, or vehicle/item repaired in repair department with a repair time less than a half-hour.	6
Low	Vehicle/Item operable but Comfort/ Convenience item(s) operable at a reduced level of performance.	Or 100% of product may have to be reworked, or vehicle/item repaired off-line but does not go to repair department.	5
Very Low	Fit and Finish/Squeak and Rattle item does not conform. Defect noticed by most customers (greater than 75%).	Or the product may have to be sorted, with no scrap, and a portion (less than 100%) reworked.	4
Minor	Fit and Finish/Squeak and Rattle item does not conform. Defect noticed by 50% of customers.	Or a portion (less than 100%) of the product may have to be reworked, with no scrap, on-line but out-of-station.	3
Very Minor	Fit and Finish/Squeak and Rattle item does not conform. Defect noticed by discriminating customers (less than 25%).	Or a portion (less than 100%) of the product may have to be reworked, with no scrap, on-line but in-station.	2
None	No discernible effect.	Or slight inconvenience to operation or operator, or no effect.	1

Source: General Motors Corporation (2001)

APPENDIX B

SUGGESTED PFMEA OCCURRENCE EVALUATION CRITERIA TABLE

PROCESS FMEA

Table 7. Suggested PFMEA Occurrence Evaluation Criteria

Probability	Likely Failure Rates*	Ranking
Very High: Persistent Failures	≥ 100 per thousand pieces	10
	50 per thousand pieces	9
High: Frequent Failures	20 per thousand pieces	8
	10 per thousand pieces	7
Moderate: Occasional Failures	5 per thousand pieces	6
	2 per thousand pieces	5
	1 per thousand pieces	4
Low: Relatively Few Failures	0.5 per thousand pieces	3
	0.1 per thousand pieces	2
Remote: Failure is Unlikely	≤ 0.01 per thousand pieces	1

Source: General Motors Corporation (2001)

APPENDIX C

SUGGESTED PFMEA DETECTION EVALUATION CRITERIA TABLE

TABLE 8. Suggested PFMEA Detection Evaluation Criteria

Detection	Criteria	Inspection Types			Suggested Range of Detection Methods	Ranking
		A	B	C		
Almost Impossible	Absolute certainty of non-detection.			X	Cannot detect or is not checked.	10
Very Remote	Controls will probably not detect.			X	Control is achieved with indirect or random checks only.	9
Remote	Controls have poor chance of detection.			X	Control is achieved with visual inspection only.	8
Very Low	Controls have poor chance of detection.			X	Control is achieved with double visual inspection only.	7
Low	Controls may detect.		X	X	Control is achieved with charting methods, such as SPC (Statistical Process Control).	6
Moderate	Controls may detect.		X		Control is based on variable gauging after parts have left the station, or Go/No Go gauging performed on 100% of the parts after parts have left the station.	5
Moderately High	Controls have a good chance to detect.	X	X		Error detection in subsequent operations, OR gauging performed on setup and first-piece check (for set-up causes only).	4
High	Controls have a good chance to detect.	X	X		Error detection in-station, or error detection in subsequent operations by multiple layers of acceptance: supply, select, install, verify. Cannot accept discrepant part.	3
Very High	Controls almost certain to detect.	X	X		Error detection in-station (automatic gauging with automatic stop feature). Cannot pass discrepant part.	2
Very High	Controls certain to detect.	X			Discrepant parts cannot be made because item has been error-proofed by process/product design.	1

Inspection Types:
- A. Error-proofed
- B. Gauging
- C. Manual Inspection

Source: General Motors Corporation (2001)

APPENDIX D

STANDARD FORM FOR PROCESS FMEA

STANDARD FORM FOR PROCESS FMEA

POTENTIAL
FAILURE MODE AND EFFECTS ANALYSIS
(PROCESS FMEA)

FMEA Number ____________

Item ____________ Process Responsibility ____________ Page ______ of ______

Model Year(s)/Vehicle(s) ____________ Key Date ____________ Prepared By ____________

FMEA Date (Orig.) ____________ (Rev.) ____________

Core Team ____________

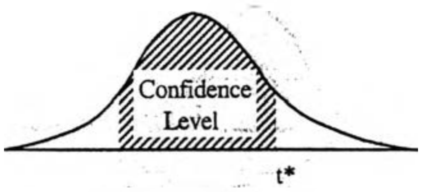
Process Function / Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Class	Potential Cause(s)/ Mechanism(s) of Failure	Occur	Current Process Controls - Prevention - Detection	Detec	R.P.N.	Recommended Action(s)	Responsibility & Target Completion Date	Action Results: Actions Taken	Sev	Occ	Det	R.P.N.

Source: General Motors Corporation (2001)

APPENDIX E

t-STATISTIC TABLE

Two-Sided Student's t-Statistic



Degrees of Freedom	Confidence Level 90%	95%	99%
1	6.314	12.706	63.656
2	2.920	4.303	9.925
3	2.353	3.182	5.841
4	2.132	2.776	4.604
5	2.015	2.571	4.032
6	1.943	2.447	3.707
7	1.895	2.365	3.499
8	1.860	2.306	3.355
9	1.833	2.262	3.250
10	1.812	2.228	3.169
11	1.796	2.201	3.106
12	1.782	2.179	3.055
13	1.771	2.160	3.012
14	1.761	2.145	2.977
15	1.753	2.131	2.947
16	1.746	2.120	2.921
17	1.740	2.110	2.898
18	1.734	2.101	2.878
19	1.729	2.093	2.861
20	1.725	2.086	2.845
21	1.721	2.080	2.831
22	1.717	2.074	2.819
23	1.714	2.069	2.807
24	1.711	2.064	2.797
25	1.708	2.060	2.787
26	1.706	2.056	2.779
27	1.703	2.052	2.771
28	1.701	2.048	2.763
29	1.699	2.045	2.756
30	1.697	2.042	2.750
40	1.684	2.021	2.704
60	1.671	2.000	2.660
120	1.658	1.980	2.617
∞	1.645	1.960	2.576

Table entries generated with TINV function in Excel

Source: John Lawson, John Erjavec (2001)

APPENDIX F

F-DISTRIBUTION TABLE

Upper 5% Points of F-Distribution with υ_1 and υ_2 Degrees of Freedom

	υ_1																	
υ_2	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120
1	161.5	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	246.0	248.0	249.0	250.1	251.1	252.2	253.2
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45	19.45	19.46	19.47	19.48	19.49
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.15	2.07	1.99	1.95	1.90	1.85	1.80	1.75
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.13	2.06	1.97	1.93	1.88	1.84	1.79	1.73
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77	1.71
28	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.10	2.03	1.94	1.90	1.85	1.81	1.75	1.70
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47
120	3.92	3.07	2.68	2.45	2.29	2.18	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22

Table entries generated with FINV function in Excel

Source: John Lawson, John Erjavec (2001)

BIOGRAPHY

Mister Sunya Sirichanyakul was born on 16 August 1974 in Bangkok, Thailand. In 1997, he has obtained his Bachelor's Degree in Electrical Engineering from Assumption University. Five year after working in the factory, he continued his Master Degree in Engineering Management at Regional Centre for Manufacturing System Engineering (RCMSE), Chulalongkorn University and University of Warwick.