Test Report For:

COMPANYNAME

Failure Mode Verification Test (FMVT®)
on
Door system

Client PO:

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Test Name	Failure Mode Verification Test (FMVT®)
Test Classification	Comparison Testing
Requester	Client
Part Description	Reference door and New Design door.

DATE RECEIVED: **4/14/2004**
DATES TESTED: **4/14/2004**

DESCRIPTION OF SAMPLES:

A Reference door system
New Design door system

NOTE: The data in this EXAMPLE has been drawn from real tests and modified to protect the confidentiality of our clients. The data should not be construed as been valid for any particular product but is representative of real data from real projects.

OBJECTIVE:

To identify potential failure modes of the part/system and to differentiate the relative durability of the new door vs the reference door using Failure Mode Verification Test Methodology (FMVT®).

Failure Mode Verification Testing or FMVT® is a patented process that incorporates accelerated testing techniques to find failures in test subjects or specimens. The objective is to quickly evaluate design concepts, compare competing designs and/or to track real world failures such as warranty. Utilizing FMVT, the design inherent weaknesses and technological limits are determined in order to allow for fast design change turn around.

The process begins by identifying failure modes or potential failure modes of the design. These failure modes are normally caused by environmental stimuli such as temperature, vibration, humidity, mechanical actuation, electrical exposure, etc.

Once defined, these environments are then combined and modified in incremental steps. Each step is harsher than the last and will drive the test subject to its eventual limits. By recording failures and times of failures from the beginning to the end of the test, it is then possible to determine the state of the design relative to its Design Maturity (DM) level.

WORK REQUESTED APPLICABLE DOCUMENTS:

FMVT® with the stress source and operational checks as described in this report. This information is provided in **Appendix A** of this report.

SPECIFIC STRESS SOURCES:

The stress sources within the FMVT on the part/system included:

Figure 1 Voltage, Sag, Swell

Figure 2: Temperature Hot, Cold, Humidity

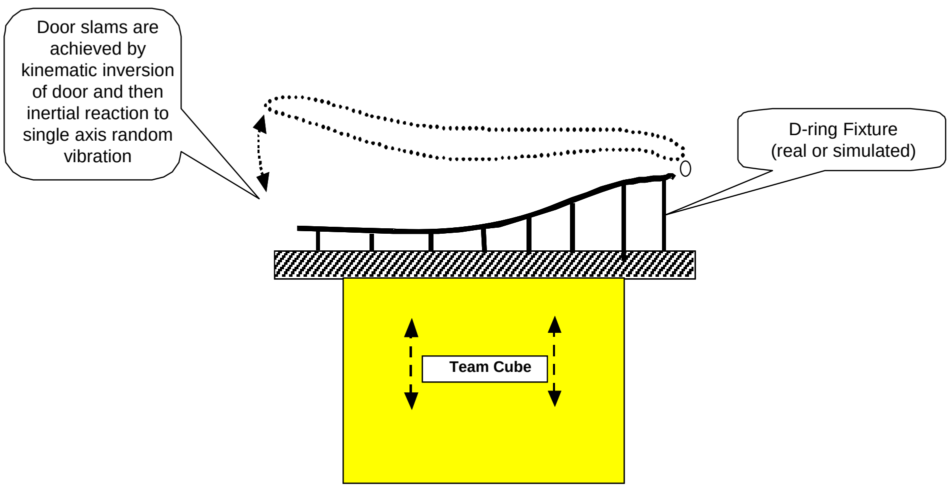

Figure 3: Door System on Shaker

TEST PLAN:

Table I details the FMVT stress level plan.

Justification/Notes on Target Test Conditions:

Each level is the same length.	max service temperatures per client; max test temperature = chamber limit; Temperature at Start of Level = Temperature at End = 25 °C; Total Hot Dwell Time = Total Cold Dwell Time; Total Dwell Time = Total Ramp Time;	max service = typical; max test = chamber limit	2.25 gRMS resulted in ~50 g door peak (Client Limit for max ft-lb energy)	Narrowband Random must be modified to each target gRMS to induce slam	outside handle lifted (door slams) for 5s then released (door rebounds) for 5s; handle lifted with minimal load (Client declined inside handle cycling)

EVENT LOG TEST PLAN:

Event Number	Estimated Duration	Ambient Temperature (lo,hi)		Total Time Ramping	Time at Hot Dwell	Time at Each Cold Dwell	Resultant Temperature Change Rate	Ambient Relative Humidity	Door Slam Energy (Random, 1 Axis, Narrowband) In-Car Lateral Acceleration		Outside Handle Load	Outside Handle Cycle Rate
	minutes	°C		minutes	minutes	minutes	°C/minute	%RH	gRMS	Hz	N	CPM
Op-0	30											
1	60	-30	80	30	15	7.5	11	95	1	2 - 20 (TBD)	50	6
Op-1	30											
2	60	-35	85	30	15	7.5	12	95	1.3125	2 - 20 (TBD)	50	6
Op-2	30											
3	60	-40	90	30	15	7.5	13	95	1.625	2 - 20 (TBD)	50	6
Op-3	30											
4	60	-45	95	30	15	7.5	14	95	1.9375	2 - 20 (TBD)	50	6
Op-4	30											
5	60	-50	100	30	15	7.5	15	95	2.25	2 - 20 (TBD)	50	6
Op-5	30											

total time = 480 minutes
8.0 hours

SPECIFIC OPERATIONAL CHECKS:

The operational checks within the FMVT on the part/system included:

Current and power draw
Visual inspection of door for cracking
Visual inspection for functionality

Test Results

Two different parts completed ten levels of the FMVT. Both designs exhibited failure modes. The design maturity will be calculated for each design separately.

New Door			
	Minutes Under Test	Test Level	Failure Number
Window fell out	640	6	1
bird beaks broken	720	6	2
handle is loosening	720	6	3
Inner handle is sloppy	840	7	4
bird beaks broken	840	7	2
handle is loosening	840	7	3
signs of grease on glass	840	7	5
Window fell out	875	8	1
bird beaks broken	960	8	2
handle is loosening	960	8	3
Inner handle is sloppy	960	8	4
fracture	960	8	6
signs of grease on glass	960	8	5
window shattered	1080	9	7
new fracture on outside of door	1080	9	8
new fracture on outside of door	1080	9	9
two attachements broke	1080	9	10
mirror fell of	1080	9	11
bird beaks broken	1080	9	2
handle is loosening	1080	9	3
Inner handle is sloppy	1080	9	4
fracture	1080	9	6
signs of grease on glass	1080	9	5

Reference Door			
	Minutes Under Test	Test Level	Failure Number
Rocker Panel (red trim) deformed	40	1	1
door Panel unattached at rear (mid beak)	120	1	2
Birds beaks broken (along bottom)	120	1	3
Rocker Panel (red trim) deformed	240	2	1
Rocker panel (red trim) paint peeling near lower rear fastner	240	2	4
Elpo Coating transer to seal	240	2	5
Deformation of sill plate causing door and sill plat to rub	240	2	6
Handle is loosening	360	3	7
latch is sticky + hard to move	360	3	8
Rocker Panel (red trim) deformed	360	3	4
Excessive Elpo on seal	360	3	5
Innera handle sloppy 2/0 fasteners	360	3	9
Glass in mirror coming loose	360	3	10
stricker wear in metal and shows signs of wear inside	360	3	11
door handle appears to be broken	405	4	12
signs of grease on glass	480	4	13
Rocker Panel (red trim) deformed	480	4	4
Excessive Elpo on seal	480	4	5
Fracture length 1.264"	480	4	14
Signs of greas on gla and more wear marks	600	5	13
weld failed on side of door	600	5	15
first fracture length 1.482	600	5	14
New fracture length 0.632 upper door near other fracture	600	5	16
window fell out	704	6	17
the two fractures are joined	720	6	14
the two fractures are joined	720	6	16
window fell out	724	6	17
original fracture now joined with second fracture	840	7	14
original fracture now joined with second fracture	840	7	16
New fracture around bolt which holds the rear window track	840	7	18
rocker panel continues to difform	840	7	1
two birds beaks broke on the bottom of door trim	840	7	3
Elpo Coating transer to seal	840	7	5
window fell out	798	7	17
mirror assembly seems to have excessive shake	840	7	10
handle broke door is latched shut	793	7	12
wear marks on glass	960	8	13
fracture grows	960	8	14
fracture grows	960	8	16
fracture grows	960	8	18
fastener torque 3 N-m	960	8	19
loss of torque on two speaker fastners	960	8	20
mirror is very loose	960	8	10
plastic rocker panel cracked in the lower forward fastener	983	9	1
handle broke door is latched shut	984	9	12
window fell out	1024	9	17
fracutre grows	1080	9	14
fracutre grows	1080	9	16
fracutre grows	1080	9	18
all birds beaks broke	1081	9	3
handle broke door is latched shut	1080	9	12
window shattered	1176	10	21
new fracture on outside of door	1200	10	22
new fracture on outside of door	1200	10	23
two attachements broke	1200	10	24
mirror fell of	1200	10	10
fracture grows	1200	10	14
fracture grows	1200	10	16
completely broke around window attachment bolt	1200	10	18

DESIGN MATURITY:

Design Maturity is a measure of the average potential for improvement in a design. Design Maturity quantifies the spread or distribution of individual failure modes in a product. (See Figure 1)

DESIGN MATURITY (cont.):

The maturity of the design is measured by conducting an FMVT and plotting the failure mode progression. Design Maturity is:

DM = ((Tmax-Tmin)/(Count-1))/Tmin

Where:

Tmax = Time to the last unique failure found
Tmin = Time to the first unique failure found
Count = The number of unique failures found

Predicted values for the Design Maturity can also be calculated by assuming that one or more of the earliest failure modes are corrected. The Predicted Design Maturity (PDM) is then determined by:

$PDM_i = ((Tmax-T_{(i+1)})/(Count-1-i))/\ T_{(i+1)}$

Where:

Tmax = Time to the last unique failure found
T(i+1) = Time to the ith+1 unique failure found
Count = The number of unique failures found.
i = i^{th} Failure Mode

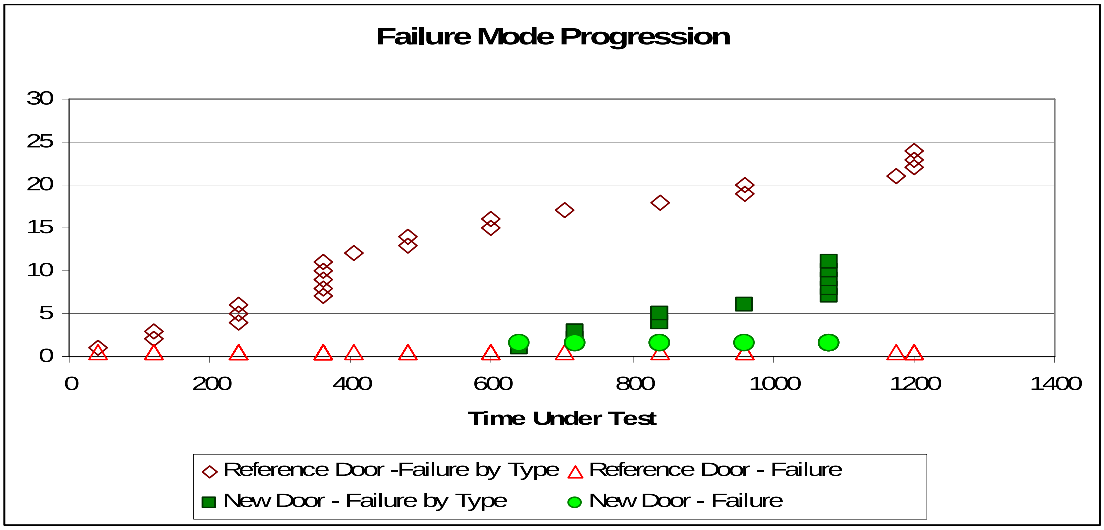

Figure 8: Failure Mode Progression

TECHNOLOGICAL LIMIT:

Technological Limit (TL) is a theoretical limit on a design's potential for improvement. The Technological Limit is the time when the Predicted Design Maturity is less than 0.1. (TL = $T_{(i+1)}$ where PDMi <0.1). A Design Maturity of > 0.1 is the point where fixing any additional failures would produce less than a 10% improvement in the product. Therefore, failures that occur before the technological limit are of particular interest.

The design maturity calculation for the reference door was 1.26. A mature product design should have a design maturity calculation below 0.1. To obtain design maturity calculation below 0.1 we would have to repair or fix the first 17 failure modes. Upon review of the chart below, if the first 17 failure modes were repaired, we would have a calculated design maturity for the reference door of 0.06, which is below the targeted 0.1 for a mature design.

The design maturity calculation for the new door was 0.07. A mature product design should have a design maturity calculation below 0.1. The new door appears to be mature.

It is expected that the new door would last considerably longer in the field then the reference door.

	Time to First Failure	DM
Reference Door	40	1.26
New Door	640	0.07
Ratio (How much better is the new door)	16	18

Here the ratio provides a relative measure of how much "better" the new door is over the reference door. Two measures are used: Time to first failure and Design Maturity. The time to first failure ratio indicates how much longer the door would be expected to last based on the FIRST failure mode only (assuming this is the primary failure mode). This is not always the case and the number should only be used as a reference. The DM measure indicates how much more mature the door is.

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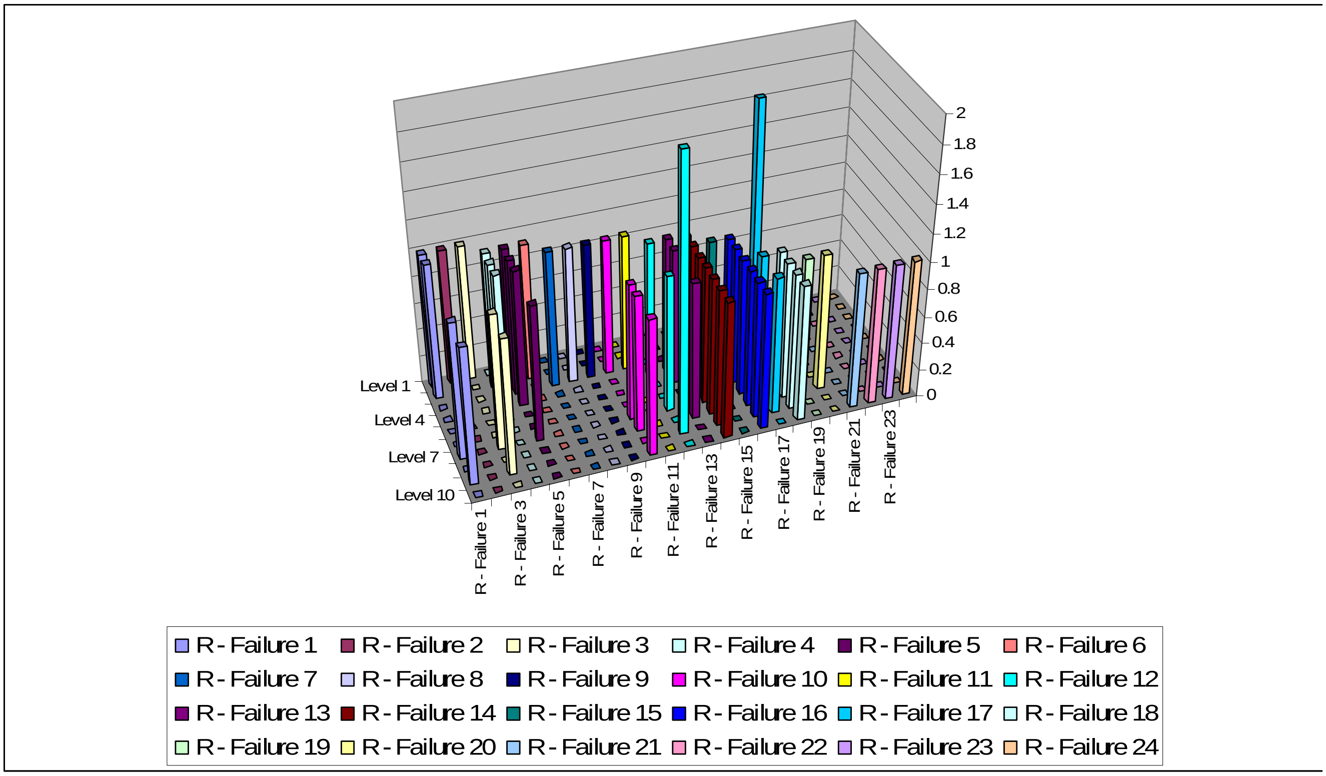

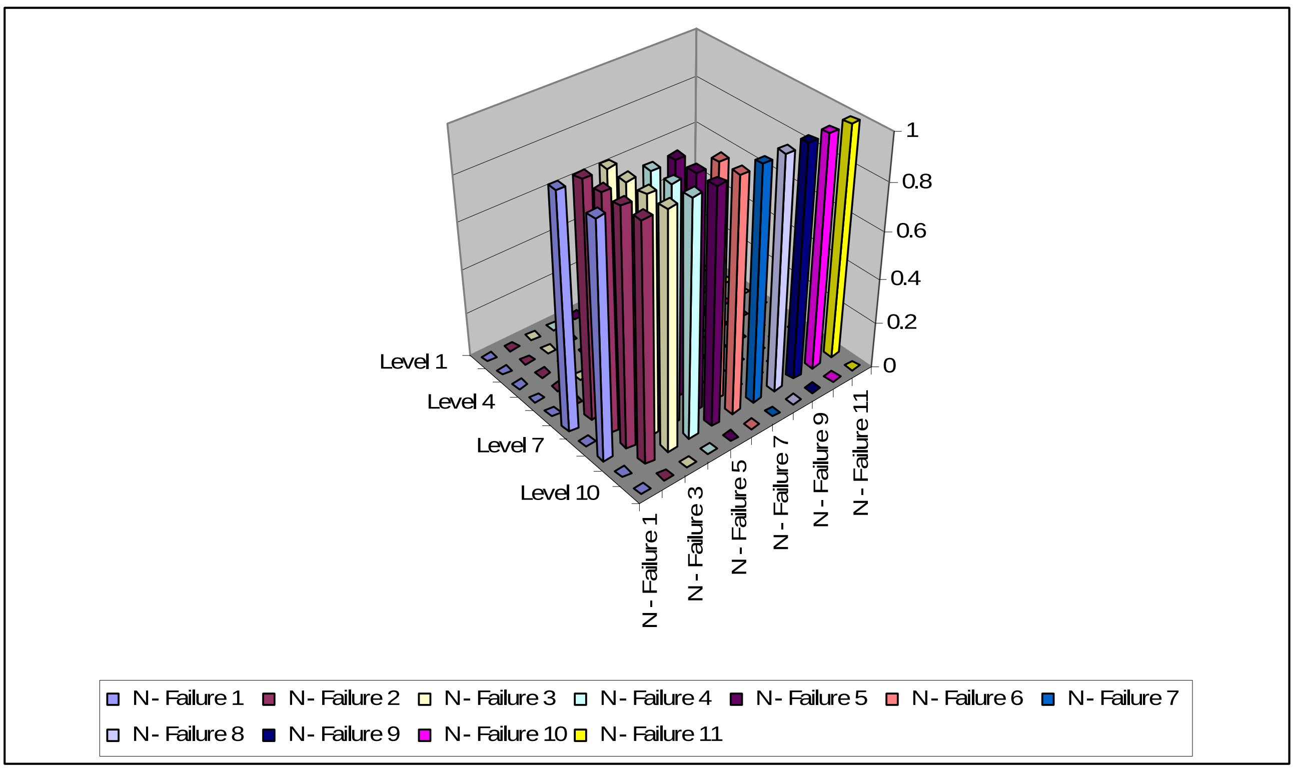

Figure 9: Histogram of Failures by Level: Levels are labeled.

HISTOGRAM OF FAILURES:

In addition to determining the maturity of a design and the technological limit, the re-occurrence of a failure during the test is of interest. A failure that occurs once (see failure 2 below) and then never reproduced is of little concern. While a failure that is chronically reproduced, starting below the technological limit and continuing throughout the test, is of great concern. Figure 2 shows the histogram of the failure modes by level.

Conclusion:

The new door is substantially more robust and is expected to have a longer life then the reference door.

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7. If the service to be performed requires more than one (1) month for completion, INTERTEK will make monthly billings of the approximate percentage of the work completed each month, supplying with the interim invoice a progress report showing accomplishments to date. Terms of all invoices shall be net cash on receipt of invoice.

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11. Prices quoted by INTERTEK are subject to change if not accepted by the client within thirty (30) days, or if the work involved is not commenced within forty-five (45) days of such acceptance through no fault of INTERTEK

12. INTERTEK's liability for damage to or loss or destruction of the client's property while it is in the possession of INTERTEK will be limited to the amount INTERTEK has agreed to charge the client for the services.

13. Any order or agreement for testing services by INTERTEK may be terminated in writing by the client before completion thereof with INTERTEK's written consent in which event the client shall pay to INTERTEK an amount to be determined by INTERTEK as being sufficient to reimburse INTERTEK for all direct and indirect costs and expenses, including (but not limited to) suppliers, materials, labor, and overhead incurred with respect to the order or agreement through the date of termination..

14. INTERTEK shall not be liable for any failure or delay in performance which is caused in whole or in part by fire, flood, accident, riot, war, operation of law, government action, strikes or other labor disturbances, fuel shortages, or any other cause beyond the control of INTERTEK.

15. All contracts between INTERTEK and the client shall be deemed to be made in and governed by the laws of the State of Michigan.

16. Should INTERTEK be required to subcontract any testing or other services, the client will be informed of such arrangement either verbally or in writing. INTERTEK shall have no liability for any deductions, inferences, or generalizations drawn by the client or others from subcontractor's data.

17. Should witness of testing or services on INTERTEK premises be requested, the client shall comply with all applicable safety regulations and precautions. Client shall supply, if requested, evidence of workers compensation coverage prior to visit.

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