PE14-005

MAZDA

4/15/2014

APPENDIX 8

Material 1-1 Field Claim Investigation Sheet

Field Claim Investigation Sheet (Purchased Part)

Subject	Defective Master Back

Defect Outline	
Identified	2009/10/1
Market	Malaysia
Vehicle	CX-9
Car-No.	JM0TB10A10[redacted]
Eng/Min-No.	
Mileage	30,343Km
Produced	2008/1/15
Affected Units	2

Quality Rank: (A) B C

Defect Description

The brake pedal is hard to step on and brake fails to work.
The pedal goes down slowly when pushed but stops briefly before going back up

Failure Mode

略図

Function/Company Responsible for Investigation

Mazda Motor Corporation
Supplier Quality Gr. Issued: 2010/1/13

Approved	Reviewed	Staff
Kanemori	Nitanda	Babasaki

TRW Automotive Japan
Function: Customer Quality
Reported: 2010/8/30

GM	Manager	AM	Staff
omatsubai	Maeda		Maeda

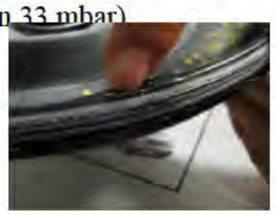
Mazda Motor Corporation
Supplier Quality Gr. Confirmed: yyyy/mm/dd

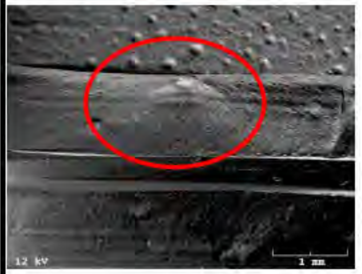
Approved	Reviewed	Reviewed	Staff

Defective Parts Investigation Result

	VIN#	Produced	Defect Found	Mileage
1	JM0TB10A10[redacted]	2008/1/15	2009/10/1	30,343Km
2	JM0TB10A[redacted]	2008/11/14	2009/7/15	14,344Km

Findings:
Through cracks were found on diaphragm (Sealing)
Airtight test results
1 Negative pressure reached 0 within 15 seconds; and
2 Negative pressure declined by 75mbar over 15 seconds, failing to meet the requirement (MES: Less than 33 mbar)





Part Number	TDY4-43-80Z
Part Name	Master Back

Defect Causes

Physicals

Diaphragm Crack:
The investigation of crack cross section revealed contamination on the cracked area (by Styrene-Butadiene Rubber). The contamination prevented rubbers from sticking together properly during the Diaphragm vulcanization process. (The diaphragm and the contamination were both SBR, but the contamination was hardened SBR) In view of 1. the area suffers the maximum tensile force when the brake is applied; 2. SBR is not a material that is strong against tear force; and 3. the cross section of the cracked area revealed rubber fatigue; it is presumed that repeated brake operations in the field caused rubber fatigue over time and imperfectly connected areas started to tear, which finally resulted in the leak of negative pressure.
Contamination:
It is presumed that hardened rubber residuals in the injection molding machine nozzles were released into the diaphragm dies along with normal materials. Such residual material release does not

Controls

The defect caused by contamination was out of assumption and not included in FMEA/Control Plan.

Reasons for Defect Outflow

Physicals

Because it was not the case of through laceration, the defect could not be detected by the negative pressure leak test or airtight test. The defect could not be detected at incoming inspection (visual inspection) of diaphragm.

Controls

The defect was out of the scope of the assumption.

Mazda HQ Supplier Quality Gr.

Supplier Responsibility
Yes ☐
No ☐

Preventive Actions for Similar Parts/Process

Internal audit conducted on similar failure modes

PCA for Defect Causes

Physicals

1. Changed purge time for injection molding nozzles (1H-3H) (From 2008/10)
2. Increased nozzle & die inspection cleaning frequency to every morning ilo. 1 /week (2008/10)
3. Changed die cleaning frequency to 50Hz ilo. 30Hz for better cleaning (2008/10)
4. Dispose first 10 shots from the start of operation each day (to ensure injection quality to stabilize) (2008/11)
5. Replaced an aged injection molding screw with new one (2008/11)

Controls

1. Revised TPM/Maintenance Procedures (2008/11)
2. Revised Work Instruction Sheet for first few hours of operation (2008/11)
3. Incorporated the defect case in P-FMEA (2008/11)

PCA for Outflow

Physicals

1. Use microscope to check that there is no contamination on the first 5 units after purge (once a week) (2008/10)
2. Check if there is contamination on the fist 10 units produced and disposed each day (2008/11)

Controls

1. Revised Inspection Procedures (Added inspection devices) (2008/11)
2. Incorporated the description of the defect, inspection procedures and frequency in the quality control plan (200811)

Confirmation after 3 months (MC)

Confirmed: yyyy/mm/dd

Approved

Nature of Defect (Repeatability/Reasons)

Nature of the Defect:
The defect could not be identified by airtight test or negative pressure leak test.
Depending on brake use frequency in the field, faulty rubber connection areas get worn out and develop through laceration, which results in lower negative pressure.
Defect Frequency:
For 2006/1-2009/3 production of 110,373 units,
Weibull distribution predicts the possibility of 2 more defective units for driving distance less than 40,000Km, and 4 more defective units for 150,000km. No defective unit was found after PCA was incorporated in 2009/1. In light that brake assist performance deteriorates by approximately 50% and the brake pedal would be felt heavier immediately by the driver, the defect can be confirmed.

Info No.. [redacted]

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Action List Material

Material 2-1 Supplier Report 25 Jul 2012

Mazda J50 Warranty

25th July 2012
TRW

Engineering Comment for Thickness Change and Material

- Material thickness - 0.85mm is a standard dimension that I've known since I started working in Actuation 19 years ago. I think we can rule that out as a variable causing the failure in this case.
- SBR vs EPDM - It is quite well known that EPDM offers superior high temperature performance to SBR, at a cost penalty. At the beginning of a project, the material is usually selected according to the following factors
- \- The OEM's basic mat'l requirement if they have one (eg VW) - would be in RFQ package
- The OEM's experience with the prior generation model/platform could drive a direction
- The OEM's predicted temp profiles, if available. For example, if a turbocharger is mounted close to the booster, early thermal modeling could give an indication
- The OEM's indicated product specification we are quoting to
- The above factors would lead to an initial material selection. Of course, a test failure in DV or PV could lead to the material selection being reviewed.
- In the case of U38x/J50, all the initial requirements came from Mazda, and there was no indication that the better EPDM properties were needed.

Engineering Comment for Thickness Change and Material

- 材料厚さ について- 0.85mmは、知る限り19年前からの標準寸法。
- 本ケースに於いては不具合を起こす変動する値とし除外するべきと考える。
- SBR vs EPDMについて – EPDMは優れた高温性能を提供することで良く知られているがコストペナルティーを伴う。
  プロジェクト開始時、通常材料は下記により選出される。
- １つの場合、OEMの通常材料要求(例 VW) – RFQパッケージ
- OEMの過去の世代モデル/プラットフォームの経験により左右される。
- 入手可能であればOEMの予測暫定プロファイル。ターボチャージャーがブースターの近くに取り付けられる場合は、熱モデルが適応される。
- OEMの指示した製品仕様を引用。

上記項目は最初の材料選出で、DVもしくはPVのテスト結果にてレビューされる。

U38x/J50の場合、最初の要求はすべてマツダ様からで、EPDM特性についての指示は無かった。

Countermeasure for the Diaphragm

- In my view, We think just looking at a thickness change as a countermeasure is not really the correct approach. To be honest & frank, I'm struggling with exactly where that idea came from, and how you (or Mazda?) latched on to that as a possible solution.

- First of all - what would it mean to change thickness? 1) a complete new tool. This would be very expensive. Would Mazda pay? I do not believe TRW would easily agree to do so. 2) The lead time would be somewhere around 5 months for the tool alone. We would then have a validation time of 3 - 4 months, and then an introduction time. Maybe in total around 1 year. Technically, this could be feasible, but at high cost, a long time, and absolutely no guarantee of solving the issue.

- As mentioned previously, TRW has ~20 years of experience with diaphragms at 0.85mm. With all other suppliers they work. This design value cannot be so wrong - we have tens of millions in the field without issues.

- We have identified the failure as a process failure. If we have such a particle in the part causing a stress raiser and crack initiation, who's to say the same failure won't occur on a slightly thicker diaphragm? Very difficult to prove that the thicker diaphragm is better, unless we can intentionally make such parts.

Countermeasure for the Diaphragm

- 我々の考えでは、厚みの変更だけを対策とすることは正しいアプローチとは思えない。正直に率直に言うと、可能な解決策としてどこから（マツダ殿から？）どうしてその様なアイデアが出て来たのか考え難い。

- まず最初に厚さの変更とはどういう意味なのか？1）完成された新しい機械はとても高価だが、マツダ殿で予算の負担をするのか？TRWで承認されるとは思えない。2）リードタイムは機械のみで約5ヶ月。その後検証に3-4カ月。それから導入期間。トータルで約1年はかかる。技術的には実行可能だが、高い費用、長期間、更にこの問題を解決する保証は無い。

- 過去に述べているよう、TRWは0.85mmのダイアフラムを20年使用した経験が有る。すべての他のサプライヤーでは問題無い。この設計値が間違っているとは考え難い – この不具合が発生していない車両は10,000,000台も有る。

- この不具合は工程不具合と認識している。もしこの様なパーティクルが部品に混入すれば、ストレスが掛かり、クラックが起爆する。ダイアフラムがもう少し厚ければ、この不具合が起きないと誰が言えますか？意図的にその様な部品を作らない限り、厚みが有るダイアフラムが良いと証明することはとても困難である。

J50サウジ販社ケース ダイアフラム メンブレ破れ不具合について

- 発生原因:材料精製後(約8週間)保管した事により、化学反応である加硫が促進され、早期加硫したゴム(パーティクルとして)が材料内に混在してしまった。
  この材料でダイアフラムを成形した際に、エッジ部分(もっとも応力が掛かる部分)に早期加硫ゴムがあり、そこを起点として市場にて破れに至り、ブレーキ動作不良及び笛吹き音等の不具合に至った。
  : 発生原因の妥当性は、製造サプライヤーのFTA及び6/27,6/28 の訪問確認にて妥当と判断
  : サプライヤー訪問時に以下を確認し問題無いと判断致します。

・ メンブレ亀裂の調査結果
・ 不具合発生要因の絞込み(プレキューブラバー/環境/メンブレの大きさ/板厚等)
・ プレキューブラバー発生メカニズム、
・ プレキューブラバーがメンブレ一部の部位に残留するメカニズム
・ 対策内容及び状況
・ 工程管理方法

- 対策:Shelf life 8 weeks → 4 weeks 保管期間を短縮し化学反応のリスクを回避する。

対策効果確認:Shelf life 1,2,3,4,5,6,7,8 週間後の材料及び製造品を検証する。
検証計画:8/20～8/24 8週間の検証が終了予定

- 多発性:多発性に関しては、現在8台確認した実績を元にワイブルにて示しておりますが、より信頼性を増す様、クレーム品の全数回収を依頼して調査する予定。

- 総合的見解:プレキューブラバー(早期加硫)発生の原因は化学反応であり、スコーチ時間(加硫までの時間)を調整する事により発生の低減可能。サウジで顕著にクレーム率が多い点については、環境(高温)に起因し、SBRが熱には比較的弱い事が原因と考える。又他社と比較してダイアフラムの板厚が薄い点も考慮する必要があると思われるが、過去同様事象が発生した履歴は無い。製造に起因する発生原因は本対策で妥当と判断するが、ロバスト性の向上を考慮するとダイアフラムの設計変更について考える必要があるかも知れません。

補足

- ダイアフラムのshelf life 4 weeks（改善品）の折り込み日については、現在確認中であり、7/31までにご報告致します。

- マスターシリンダーからのフルード漏れ市場クレーム調査結果について：

Valve body の表面に傷があり、それがシールに傷を付けリークに至ったという現時点に見解ですが、サプライヤーかの調査結果及びレポートが今週中に提出される予定なので、7/31までにご報告致します。

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Action List Material

Material 2-1_P6

J50 Saudi Arabia sales company case Regarding the fault of the diaphragm tear

☐Cause of occurance:Due to keeping materials (for about eight weeks) after refining, the vulcanization which is a chemical reaction was promoted and the rubber which was vulcanied earlier has been mixed in material (as When a diaphragm was fabricated with this material, there is the rubber which vulcanized earlier at edge portion (where stress is applied most), and it resulted in the tear with there as a trigger in the market, and resulted in faults, such as poor brake operation and whistling noise.
: The validity of the cause of occurance is confirmed by FTA of a manufacture supplier, the visit check on 6/27,
: TRW checked the following at a supplier visit, and judged that there is no problem.
・Investigation result of diaphragm crack
・Narrowing down of a fault generating factor (precure rubber/environment/the size of diaphragm/ thickness etc.)
・mechanism to a precure rubber generating mechanism which precure rubber remains as a part of diaphragm
・ the countermeasure, and a situation
・the process control method

☐Measure:Shelf life 8 weeks -> 4 weeks   Shorten a storage term, and avoid the risk of a chemical reaction.
The measure effect check: The material and the product after a week are cheked after shelf life 1, 2, 3, 4, 5, 6, 7,
Verification plan: 8/20?8/24 The verification for eight weeks will be completed.

☐Multiple: we will request the supplier to recover all the claim parts and investigate so that reliability may be increased more although Weibull shows frequent occurrence nature based on the track record checked eight sets

☐Integrated view: The cause of precure rubber (prevulcanization) is a chemical reaction, and we can be reduced the occurance of precure rubber by adjusting scorching time (time until vulcanized).
The rate of incidence reported from Saudi Arabia is high. It is becthat it is due to environment (high temperature) is and that SBR is comparatively weak with heat considers.
Moreover, although it seems that the thickness of a diaphragm also needs to take a thin point into consideration as compared with the other company, there is no history which the similar phenomenon occured in the past.
Although the cause of generating resulting from manufacture judges that it is appropriate in this measure, if improvement in robustness is taken into consideration, it may need to consider the change of design of a diaphragm.

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APPENDIX 8

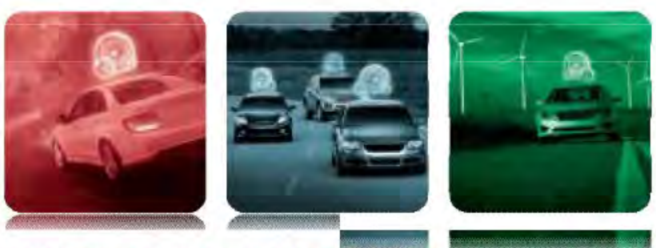
Action List Material

Material 2-10 Supplier Report 20 Feb 2013

Mazda J50C Booster Warranty

Update Slides

February 20, 2013
TRW Automotive



ADVANCED THINKING / SMART THINKING / GREEN THINKING

Agenda

1. DOE status update
2. Correlation of Warranty returns (Tool 1) to DOE test parts
3. Measurement results of thickness in tear area of the 8 wk shelf life Tool 1 parts that were suspended
4. Measurement results of thickness of the (3) Tool 2 DOE parts that were suspended
5. Dimensional results of thickness for Tool 3
6. Accelerated testing results for Tool 3
7. Why the tear location moved for Tool 2 DOE parts
8. Durability test (Mazda MES with 120℃ temperature) schedule
9. Rubber material data – scorch time , viscosity, hardness, tensile and specific gravity
10. PPAP submission timing to Mazda for Tool 3 and date of switch to Tool 3 stock
11. Next face to face meeting schedule - Target 3/13

DOE Status Update

DOE Phase	Test Order	A: Shelf Life	B: Thickness	C: Particles / Supplier	Qty	Supplier Lead Time	Estimated Test Completed Date	Wk ending	Estimated Test Completion date as of Jan 28th
Pre-DOE	0	Current Production			4	NA	Wk 46	11-Nov	Completed Dec 12
Part 1	1	1 wk	+(Thin)	- (Hi Count) / HSM	4	1 wk	wk 47	18-Nov	Completed Jan 7
	2	1 wk	- (Thick)		4	2 wks	wk 49	2-Dec	Completed Dec 28
	3	4 wk	+(Thin)		4	5 wks	wk 2	13-Jan	75% complete, finish Feb 1
	4	4 wk	- (Thick)		4	6 wks	wk 2	13-Jan	~~Completed Jan 16~~
	5	8 wks	+(Thin)		4	9 wks	wk 3	20-Jan	Expected Feb 18
	6	8 wks	- (Thick)		4	9 wks	wk 4	27-Jan	Expected Feb 18
Part 2a	7	+(1 wk or Min)	+(Thin)	+(Lo Count)/ Rubena	4	12 wks	wk 11	17-Mar	Expected Mar 28
	8	-(30 days Max)	+(Thin)		4	16 wks	wk 15	14-Apr	Expected Apr 28
Part 2b	9	+(1 wk or Min)	+(Thin)	+(Lo Count)/ Daetwyler	4	22 wks	wk 18	5-May	Expected May 17
	10	-(6 months)	+(Thin)		4	48 wks	wk 44	3-Nov	Expected Nov 15

New date: Feb. 25

Notes:

1. Original DOE timing plan assumed Pre-DOE phase (Dev test) worked 1st time.
First new test method tried was not successful. Extra time to develop & evaluate a second test method delayed start of DOE testing approx. 3-4 weeks.
2. Increased Qty to test from 2 to 4.

DOE Status Update

1. Develop & evaluate accelerated evaluation test
   Test Method 1: "Air pressure cycling" approach did not work out- difficulty sealing under pressure
   Test Method 2: "Modified endurance" Successful: Replicated failure mode in short time. **COMPLETED** Dec 12.

2. Order diaphragm test configurations
   COMPLETE: All test parts have been ordered from suppliers.

3. Build booster assembles
   ONGOING: Per plan as DOE diaphragms are received.

4. Complete Part 1 Testing
   IN PROGRESS:
   1 wk "thick" parts: **COMPLETE**
   1 wk "thin" parts: **COMPLETE** (note: cracked in different position)
   4 wk "thick parts: **COMPLETE**
   4 wk "thin parts: **COMPLETE**
   8wk "thick parts" Test completion expected ~~Feb 18~~ Feb 25
   8 wk "thin parts" Test completion expected ~~Feb 18~~ Feb 25

5. Analyze & publish Part 1 results
   Following completion of Part 1 testing: Expected ~~Feb 25~~ Mar 4

6. Complete Part 2a Testing & publish results
   Following completion of Part 2a testing: Expected May 3

DOE Status Update

- Tool 1, 8 week material diaphragms (3 remaining) have resumed testing
- One Tool 1 (8 week) failure has been analyzed and tear analysis updated
- Tool 2, 8 week material diaphragms are pending

Sample ID	Shelf Life	Part No	Rev Level	Status	No. of Tears	Length of Tear(mm)	Cycles	Material Lab Request
HSM_C_08_8week	8 week	32484764	C	in process	0	—	22,925	—
HSM_C_04_8week	8 week	32484764	C	in process	0	—	35,147	—
HSM_C_11_8week	8 week	32484764	C	in process	0	—	37,481	—
HSM_C_05_8week	8 week	32484764	C	failed	1	8	10,310	—

Sample ID	Cycles	Shelf Life (weeks)	Failure Mode	Failure Location	Failure Size (mm)	Embedded Particle length (microns)	Embedded Particle height (microns)	Material Thickness (greatest) at defect site (mm)	Material Thickness at Location T2 (mm)
HSM_C_08_8week	22,925	8	—	T0	—	—	—	—	—
HSM_C_04_8week	35,147	8	—	T0	—	—	—	—	—
HSM_C_11_8week	37,481	8	—	T0	—	—	—	—	—
HSM_C_05_8week	10,310	8	tear	T3	8	109	106	1.306	1.08

Correlation of warranty returns DOE results to date

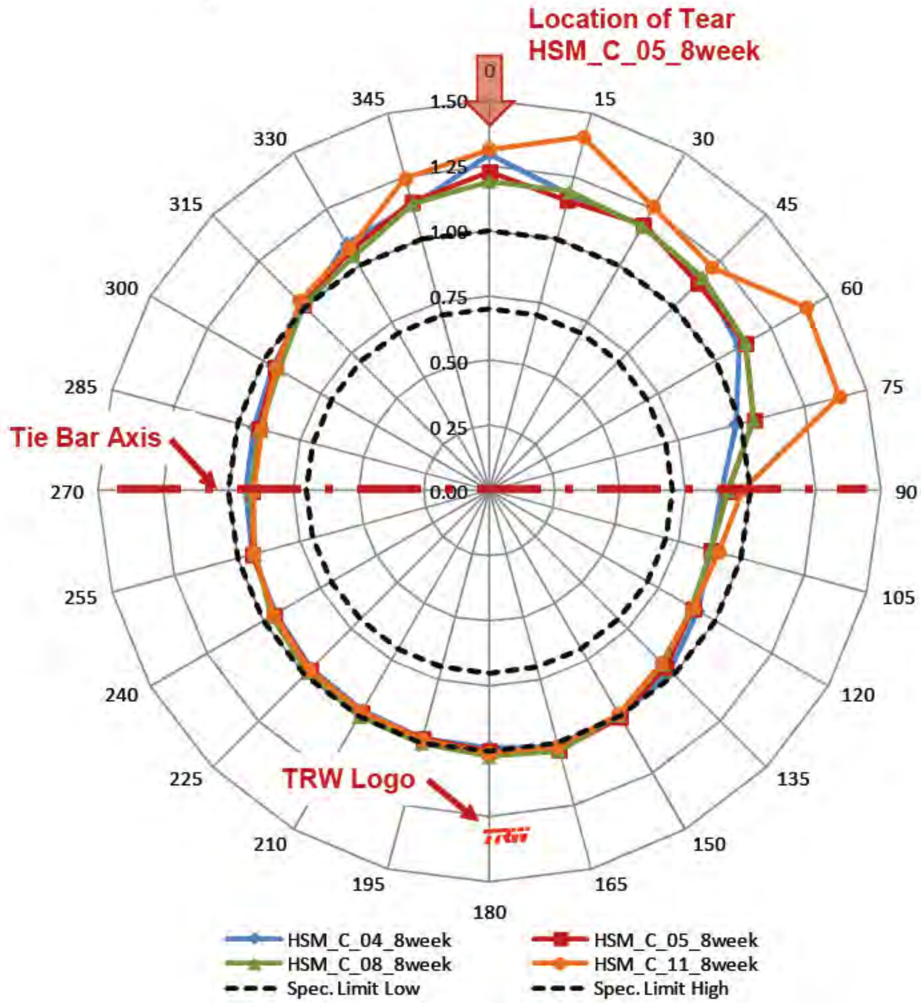
- **Comparison of 40 warranty samples and 17 DOE samples exhibiting diaphragm failures**
- **Tool 1 and Tool 2 diaphragms are included in comparison**

Attribute	Warranty Returns 40 Diaphragms 55 Tears			Tool 1 DOE Evaluations 13 Diaphragms 10 Tears			Tool 2 DOE Evaluations 8 Diaphragms 5 Tears		
	Occurrence	Quantity	% of Total	Occurrence	Quantity	% of Total	Occurrence	Quantity	% of Total
Tear Location @ T2	Yes	40	100%	Yes	9	90%	Yes	1	20%
Tear Location @ T3	No	0	0%	Yes	1	10%	Yes	3	60%
Tear Location other	No	0	0%	No	0	0%	Yes	1	20%
Tear location 1st quadrant	Yes	17	31%	Yes	1	10%	Yes	2	40%
Tear location 2nd quadrant	Yes	11	20%	Yes	1	10%	Yes	1	20%
Tear location 3rd quadrant	Yes	5	9%	Yes	3	30%	No	0	0%
Tear location 4th quadrant	Yes	22	40%	Yes	5	50%	Yes	1	20%
Tear Count > 1 per diaphragm	Yes	9	23%	Yes	1	10%	No	0	0%
Thickness at position 99 (t > 1.10)	Yes	23	58%	Yes	7	70%	No	0	0%
Thickness at position 99 (t ≤ 1.10)	Yes	17	43%	Yes	3	30%	Yes	5	100%
Shelf Life ≤ 5 weeks	No	0	0%	Yes	9	90%	Yes	5	100%
Shelf Life > 5 weeks	Yes	55	100%	Yes	1	10%	No	0	0%
Tear with particle @ origin	Yes	55	100%	Yes	10	100%	Yes	4	80%
Particle ≤ 200 microns	Yes	14	25%	Yes	2	20%	Yes	2	40%
Particle > 200 microns	Yes	41	75%	Yes	8	80%	Yes	2	40%

Tool 1 Thickness Measurement
4 Diaphragms in DOE test with 8 week shelf life material

- Diaphragms from Tool 1 with 8 week shelf life material, have thickness at position 99 measured circumferentially:
  - Max thickness of 1.05 – 1.11 mm
  - Min thickness of 0.92 – 0.97 mm
  - Mean thickness of 0.99 – 1.02 mm

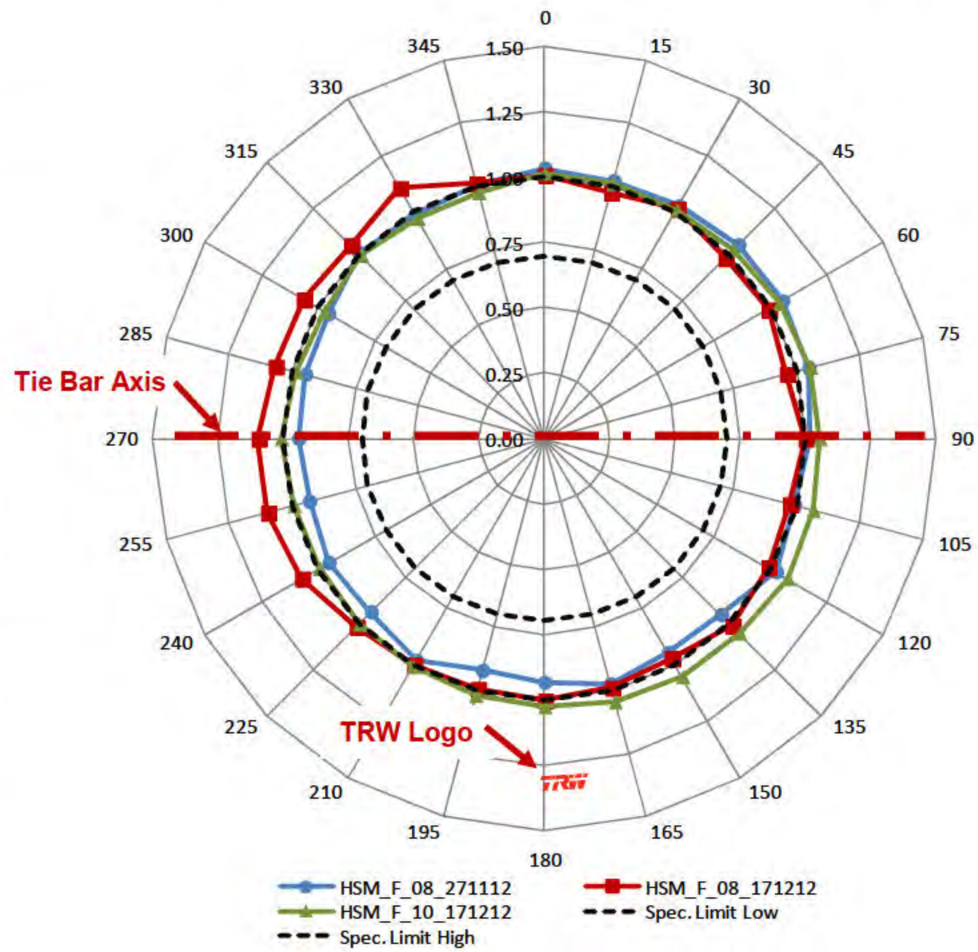
Measurement Degree	Thickness at Position 99 (mm)			
	HSM C 04 8week	HSM C 05 8week	HSM C 08 8week	HSM C 11 8week
0	1.29	1.23	1.19	1.31
15	1.18	1.16	1.19	1.40
30	1.18	1.18	1.17	1.26
45	1.15	1.13	1.16	1.21
60	1.11	1.13	1.14	1.41
75	0.98	1.05	1.05	1.39
90	0.89	0.91	0.92	0.97
105	0.88	0.88	0.88	0.91
120	0.92	0.90	0.90	0.90
135	0.98	0.96	0.94	0.94
150	1.00	1.00	0.99	0.99
165	1.01	1.03	1.03	1.02
180	0.99	1.00	1.02	1.01
195	0.98	0.98	1.00	0.99
210	0.97	0.98	1.00	0.98
225	0.96	0.97	0.99	0.97
240	0.94	0.95	0.96	0.95
255	0.94	0.94	0.93	0.93
270	0.93	0.91	0.92	0.90
285	0.93	0.92	0.91	0.90
300	0.96	0.95	0.93	0.94
315	1.00	1.01	1.01	1.03
330	1.09	1.07	1.04	1.08
345	1.13	1.15	1.14	1.24
MIN	0.88	0.88	0.88	0.90
MAX	1.29	1.23	1.19	1.41
MEAN	1.02	1.02	1.02	1.07
STD DEV	0.11	0.10	0.10	0.17



Tool 2 Thickness Measurement
3 Diaphragms suspended > 100,000 cycles in DOE

- Diaphragms suspended in DOE have thickness at position 99 measured circumferentially:
  - Max thickness of 1.05 – 1.11 mm
  - Min thickness of 0.92 – 0.97 mm
  - Mean thickness of 0.99 – 1.02 mm

Measurement Degree	Thickness at Position 99 (mm)		
	HSM_F_08_271112	HSM_F_08_171212	HSM_F_10_171212
0	1.04	1.01	1.02
15	1.02	0.98	1.01
30	1.03	1.02	1.01
45	1.05	0.98	1.02
60	1.05	0.99	1.04
75	1.05	0.96	1.05
90	1.02	1.00	1.05
105	0.99	0.97	1.06
120	1.02	0.99	1.07
135	0.96	1.02	1.06
150	0.95	0.97	1.06
165	0.97	0.99	1.05
180	0.93	1.00	1.03
195	0.92	0.99	1.02
210	0.98	1.00	1.01
225	0.94	1.02	1.01
240	0.95	1.07	1.00
255	0.93	1.10	0.99
270	0.94	1.10	1.01
285	0.95	1.07	0.99
300	0.96	1.07	0.97
315	1.01	1.05	0.99
330	0.99	1.11	0.97
345	1.01	1.01	0.98
MIN	0.92	0.96	0.97
MAX	1.05	1.11	1.07
MEAN	0.99	1.02	1.02
STD DEV	0.04	0.04	0.03

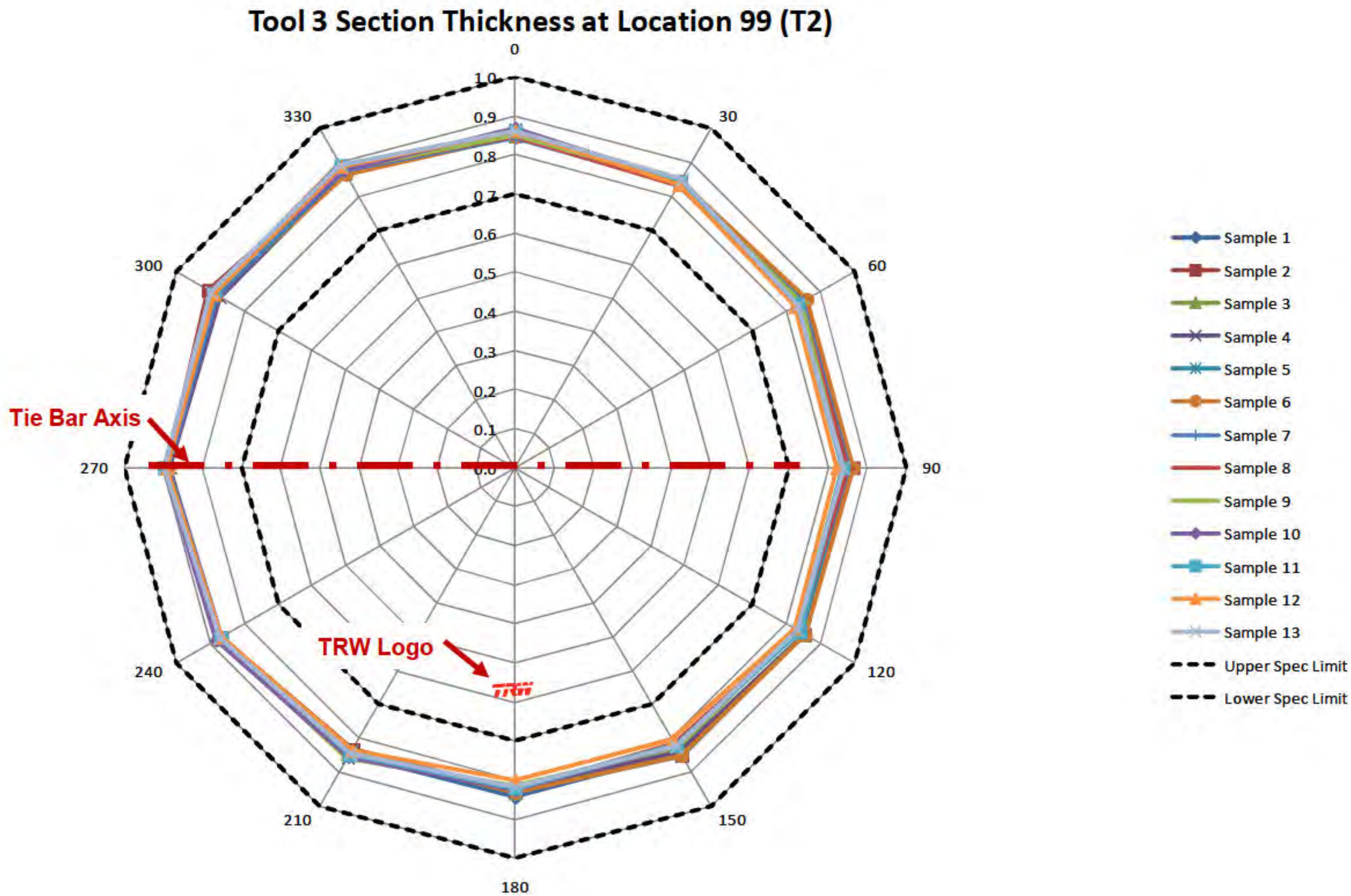


Tool 3 Thickness Measurement
13 Diaphragms Evaluated

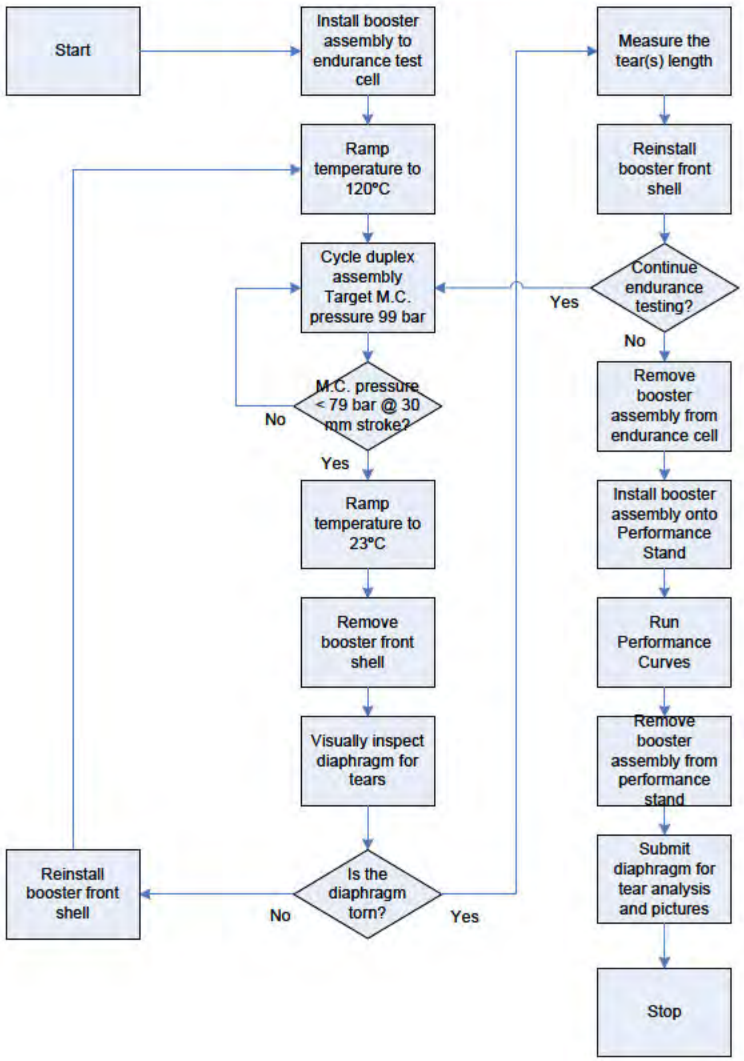
- 13 Tool 3 diaphragms section thickness at position 99 measured circumferentially
- Measurements taken on the TRW developed fixture

Position	Section Thickness at Position 99 for 13 Samples (mm)													High	Low	Average	Std.Dev.
(Degrees)	1	2	3	4	5	6	7	8	9	10	11	12	13	(mm)	(mm)	(mm)	(mm)
0	0.86	0.85	0.85	0.87	0.85	0.85	0.84	0.85	0.85	0.87	0.86	0.86	0.86	0.87	0.84	0.85	0.008
30	0.84	0.85	0.85	0.84	0.84	0.85	0.84	0.83	0.84	0.85	0.84	0.84	0.85	0.85	0.83	0.84	0.005
60	0.86	0.84	0.85	0.84	0.84	0.86	0.85	0.84	0.84	0.83	0.83	0.82	0.83	0.86	0.82	0.84	0.011
90	0.85	0.86	0.85	0.85	0.85	0.86	0.85	0.85	0.84	0.84	0.84	0.82	0.84	0.86	0.82	0.85	0.012
120	0.86	0.85	0.86	0.85	0.85	0.86	0.83	0.84	0.84	0.84	0.84	0.82	0.83	0.86	0.82	0.84	0.011
150	0.85	0.85	0.83	0.84	0.85	0.85	0.82	0.81	0.83	0.82	0.82	0.80	0.82	0.85	0.80	0.83	0.015
180	0.84	0.83	0.83	0.83	0.83	0.83	0.82	0.83	0.81	0.83	0.82	0.80	0.82	0.84	0.80	0.82	0.011
210	0.85	0.83	0.84	0.86	0.83	0.84	0.85	0.85	0.86	0.85	0.85	0.84	0.84	0.86	0.83	0.85	0.009
240	0.88	0.87	0.88	0.87	0.87	0.87	0.87	0.87	0.88	0.88	0.87	0.87	0.87	0.88	0.87	0.87	0.005
270	0.88	0.89	0.90	0.88	0.89	0.89	0.89	0.89	0.90	0.90	0.90	0.89	0.90	0.90	0.88	0.89	0.006
300	0.90	0.91	0.88	0.87	0.89	0.88	0.88	0.90	0.89	0.89	0.89	0.89	0.90	0.91	0.87	0.89	0.009
330	0.88	0.88	0.87	0.87	0.87	0.87	0.88	0.88	0.88	0.88	0.89	0.89	0.89	0.89	0.87	0.88	0.008

Tool 3 Thickness Measurement
13 Diaphragms Evaluated



Performance test results for Tool 3

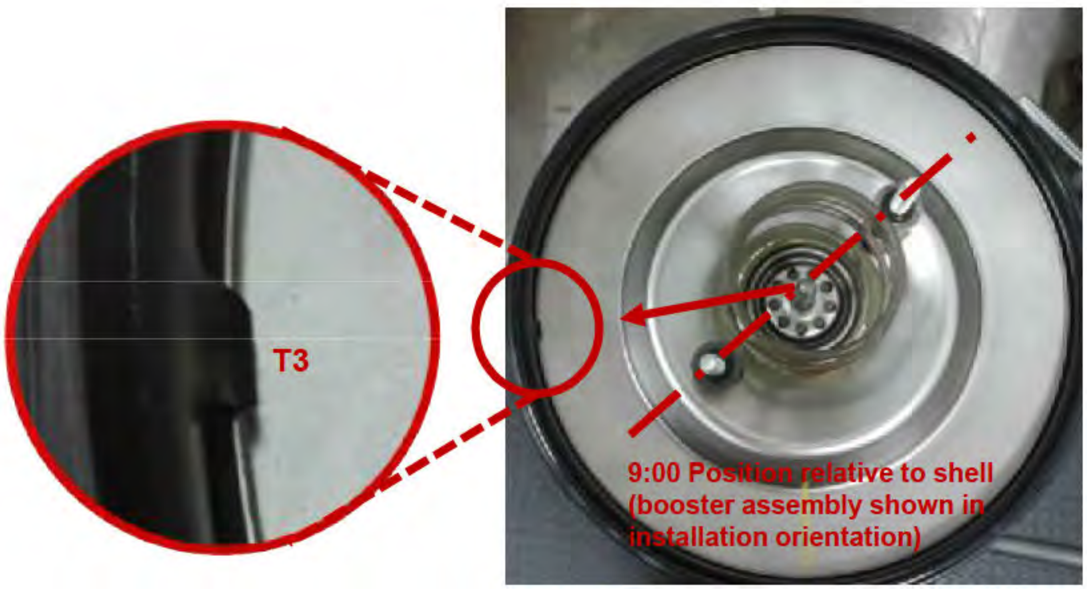


- **Accelerated High Temperature Endurance Test for Diaphragm Evaluations:**
  - Duration: 100,000 cycles
  - Rate: 1000 +/- 100 cycles per hour
  - Temperature: 120°C +/- 5°C
  - Booster vacuum level: 810 +/- 50 mbar
  - System stiffness: set consumers to achieve target m.c. pressure at 30 mm stroke
  - M.C. target pressure: 99 bar (ref)
  - Adjust booster input force to achieve target m.c. pressure
  - Monitor m.c. pressure and halt test for diaphragm inspection if the m.c. pressure drops to 79 bar
- **Tool 3 diaphragms have been evaluated:**

Station No.	Cycle Count	Status	Comment
1	100,000	Suspended	No Tear
2	86,636	Failure	Tear in T3 position, no particle present
3	100,000	Suspended	No Tear
4	100,000	Suspended	No Tear

Performance test results for Tool 3

- **Station 2 failure at 86,636 cycles in accelerated high temperature endurance test**
  - Tool 3 sample
  - Tear at the plate area (T3)
  - 9:00 position relative to shell (tie bars @ 36°)
  - 8:00 position relative to diaphragm (logo @ 6:00)



Performance test results for Tool 3

- **Tear analysis**
  - The tear is a U shape
  - A cross-sectional dimensional analysis reveals a radius near the tear measuring approximately 0.74mm to 0.87mm
  - No non-homogeneous particle at tear origination point
  - The presence of a radius and absence of a particle at the tear origination point indicates the initial tear is likely from mechanical impingement, possibly during assembly.
  - This type of diaphragm tear is not consistent with tears found in warranty samples (@ location T2) nor tears found in DOE samples (@ location T2 or T3)
- **DOE test samples are experimental and not assembled using the production process**

Explanation as to why tear location moved for Tool 2 DOE diaphragms

- Diaphragm failure locations during accelerated high temperature endurance testing:

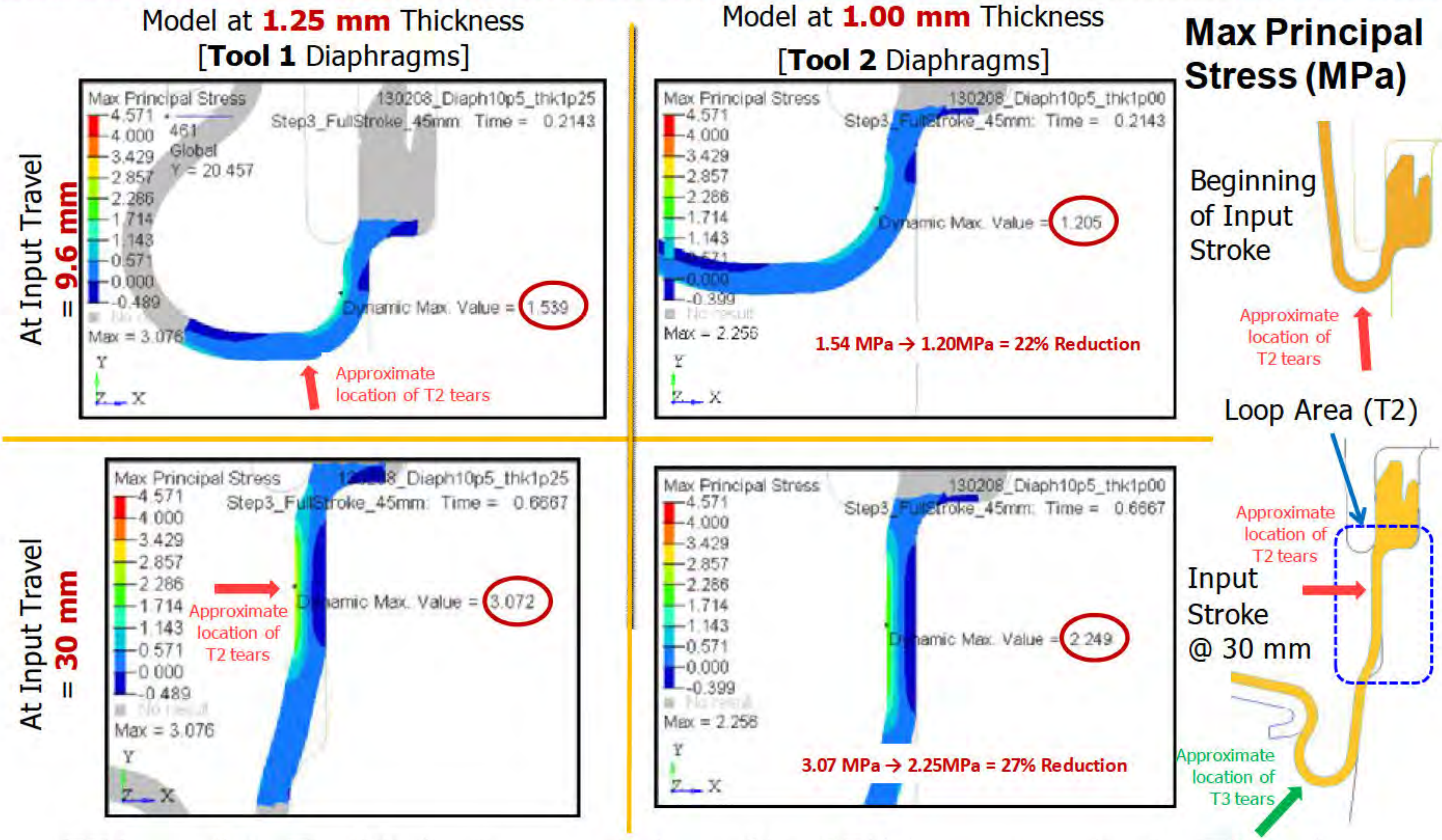
Number of Diapragm Failures During Accelerated High Temperature Endurance Test at Location

Tool Number	T2	T3	Other
Tool 1	10	1	0
Tool 2	1	3	1*
Tool 3	0	1*	0

* Denotes diaphragm failure without non-homogeneous particle at tear initiation location (tear root cause determined to be mechanical impingement).

- Thickness in loop (@ T2 location) is 1.0 - 1.5 mm on Tool 1 diaphragms
  - The FEA model predicts maximum principle stress occurs in the loop (T2 location) when the diaphragm thickness in the loop area is 1.25 mm – this prediction correlates well with observed failures in Tool 1 diaphragms
  - Reducing the thickness of the loop section as in Tool 2 diaphragms reduces the maximum principle stress by 22 - 27% in the loop (T2 location)
- FEA predicts Tool 2 diaphragms to have 36% increased stress in the plate area (T3 location) with a 30 mm input stroke v. 9 mm input stroke, and a 60% increased stress in the plate area (T3 location) with a 40 mm input stroke v. 30 mm input stroke
- If loop section is < 1.25 mm, predicted max principle stress at T3 approaches max principle stress at T2 and surpasses T2 stress at input strokes near 30 mm and greater; therefore **the highest predicted stress zone changes from T2 to T3 in Tool 2 as the input stroke approaches 30 mm**

Explanation as to why tear location moved for Tool 2 DOE diaphragms



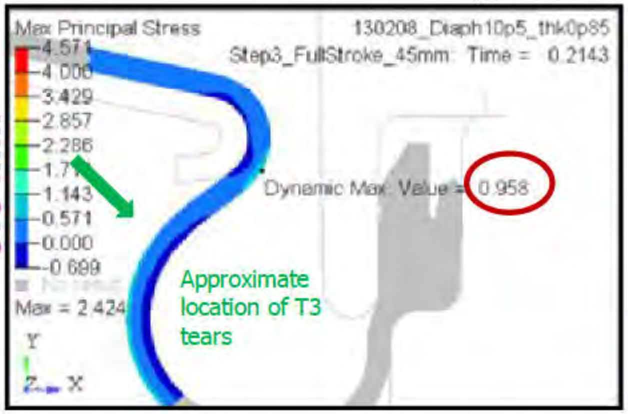
- FEA predicts **Tool 2** diaphragms to have 22 - 27% less stress in the T2 region than **Tool 1** depending on the stroke position of the diaphragm

Explanation as to why tear location moved for Tool 2 DOE diaphragms

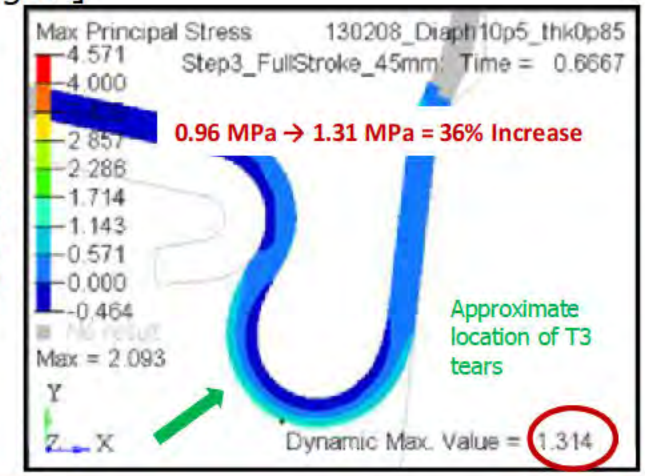
Model at **0.85 mm** Thickness
[**Tool 2** Diaphragms]

Max Principal Stress (MPa)

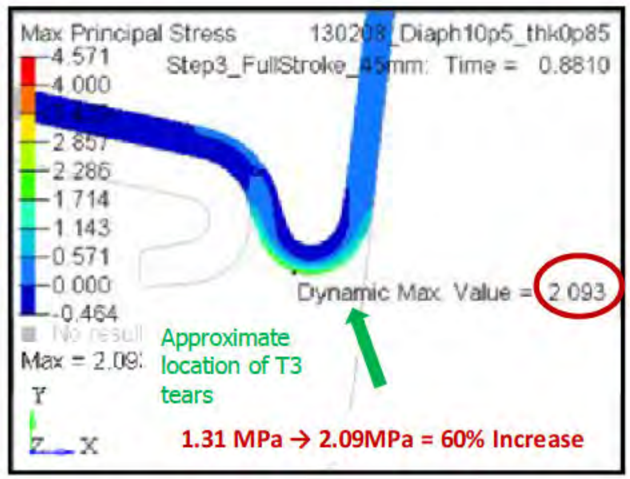
At Input Travel = **9.6 mm**

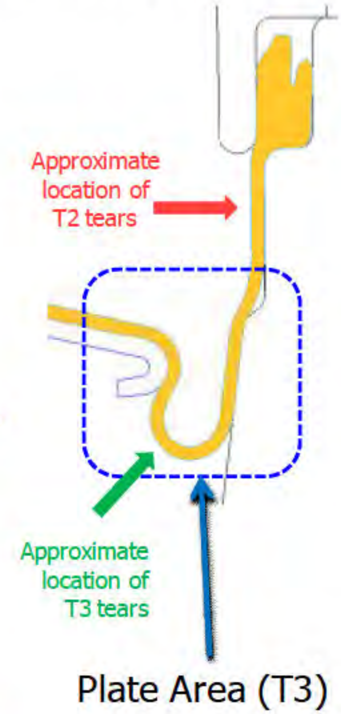


At valve body travel = **30 mm**



At valve body travel = **40 mm**





- FEA predicts **Tool 2** diaphragms to have 36% increased stress in the plate area (T3 location) with a 30 mm input stroke v. 9 mm input stroke, and a 60% increased stress in the plate area (T3 location) with a 40 mm input stroke v. 30 mm input stroke

Performance test results for Tool 3

- **MES test schedule for validation of Cavity 4 diaphragms:**

Technical Specification	Test Description	Release Level	Qty.	ELR #	Target Test Start Date	Target Test Comletetion Date
MES PA 43800	Room temperature durability	PV	4	13-0076	18-Feb-13	17-Apr-13
MES PA 43800	High temperature durability	PV	4	13-0074	19-Feb-13	21-Mar-13
MES PA 43800	Low temperature durability	PV	4	13-0075	18-Feb-13	18-Apr-13

Rubber Material Data

HUTCHINSON SEAL de MEXICO

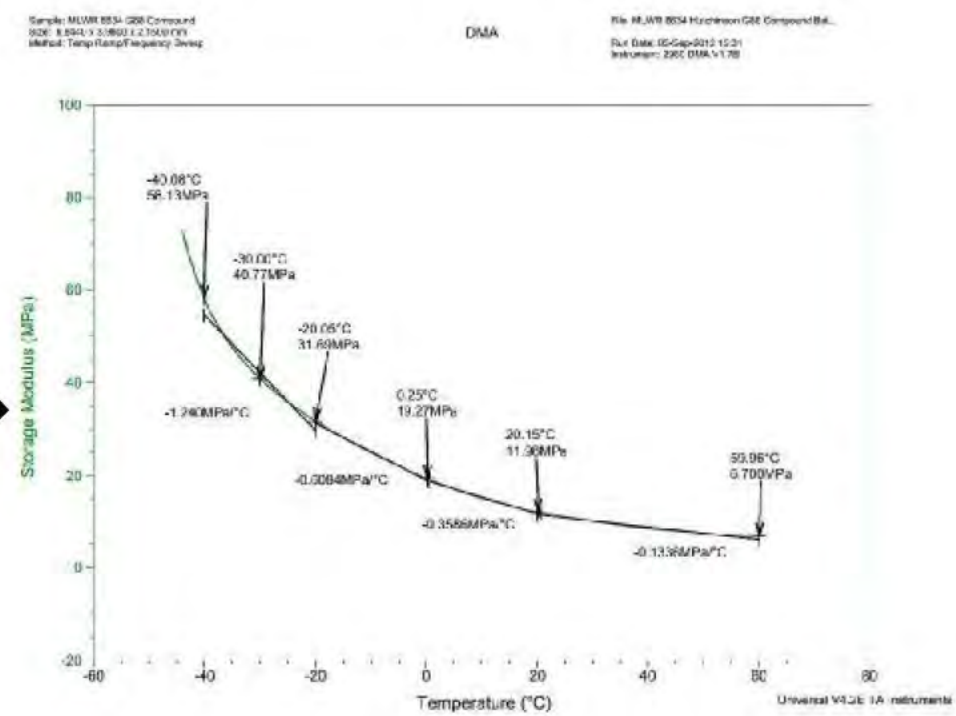
Customer: TRW
Mat specification
Specification: TS2 18 74
Grade:
Issue N°: AE
Revision date: 13/08/2012
Origin: TRW

Report N°: 2013020501A
Edition date: 05/02/2013
Order N°: Pass: QC
Part N°: 32484764F
Dimension: CAV4
HUT code:
HUT compound: G88
Batch N°:

Characteristic	Unit	Test Method	Specification	Slab	Diaphragm
* Color				Black	Black
* IRHD Hardness	Point	ASTM D 1415	65 ± 5	68	68
* Tensile strength	MPa	ASTM D 412	Min 14.0	16.5	19.7
* Elongation at break	%	ASTM D 412	Min 250 to 500	352	363
* Modulus 100%	MPa	ASTM D 412	Min 2.5	2.9	3.2
* Modulus 200%	MPa	ASTM D 412	Min 7.0	7.8	9.0
* Tear Method C (croissant) (die B)	N/mm	DIN 53515	Min 30.0	106	-
*Method B,prise b(entaillee angular) (die C)		ISO 34-1	Min 20.0	43	46
*Method A (pantalon) (Die T)		ISO 34-1	Min 6	7	-
* Compression set 24hrs at 120°C	%	ASTM D 395	Max 30.0	17	-
* Tension set, 24h at 120°C On Slab	%	DIN 53518	Max 50.0	-	37
			Max 25.0	21	-
Heat ageing 70hrs at 120°C					
* IRHD change	Point	ASTM D 573	-5 to 10	+4	10
* Tensile strength retained	%		Min 75	96	104
* Elongation at break retained	%		Min 50	71	63
* Tear strength retained	%		Min 65	97	87
Dynamic Mechanical Analysis		TS2-10-003			
* Typical values are not necessarily required				See attached	
After 168hrs at 120°C in DOT 4		ASTM D 471			
* Hardness change	Point		-12 to 0	-5	
* Tensile strength retained	%		Min 70	78	
* Elongation at break retained	%		Min 60	67	
Precipitation in SAE compatibility Fluid			0.3 Max On Slab	Non Precip Pass	
* Extractable matter (Hexane)	%			6.5	
* Extractable matter (Acetone)		TS2-10-003	Max. 15	12.1	
* Ozone resistance, 70h at 50pphm	Visual		Rating 0	No cracks	
* Rigidity, TR10	°C	TS-2-10-004	Min –35	-50	
* Low temp. Brittleness at –40°C		ASTM D 2137	No cracks	Pass	
Volume change in DOT 4 after		ASTMD 471			
* 70hrs at 70°C	%		-5 to 5	-2.4	
* 4 weeks at 70°C	%		-5 to 5	-4.1	
* 70hrs at 120°C	%		-5 to 10	-3.9	
* 4 weeks at 120°C	%		-5 to 10	-1.7	
*Corrosive Action on Cooper			No discolouration	Non Discolouration	

Comment: HUTCHINSON SEAL compound G88 complies all tested requirements of TS2-18-074 specification.

Name: Daniel CORTARELLI
Compound R&D - Technical Mgr
Visa: [signature]



Specific Gravity on the measured part was 1.138g/cm³.

Hutchinson deem Scorch Time and Viscosity as compound proprietary Information.

Tool 3 PPAP and Production timing

- Tool 3 PPAP dimensionals submitted and reviewed with Mazda February 21st
- Next production run on February 24th will use Tool 3 parts

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 2-11 Supplier Report 28 Feb 2013

COGNITIVE SAFETY SYSTEMS | TRW

Mazda J50C Booster Warranty

Update Slides

February 28, 2013
TRW Automotive

ADVANCED THINKING / SMART THINKING / GREEN THINKING

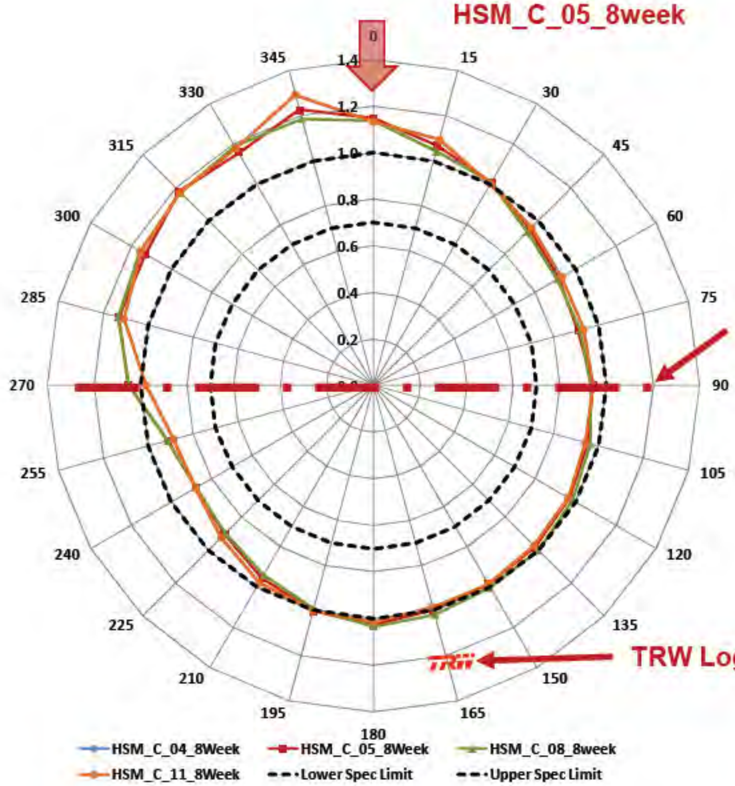
Agenda

1. Corrected radial plots
2. DOE status update
3. Tear locations of warranty returned parts and DOE test failures
4. FEA clarification of T3 area for Tool 1 and Tool 2 with thickness of .85, 1.0 and 1.25mm
5. Tear size and warranty VIN on November 1, 2012 presentation (page 11, 13 graphs)
6. Additional information to January 11, 2013 presentation
   - Need comparison analyze the difference from graph of Jan.11/2013 presentation page 26,27,28,29
   - Need more samples evaluation by Warranty returned units
   - Need test condition of the speed during applying force Based on the Jan 11 2013 presentation page 32
7. Diaphragm tear effect
8. Diaphragm thickness controls
9. Hutchinson material data

Tool 1 Thickness Measurement (Corrected Radial Plot)
4 Diaphragms in DOE test with 8 week shelf life material

- Diaphragms from Tool 1 with 8 week shelf life material, have thickness at position 99 measured circumferentially:
  - Max thickness of 1.05 – 1.11 mm
  - Min thickness of 0.92 – 0.97 mm
  - Mean thickness of 0.99 – 1.02 mm

Measurement Degree	Thickness at Position 99 (mm)			
	HSM_C_05_8week	HSM_C_11_8week	HSM_C_08_8week	HSM_C_04_8week
0	1.15	1.24	1.14	1.13
15	1.07	1.08	1.04	1.09
30	1.01	1.03	1.01	1.00
45	0.95	0.94	0.93	0.96
60	0.92	0.90	0.91	0.93
75	0.91	0.90	0.92	0.93
90	0.94	0.93	0.93	0.94
105	0.95	0.95	0.96	0.94
120	0.97	0.97	0.99	0.96
135	0.98	0.98	1.00	0.97
150	0.98	0.99	1.00	0.98
165	1.00	1.01	1.02	0.99
180	1.03	1.02	1.03	1.01
195	1.00	0.99	0.99	1.00
210	0.96	0.94	0.94	0.98
225	0.90	0.90	0.90	0.92
240	0.88	0.91	0.88	0.88
255	0.91	0.97	0.92	0.89
270	1.05	1.39	1.05	0.98
285	1.13	1.41	1.14	1.11
300	1.13	1.21	1.16	1.15
315	1.18	1.26	1.17	1.18
330	1.16	1.40	1.19	1.18
345	1.23	1.31	1.19	1.29
MIN	0.88	0.90	0.88	0.88
MAX	1.23	1.41	1.19	1.29
MEAN	1.02	1.07	1.02	1.02
STD DEV	0.10	0.17	0.10	0.11



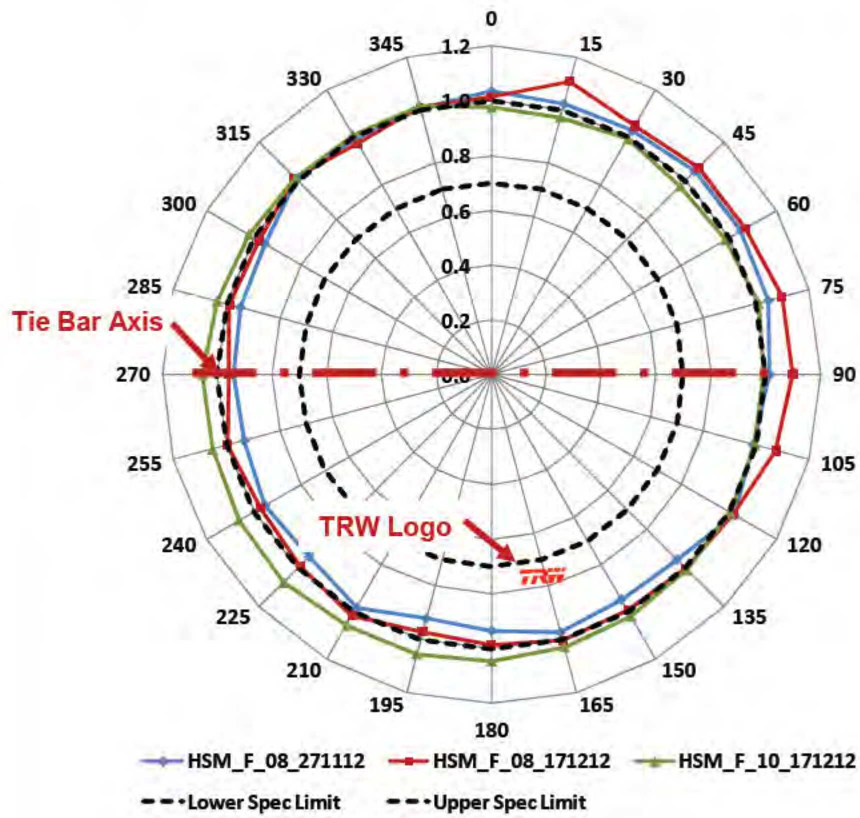
Diaphragms are measured with logo facing down and measurements reported with logo facing up

Radial Plot updated to reflect correct measurement direction

Tool 2 Thickness Measurement (Corrected Radial Plot)
3 Diaphragms suspended > 100,000 cycles in DOE

- Diaphragms suspended in DOE have thickness at position 99 measured circumferentially:
  - Max thickness of 1.05 – 1.11 mm
  - Min thickness of 0.92 – 0.97 mm
  - Mean thickness of 0.99 – 1.02 mm

Measurement Degree	Thickness at Position 99(mm)		
	HSM F 08 271112	HSM F 08 171212	HSM F 10 171212
0	1.04	1.01	0.98
15	1.02	1.11	0.97
30	1.03	1.05	0.99
45	1.05	1.07	0.97
60	1.05	1.07	0.99
75	1.05	1.10	1.01
90	1.02	1.10	0.99
105	0.99	1.07	1.00
120	1.02	1.02	1.01
135	0.96	1.00	1.01
150	0.95	0.99	1.02
165	0.97	1.00	1.03
180	0.93	0.99	1.05
195	0.92	0.97	1.06
210	0.98	1.02	1.06
225	0.94	0.99	1.07
240	0.95	0.97	1.06
255	0.93	1.00	1.05
270	0.94	0.96	1.05
285	0.95	0.99	1.04
300	0.96	0.98	1.02
315	1.01	1.02	1.01
330	0.99	0.98	1.01
345	1.01	1.01	1.02
MIN	0.92	0.96	0.97
MAX	1.05	1.11	1.07
MEAN	0.99	1.02	1.02
STD DEV	0.04	0.04	0.03



Diaphragms are measured with logo facing down and measurements reported with logo facing up

Radial Plot updated to reflect correct measurement direction

DOE Status Update

DOE Phase	Test Order	A: Shelf Life	B: Thickness	C: Particles / Supplier	Qty	Supplier Lead Time	Estimated Test Completed Date	Wk ending	Estimated Test Completion date as of Jan 28th
Pre-DOE	0	Current Production			4	NA	Wk 46	11-Nov	Completed Dec 12
Part 1	1	1 wk	+(Thin)	- (Hi Count) / HSM	2	1 wk	wk 47	18-Nov	Completed Jan 7
	2	1 wk	- (Thick)		2	2 wks	wk 49	2-Dec	Completed Dec 28
	3	4 wk	+(Thin)		2	5 wks	wk 2	13-Jan	Finish Feb 1
	4	4 wk	- (Thick)		2	6 wks	wk 2	13-Jan	Completed Jan 16
	5	8 wks	+(Thin)		2	9 wks	wk 3	20-Jan	90% complete, finish Mar 1
	6	8 wks	- (Thick)		2	9 wks	wk 4	27-Jan	75% complete, finish Mar 1
Part 2a	7	+(1 wk or Min)	+(Thin)	+(Lo Count)/ Rubena	2	12 wks	wk 11	17-Mar	Expected Mar 28
	8	-(30 days Max)	+(Thin)		2	16 wks	wk 15	14-Apr	Expected Apr 28
Part 2b	9	+(1 wk or Min)	+(Thin)	+(Lo Count)/ Daetwyler	2	22 wks	wk 18	5-May	Expected May 17
	10	-(6 months)	+(Thin)		2	48 wks	wk 44	3-Nov	Expected Nov 15

Notes:

1. Original DOE timing plan assumed Pre-DOE phase (Dev test) worked 1st time.
First new test method tried was not successful. Extra time to develop & evaluate a second test method delayed start of DOE testing approx. 3-4 weeks.
2. Increased Qty to test from 2 to 4.

DOE Status Update

1. Develop & evaluate accelerated evaluation test
   Test Method 1: “Air pressure cycling” approach did not work out- difficulty sealing under pressure
   Test Method 2: “Modified endurance” Successful: Replicated failure mode in short time. **COMPLETED** Dec 12.

2. Order diaphragm test configurations
   COMPLETE: All test parts have been ordered from suppliers.

3. Build booster assembles
   ONGOING: Per plan as DOE diaphragms are received.

4. Complete Part 1 Testing
   IN PROGRESS:
   1 wk “thick” parts:” **COMPLETE**
   1 wk “thin” parts:” **COMPLETE** (note: cracked in different position)
   4 wk “thick parts:” **COMPLETE**
   4 wk “thin parts:” **COMPLETE**
   8wk “thick parts”: Test completion expected Mar 1
   8 wk “thin parts” : Test completion expected Mar 1

5. Analyze & publish Part 1 results
   Following completion of Part 1 testing: Expected Mar 8

6. Complete Part 2a Testing & publish results
   Following completion of Part 2a testing: Expected May 3

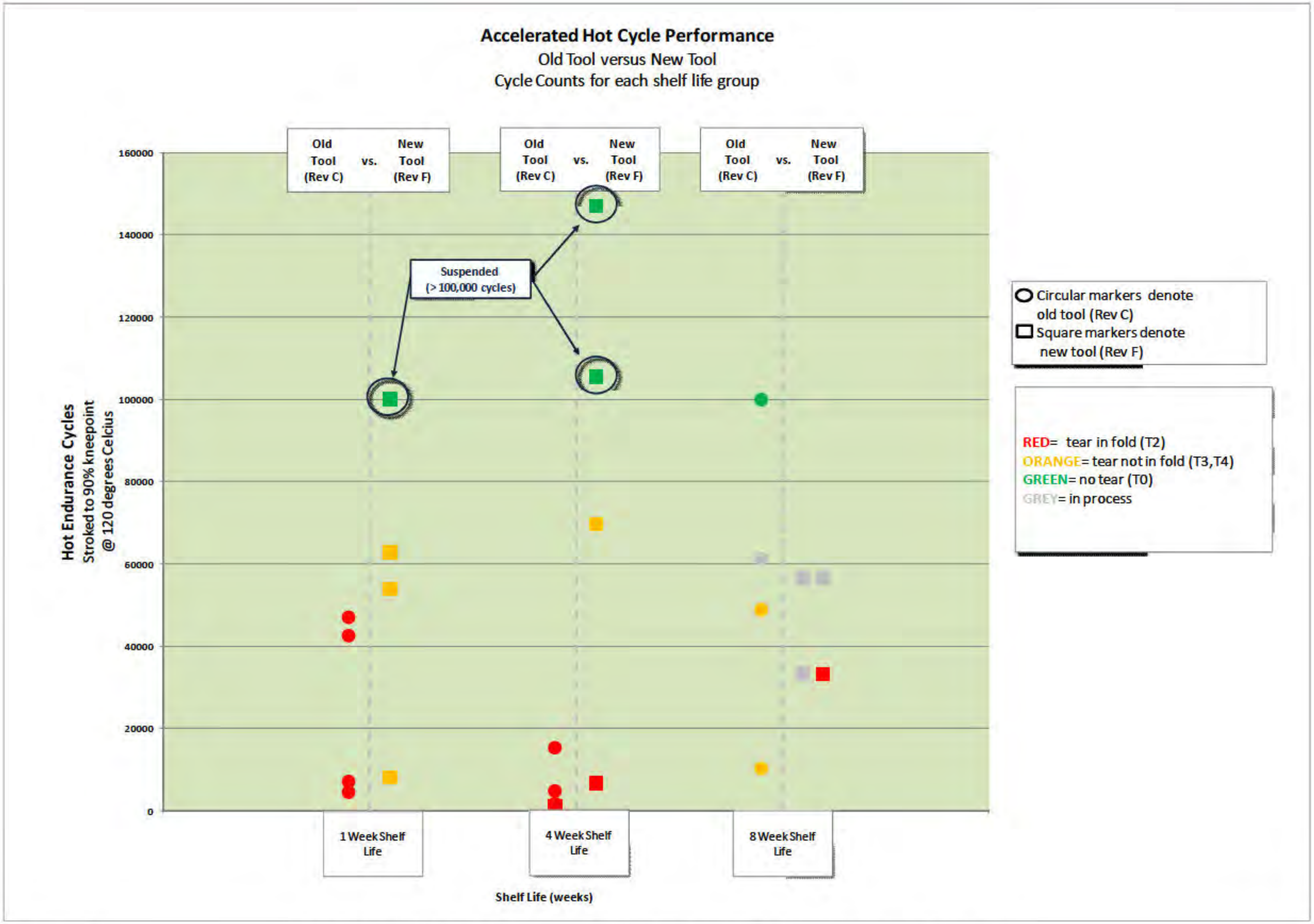
DOE Status Update

- **Tool1, 8 week material diaphragms: 1 suspended; 2 T3 failures; 1 in process**
- **Tool 2, 8 week material diaphragms: 1 T2 failure; 3 in process**

Sample ID	Shelf Life	Part No	Tool Number	Status	No. of Tears	Length of Tear(mm)	Cycles @ Tear	Material Lab Request
HSM_C_08_8week	8 week	32484764	1	failed	1	8	48,909	MLWR_9067
HSM_C_04_8week	8 week	32484764	1	in process	0	—	61,503	—
HSM_C_11_8week	8 week	32484764	1	suspend	0	—	100,000	—
HSM_C_05_8week	8 week	32484764	1	failed	1	8	10,310	MLWR_9035
HSM_F_03_8week	8 week	32484764	2	in process	0	—	56,652	—
HSM_F_06_8week	8 week	32484764	2	failed	1	29	33,292	MLWR_9067
HSM_F_08_8week	8 week	32484764	2	in process	0	—	56,652	—
HSM_F_12_8week	8 week	32484764	2	in process	0	—	33,443	—

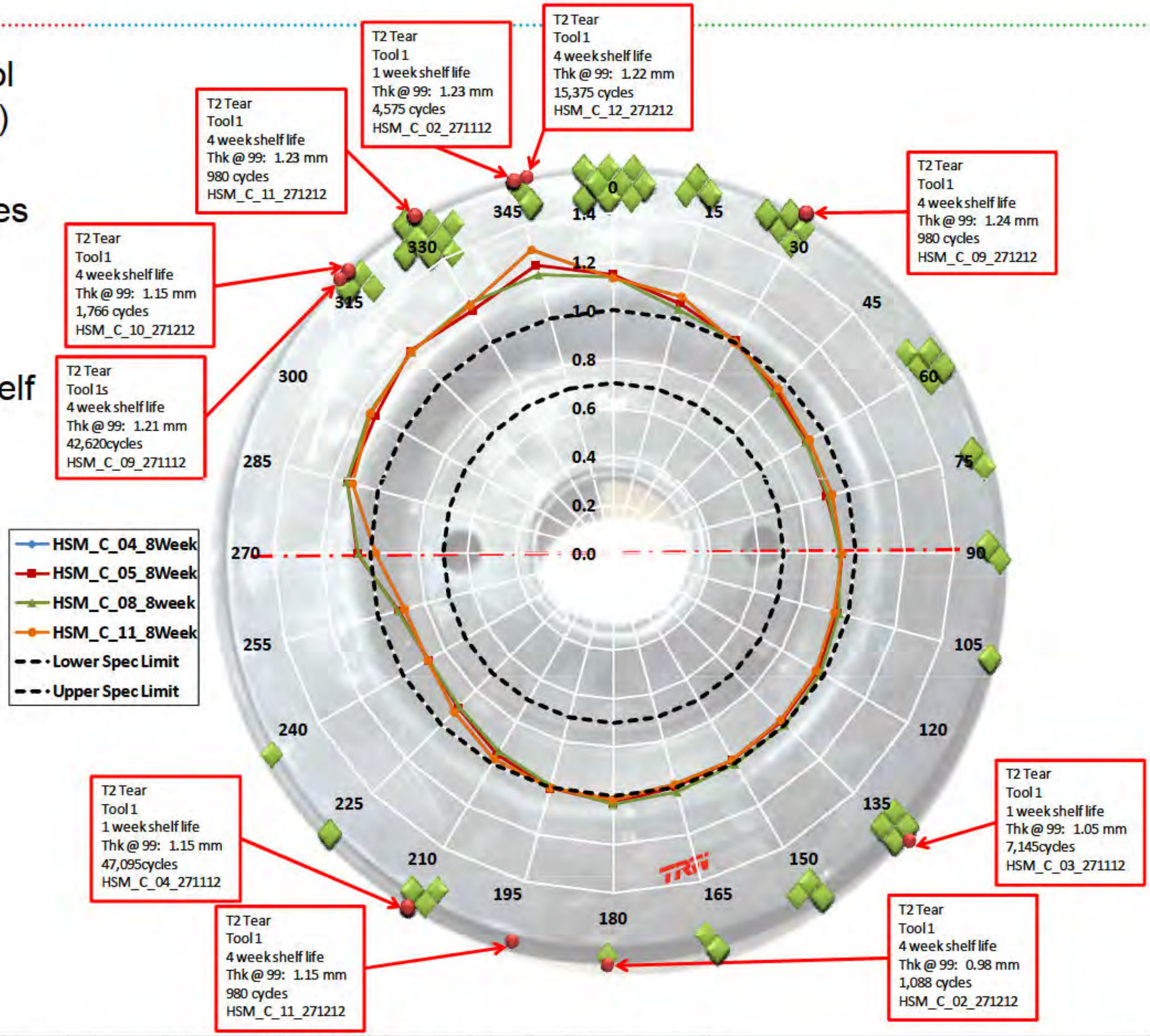
Sample ID	Cycles	Shelf Life (weeks)	Failure Mode	Failure Location	Failure Size (mm)	Embedded Particle length (microns)	Embedded Particle height (microns)	Material Thickness (greatest) at defect site (mm)	Material Thickness at Location T2 (mm)
HSM_C_08_8week	48,909	8	tear	T3	8	106	100	1.27	1.15
HSM_C_04_8week	61,503	8	—	T0	—	—	—	—	—
HSM_C_11_8week	100,000	8	—	T0	—	—	—	—	—
HSM_C_05_8week	10,310	8	tear	T3	8	109	106	1.306	1.08
HSM_F_03_8week	56,652	8	—	T0	—	—	—	—	—
HSM_F_06_8week	33,292	8	tear	T2	29	178	106	1.05	1.05
HSM_F_08_8week	56,652	8	—	T0	—	—	—	—	—
HSM_F_12_8week	33,443	8	—	T0	—	—	—	—	—

DOE Status Update



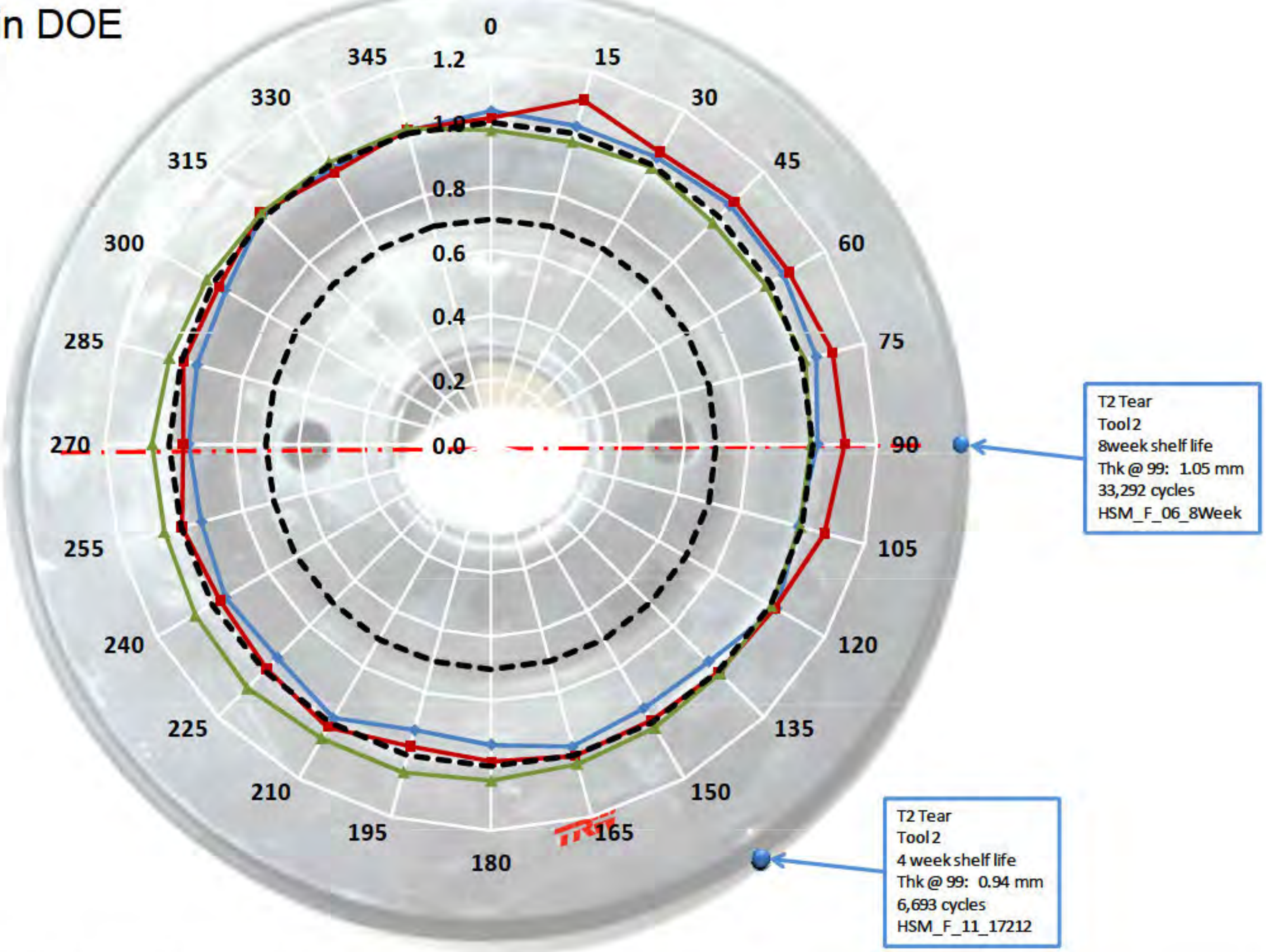
Tool 1 Tear Locations with Tool 1 thickness at position 99

- T2 DOE failures for Tool 1 diaphragms (red dots) Quantity = 10 tears
- Warranty Return Failures (Green Diamonds) Quantity = 55 tears
- Radial plot of Tool 1 diaphragms, 8 week shelf life material



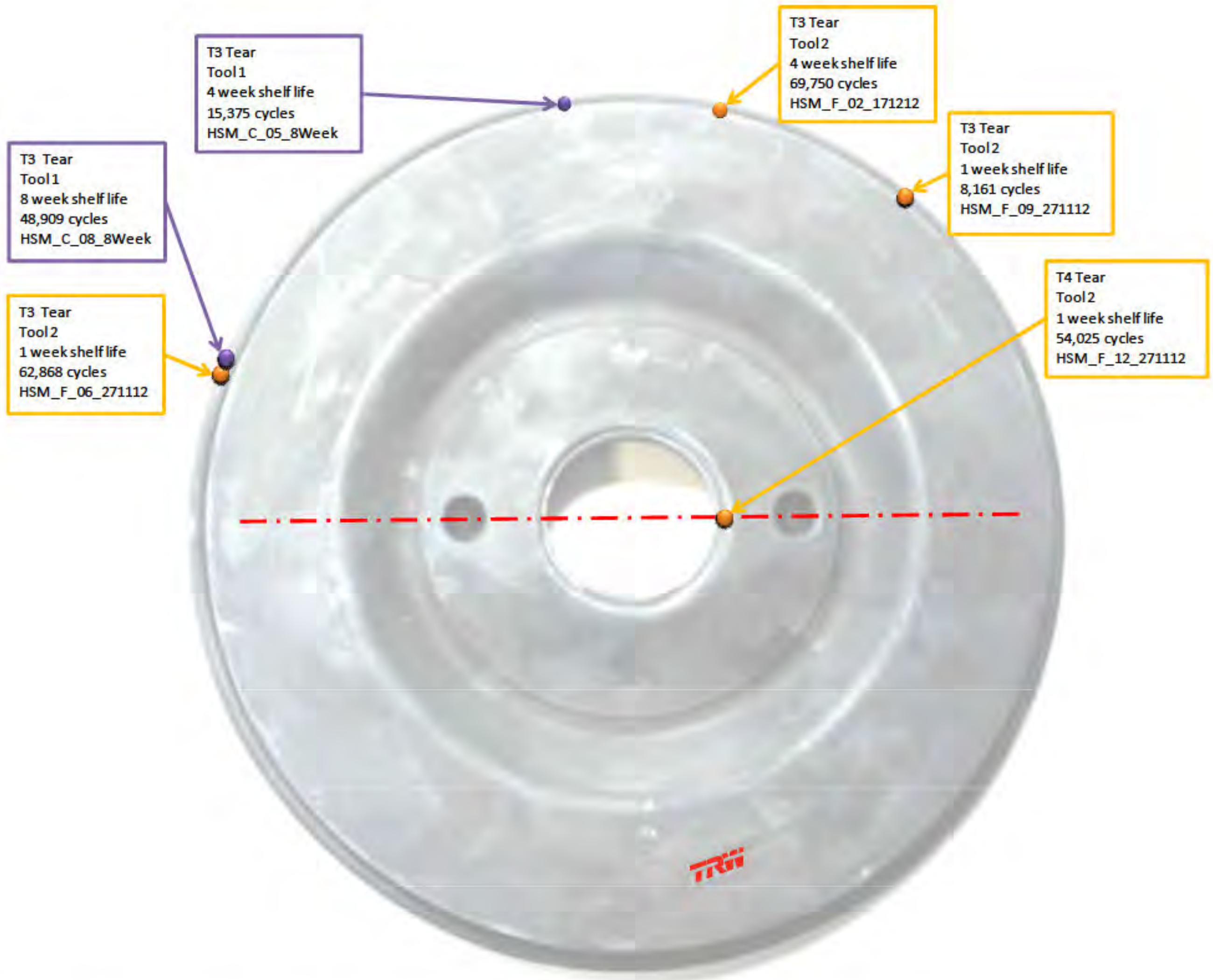
Tool 2 Tear Locations with Tool 2 thickness at position 99

- T2 DOE failure for Tool 2 diaphragms
- Radial plot of Tool 2 diaphragms suspended in DOE Quantity = 2 tears



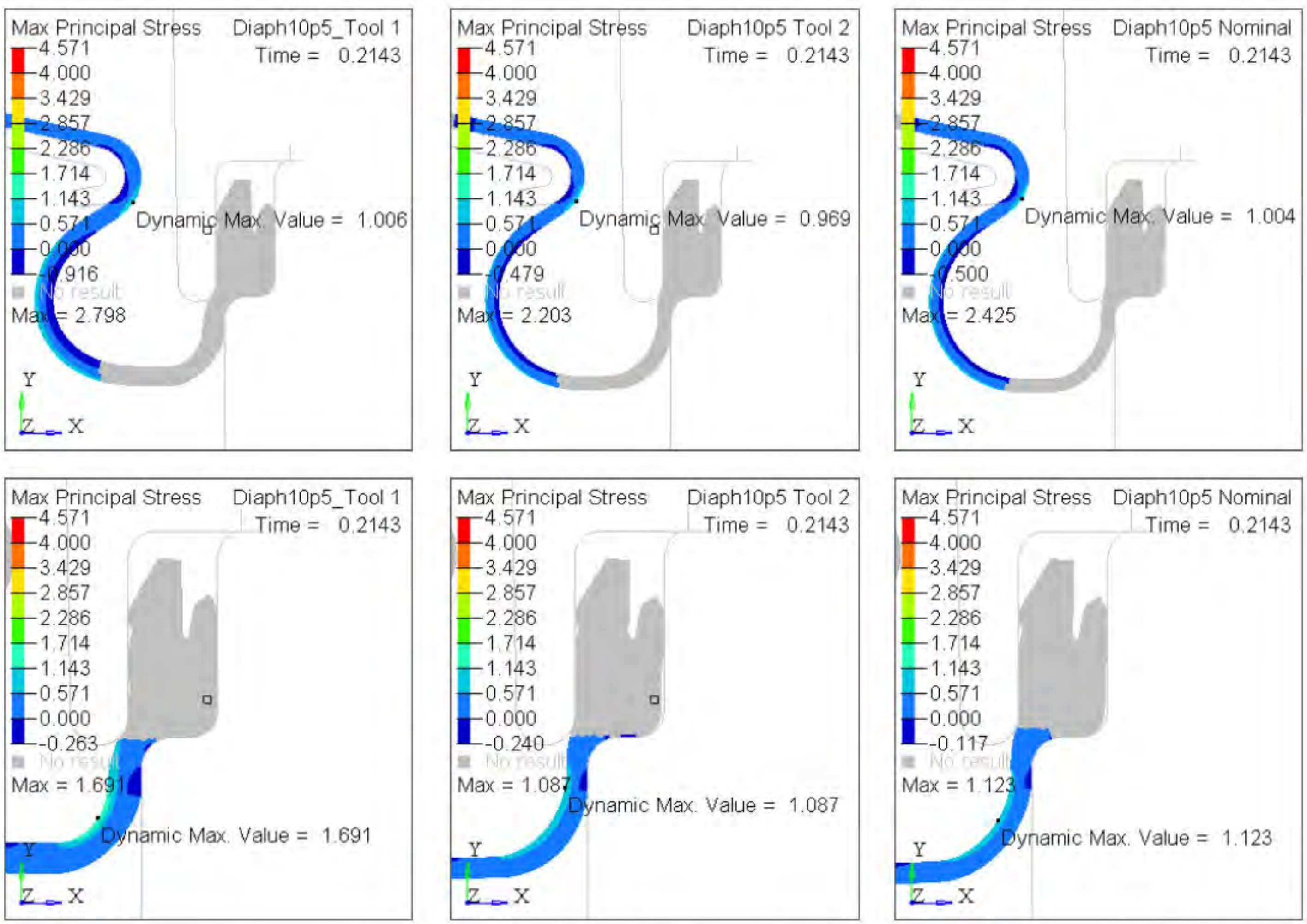
Tool 2 Tear Locations with Tool 1 and Tool 2

- T3 & T4 DOE failures for Tool 1 and Tool 2 diaphragms
- Tool 1 quantity = 2 tears
- Tool 2 quantity = 3 tears (T3 only)

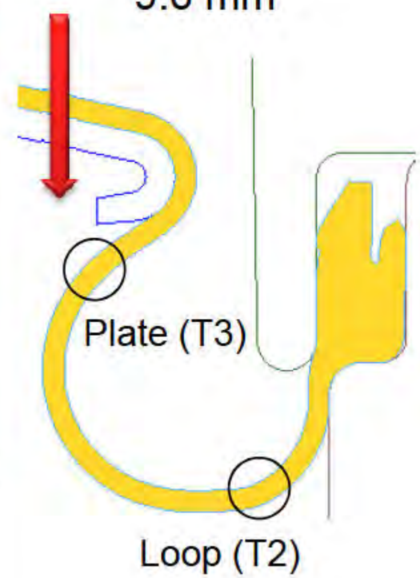


FEA Results Tool 1, Tool 2, Tool 3 at T2 & T3 Locations

Tool 1 [T2 = 1.25 mm, T3 = 1.0 mm] Tool 2 [T2 = 1.0 mm, T3 = 0.85 mm] Tool 3 [T2 = 0.85 mm, T3 = 0.85 mm]

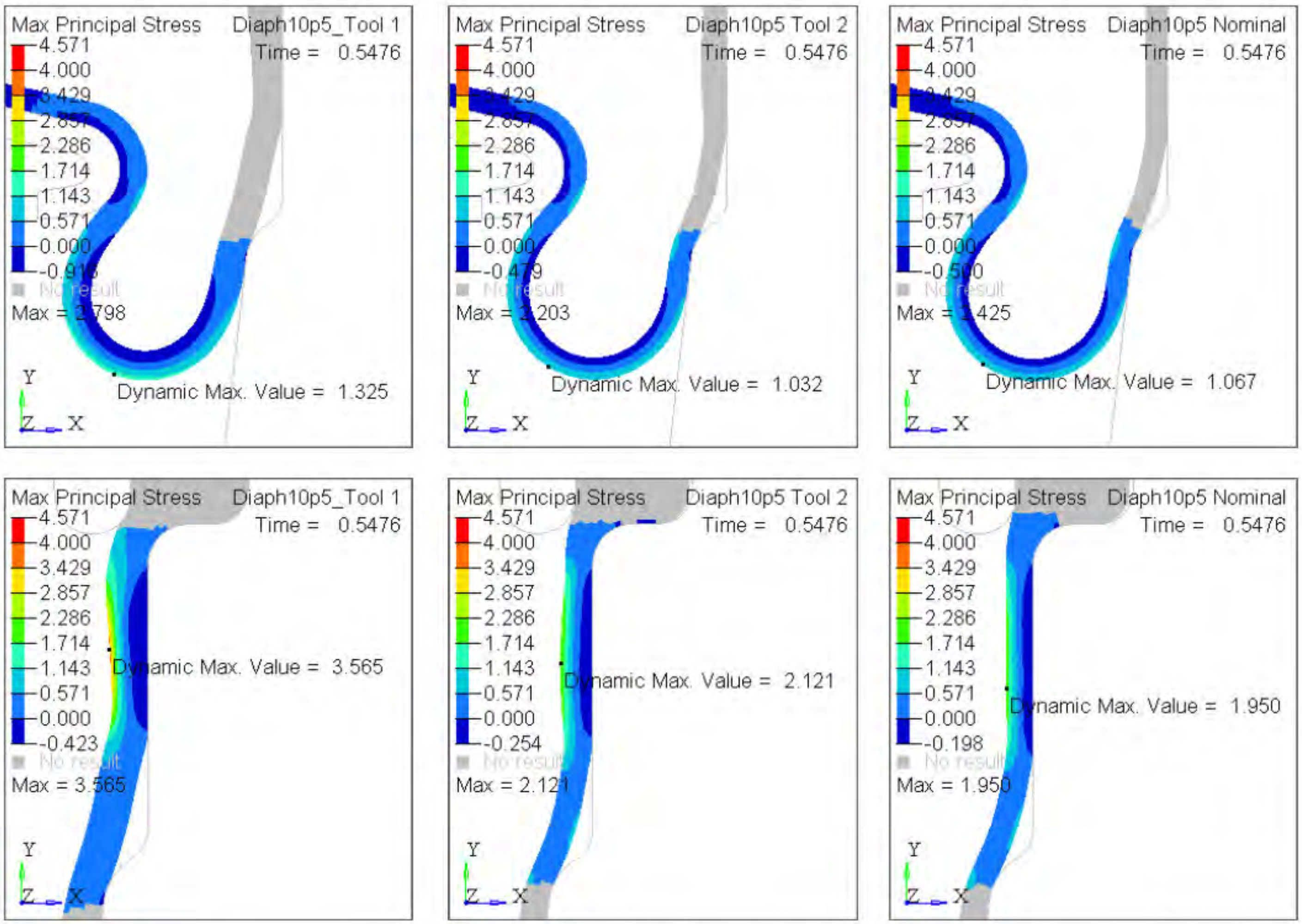


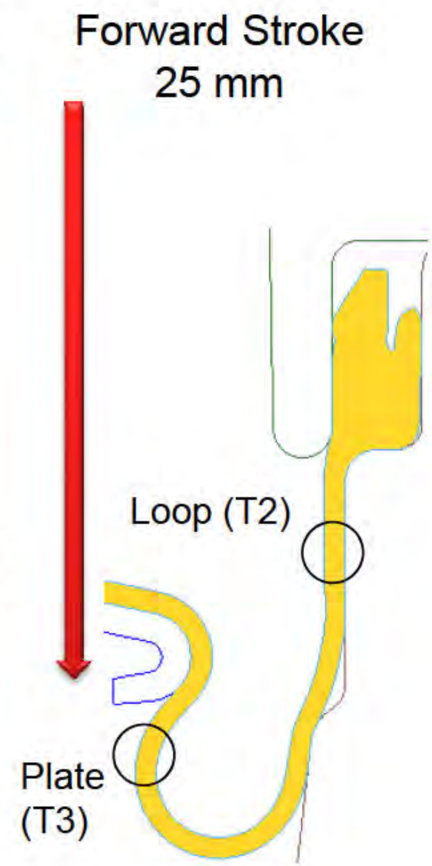
Forward Stroke
9.6 mm



FEA Results Tool 1, Tool 2, Tool 3 at T2 & T3 Locations

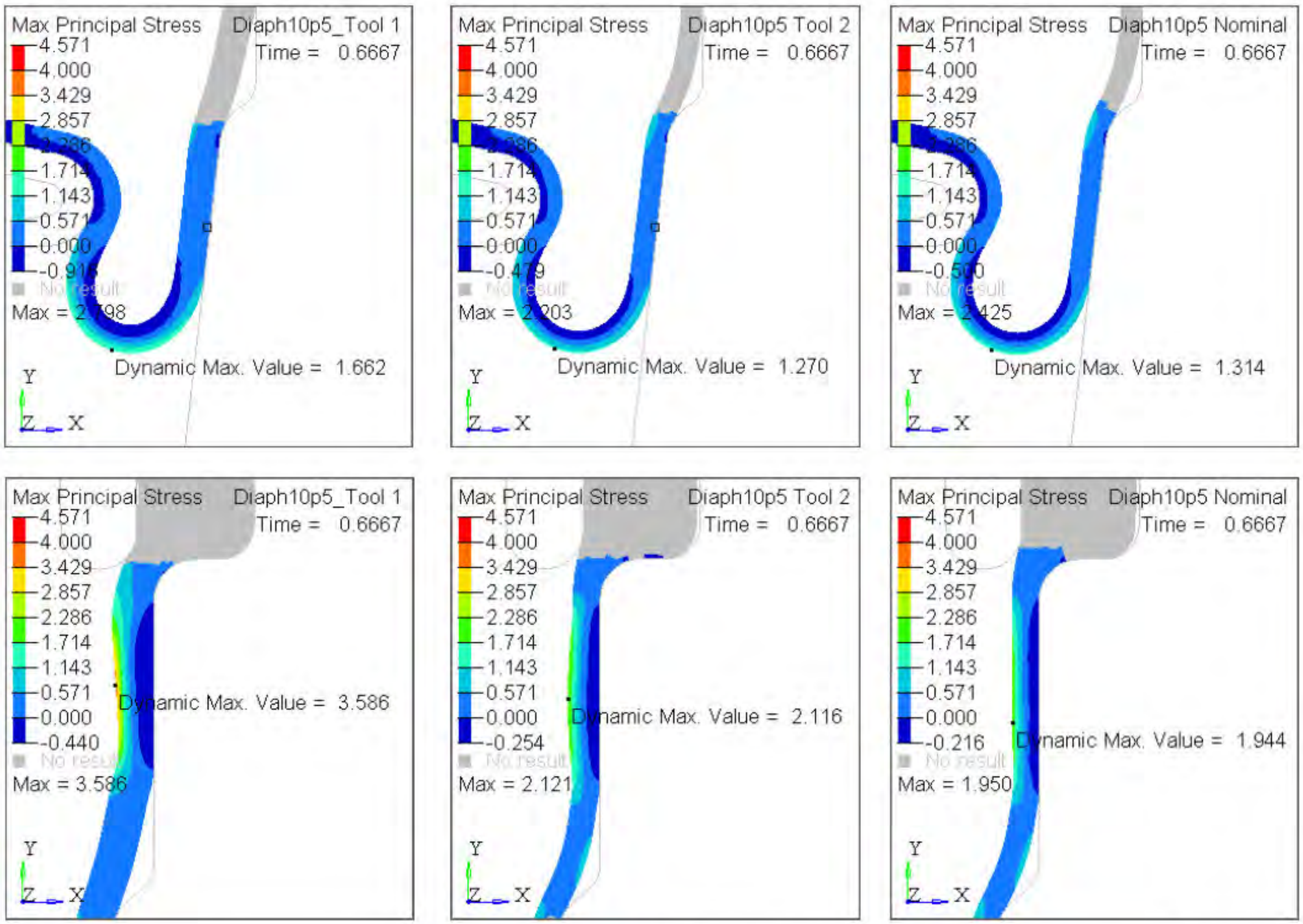
Tool 1 [T2 = 1.25 mm, T3 = 1.0 mm] Tool 2 [T2 = 1.0 mm, T3 = 0.85 mm] Tool 3 [T2 = 0.85 mm, T3 = 0.85 mm]

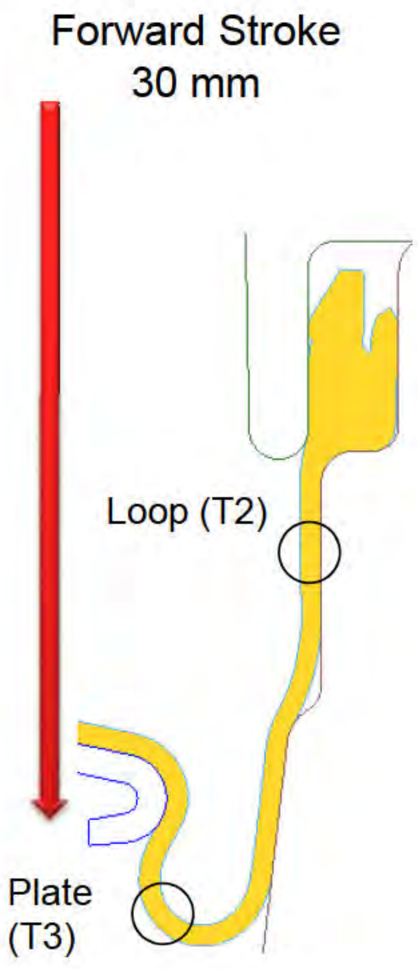




FEA Results Tool 1, Tool 2, Tool 3 at T2 & T3 Locations

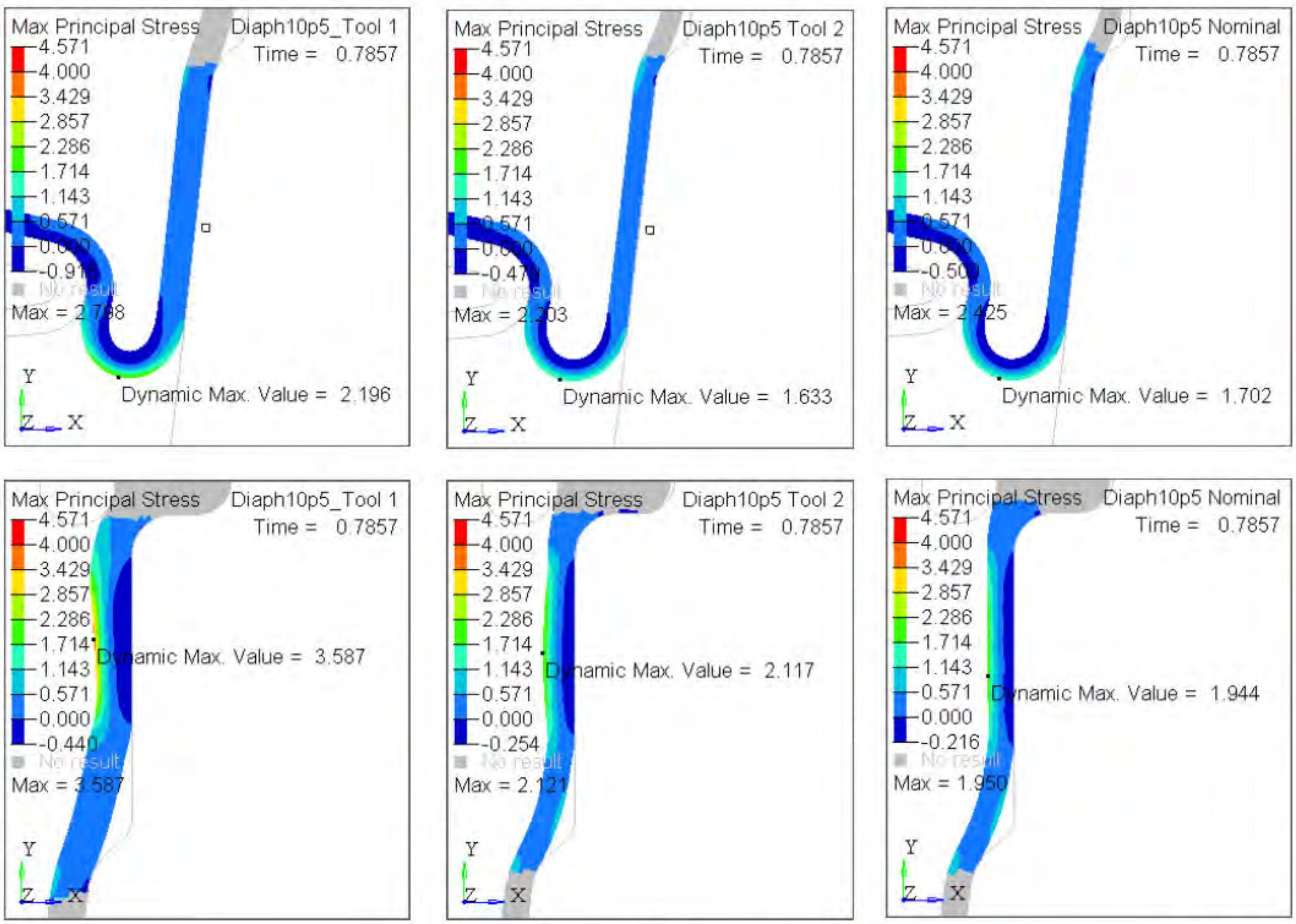
Tool 1 [T2 = 1.25 mm, T3 = 1.0 mm] Tool 2 [T2 = 1.0 mm, T3 = 0.85 mm] Tool 3 [T2 = 0.85 mm, T3 = 0.85 mm]

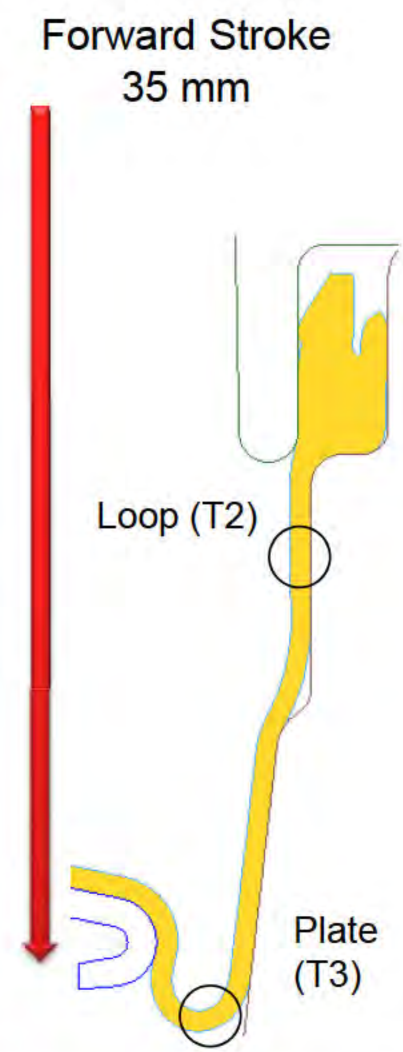




FEA Results Tool 1, Tool 2, Tool 3 at T2 & T3 Locations

Tool 1 [T2 = 1.25 mm, T3 = 1.0 mm] Tool 2 [T2 = 1.0 mm, T3 = 0.85 mm] Tool 3 [T2 = 0.85 mm, T3 = 0.85 mm]





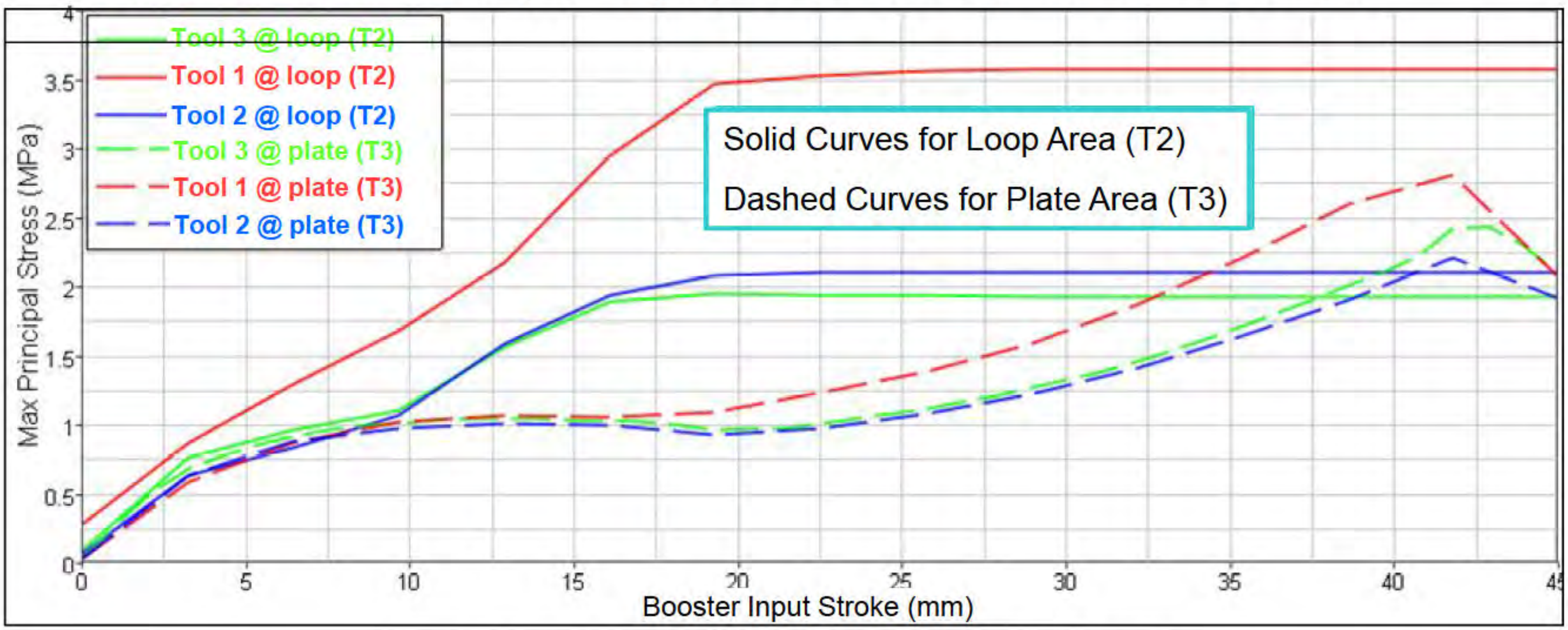
FEA Results Tool 1, Tool 2, Tool 3 at T2 & T3 Locations

- Tabular summary of FEA predicted maximum principal stress in diaphragm models simulating Tool 1, Tool 2 and Tool3 at locations T2 and T3
  - Predicted maximum principal stress at T2 location increases with booster input stroke until diaphragm at T2 location is supported by front shell (approx. 19 mm stroke), then stress remains constant with continued input stroke
  - Predicted maximum principal stress at T3 location increases steadily with booster input stroke

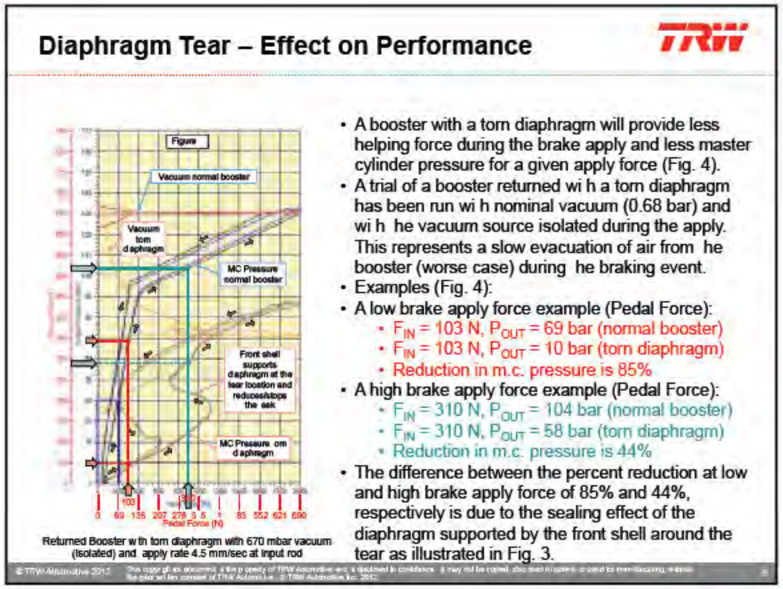
		Model 1 (tool 1)	Model 2 (tool 2)	Model 3 (tool 3)
	T2 Thickness	1.25 mm	1.00 mm	0.85 mm
	T3 Thickness	1.00 mm	0.85 mm	0.85 mm
T2 Stress	9.6mm	1.69 MPa	1.09 MPa	1.12 MPa
	25 mm	3.57 MPa	2.12 MPa	1.95 MPa
	30 mm	3.59 MPa	2.12 MPa	1.94 MPa
	35 mm	3.59 MPa	2.12 MPa	1.94 MPa
T3 Stress	9.6mm	1.01 MPa	0.97 MPa	1.00 MPa
	25 mm	1.33 MPa	1.03 MPa	1.07 MPa
	30 mm	1.66 MPa	1.27 MPa	1.31 MPa
	35 mm	2.20 MPa	1.63 MPa	1.70 MPa

FEA Results Tool 1, Tool 2, Tool 3 at T2 & T3 Locations

- Tabular summary of FEA predicted maximum principal stress in diaphragm models simulating Tool 1, Tool 2 and Tool3 at locations T2 and T3
  - Although the FEA predicted maximum principal stress at location T3 does not exceed the stress at location T2 through 35 mm input stroke, the stress levels do approach those in location T2 and localized stress risers from non-homogeneous particles located at either T2 or T3 regions potentially raise the stress to higher levels.
  - These FEA models are axis-symmetric and do not account for T2 or T3 thickness variations that are known to exist circumferentially in all samples; therefore predicted values are useful for comparison purposes; absolute values are not accurate.

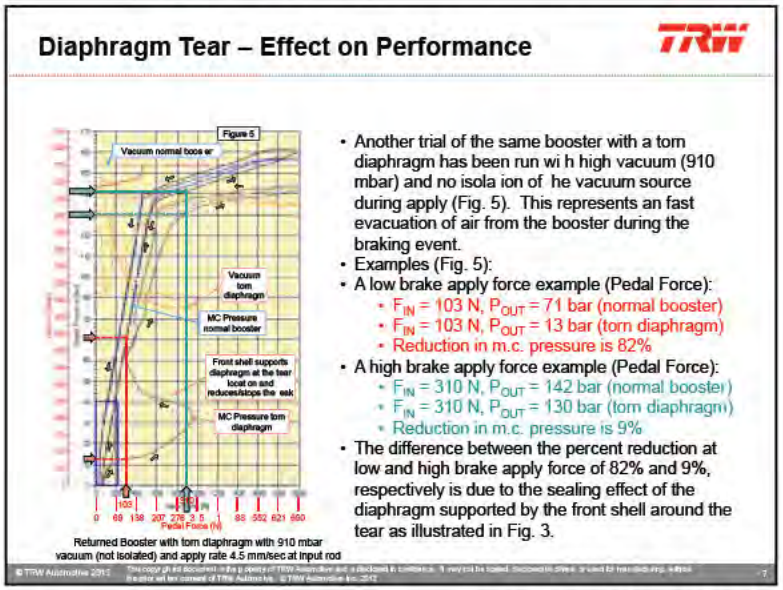


Add Tear Size and VIN to Graphs in November 2012 Presentation


Diaphragm Tear – Effect on Performance

- A booster with a torn diaphragm will provide less helping force during the brake apply and less master cylinder pressure for a given apply force (Fig. 4).
- A trial of a booster returned wi h a torn diaphragm has been run wi h nominal vacuum (0.68 bar) and wi h he vacuum source isolated during the apply. This represents a slow evacuation of air from he booster (worse case) during he braking event.
- Examples (Fig. 4):
- A low brake apply force example (Pedal Force):
  - F_{IN} = 103 N, P_{OUT} = 69 bar (normal booster)
  - F_{IN} = 103 N, P_{OUT} = 10 bar (torn diaphragm)
  - Reduction in m.c. pressure is 85%
- A high brake apply force example (Pedal Force):
  - F_{IN} = 310 N, P_{OUT} = 104 bar (normal booster)
  - F_{IN} = 310 N, P_{OUT} = 58 bar (torn diaphragm)
  - Reduction in m.c. pressure is 44%
- The difference between the percent reduction at low and high brake apply force of 85% and 44%, respectively is due to the sealing effect of the diaphragm supported by the front shell around the tear as illustrated in Fig. 3.

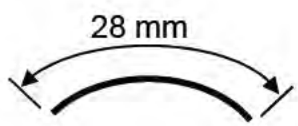
Returned Booster w th torn diaphragm with 670 mbar vacuum (isolated) and apply rate 4.5 mm/sec at input rod


Diaphragm Tear – Effect on Performance

- Another trial of the same booster with a torn diaphragm has been run wi h high vacuum (910 mbar) and no isola ion of he vacuum source during apply (Fig. 5). This represents an fast evacuation of air from the booster during the braking event.
- Examples (Fig. 5):
- A low brake apply force example (Pedal Force):
  - F_{IN} = 103 N, P_{OUT} = 71 bar (normal booster)
  - F_{IN} = 103 N, P_{OUT} = 13 bar (torn diaphragm)
  - Reduction in m.c. pressure is 82%
- A high brake apply force example (Pedal Force):
  - F_{IN} = 310 N, P_{OUT} = 142 bar (normal booster)
  - F_{IN} = 310 N, P_{OUT} = 130 bar (torn diaphragm)
  - Reduction in m.c. pressure is 9%
- The difference between the percent reduction at low and high brake apply force of 82% and 9%, respectively is due to the sealing effect of the diaphragm supported by the front shell around the tear as illustrated in Fig. 3.

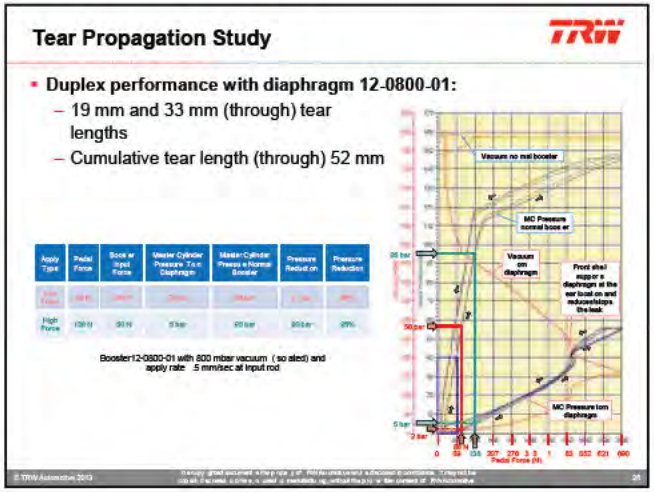
Returned Booster with torn diaphragm with 910 mbar vacuum (not isolated) and apply rate 4.5 mm/sec at input rod

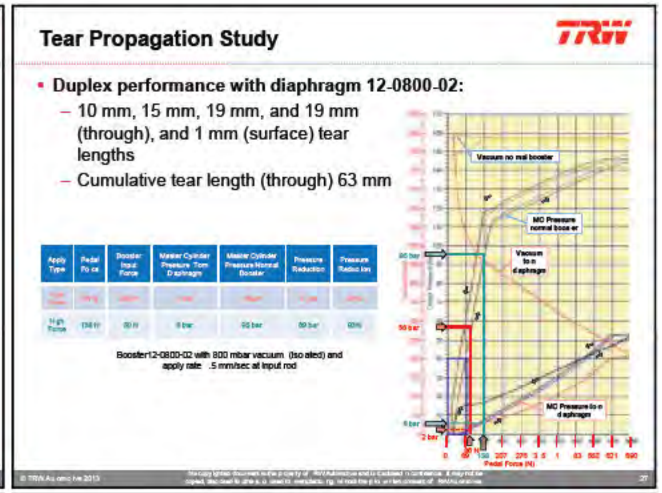
- Function plots of a duplex with a warranty return booster (presented 01-Nov-2012) with a confirmed torn diaphragm are shown on the left. The two graphs represent the same booster evaluated under different test conditions:
  - **Top Image**: 680 mbar vacuum, booster assy is isolated from the vacuum source during apply
  - **Bottom Image**: 910 mbar vacuum, booster assy is not isolated from the vacuum source during apply
- Request from Mazda Engineering to provide the following information on the booster used in this evaluation:
  - Tear size: 28 mm (measured along tear)
  - Vehicle VIN: JM7-TB19A2-AO-204847

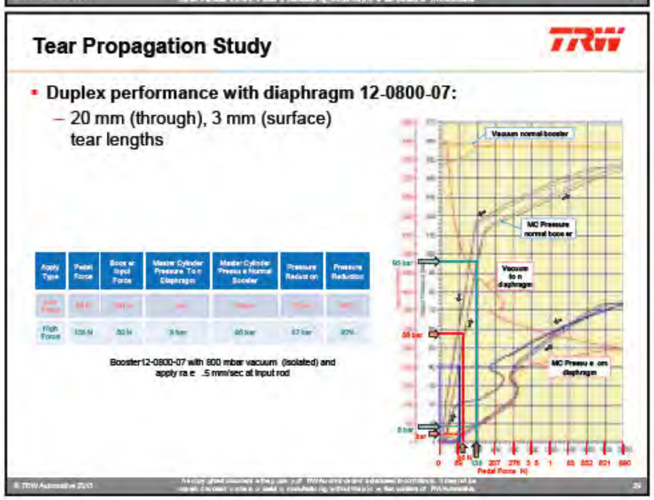


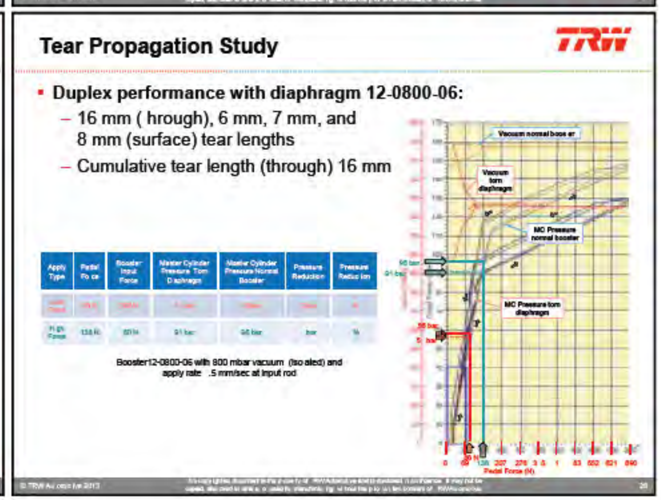
Mazda additional information request from January 11, 2013 presentation

- Need comparison analyze the difference from graph of Jan.11/2013 presentation page 26,27,28,29 (shown below):
  - Not clear what Mazda is expecting with this request.







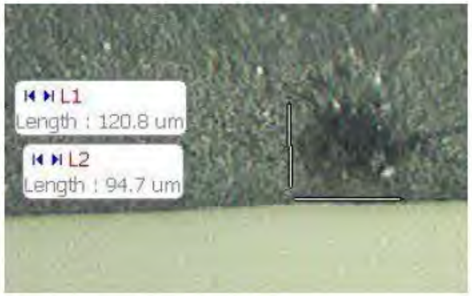


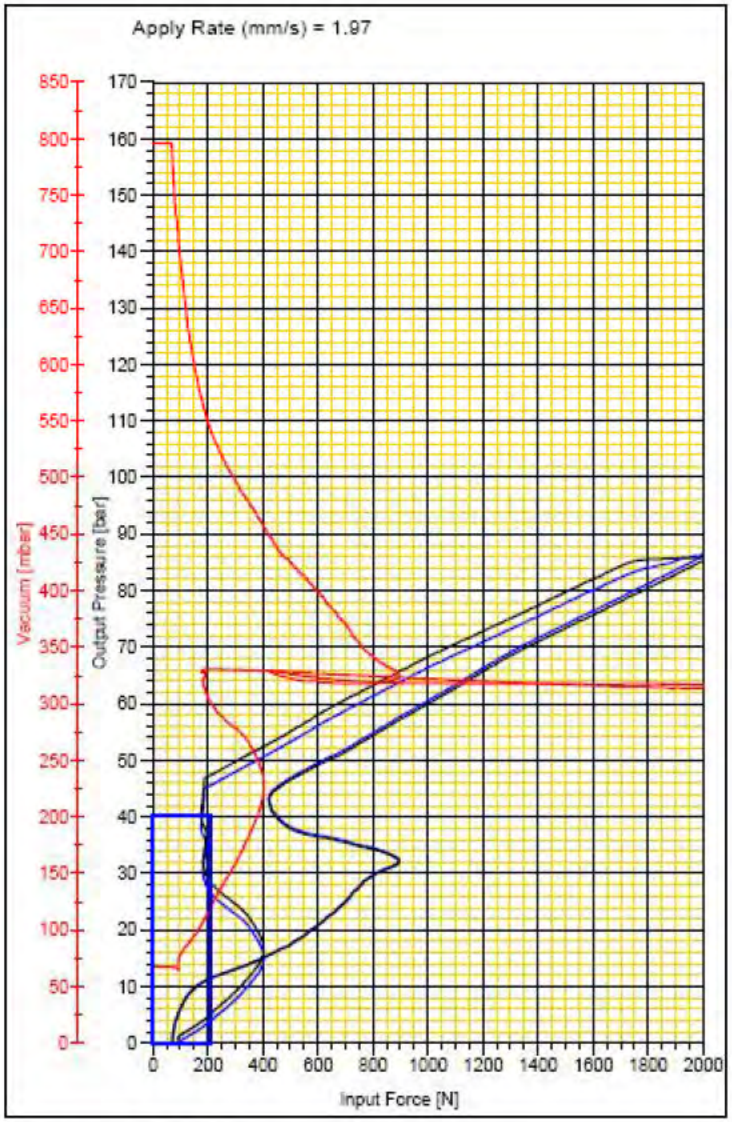
Mazda additional information request from January 11, 2013 presentation

- [4]Need more samples evaluation by Warranty returned units
  - One unit returned to Livonia Engineering from UAE field warranty (no VIN provided)
  - Analysis results are shown below
  - With slow apply rate (2 mm/sec at the input rod), the booster vacuum recovers as the diaphragm unfolds and the tear region is supported by the front shell.

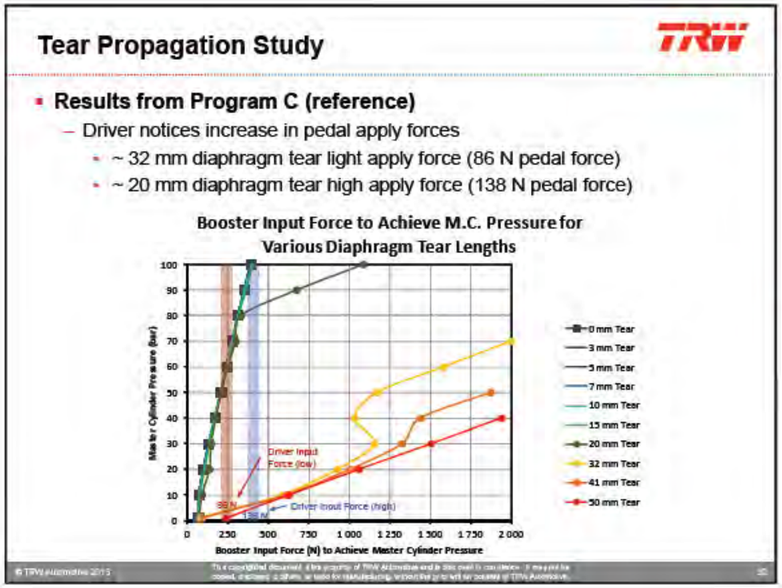
Tear Length	31mm
Particle size	124µmX95µm
Particle Location	5 o'clock
Logo side or backside	Logo Side
Average Hardness IRHD	79.2
Cross Sectional Thickness Range @ 5:15 o'clock	1.13mm-1.31mm

Location (Clock Position)	Thickness (mm)
4:45	1.270
5:15	1.355
9	1.313
12	1.512
3	1.351





Add apply speed to the graph presented in January 11, 2013



- Function plots of a duplex with a booster diaphragm that has manual tear lengths progressively larger with each evaluation (Program C) (presented 11-Jan-2013) is shown on the left.
- Mazda Engineering requests the following information regarding Program C function curves:
  - Vacuum during evaluations: 800 mbar (isolated)
  - Apply rate during evaluations: 4.5 mm/sec at the input rod

Diaphragm Tear Effect on Performance Conclusion presented to Mazda (November 2012)

- Conclusions regarding a torn diaphragm effect on vehicle braking performance has not changed since November 1, 2012 presentation (shown below).
- The helping force of a booster with a torn diaphragm will be less than a booster without a torn diaphragm, and is dependent on:
  - the size of the tear in the diaphragm (larger has greater effect);
  - the vacuum level within the booster at the time of the braking event (smaller initial vacuum level has greater effect);
  - the in-stop air evacuation rate of the booster (slower has greater effect);
  - the driver's apply rate of the brake pedal (faster apply rate has greater effect);
  - the driver's apply force on the brake pedal (lower apply force has greater effect).

Diaphragm Tear – Effect on Performance

Conclusions:

- The helping force of a booster with a torn diaphragm in a vehicle during a braking event will be less than a normal booster without a torn diaphragm, and is dependent upon:
  - the size of the tear in the diaphragm (larger has greater effect);
  - the vacuum level within the booster at the time of the braking event (smaller initial vacuum level has greater effect);
  - the in-stop air evacuation rate of the booster (slower has greater effect);
  - the driver's apply rate of the brake pedal (faster apply rate has greater effect);
  - the driver's apply force on the brake pedal (lower apply force has greater effect).
- The condition of the diaphragms returned to TRW exhibited similar tear position and tear size characteristics, therefore it is assumed the effect of a torn diaphragm will be relatively consistent within the population of affected boosters.
- Within he input stroke of brake apply event, the diaphragm will be supported by the inner surface of the front shell diminishing or eliminating the air leak path through a tear in the diaphragm. Once the tear region of the booster is supported by the front shell, the in-stop air evacuation of the booster will increase the booster helping force. This will occur as the driver increases the braking force.

TRW Control Plan

Control Plan

	ES6-002-CP-J50CLH-J50CRH-MAZDA-2009	Prototype	Pre-Launch	**Production X**	**Date Orig.:** 04-dic-07
Part Number / Latest change level:	32068913 / Level "B" 32069456 / Level "B"	**Key Contact / Phone:**	Eduardo Santana [redacted]		**Date Rev.:** 02/20/2013
Customer part number:	TD11-43950-E TD84-43950	**Core Team:**	P. Verduzco(Quality), G. Edwards (AME), V. Camarena (AME), A. Saucedo(Product), G. Rodriguez(Quality)		**Customer Engineering Approval / Date (If req'd):**
Part Name Description / Model Year:	MAZDA J50C (RH) / (LH) 2009	**Supplier / Plant Approval / Date:**			**Customer Quality Approval / Date (If req'd):**
Supplier/Plant:	TRW Santa Rosa Plant	**Other Approval / Date**			**Other Approval / Date (If req'd):**
Supplier Code:	N10DE				

Part/ Process Number	Process Name/ Operation Description	Machine, Device, Jig, Tools For Mfg.	Characteristics			Special Char. Class	Methods					Reaction Plan
			No.	Product	Process		Prod./Process Specification/ Tolerance	Evaluation Measurement Technique	Sample		Control Method	
									Size	Frequency		
Receive	Receiving and Inspection		Gen-01		Receive and Transport		Material inspected Y/N (appropiate work instruction)	According to characteristic	Sample table	Prior to Production	Acceptance criteria: no non-conforming material in sample (0, zero). Material is inspected according to inspection sheets, supplier reliability, and sample tables (attribute or variable). Work instruction SR-E120-2-01	Segregate material and notify to supplier. All batchs must be inspected and identified until corrective actions are implemented.
			Gen-01	Diaphragm Thinkness			0.85 ± 0.15 mm		Sample table	Prior to Production	Acceptance criteria: no non-conforming material in sample (0, zero). Material is inspected according to inspection sheets, supplier reliability, and sample tables (attribute or variable). Work instruction SR-E120-2-01	Segregate material and notify to supplier. All batches must be inspected and identified until corrective actions are implemented.
	Setup		Gen-02		Set Up		Confirm set-up Y/N (appropiate work instruction)	Verify mistake proofing	Each Station	Prior to Production	Any set up or change over is made until pallets are complete and there are no subassembles in production line. If set up or change over is not done correctly, assemblies would be rejected.	Segregate material and notify to supplier. All batches must be inspected and identified until corrective actions are implemented.
	Change Over		Gen-03		Change Over		Confirm change over Y/N (appropiate work instruction)	Verify mistake proofing	Each Station	Prior to Production	Any set up or change over is made until pallets are complete and there are no subassembles in production line. If set up or change over is not done correctly, assemblies would be rejected.	Segregate material and notify to supplier. All batches must be inspected and identified until corrective actions are implemented.

Frenos y Mecanismos, S. A. de C. V.

SISTEMAS DE CALIDAD

INSPECCION RECIBO

REPORTE DE INSPECCION

PROVEEDOR: HUTCHINSON SEAL PARTE No: 32484764 REV : C DESCRIPCION: DIAPHRAGM 10.5

INSPECTOR: ____ LOTE PROV. No : ____ LOTE TRW : ____

CANTIDAD: ____ ACEPTADO ☐ RECHAZADO ☐ SORTEADO/RETRAB. ☐ FECHA : ____

ITEM #	LOC	ESPECIFICACION	METODO	MUESTRAS 1	2	3	4	5	6	7	8	9
1	----	Verificar Nivel de Revision de Ingenieria	Visual									
2	N04	Libre de flash, particulas y marcas de herramienta	Visual									
3	N08	Area de sellado limpia y sin fisuras	Visual									
4	N10	Impreso "TRW", fecha de prod. y "32484764"	Visual									
5	C8	Diametro de 50.00 - 50.30 mm <I>	Proyector de sombra									
6	----	Espesor del Diafragma (0.85 ± 0.15)mm	Gage					Muestra				
7	----	Falta de material	Visual									
8												
9												
10												

COMENTARIOS: #N/A Dibujo

NV R - Aplica para caracteristicas a ser evaluadas en Laboratorio

TAMAÑO DE MUESTRA	
Insp.Dimensional	
Inspeccion Visual	

LOTES SOSPECHOSOS EN TRANSITO PARA SORTEO 100% :

MATERIAL CERTIFICADO

REVISION : 7 SR-E120-4-01-07

Hutchinson Control Plan – Tool 3

CONTROL PLAN

Customer: TRW Automotive (Chassis Systems)	Company: Hutchinson Seal de México	Date (Orig): 18-Nov-03		Process Type: 1	Prototype ☐
Mold No: 5721-3	Part No: 32484764	Last Rev: 30-Jan-13			Pre-Launch ☐
BluePrint Rev: F	Part Name: Diaphragm 10.5"	Customer Approval:			Production ☒
Core Team: J.C. Gomez / J. Villalba / Mario G. D. Cortarelli / D. Lopez / A. Avalos	Key Contact/Phone: [redacted]	Prepared By: J.C. Gomez / J. Villalba			

PART PROCESS NUMBER	PROCESS NAME OPERATION DESCRIPTION	MACHINE DEVICE, JIG, TOOL FOR MFG.	CHARACTERISTICS No.	CHARACTERISTICS PRODUCT	CHARACTERISTICS PROCESS	SPECIAL CHAR. CLASS.	METHODS PRODUCT/PROCESS SPECIFICATION TOLERANCE	METHODS EVALUATION MEASUREMENT TECHNIQUE	METHODS SAMPLE SIZE AND FREQUENCY	METHODS CONTROL METHOD	RESPONSIBLE DEPARTMENT	REACTION PLAN
			21.05	Thickness cross section Item # 7		BT2	0.85 +/- 0.15 mm	Dimensional Check using Thickness gauge / Quality Auditor	2 parts per run (6 000 pieces aprox.)	Measure report sheet 10.11.03-13 / Dimensional Control chart WI 20.01.01-2	Production Dept.	Inform supervisor Isolate and tag nonconforming product. According to MRB Hold procedure.
			21.06	Item # 28		BT2	4.45 ± 0.15 mm	Dimensional Control Chart using Vertex during Annual Revalidation	100 % Inspection	Dimensional Control chart WI 20.01.01-2	Quality Department	Inform Quality Engineer Isolate and tag nonconform products According to MRB Hold procedure
			21.07	Item # 29		BT2	3.3 ± 0.1 mm	Dimensional Check using Vertex / Quality Auditor	2 parts per month (36 000 pieces aprox)	Dimensional Control chart WI 20.01.01-2	Quality Department.	Inform Quality Engineer Isolate and tag nonconform products According to MRB Hold procedure
			21.08	Item # 45		BT2	5.5 ±0.1	Dimensional Check using Vertex / Quality Auditor	2 parts per month (36 000 pieces aprox)	Dimensional Control chart WI 20.01.01-2	Quality Department	Inform Quality Engineer Isolate and tag nonconform products According to MRB Hold procedure
			21.09	Item # 49		BT2	3.3 ± 01 mm	Dimensional Check using Vertex / Quality Auditor	2 parts per month (36 000 pieces aprox)	Dimensional Control chart WI 20.01.01-2	Quality Department	Inform Quality Engineer Isolate and tag nonconform products According to MRB Hold procedure
			21.10	Item # 99		----	Control limits 0.85 ± 0.15	Dimensional Check using Optical Comparator / Quality Auditor	1 part per shift 4 points (480 pieces aprox.)	Dimensional Control WI 20.01.01-2 / Not SPC	Quality Department	Inform supervisor Isolate and tag nonconforming product. According to MRB Hold procedure.

Hutchinson Rubber Material Data

- **Hutchinson raw material data on following pages. No additional raw data released by Hutchinson.**
- **Hutchinson deem Scorch Time and Viscosity as compound proprietary information.**

LABORATORY REPORT ON PLAQUES

HUTCHINSON SEAL de MEXICO

Customer	TRW	Report N :	2013020501A
		Edition date :	05/02/2013
Mat specification			
Specification:	TS2 18 74	Order N :	Post : QC
Grade :		Part N :	32484764F
		Dimension :	CAV4
Issue N :	AE	HUT code :	
Revision date :	13/08/2012	HUT compound :	G88
Origin :	TRW	Batch N :	

Characteristic	Unit	Test Method	Specification	Slab	Diaphragm
* Color				Black	Black
* IRHD Hardness	Point	ASTM D 1415	65 ± 5	68	68
* Tensile strength	MPa	ASTM D 412	Min 14.0	16.5	19.7
* Elongation at break	%	ASTM D 412	Min 250 to 500	352	363
* Modulus 100%	MPa	ASTM D 412	Min 2.5	2.9	3.2
* Modulus 200%	MPa	ASTM D 412	Min 7.0	7.8	9.0
* Tear Method C (croissant) (die B)	N/mm	DIN 53515	Min 30.0	106	-
*Method B,proc b(entaillee angular) (die C)		ISO 34-1	Min 20.0	43	46
*Method A (pantalon) (Die T)		ISO 34-1	Min 6	7	-
* Compression set 24hrs at 120°C	%	ASTM D 395	Max 30.0	17	-
* Tension set, 24h at 120°C On Slab	%	DIN 53518	Max 50.0	-	37
			Max 25.0	21	-
Heat ageing 70hrs at 120°C					
* IRHD change	Point	ASTM D 573	-5 to 10	+4	10
* Tensile strength retained	%		Min 75	96	104
* Elongation at break retained	%		Min 50	71	63
* Tear strength retained	%		Min 65	97	87
Dynamic Mechanical Analysis * Typical values are not necessarily required values.		TS2-10-003		See attached chart	
After 168hrs at 120°C in DOT 4		ASTM D 471			
* Hardness change	Point		-12 to 0	-5	
* Tensile strength retained	%		Min 70	78	
* Elongation at break retained	%		Min 60	67	
Precipitation in SAE compatibility Fluid			0.3 Max On Slab	Non Precip Pass	
* Extractable matter (Hexane)	%			6.5	
* Extractable matter (Acetone)		TS2-10-003	Max 15	12.1	
* Ozone resistance, 70h at 50pphm	Visual		Rating 0	No cracks	
* Rigidity, TR10	°C	TS-2-10-004	Min –35	-50	
* Low temp. Brittleness at –40°C		ASTM D 2137	No cracks	Pass	
Volume change in DOT 4 after		ASTMD 471			
* 70hrs at 70°C	%		-5 to 5	-2.4	
* 4 weeks at 70°C	%		-5 to 5	-4.1	
* 70hrs at 120°C	%		-5 to 10	-3.9	
* 4 weeks at 120°C	%		-5 to 10	-1.7	
*Corrosive Action on Cooper			No discolouration	Non Discolouration	

Comment: HUTCHINSON SEAL compound G88 complies all tested requirements of TS2-18-074 specification.

Name: Daniel CORTARELLI
Co po d R&D / Tec ca Mg
Visa : Daniel Cortarelli

From [redacted]
Sent: Friday, September 07, 2012 7:47 AM
T[redacted]
S[redacted]

[redacted]

Attached are the results of the DMA testing. These results meet the DMA guidelines per the latest revision of TS2-18-074 (also attached).

Best Regards,

[redacted]

>>>[redacted] 9/5/2012 1:48 PM >>>
Thanks!

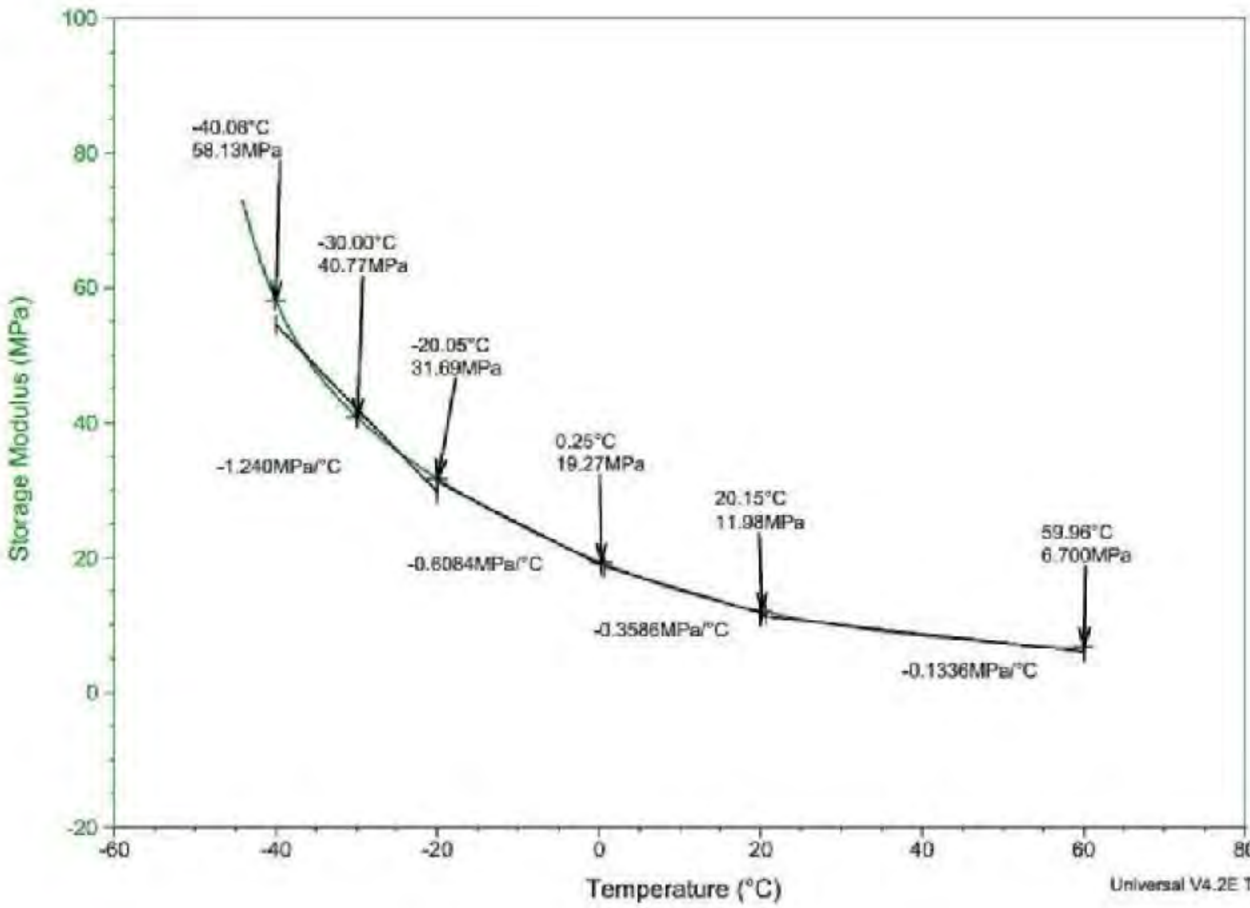
[redacted]

Before printing, think about the environment

Sample: MLWR 8634 G88 Compound
Size: 6.8440 x 3.9800 x 2.1500 mm
Method: Temp Ramp/Frequency Sweep

DMA

File: MLWR 8634 Hutchinson G88 Compound Bat...
Run Date: 05-Sep-2012 15:31
Instrument: 2980 DMA V1.7B



Universal V4.2E TA Instruments

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 2-2 Supplier Report 1

Pre Cured Particle on part number 32484764

HSM

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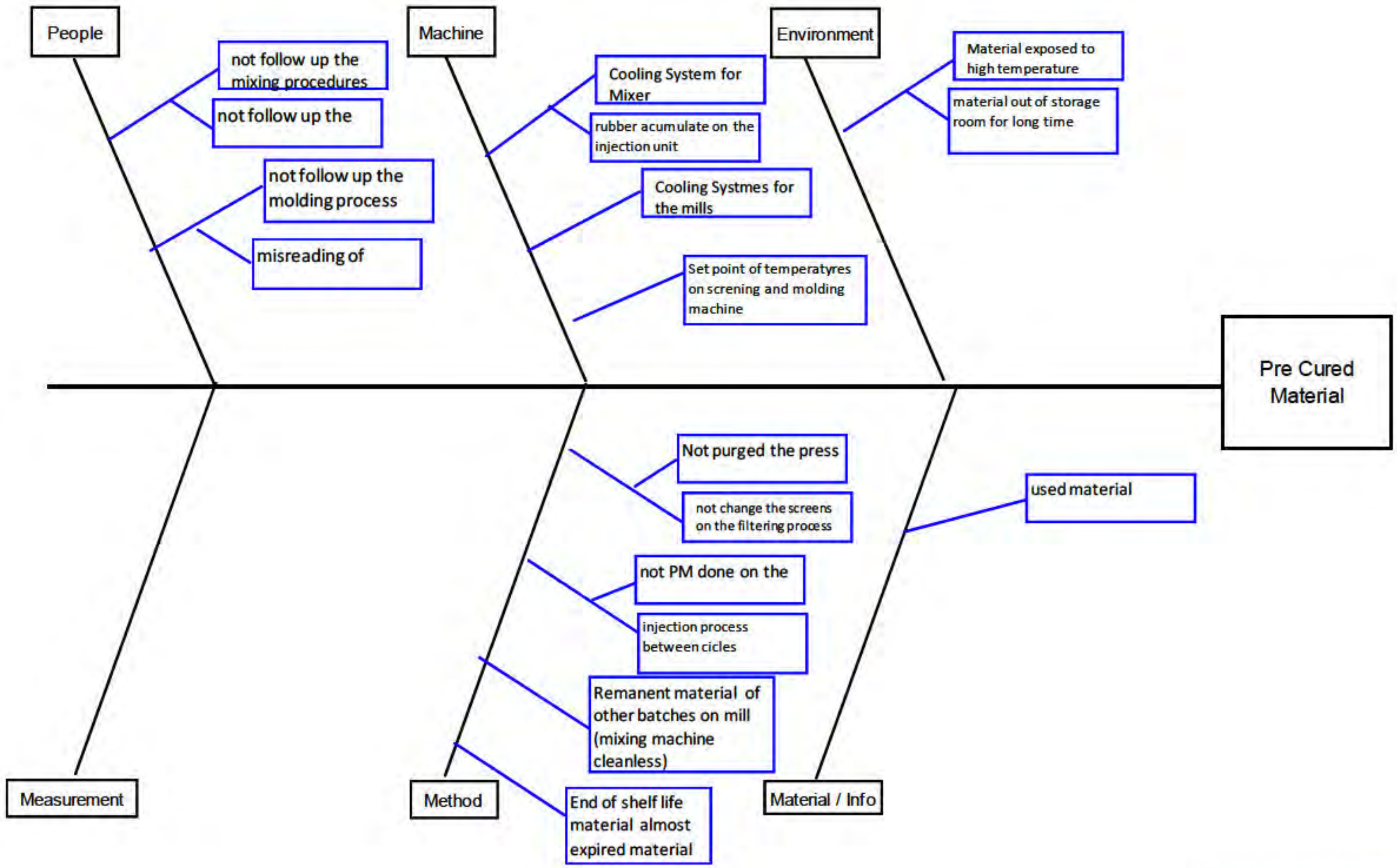
WORLDWIDE

First Step- Ishikawa

We start our analysis based on the Ishikawa tool in order too determinate all the posible causes for the pre cured parts

The next slide will show all the posible causes based on a storm of ideas made by engineering, quality, laboratory and production

Root Cause



HUTCHINSON WORLDWIDE

FACTOR TREE ANALYSIS FOR OCURRENCE AND DETECTION

All possible causes found on the Ishikawa exercise were analized using the FTA methodology in order to evaluate each one, how they are controlled and determine which ones could be the potential root cause of the failure

On the next slide is the complete FTA with the controls and explanation of each one

FACTOR TREE ANALYSIS FOR OCURRENCE AND DETECTION

Factors		CONTROLS	Standard/ Specification	Good Parts	NOK Parts	Evaluation Standard OK	Evaluation Meet std	Evaluation Direct Ink	Potencial Root Cause	Obev
MATERIAL	1 . used expired material	1 . ERP System not allow use expired material	1. ERP system is automated and not allowed to use expired material	using material inside of that dates	if we use parts with expired material	meet according to the system	Yes		No	
	2 . Material exposed to high temperature	Daily check of the graphic by quality dept	2 . Temperature established as 68 F according to S.P 10.01	when we meet the spec	whren the material is out of the room	controlled temp	Yes		No	
	3 . material out of storage room for long time	random audits by QC	3 . Time established (1 shift) according to WI 9.12.91 / Material handle procedure established	whem we meet the WI	whren the material is out of the room	Follow UP WI	Yes		No	
METHOD	1 . Not purged the press	1 . PLC Machine don't allow to mold if not purge .	1 . Procedure indicate send it to the QA dept to measured WI 9.12.02 / The first pieces molded not send to customer	the PLC don't allow	when yount start the machine again	Follow UP WI	Yes		No	
	2 . not change the screens on the filtering process	2 format that they filled up with batches they screen	2 . Change each 12 batches the screens WI 9.12.91 / WI and check ist estab ished to change	molding the parts before 12 as the WI	more that 25 batches screned	Follow UP WI	Yes		No	
	3 . not PM done on the molding press	follow up the scheduled and checked by manager	3 . A schedule established for their control SP 9.06 3 . Preventive maintenance schedule	when completed	when not met	PM done correctly	Yes		No	
	4 . Injection process between cycles	4 . Machine programmed to require purge after 30 sec. of inability	4 . If machine stop for more than 30 seconds have to purge WI 9.12.02	4 . Not prevulcanized material before 30 sec.	if the PLC didn't work	PM done correctly	Yes		No	
	5 . Remnant material of other batches on mill (mixing machine cleanness)	check list implemented	5 . A procedure established to clean critical points before run WI 9.01.02-5	5 . Good batches, we test 100% all batches	Remanent material of other batches	procedure	Yes		No	
	End of shelf ife material almost expired material	ERP System	6 .expiration date is assigned automatically by ERP system (8 weeks) / not estab ished correctly	6. record of cauising high viscosity and shorter scorth	no difference in both	Meet ,but see a significant difference	Yes, but with variation		Yes	See Chart attached / must be evaluated
MAN										
MACHINE										
MATERIAL										
METHOD										
MAN	1 .not follow up the mixing procedures	measuring the properties of rubber	1 . Already established on the Mix Vision (Computer Based) 1 . Digital procedures and controls	good results on the properties	bad results on the properties	Follow UP WI	Yes		No	
	2 .not follow up the filtering process	layer audits	2 . Already established on the technical sheet WI 9.12.91	good results on the molding	when don't follow up WI	Follow UP WI	Yes		No	
	3 . not follow up the molding process	process inspector audits	3 . Already established on the technical sheet WI 9.12.02	when we meet the WI	bad parts molded	Follow UP WI	Yes		No	
	[illegible] temperature	4 . Calibration system implemented	4 . A schedule established [illegible] control SP 11.01	when we follow the program	when we don't follow the program	Follow UP SP	Yes		No	
MACHINE	1 . Cooling System for Mixer	1 . Temperature alarm available	1 . When exceed 70 F alarm start (below)	when alarm work	when alarm don't work	PM done correctly	Yes		No	
	2 . rubber accumulate on the injection unit	layer audits	2. after 3 minutes machine is not working, we have to purge WI 9.12.02 2 purge procedure on molding	2. Not prevulcanized material before 3 min	prevulcanized material	PM done correctly	Yes		No	
	3 . Cooling Systems for the mills	3 . Temperature alarm available	1 . When temperature exceed 70 F alarm start	3. Good batches, we test 100% all batches	when we don't test 100%	PM done correctly	Yes		No	
	4 . Set point of temperatures on screening and molding machine	process inspector	2 . Already established on the technical sheet WI 9.12.02-32. Technical sheet and procedure available	4. Records of good parts at the same period	correct temperatyre	Incorrect temperat	Yes		No	

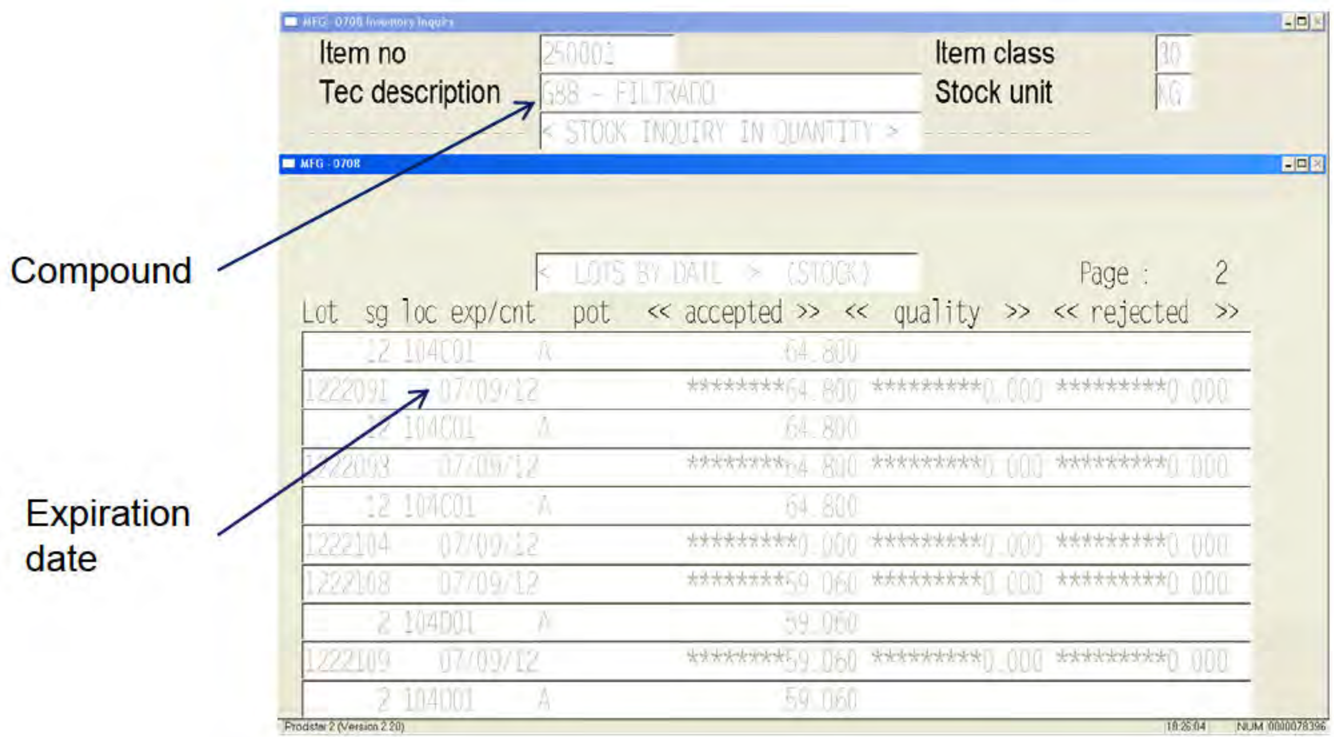
HUTCHINSON WORLDWIDE

FTA

OCCURRENCE

MATERIAL

FACTORS	CONTROLS	STANDARD/SPECIFICATION
1 . USED EXPIRED MATERIAL	1 . ERP SYSTEM NOT ALLOW USE EXPIRED MATERIAL	1. ERP SYSTEM IS AUTOMATED AND NOT ALLOWED TO USE EXPIRED MATERIAL



HUTCHINSON WORLDWIDE

FTA

OCCURRENCE

MATERIAL

FACTORS	CONTROLS	STANDARD/SPECIFICATION
2 . MATERIAL EXPOSED TO HIGH TEMPERATURE	DAILY CHECK OF THE GRAPHIC BY QUALITY DEPT	2 . TEMPERATURE ESTABLISHED AS 68 °F ACCORDING TO S.P 10.01

Hutchinson Seal de México

Monitoreo Diario de temperatura del cuarto frío

La temperatura máxima recomendada es de 68 °F

Fecha	Turno	Auditor	Lectura de temperatura	No. de control del equipo	Comentarios

HUTCHINSON WORLDWIDE

FTA

OCCURRENCE

MATERIAL

FACTORS	CONTROLS	STANDARD/SPECIFICATION
3 . MATERIAL OUT OF STORAGE ROOM FOR LONG TIME	RANDOM AUDITS BY QC	3 . TIME ESTABLISHED (1 SHIFT) ACCORDING TO WI 9.12.91 / MATERIAL HANDLE PROCEDURE ESTABLISHED

7.5 Limpie los restos de compuesto de la cabeza y coloque nuevamente el plato asi como el dado y la tuerca de fijacion.

7.6 Asegure que quede limpio y apague interruptor general de corriente como lo indico el punto 6.1. o inicie todo el proceso si va a filtrar mas compuesto.

7.7 Al termino de su jornada el operador de la maquina filtradora se asegurara que todo el material filtrado y/o por filtrar debe ser retornado al almacén de tal forma que no quede en el área de preformado.

FTA

OCCURRENCE

METHOD

FACTORS	CONTROLS	STANDARD/SPECIFICATION
1 . NOT PURGED THE PRESS	1 . PLC MACHINE DON'T ALLOW TO MOLD IF NOT PURGE	1 . PROCEDURE INDICATE SEND IT TO THE QA DEPT TO MEASURED WI 9.12.02 / THE FIRST PIECES MOLDED NOT SEND TO CUSTOMER

6.40 Al término de la limpieza se deberá limpiar la banda transportadora.

6.41 Se gira el botón de seguridad (para quitar esta función) y el botón para encender la bomba hidráulica de la prensa.

Encender bomba hidráulica (START)

Botón de seguridad

6.42 El facilitador modificara parámetros de apertura para trabajar en producción normal.

6.43 El operador cerrará el molde dejando una apertura de 1 pulgada aprox. entre plato fijo y plato móvil y esperar a que el molde alcance su temperatura apropiada, solo así podrá reanudar su producción y destruirá la primer pieza después de la limpieza y el inspector de procesos evaluara las siguientes 5 piezas moldeadas. Al inicio de turno el inspector de proceso tomara 5 piezas después de la limpieza 4para dimensional y 1 para prueba destructiva de acuerdo a la WI 10.1103.

6.44 El operador reanudara su producción solo si el molde tiene las temperaturas adecuadas y destruirá la primera pieza después de la limpieza y reportarlo en el reporte general de producción (Forma # WI 9.12.02-28), el inspector de procesos evaluara las siguientes 5 piezas.

HUTCHINSON WORLDWIDE

FTA

OCCURRENCE

METHOD

FACTORS	CONTROLS	STANDARD/SPECIFICATION
2 . NOT CHANGE THE SCREENS ON THE FILTERING PROCESS	2 FORMAT THAT THEY FILLED UP WITH BATCHES THEY SCREEN	2 . CHANGE EACH 12 BATCHES THE SCREENS WI 9.12.91 / WI AND CHECK LIST ESTABLISHED TO CHANGE

Nota. Los filtros mesh deberán de ser reemplazados cada vez que se cumpla la cantidad máxima de bath a filtrar, la cantidad máxima estará definida en el formato de reporte de Producción Filtradora Forma # WI 9.12.07-2.

REPORTE DE PRODUCCION

FILTRADORA RUTIL PMD Diafragmas

	FECHA	TURNO	NUM.OPER	COMP	BATCH	PESO	EXPIRACION
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

HUTCHINSON WORLDWIDE

FTA

OCCURRENCE

METHOD

FACTORS	CONTROLS	STANDARD/SPECIFICATION
3 . NOT PM DONE ON THE MOLDING PRESS	FOLLOW UP THE SCHEDULED AND CHECKED BY MANAGER	3 . A SCHEDULE ESTABLISHED FOR THEIR CONTROL SP 9.06 3 . PREVENTIVE MAINTENANCE SCHEDULE

HUTCHINSO N SEAL DE

PLAN PROVISIONAL DE MANTENIMIENTO PREVENTIVO 2012 ■ = Programado ■ = Realiza

Numéro de série	Número de Equipo GMAO	Marca	Tps téorico anual	Tps paso téorico	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
73 / 596	3RUT003	Rutil 180 T	24.00	12.00		8.00													
73 / 607	3RUT004	Rutil 180 T	24.00	12.00				8.00											
73 / 548	3RUT005	Rutil 180 T	24.00	12.00						8.00									
73 / 599	3RUT006	Rutil 180 T	24.00	12.00								8.00							
73 / 603	3RUT008	Rutil 180 T	36.00	12.00										RE		8.00			
73 / 660	3RUT013	Rutil 180 T	36.00	12.00												RE		12.00	
73 / 637	3RUT014	Rutil 180 T	36.00	12.00														RE	
73 / 636	3RUT015	Rutil 180 T	36.00	12.00															
N/A	6BEN001	(EXTRUSORA RUTIL)	72.00	12.00		8.00													
R20132	6RST002	Roto Strip filtradora	36.00	6.00		2.00													
[illegible]	3MAP001	Maplan 600T	32.00	16.00															

Número de Equipo GMAO	17	18	19	20	21	22	23	24	25	26	27	28	29	30
3RUT003														
3RUT004														
3RUT005														
3RUT006														
3RUT008														
3RUT013														
3RUT014	8.00													
3RUT015	RE		8.00											
6BEN001													P	
6RST002													P	
3MAP001					20.00									

FTA

OCCURRENCE

METHOD

FACTORS	CONTROLS	STANDARD/SPECIFICATION
4 . INJECTION PROCESS BETWEEN CYCLES	4 . MACHINE PROGRAMED TO REQUIERE PURGE AFTER 30 SEC. OF INABILITY	4 . IF MACHINE STOP FOR MORE THAN 30 SECONDS HAVE TO PURGE WI 9.12.02

trabajo.

- Si un trabajo de mantenimiento es requerido por el departamento usar la Orden de trabajo para mantenimiento (Forma # S.P. 9.06-2)
- Siempre que exista un paro de máquina prolongado (más de 1 hora) se debe cubrir el hule con el plástico cerrando la bolsa con un nudo para evitar cualquier contaminación en el hule.
- Todas las canastas de material que no estén en prensa deberán estar debidamente cerradas también con la bolsa de plástico.
- Cada vez que se cambie un molde después de hacer el set up se deberán tirar las primeras 5 piezas de arranque, es decir a partir de la 6ta. piezas se valida el inicio de producción.
- ***El operador sólo purgará la máquina cuando pare más de 3 minutos su producción purgando solo 2 a 5 pulgadas aprox. de la punta tal y como lo indica el punto 6.17***
- ***En ciclo automático la maquina no podrá ser reiniciada después de 30segundos si la pieza moldeada no ha sido detectada por la fotocelda solo se reiniciará cambiándola a manual y purgando el material tal como lo indica el punto 6.17***

HUTCHINSON WORLDWIDE

FTA

OCCURRENCE

METHOD

FACTORS	CONTROLS	STANDARD/SPECIFICATION
5 . REMAINING MATERIAL OF OTHER BATCHES ON MILL (MIXING MACHINE CLEANLINESS)	5. CHECK LIST IMPLEMENTED	5 . A PROCEDURE ESTABLISHED TO CLEAN CRITICAL POINTS BEFORE RUN WI 9.01.02-5

Lista de verificación para limpieza de línea de mezclado para compuesto G88

Etapa	Limpieza de la Línea de Mezclado para Compuesto G88	Material para limpiar	Validación	Tiempo Estimado
1	Limpiar del piso alrededor del mezclador	Escoba, agua y jabón		30 min
2	Limpiar de la banda de pesaje y transporte de material	Escoba de cerdas, trapos y limpiador tipo AJAX		10 min
3	Accionar la válvula mariposa de la descarga de negro de humo para purgar la línea.	Desarmador		2 min
4	Apagar la aspiración de negro de humo	-		5 min
5	Con auxilio de un palo, tocar la tubería flexible de aspiración de negro, para que el polvo acumulado baje por la tubería.	Palo		1 min
6	Subir el pistón	-		1 min
7	Limpiar el pistón con aire comprimido, escoba y raspador.	Soplete, escoba, raspador, trapos		5 min
8	Limpiar toda entrada del mezclador con aire comprimido, escoba y raspador.	Soplete, escoba, rapador, trapos		10 min
		Soplete, escoba		

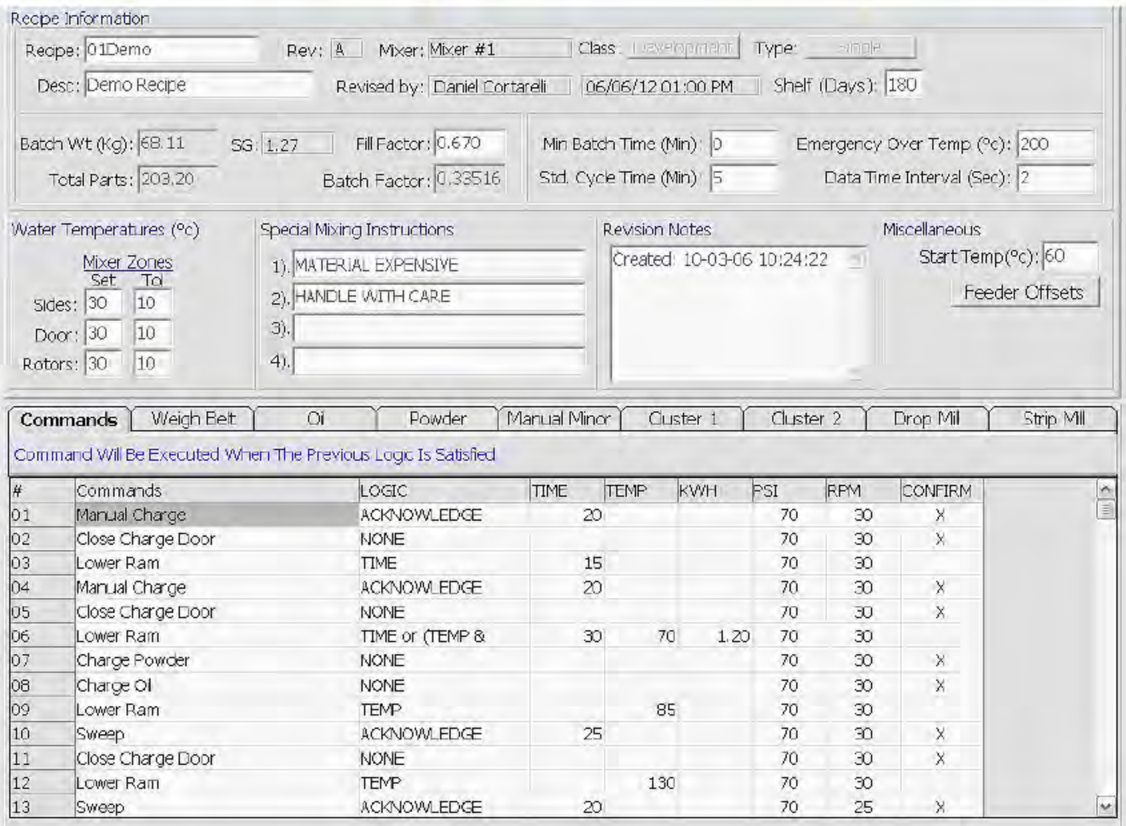
HUTCHINSON WORLDWIDE

FTA

DETECTION

MAN

FACTORS	CONTROLS	STANDARD/SPECIFICATION
1 .NOT FOLLOW UP THE MIXING PROCEDURES	MEASURING THE PROPERTIES OF RUBBER	1 . ALREADY ESTABLISHED ON THE MIX VISION (COMPUTER BASED) 1 . DIGITAL PROCEDURES AND CONTROLS



Recipe Information

Recipe: 01Demo   Rev: A   Mixer: Mixer #1   Class: Development   Type: Single

Desc: Demo Recipe   Revised by: Daniel Cortarelli   06/06/12 01:00 PM   Shelf (Days): 180

Batch Wt (Kg): 68.11   SG: 1.27   Fill Factor: 0.670   Min Batch Time (Min): 0   Emergency Over Temp (°c): 200

Total Parts: 203.20   Batch Factor: 0.33516   Std. Cycle Time (Min): 5   Data Time Interval (Sec): 2

Water Temperatures (°c)

Mixer Zones

	Set	Tol
Sides:	30	10
Door:	30	10
Rotors:	30	10

Special Mixing Instructions

1). MATERIAL EXPENSIVE
2). HANDLE WITH CARE
3).
4).

Revision Notes

Created: 10-03-06 10:24:22

Miscellaneous

Start Temp(°c): 60

Feeder Offsets

Commands | Weigh Belt | Oil | Powder | Manual Minor | Cluster 1 | Cluster 2 | Drop Mill | Strip Mill

Command Will Be Executed When The Previous Logic Is Satisfied

#	Commands	LOGIC	TIME	TEMP	KWH	PSI	RPM	CONFIRM
01	Manual Charge	ACKNOWLEDGE	20			70	30	X
02	Close Charge Door	NONE				70	30	X
03	Lower Ram	TIME	15			70	30	
04	Manual Charge	ACKNOWLEDGE	20			70	30	X
05	Close Charge Door	NONE				70	30	X
06	Lower Ram	TIME or (TEMP &	30	70	1.20	70	30	
07	Charge Powder	NONE				70	30	X
08	Charge Oil	NONE				70	30	X
09	Lower Ram	TEMP		85		70	30	
10	Sweep	ACKNOWLEDGE	25			70	30	X
11	Close Charge Door	NONE				70	30	X
12	Lower Ram	TEMP		130		70	30	
13	Sweep	ACKNOWLEDGE	20			70	25	X

HUTCHINSON WORLDWIDE

FTA

DETECTION

MAN

FACTORS	CONTROLS	STANDARD/SPECIFICATION
2 .NOT FOLLOW UP THE FILTERING PROCESS	LAYER AUDITS	2 . ALREADY ESTABLISHED ON THE TECHNICAL SHEET WI 9.12.91

	Hutchinson Seal de México Operación Filtradora Rutil	Revisión: D
W.I 9.12.91	Sistema de Calidad	Fecha: May-07-12

1.0 Propósito

1.1 Describir el proceso de filtrado de compuestos de hule de Hutchinson Seal de México.

2.0 Alcance

2.1 Aplica a compuestos de hule mezclados Hutchinson y de sus proveedores.

3.0 Responsabilidades

3.1 Del operador de Filtradora seguir lo establecido en esta instrucción y llenar los formatos correspondientes a esta operación.
3.2 Del supervisor y auditor de calidad vigilar el cumplimiento de esta instrucción.
3.3 Es responsabilidad del Técnico de Investigación y Desarrollo la revisión y el mantenimiento de esta instrucción.

4.0 Material Asociado

4.1 WI 9.12.07-8 Check List Diario Filtradora RUTIL
4.2 WI 9.12.91-1 Tabla de Set Up de Filtradora RUTIL
4.3 WI 9.12.07-2 Rep. Producción Maquina Filtradora

5.0 Definiciones

N/A

6.0 Procedimiento

6.1 Realizar y registrar las actividades solicitadas en el Check List Diario Filtradora Rutil formato WI 9.12.07-8 antes de comenzar a Filtrar.

6.1.1 Limpieza del Equipo.

Tablero de Control

Exterior de la Filtradora

FTA

DETECTION

MAN

FACTORS	CONTROLS	STANDARD/SPECIFICATION
3 . NOT FOLLOW UP THE MOLDING PROCESS	3. PROCESS INSPECTOR AUDITS	3 . ALREADY ESTABLISHED ON THE TECHNICAL SHEET WI 9.12.02

	Hutchinson Seal de México Instrucción de Moldeo en Celda de Diafragma	**Revisión: U**
WI 9.12.02	**Sistema de Calidad**	Fecha: Abril-11-12

1.0 Propósito

1.1 Establecer una instrucción de trabajo estándar, para cada etapa del proceso de Producción en el área AMPD, establecer reglas de seguridad, así como definir las Responsabilidades básicas de cada operador.

2.0 Alcance

2.1 Aplica a todo el personal que trabaja en el área de AMPD, estos deberán de utilizar y seguir la instrucción de trabajo, reportar cualquier transgresión, actualización o mal uso de la misma.

3.0 Responsabilidades

3.1 Supervisor de Producción: Es responsable de coordinar el adecuado desempeño del área, así como asegurar el cumplimiento de esta instrucción.
3.2 Facilitador: Es responsable de coordinar la correcta interacción del personal del área, así como asegurar el cumplimiento de los objetivos de producción y calidad.
3.3 Inspector de Procesos: Es responsable de monitorear el proceso, así como auxiliar al facilitador y/o Supervisor en la verificación de las temperaturas, análisis dimensionales y la evaluación de los defectos.
3.4 Materialista: Es responsable de asegurar el abastecimiento de todos los materiales necesarios para llevar a cabo la producción, así como auxiliar al supervisor y/o facilitador en el proceso.
3.5 Operador: Es responsable de cumplir con los objetivos de producción y calidad, además de reportar inmediatamente cualquier anomalía dentro del producto y/o el equipo.
3.6 Técnico de Mantenimiento: Es responsable de auxiliar al facilitador y/o Supervisor de Producción en la resolución de problemas electromecánicos cuando así se solicite.

4.0 Material Asociado

4.1 Hoja de ruta (Forma # WI 9.12.02-36)
4.2 Ficha técnica (Forma # WI 9.12.02-32)
4.3 Formato General de Producción. (Forma # WI 9.12.02-28)
4.4 Etiqueta de identificación de MRB (Forma # SP 13.06-3)
4.5 Formato Orden de Mantenimiento (Forma # SP 9.06-2)
4.6 Instrucción de proceso MRB y Disposición de producto no conforme (SP 13.06)
4.7 Instrucción de Verificación e Inspección final AMPD (WI 10.11.03)

HUTCHINSON WORLDWIDE

FTA

DETECTION

MAN

FACTORS	CONTROLS	STANDARD/SPECIFICATION
4 . MISREADING OF TEMPERATURE	4 . CALIBRATION SYSTEM IMPLEMENTED	4 . A SCHEDULE ESTABLISHED FOR THEIR CONTROL SP 11.01

	Hutchinson Seal de México CONTROL DE EQUIPO DE MEDICION, INSPECCION Y PRUEBA	Revisión: K
SP 11.01	Sistema de Calidad	Fecha: Ago-12-09

1.0 Propósito

1.1 Establecer los controles y las responsabilidades de cada persona y/o áreas que cuente con equipo de prueba o instrumentos de medición, que puedan afectar la calidad del producto.

2.0 Alcance

2.1 Aplica a todos aquellos departamentos que cuenten con equipo de prueba o instrumentos de medición, que sean utilizados en la correcta manufactura del producto y/o en la toma de decisiones (aceptación / rechazo).

3.0 Responsabilidades

3.1 El departamento de calidad es responsable de contratar la(s) compañía(s) que se encargara (n) de la calibración externa, así como de preparar todo lo necesario, para que al efectuar dicha calibración en su fecha programada y es responsabilidad del usuario tener repuesto si requiere para que se de dicha calibración, o en su defecto acordar un tiempo para esto.

3.2 El responsable del área de calibración es quien debe coordinar la preparación de envios de equipo que requeran calibración fuera de planta y de la elaboración de la requisición del servicio en PRODSTAR y formato de requisición de envio.
NOTA: para el caso de los equipos Alpha del área de laboratorio, tanto el área de calibración como el personal de laboratorio serán responsables del completado de la requisición de PRODSTAR y formato de envío.

3.3 El departamento de Logística es responsable de realizar los envios de los equipos a calibrar por cualquier proveedor externo.

3.4 El departamento de compras es responsable de dar seguimiento al estatus del equipo una vez que éste haya sido enviado al proveedor y hasta el regreso del mismo.

3.5 Todos los departamentos de HSM verificaran que el equipo de prueba o instrumentos de medición que se encuentran en sus áreas de trabajo, cuenten con la calibración vigente y/o verificación, de no ser así, retirar inmediatamente el equipo de uso y reportarlo al departamento de calidad.

3.6 El departamento de calidad dará de baja de la base de datos el equipo que haya sufrido daño no reparable y/o definitivo, y entregará al departamento de logística, representado por el personal de importación / exportación los datos del equipo para ser dado de baja de los pedimentos de importación.

3.7 Es responsabilidad de todos los departamentos que soliciten la compra de un equipo de medición el llevar acabo este procedimiento para asegurar que dichos equipos cumplan con la especificación técnica ISO/TS16949 de acuerdo al punto 6.9 de este procedimiento

3.8 El departamento de calidad es responsable de levar a cabo las verificaciones internas del equipo de medición seleccionado.

FTA

DETECTION

MACHINE

FACTORS	CONTROLS	STANDARD/SPECIFICATION
1 . COOLING SYSTEM FOR MIXER	1 . TEMPERATURE ALARM AVAILABLE	1 . WHEN EXCEED 70 ° F ALARM START (BELOW)

FTA

DETECTION

MACHINE

FACTORS	CONTROLS	STANDARD/SPECIFICATION
2 . RUBBER ACCUMULATE ON THE INJECTION UNIT	LAYER AUDITS	2. AFTER 3 MINUTES MACHINE IS NOT WORKING, WE HAVE TO PURGE WI 9.12.02 2 PURGE PROCEDURE ON MOLDING

- Coloca la tira de hule por los rodillos del alimentador para dosificar y purgar la prensa asegurándose que el canal y rodillos se encuentren limpios evitando cualquier fuente de contaminación.

6.17 El operador sólo purgara la máquina cuando pare mas de 3 minutos su producción purgando solo 2 a 5 pulgadas aprox. de la punta y cuando se realice Cambio de compuesto purgando 5 veces la máquina.

6.18 El operador comenzara a producir girando el botón de ciclo en posición automático y presionara el botón inicio de ciclo.

Nota: Cuando se inicie la producción con un Batch nuevo y aparezcan defectos en las piezas se segregarán de acuerdo al Procedimiento de MRB y Disposición de producto no conforme (SP 13.06)

FTA

DETECTION

MACHINE

FACTORS	CONTROLS	STANDARD/SPECIFICATION
3 . COOLING SYSTEM FOR THE MILLS	3 . TEMPERATURE ALARM AVAILABLE	1 . WHEN TEMPERATURE EXCEED 70 ° F ALARM START

HUTCHINSON WORLDWIDE

FTA

DETECTION

MACHINE

FACTORS	CONTROLS	STANDARD/SPECIFICATION
4 . SET POINT OF TEMPERATURES ON SCREENING AND MOLDING MACHINE	4. PROCESS INSPECTOR	2 . ALREADY ESTABLISHED ON THE TECHNICAL SHEET WI 9.12.02-32 TECHNICAL SHEET AND PROCEDURE AVAILABLE

HUTCHINSON POR. DWIDI
THE STRENGTH OF INNOVATION

AMPD

FICHA TECNICA

COMPUESTO
G88

TEMPERATURAS

PLATO FIJO		PLATO MOVIL		CAMARA		CURADO
Maximo		Maximo		Maximo		
Minimo		Minimo		Minimo		

Forma # WI 9.12.02-32 Rev. B

HUTCHINSON WORLDWIDE

5X3 Why's Analysis

After evaluate the factors from the FTA and find the potential failure mode, we used the "5x3 why's" tool in order to find the root cause

Below you will find the "5x3 why's" analysis

HUTCHINSON WORLDWIDE

Non Conformity	5 Why Analysis					Root cause
cured particle	**Use this section to determine why the defect occurred (potential risks)**					
	Why ? →	Why ? →	Why ? →	Why ? →	Why ? →	
	cured particle on diaphragm found	particle passed through screening process	particule is injected with the compound to form the piece	particles might form when the compound gets older	longer shelf life modifies compound characteristics, creating possibility of particle formation (shorter scorch time, higher viscosity)	compound used with longer shefl life
cured particle	**Use this section to determine why the defect was not detected**					
	Why ? →	Why ? →	Why ? →	Why ? →	Why ? →	
	cured particle on diaphragm found	cured particle not caught by screen	screen filter is larger that particle	screen filter manufactured in accordance with customer specifications	screen to big to catch particles below mesh 80	screen cannot be change to a smlaller mesh
cured particle	**Use this section to determine the systemic root cause**					
	Why ? →	Why ? →	Why ? →	Why ? →	Why ? →	
	particle not detectable	particle too small to be detected in our visual inspections system established	don't have knowledge of small particles were generated on the compound during manufacturing process	>>>>>>>>>>>>>>>>>>	>>>>>>>>>>>>>>>>>>	Failure Mode not contemplate on PFEMA

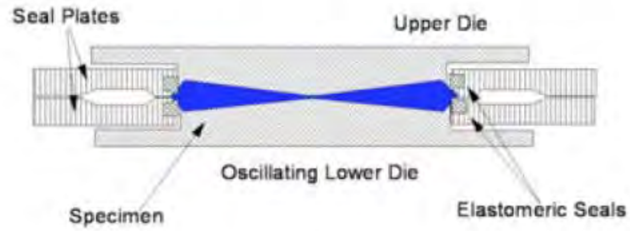
HUTCHINSON WORLDWIDE

Aged compound: This property cannot be verified or measured in the process, so a study was launched to validate time effect on the characteristics which may cause precured particles during the screening process in the rubber compound.

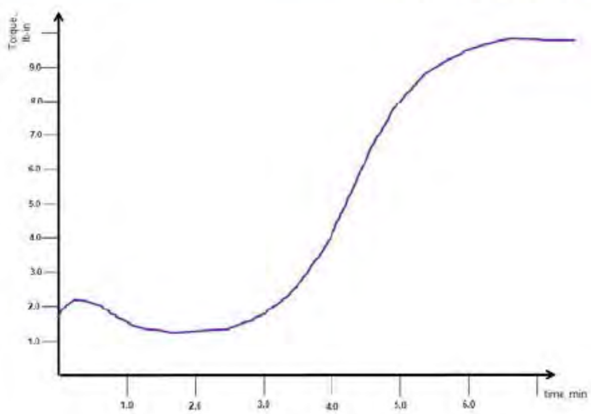
In order to make a better understanding of compound characteristics, a technical report has been included on the following slides

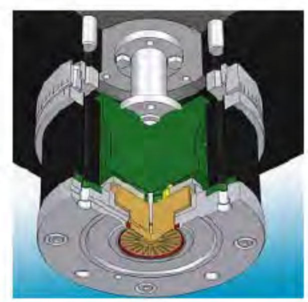
Rheometer Curve

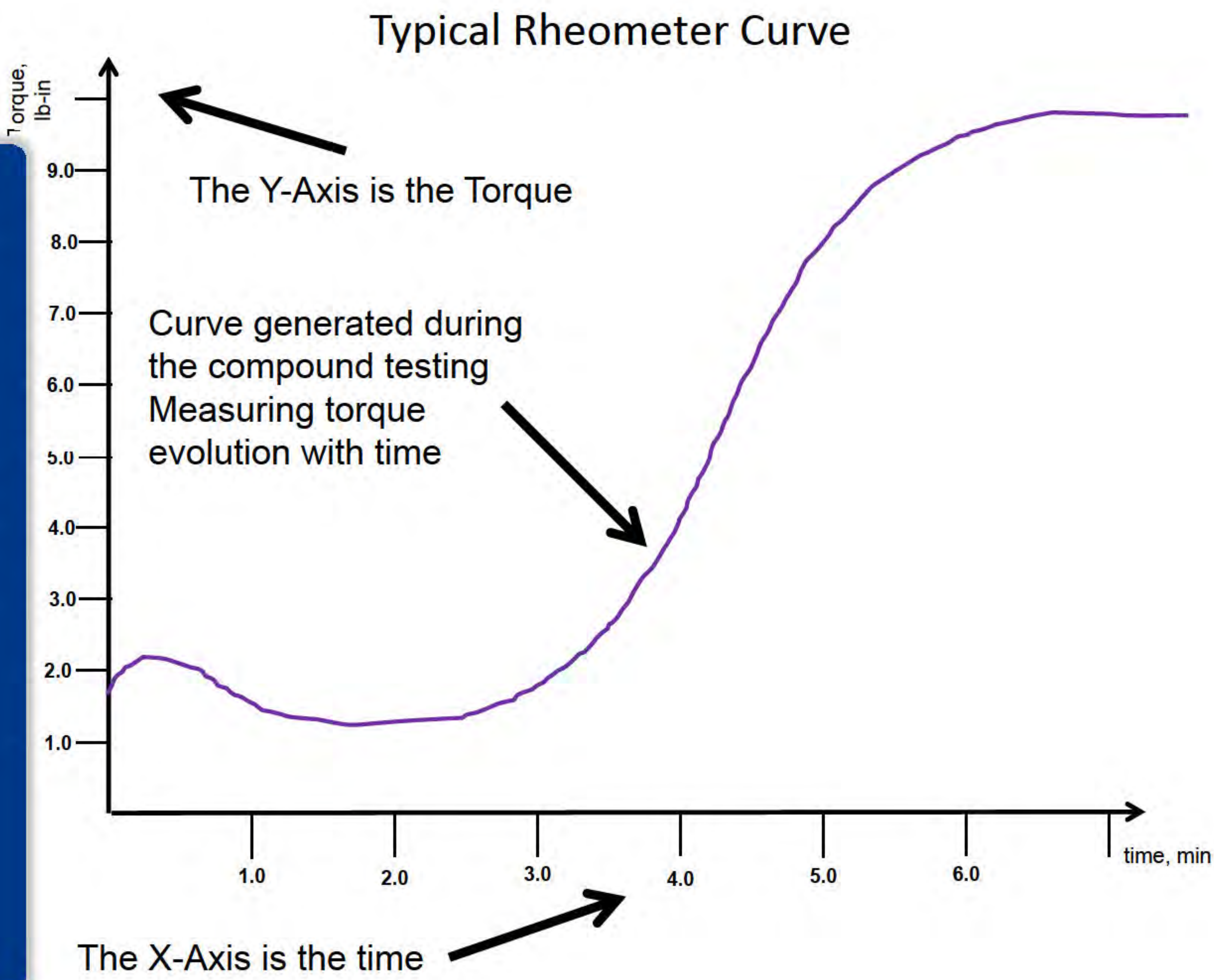
Each batch produced is tested in a Moving Die Rheometer - MDR



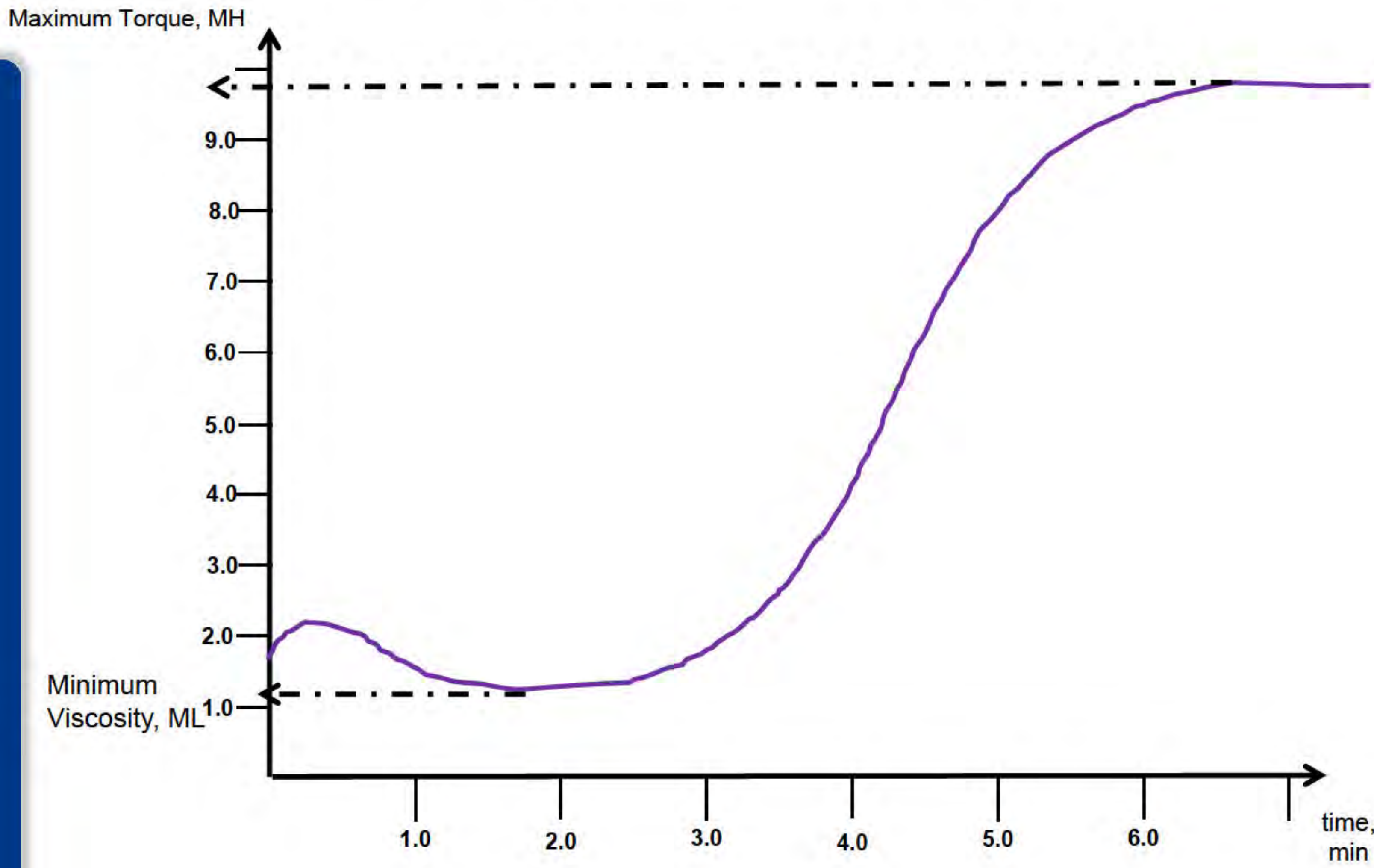
The MDR measures the torque change that is caused by the compound cure.
Each compound has its proper curve.
A sample of each produced compound batch is placed between 2 heated dies.
The lower die oscillates ± 0.5°.
The upper die measures the force transmitted from the lower die through the compound.



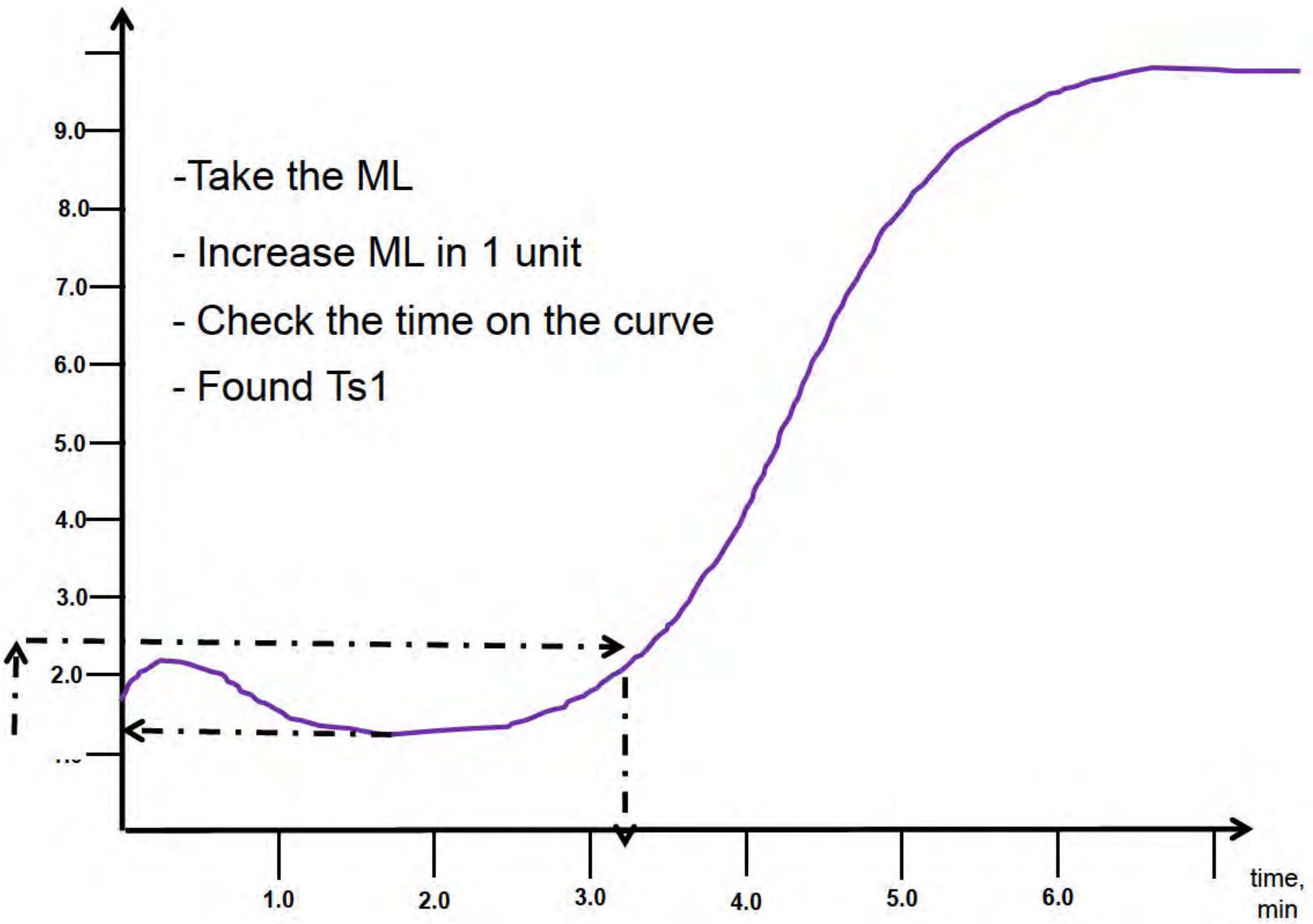



Typical Rheometer Curve
Torque, lb-in
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
The Y-Axis is the Torque
Curve generated during the compound testing Measuring torque evolution with time
1.0
2.0
3.0
4.0
5.0
6.0
time, min
The X-Axis is the time

Direct Results, S'min (ML) & S'max (MH)

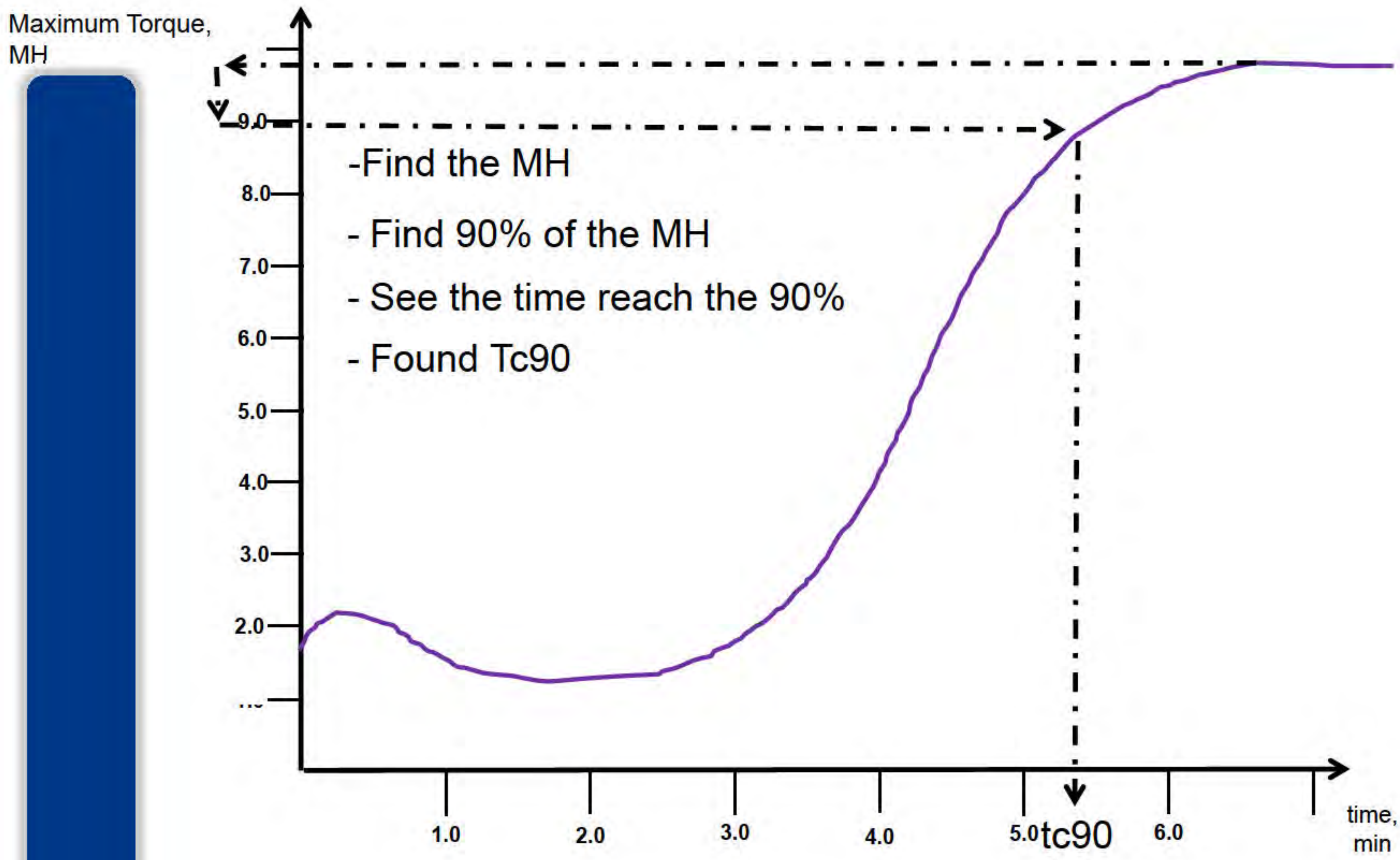


Indirect Results, ts1; Tc50; Tc90



ts1

Indirect Results, ts1; Tc50; Tc90



Typical Rheometer Curve

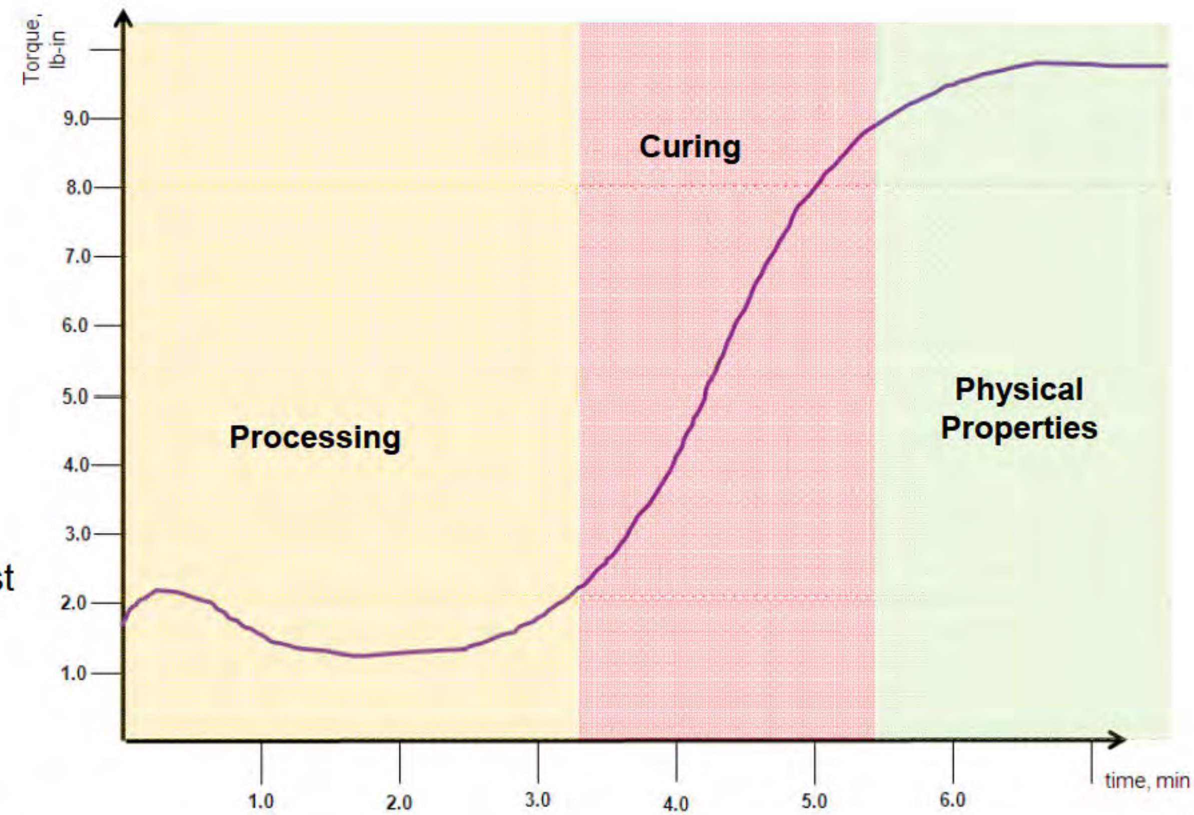
The curve is divided in 3 zones:

The Processing windows is between the start of the test, until de cure starts → ts1 = Scorch Time

The rubber compound is a mixture of polymer, filler, plasticizer and curative.
The curative starts to react at the moment it is added to the rubber compound.

At room temperature, this reaction exists, but is very slow, but still exist

At room temperature, this reaction exists, but is very slow, but still exist. It is know that for each 10C in tempera..re change, the speed of a reaction is changed of a rate approximately of 2.

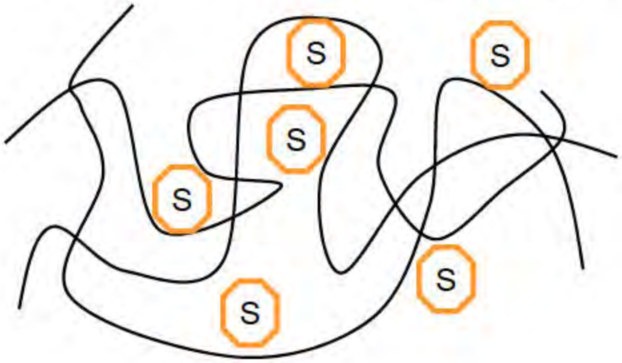


Temperature	Cure Time
180C	3min
170C	6min
160C	12min
140C	24min

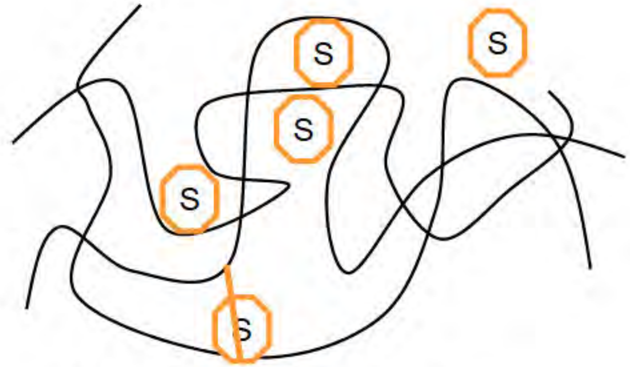
Temperature	Cure Time
60C	12288min = 8days
50C	24576min = 16 days
40C	49152min ~ 34 days
30C	98304min ~ 68 days

Importance of the ts1

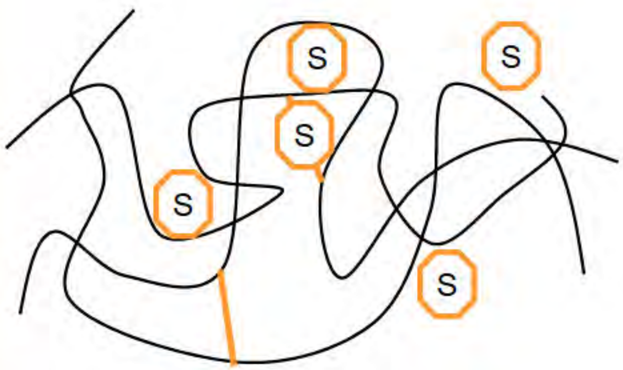
The Ts1 relates to the safety of the process. It means the compound has started to reach, creating cross linking.
It is difficult to precise measure the start of the cure, so the ts1 is the minimum variation we are able to detect.
Some companies uses ts2, ts5. The ts1 is being more severe.



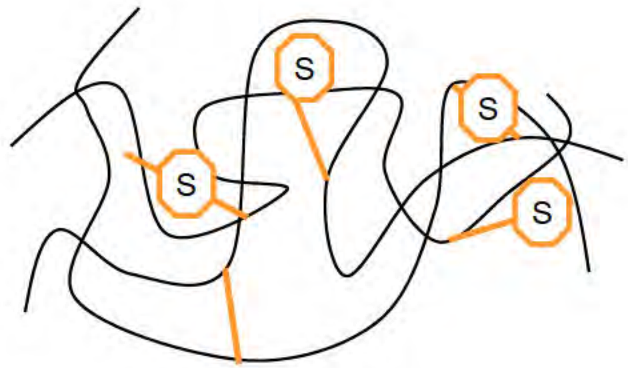
Mixed Compound



1st cross-linking appearing



ts1 – Enough Resistance to be noted



Fully cured material

The Molding Process

The perfect molding process would be like making ice cube. The rubber compound would flow very readily at constant viscosity in the cavity and then vulcanize very quickly and homogenously to yield uniform product.
However rubber compound is not like water. They are based on high viscosity polymers which requires very substantial force and elevated temperature to flow.

Two characteristics of elastomers complicate the molding:
-The compound viscosity is reduced as the rate of flow is increased by higher forces (shear thinning) and also by increase temperature.
-This helps the molding, facilitating the flow; but also make rubber's viscosity to change due to restrictions of pressure drops on the flow path.

- Conversely, compound viscosity starts to increase if the cure reaction begins prematurely, caused by elevated temperature of the mold or its part, and also due heat generation caused by molecular friction occurring during high shear flow of the rubber. Forcing high viscosity fluids to flow, always generates some heat and the higher the viscosity and flow rate, the greater the heat. Any increase in viscosity due to premature vulcanization prevents efficient filling of molds.

In the worst case, the combination of processing temperature and hysteretic heat initiates enough vulcanization that the chemical reaction, which is itself exothermic, starts adding to the temperature increase even further.

This can lead to recurrent problem, in which the cross linking due to heat raises the compound viscosity, which makes it more resistant to flow, the forced flow at the higher viscosity generates more heat, which then increases the rate and level of cross linking even further. This raises the material viscosity yet again to create still higher shear heating and more cross linking, until the materials viscosity becomes so high that the rubber will no longer flow at all and the final article is defective.
This is a form of rubber scorching.

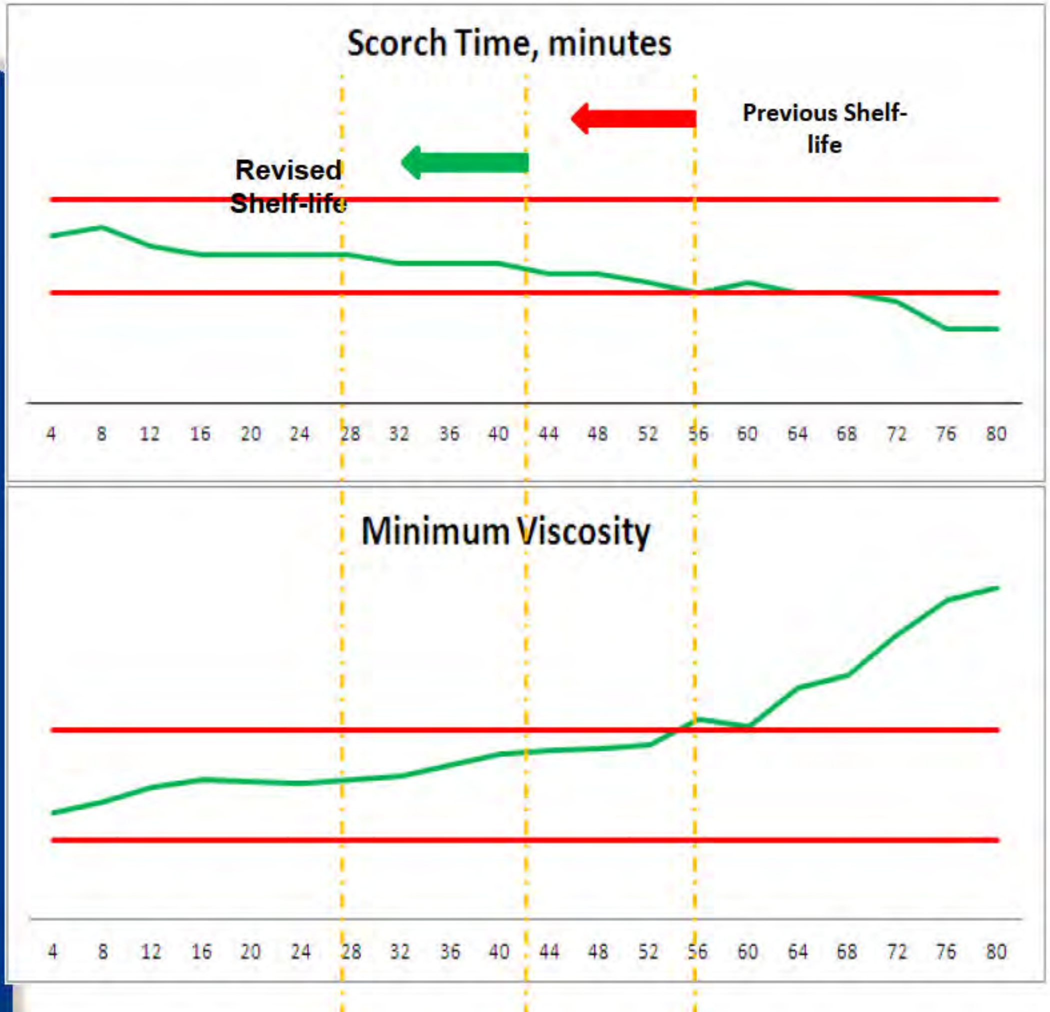
In lesser instances, of this problem, the rubber may fill out the article, but various kinds of defects relating to premature cross linking (small void, knit lines, flow marcs, poor bonding) will still cause it to be rejected.

Extract of "Fundamentals of Rubber Technology"; edited by R.J. Del Vecchio. Published by ACS – American Chemical Society

Also an analysis of the historical data of the physical properties (Tension, Elongation and Modulus) of the molded diaphragm, collected during 2011-2012 was done to verify time effect on those properties as well.

See below both experiments and results

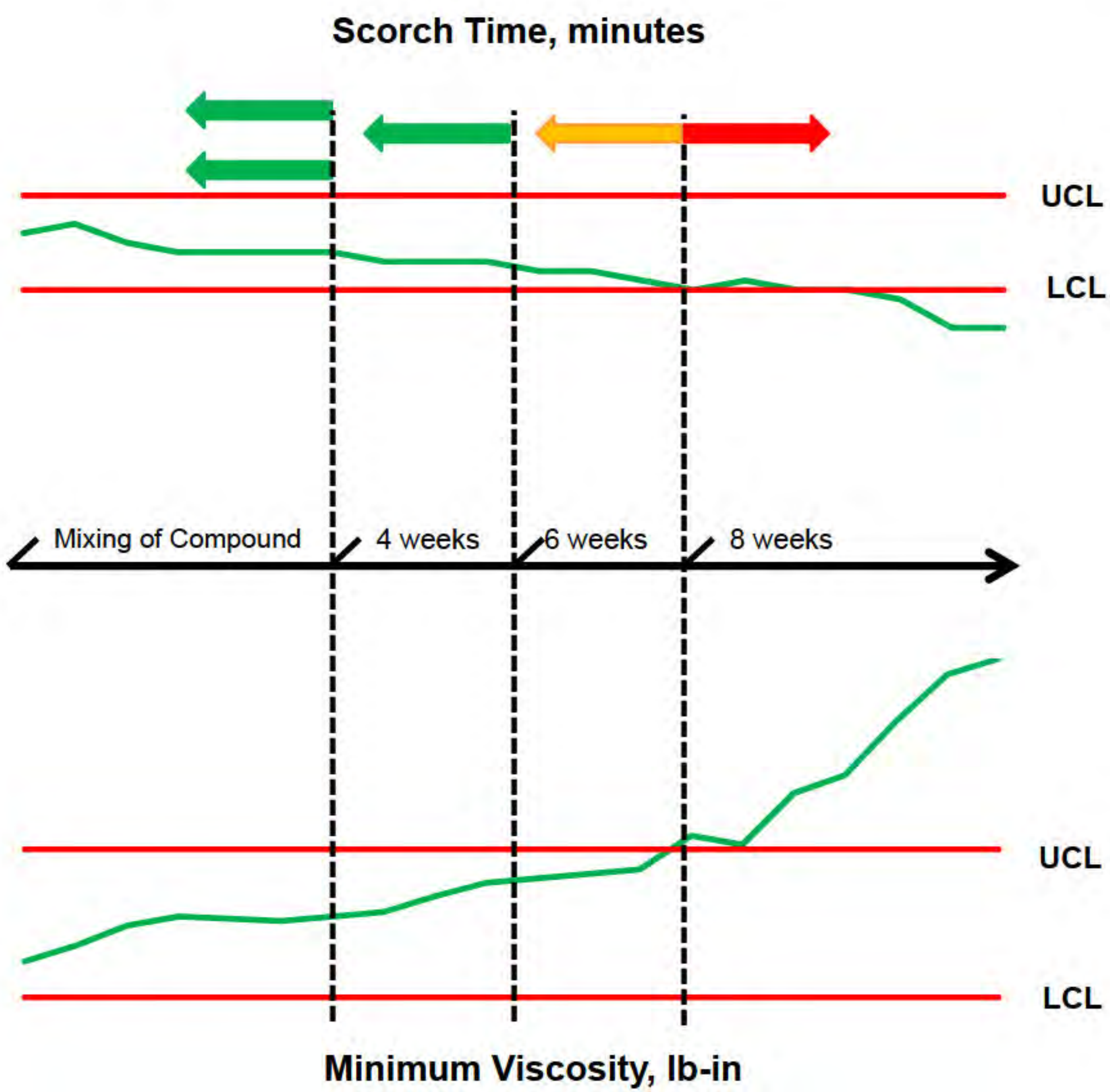
Age Effect on Compound Rheological Properties



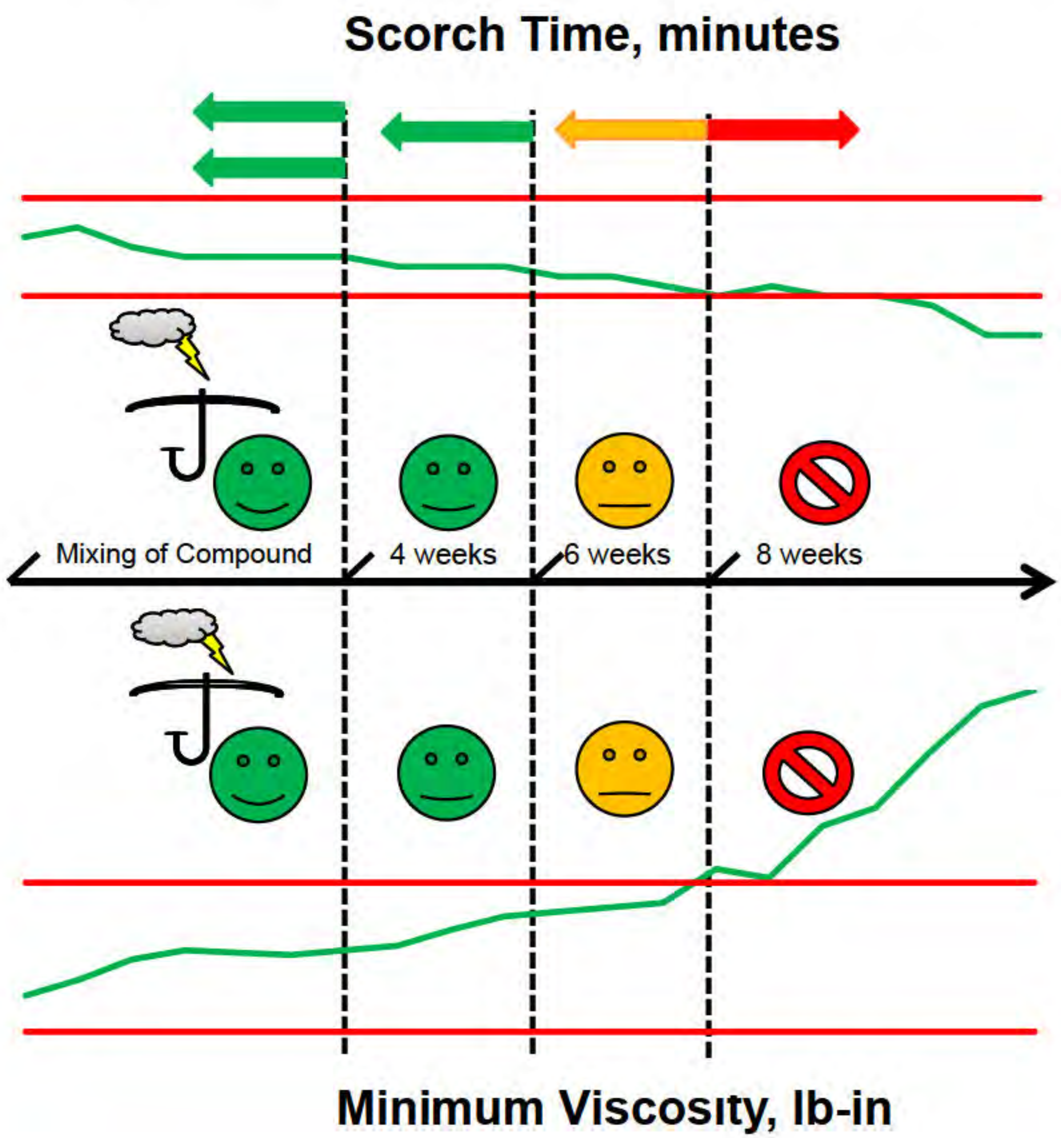
With the previous Shelf-life (8 weeks) was possible to use material with higher viscosity (causing more shear during the screening and injection process) and shorter scorch (time to start the cure process).

The measures were done on the same batch of G88 compound stored in the cold room

Age Effect on Compound Rheological Properties



Age Effect on Compound Rheological Properties



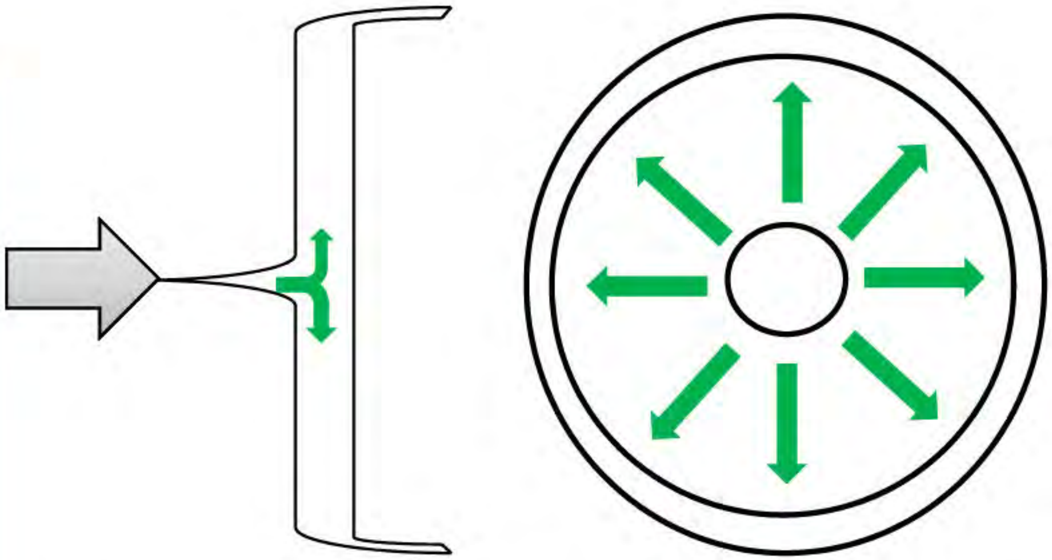
Compound with more than 8 weeks increases the viscosity and reduces the scorch.

Between 6 to 8 weeks the properties can be borderline, presenting risk of pre-cure.

Between 4 to 6 weeks, the behavior is OK.

For extra safety in the process, it was established the maximum shelf-life as 4 weeks

The compound needs a first rest in order to relieve internal stress, coolin˛ and ˛ erfect dis˛ ersion of ingredients.

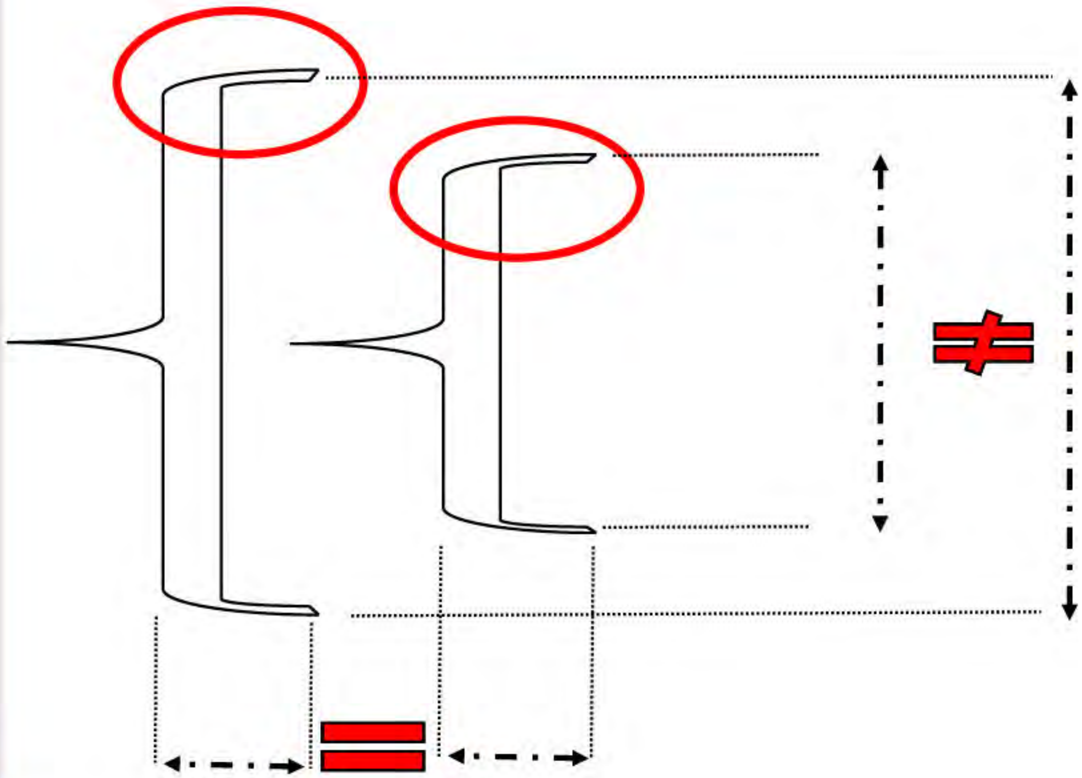


The compound is injected in a single shot, from the middle of the cavity, to the extremities, in radial path.
The material will flow. If there is a starting point for the cure (pre-scorched portion), it will have the viscosity little higher than the rest of the compound.
With the flow being constrained due the part design (interruption of free path), this particle will likely to be retained on the border of the piece.
The border is the most critical area of the diaphragm, due the fact it is the portion that suffers the moment during the usage.

Other factors must be considered on the failure:

Why this part has higher failure rate

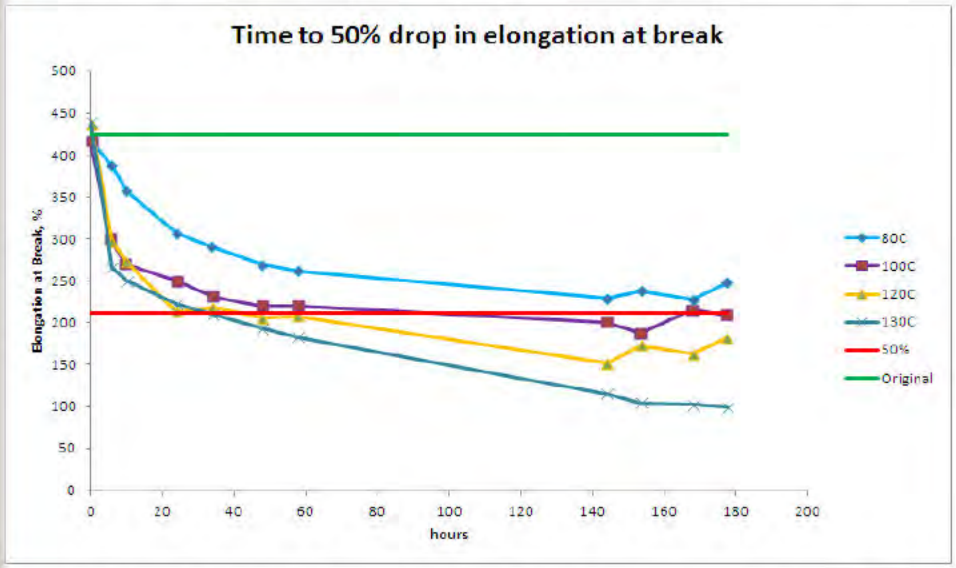
- It can be linked to the design of the piece, especially what concerns the critical area.
- Is the bead wall uniform between all the part numbers?
- Should not be thicker or longer, to be able to give the same extension when the parts are being used?



Another question that must be considered on the failure, is the condition of the usage of the parts.

The warranty parts have the same origin – Saudi Arabia – which is known for the hot weather in the summer.

With hot environment, the motor compartment may have higher temperature, which will be detrimental to the performance of the membrane booster.



It is possible to see that at 80C, the time to reduce in half the original elongation is around 150h.

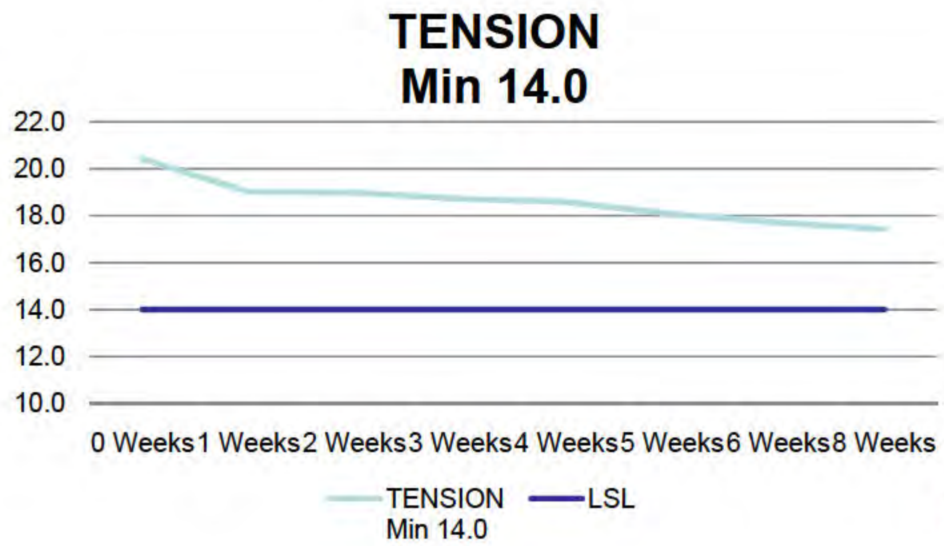
As the temperature increases, the time is very reduced:
100h at 100C
45h at 120C
35h at 130C

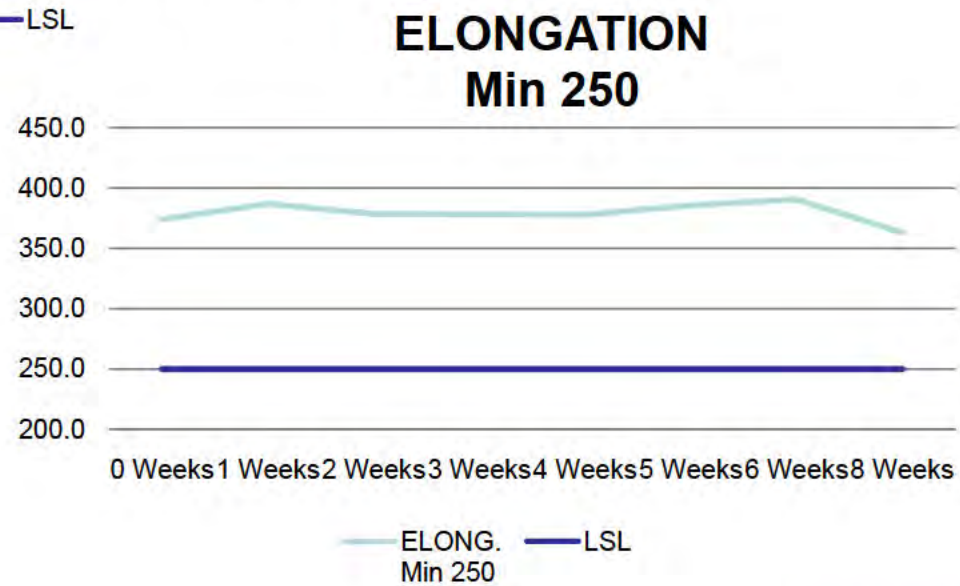
For some applications where high temperature is expected or the customer has a severe validation protocol, it is know that Peroxide EPDM are used.
The current material specified is Sulfur SBR, which has less resistance to heat.

Age Effect on Compound Rheological Properties

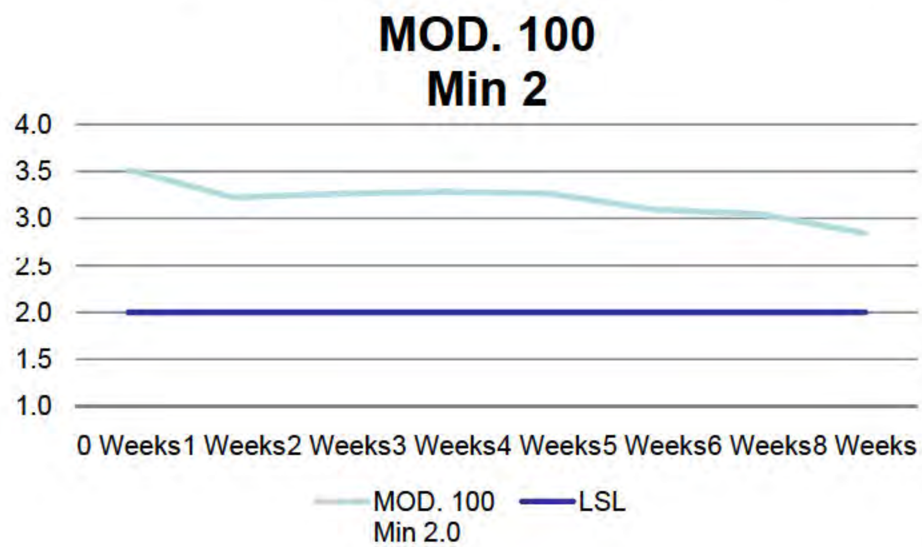
By the previous chart is possible to see that aged compounds have increased viscosity and reduced scorch time which may promote the generation of cured particles during the screening and molding operation

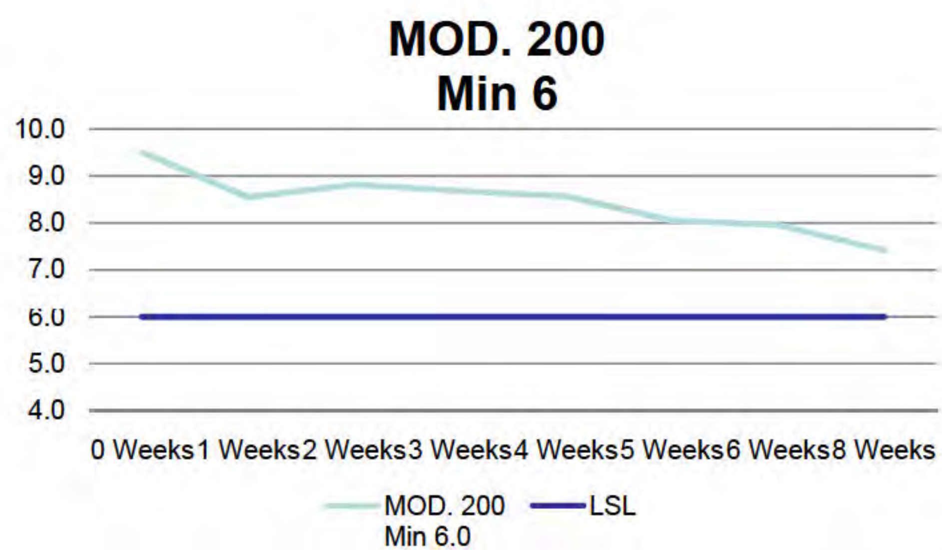
Age Effect on Compound Physical Properties





Age Effect on Compound Physical Properties





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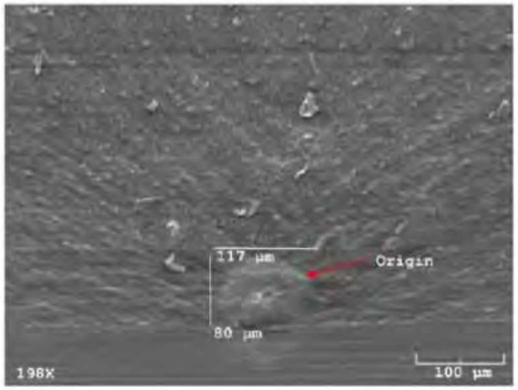
Age Effect on Compound Physical Properties

Physical properties as tension and modulus are affected by the age of compound, it could be due to the sensitivity of the aged compound to modify viscosity and scorch time which may promote the generation of cured particles during the screening and molding operation.

Conclusion:

The 17 risk factors identified and the controls established are preventive control activities.



The modification of the expiration date from 8 to 4 weeks is to prevent the generation of particles during screening and molding process since the aged compound is more sensitive to this for the modification of rheological and pnysical properties by the effect of time.

Validation of Root Cause

In order to validate the new change on the expiration date from 8 to 4 weeks , to prevent the generation of particles on the compound we design the following experiment.

6 batches of diaphragms compound will be separate on two control groups of 3 batches each. One group will be storage in the cool room (normal operation condition) and the other out of the cool room (extreme operation condition).

The two groups will be evaluate it as compound and molded diaphragms with 9 probes each one. Rheological and Physical properties will be measured on week 0,1,2,3, 4,5,6,7 ,8,12,&16 in order to validate the degradation of compound during time.

HUTCHINSON WORLDWIDE

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 2-3 Supplier Report 1 Nov 2012

Mazda J50C Booster

Response to Questions from October 25, 2012 Meeting

November 1st, 2012
TRW Automotive

ADVANCED THINKING / SMART THINKING / GREEN THINKING

Diaphragm Tear

1. ***Need pictures of particle with 1 week, 2 week, 3 week shelf shelf life material.***

2. ***1w, 2w, 3w shelf life diaphragms have particles?***

3. ***What is OK criteria of particle size, numbers?***

   Response:

   All diaphragms have particles. This includes diaphragm suppliers other than Hutchinson. The presence of a particle does not necessarily indicate that a diaphragm will fail. The intent of reducing shelf life is to limit the number and size of the particles and improve mechanical rubber properties, which can contribute to a failure. The permanent corrective action will be implemented based on the findings of the RedX investigation.

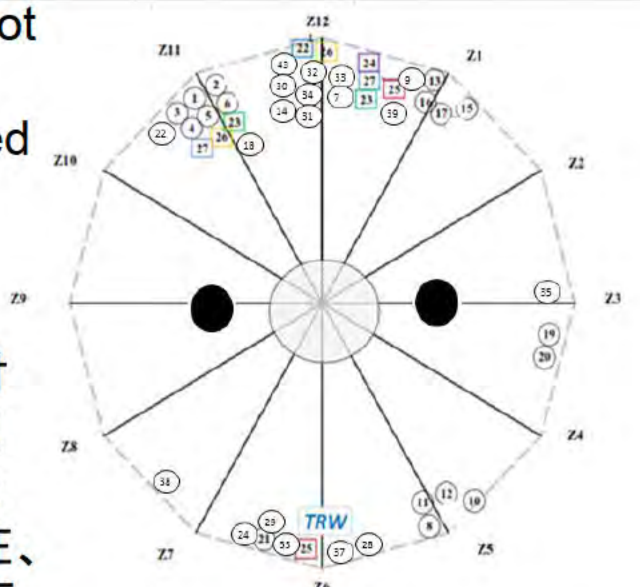
   回答:

   全てのダイアフラムにはパーティクルが存在し、これはHutchinsonだけではなく他のサプライヤーのダイアフラムでも同様です。パーティクルの存在が必ずしも不具合に繋がる訳ではありません。保存期間短縮の目的はパーティクルの数やサイズを制限し、機械的ラバー性質を向上させ不具合を防止することです。恒久対策は、RedX調査の結果に基づき実施する予定です。

Diaphragm Tear

4. *Need pictures of particle size, location, numbers of each 49 returned diaphragm in Matrix file.*

Response: Matrix file sent. Not all returns have pictures, etc. available, however all appeared consistent. TRW is currently focusing its resources on the RedX investigation.
回答：マトリックスファイルは送付済みです。全ての返却品の写真他情報は入手出来ませんでしたが、一貫性が見られました。現在、RedX調査の為のリソースに重点をおいて取り組んでいます。



Item	TRW reference Number	Failure legth mm
1	12-20581	32
2	12-21079	25
3	12-22470	25
4	12-23029	25
5	12-21238	25
6	12-20580	22
7	12-26042	35
8	12-20577	32
9	12-26055	25
10	12-21243	25
11	12-21242	25
12	12-21237	36
13	12-22478	25
14	12-26051	23
15	12-20579	27
16	12-21080	30
17	12-22474	31
18	12-26060	25
20	12-21241	21
21	12-22476	35
22	12-26049	24
23	12-21078	33/3
24	12-26052	34
25	12-20578	30/12
26	12-21244	20/24
27	12-22477	24/14
28	12-26038	26
29	12-26058	32
30	12-26048	24
31	12-26059	33
32	12-26040	25
33	12-26041	33
34	12-26061	30
35	12-26054	16
36	12-26043	24
37	12-26050	30
38	12-26053	25
39	12-26039	28

Diaphragm Tear – RedX

5. *What are you investigating right now? What are you planning to submit on November 8th? Please submit the schedule of RedX project.*

Response :
RedX investigation is focused on understanding variables/differences which cause some diaphragms to tear and other not to.
Diaphragms tear when the input ENERGY exceeds the material STRENGTH.

Suspect Factors found that could affect the STRENGTH:

A. Quantity and size of non-homogeneous particles including pre-cured rubber
B. Shelf life age of the material
C. Time exposure to high temperature (Decays the strength)

Suspect Factors found that could affect the input ENERGY:

D. Thickness of the diaphragm in the fold area (thicker increases stress)

A Full Factorial DOE to test the main effects and interactions of the Factors is being planned. Timing to make DOE parts, develop accelerated evaluation test & complete the DOE is being established & will be submitted Nov 8th.

An FEA performed by TRW engineering shows that thicker material in the diaphragm fold region can lead to higher stresses, which may contribute to the likelihood of a tear.

As a proactive measure, TRW launched new tooling that reduces the thickness in the diaphragm fold region, to be used in the event that the RedX DOE demonstrates thickness as a significant contributor to diaphragm stress.

Durability testing is expected to take 8 weeks and will commence as soon as the new tool is validated.

Diaphragm Tear – RedX

5. What are you investigating right now? What are you planning to submit on November 8th? Please submit the schedule of RedX project.

回答：
RedX調査では、ダイアフラム破裂を引き起こす可変要素/相違を把握する事にフォーカスしている。
材料**強度**を超えた**エネルギー**が加わった際、破裂が発生する。

強度に影響するであろう要因:
A. 硬化ラバーを含む均質ではないパーティクルの品質とサイズ
B. 材料の保管期間
C. 高温にさらされている時間 (強度低下)

入力エナジーに影響するであろう要因:
D. ダイアフラム折り目の厚み (厚いほどストレス増加)

主な影響と相互作用をテストする全ての要因DOEを計画中。 DOE部品の製造、評価テスト促進を展開、完成DOEを作成し11/8に提出予定。

TRWエンジニアにて実施されたFEAにて、ダイアフラムの折り目部が厚いと破裂の可能性と考えられるストレスを増加させることを確認。

未然防止策とし、RedX DOEにてダイアフラムへのストレスに影響する厚みをデモンストレーションする為、ダイアフラムの折り目部の厚みを軽減する新しいツールを導入。

耐久テストは8週間で、新しいツールの認証が済み次第実施予定。

Diaphragm Tear

6. ***Please prove the reason why can not use earlier shelf life compound even the relation between scorch time and viscosity is clear with data. Other suppliers use the compound after 24 hours. We think that even one week shelf life is too long.***

Response : 回答

- The minimum shelf life due to technical factors (cooling, stress relief, etc. is 50 hours.
  技術的要因による最低保存期間（冷却、ストレス解放など）は50時間
- In order to have better properties on the compound (viscosity and scorch time), the shelf life was reduced to from 8 to 4 weeks.
  構成物のより良い性質（粘度&スコーチ時間）の為、保存期間は8週から4週間に短縮。
- The material used in molding could have anywhere from 50 hours to 4 weeks of shelf life.
  形成で使用される材料は、50時間から4週間の間の保存期間であれば使用可能。
- Due to logistic issues, Hutchinson cannot commit to consistently having compound with less than a 4 week shelf life.
  物流問題の理由で、常に4週間以下の保存期間の構成物であるとHutchinsonは明言出来ない。
- Further detail on the technical and logistic factors is provided on the next slide.
  技術的、物流要因の詳細は次のスライド参照。

Diaphragm Tear

From the technical stand point:

- The G88 compound is mixed in two non consecutives phases,. This means, the master batch is produced and then , in a later operation, it is brought back to the mixer and accelerated. The reason for this: if mixed in single pass, the heat developed during the mixing process is excessive and if accelerator is added, the complete batch will start to cure, rendering a non-usable batch.
- So the compound is mixed first in a master batch (all chemicals except for accelerators/curatives). Extensive mixing is done and temperature is not a problem.
- The master batches are left to rest at least 24 hours. This is based on the industry best practice. The compound cools down, relieve internal stress and this helps on the ingredient s dispersion.
- After the 24hours, the compound then can be accelerated (brought back to the mixer and add the curatives/accelerators). As the ingredients that are harder to disperse are already dispersed on the master batch, the temperature is lower.
- The final compound (master + accelerators/curatives) is left for resting 24h minimum (for the same reason as before).
- After 24hours minimum, the compound can then be screened. After the screening, the minimum time allowed is 2 hours. In most cases the compound is molded on the next day.
- Experience shows the overall processability of the compound / properties are better with rest.

From the logistics stand point:

- Prior to mixing the compound, the mixer must be cleaned in a process that takes between 5 to 8 hours of work.
- When the compound is mixed, the production runs are large enough to produce the quantity needed to supply all the parts produced with G88 compound. The production run is about 1 day long.
- The Banbury mixer not only mixes compound G88, but all the compounds produced at the plant, which involves production planning in order to minimize the change over between series of compounds. Due the production runs, the G88 compound is normally mixed every 7 ~ 10 days.
- Hutchinson must have inventory in stock to fulfill spikes on production, maintenance or any production problem .
- From the 8 weeks (original shelf life) it was seen an increase on the viscosity and reduction of the scorch time on the sample tested after the 8^{th} week. In order to have better safety on the process, the shelf life was reduced to 4 weeks. This is the maximum shelf time of the compound G88 used on the production of TRW Parts.
- Hutchinson reserves the right to use material with shelf life between the Minimum Technical Time (50hours) and Maximum Shelf Life (4 weeks).

Diaphragm Tear

技術的視野での論点:

•G88構成物は、間欠的段階で混合される。これは、マスターバッチが製造され、後の工程にて、混合工程に戻され、硬化が促進される。理由としては、混合が単独だと、混合工程にて発生する熱が過剰で、硬化促進剤が加えられた際、完成バッチは硬化を開始し、使用出来ない状態となるためである。

•そのため構成物はマスターバッチで最初に混合される。(促進剤/硬化剤以外の全ての化学薬品） 広域にて混合されるため、温度は問題とならない。

•マスターバッチは24時間保管される。これは工業界でのベストな実践に基づいている。構成物は冷却され、内部ストレスを解放し、原料を分散させる。

•24時間後、構成物の硬化を促進させることが出来る。(混合工程に戻され、促進剤と硬化剤が加えられる） 分散が困難な原料もマスターバッチにて既に分散されており、温度は低温に保たれる。

•最終構成物（マスター+促進剤/硬化剤）は最低24時間保管される。(上記と同様の理由)

•最低24時間後、構成物はスクリーニングされる。その後、最低2時間保管が必要。通常、次の日に形成される。

•経験から、総合的に構成物の性質は保管することで工程が可能になると言える。

物流的視野での論点:

•構成物混合の前に、ミキサーは工程にて洗浄する必要が有り、それには5-8時間掛かる。

•混合中の製造は連続稼働で、全ての部品で使用するG88構成物を製造する。製造稼働は約1日。

•Banburyミキサーは、G88のみではなく、構成物のシリーズ間の交代を最小限にするための製造計画に影響する、工場の全ての構成物で使用する。連続稼働のため、G88構成物は通常7-10日おきに混合される。

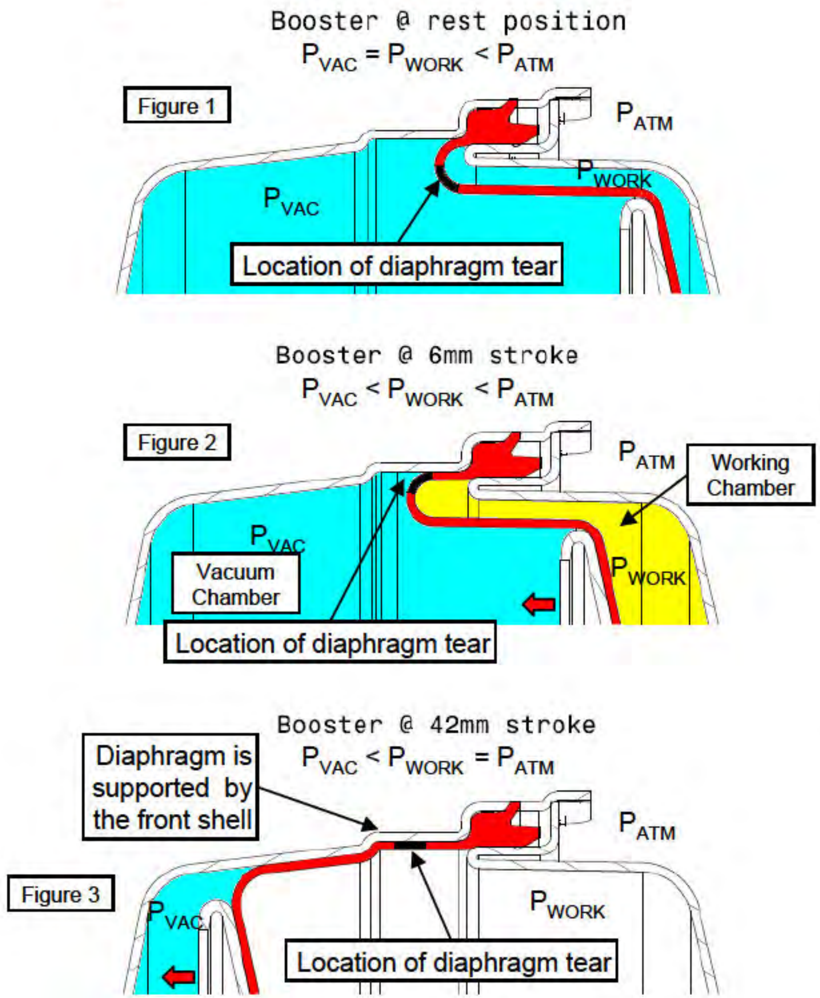
•Hutchinsonは、製造の急増、メンテナンス、もしくは何らかの製造問題に備え在庫を持つ必要がある。

•8週間(元の保存期間)から、粘度が増加し、スコーチ時間が減少されることが8週間後テストしたサンプルにて確認されている。工程での安全性を考え、保存期間を4週間に短縮した。これはTRW部品で使用されるG88構成物での最長の保存期間である。

•Hutchinsonでは、最短技術時間（50時間）から最長保存期間（4週間）の材料を適切に使用するため備えている。

Diaphragm Tear – Risk Opinion

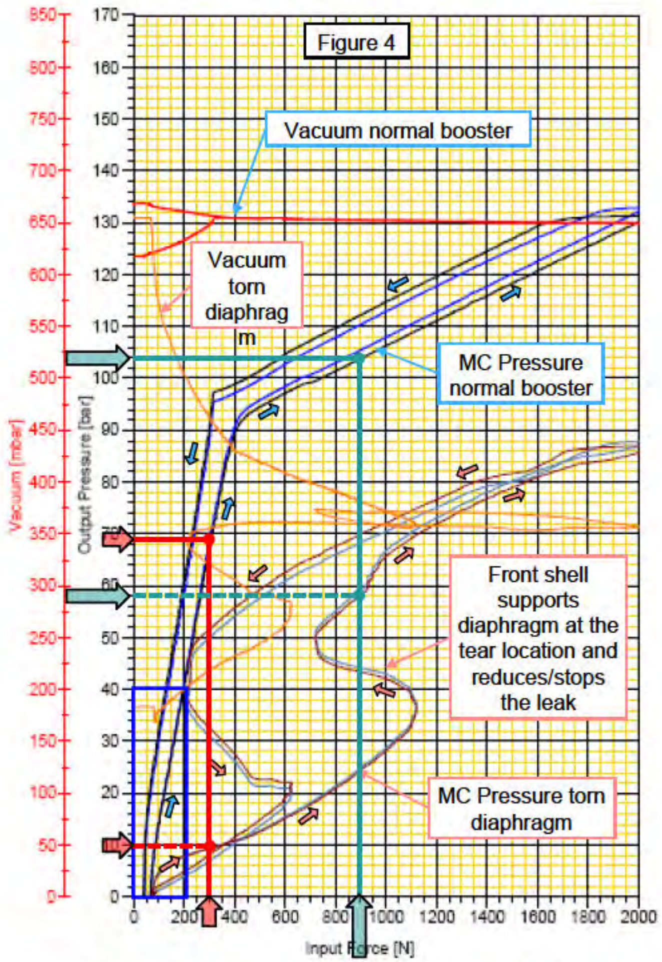
7. *Please prove a degree of performance deterioration of returned parts by diaphragm tear with data.*



- The diaphragm tear is located in the high-stress area of the diaphragm (Fig. 1).
  ダイアフラムの破裂は強くストレスが掛かる部位で発生。
- As the driver applies the brake pedal, air enters the working chamber from outside the booster and the diaphragm moves forward (Fig. 2).
  ドライバーがブレーキを踏むとブースターの外から作動チャンバーに空気が侵入し、ダイアフラムが前方に移動する。
- As the booster diaphragm moves during the brake apply it rolls out against the inner surface of the front shell.
  ブレーキ中にブースターダイアフラムが移動することで、フロントシェルの内面へ押し出される。
- Pressure difference between the working chamber and the vacuum chamber will push the diaphragm against the inner surface of the front shell.
  作動チャンバーとバキュームチャンバーの圧力の差でダイアフラムがフロントシェルの内面へ押される。
- The front shell supports the diaphragm around the tear blocking the air path through the tear (Fig. 3).
  フロントシェルは亀裂からの空気孔をブロックしダイアフラムを保護する。

Diaphragm Tear – Risk Opinion

7. Continued

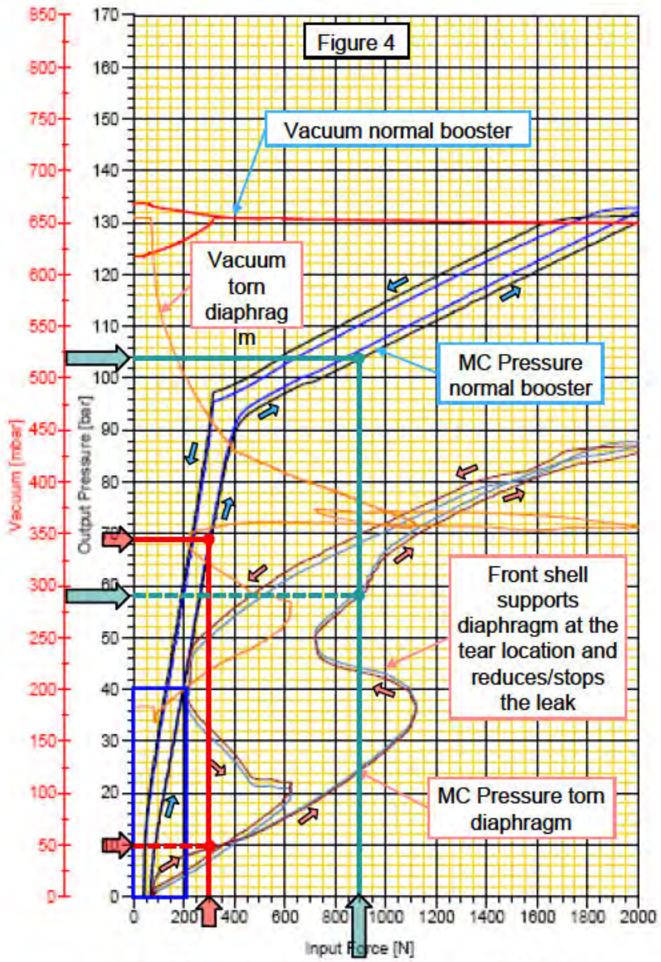


Returned Booster with torn diaphragm with 670 mbar vacuum (isolated) and apply rate 4.5 mm/sec at input rod

- A booster with a torn diaphragm will provide less helping force during the brake apply and less master cylinder pressure for a given apply force (Fig. 4).
- A trial of a booster returned with a torn diaphragm has been run with nominal vacuum (0.68 bar) and with the vacuum source isolated during the apply. This represents a slow evacuation of air from the booster (worse case) during the braking event.
- A low brake apply force example (Fig. 4):
  - F_{IN} = 300 N, P_{OUT} = 69 bar (normal booster)
  - F_{IN} = 300 N, P_{OUT} = 10 bar (torn diaphragm)
  - Reduction in m.c. pressure is 85%
- A high brake apply force example (Fig. 4):
  - F_{IN} = 900 N, P_{OUT} = 104 bar (normal booster)
  - F_{IN} = 900 N, P_{OUT} = 58 bar (torn diaphragm)
  - Reduction in m.c. pressure is 44%
- The difference between the percent reduction at low and high brake apply force of 85% and 44%, respectively is due to the sealing effect of the diaphragm supported by the front shell around the tear as illustrated in Fig. 3.

Diaphragm Tear – Risk Opinion

7. Continued

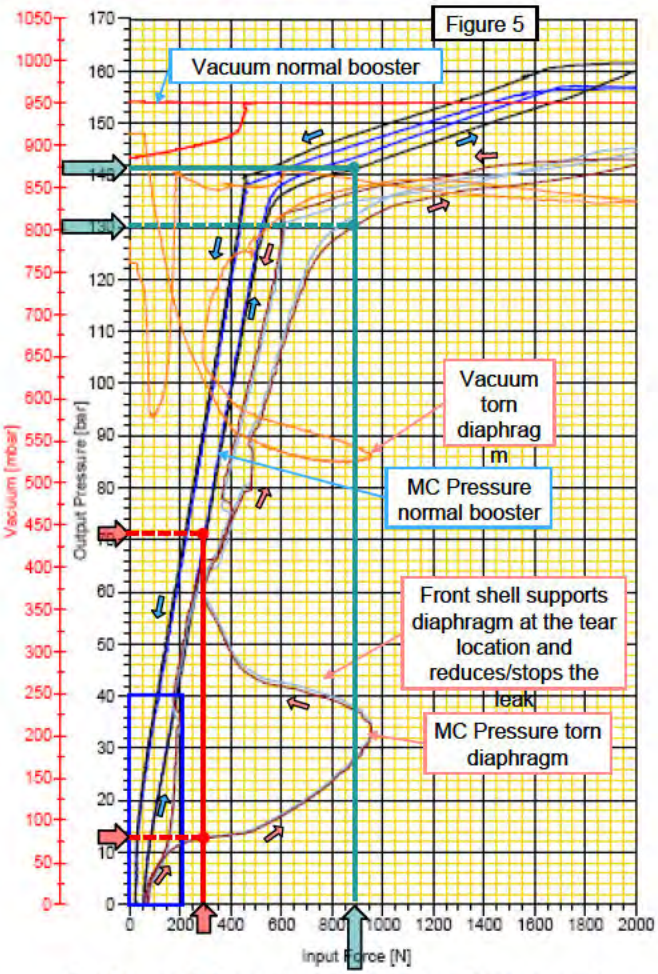


670mbar（単独）バキュームとインプットロッド作動率4.5mm/秒での亀裂ダイアフラムの返却ブースター

- 亀裂が入ったダイアフラムのブースターは、ブレーキ踏込中に補助する力が軽減し、作動力に対してのマスターシリンダーの圧力も軽減する。(Fig. 4).
- ダイアフラムに亀裂が入った返却ブースターを正常バキューム（0.68 mbar)とブレーキ中単独のバキュームソースでトライアルを実施。これによりブレーキ作動中、ブースター（悪い状況）からゆっくり空気が排出されていることが示された。
- 低ブレーキ作動力の例 (Fig. 4):
  - F_{IN} = 300 N, P_{OUT} = 69 bar (通常ブースター)
  - F_{IN} = 300 N, P_{OUT} = 10 bar (破裂ダイアフラム)
  - m.c.圧力の低下率 85%
- 高ブレーキ作動力の例 (Fig. 4):
  - F_{IN} = 900 N, P_{OUT} = 104 bar (通常ブースター)
  - F_{IN} = 900 N, P_{OUT} = 58 bar (破裂ダイアフラム)
  - m.c.圧力の低下率 44%
- 低と高ブレーキ作動力低下率の85%と44%の違いは、イラスト図3のよう亀裂付近のフロントシェルで保護されているダイアフラムのそれぞれのシーリング効果によっている。

Diaphragm Tear – Risk Opinion

7. *Continued*

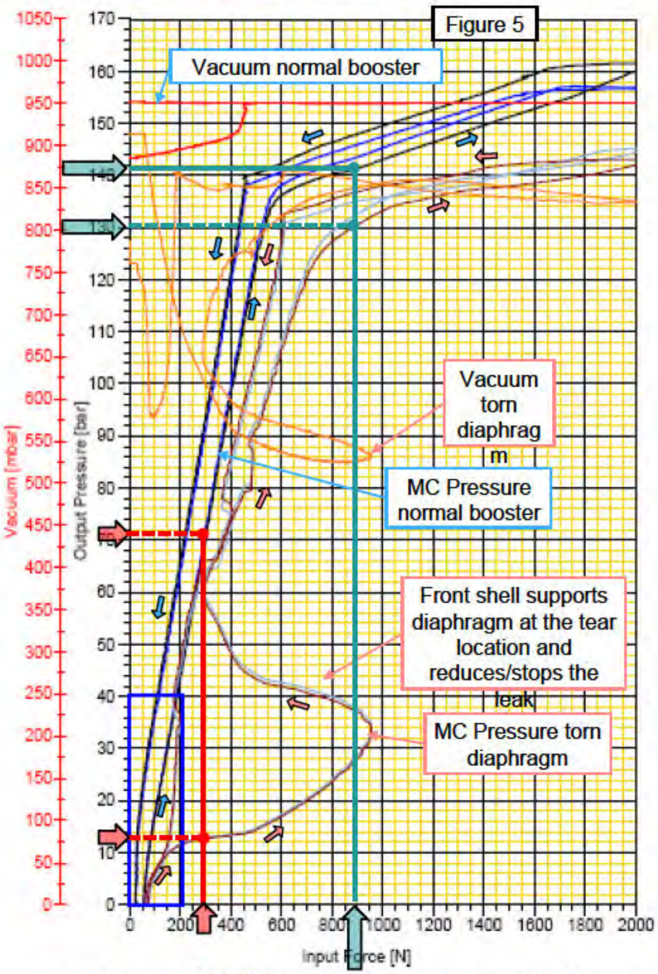


Returned Booster with torn diaphragm with 910 mbar vacuum (not isolated) and apply rate 4.5 mm/sec at input rod

- Another trial of the same booster with a torn diaphragm has been run with high vacuum (910 mbar) and no isolation of the vacuum source during apply (Fig. 5). This represents an fast evacuation of air from the booster during the braking event.
- A low brake apply force example (Fig. 5):
  - F_{IN} = 300 N, P_{OUT} = 71 bar (normal booster)
  - F_{IN} = 300 N, P_{OUT} = 13 bar (torn diaphragm)
  - Reduction in m.c. pressure is 82%
- A high brake apply force example (Fig. 5):
  - F_{IN} = 900 N, P_{OUT} = 142 bar (normal booster)
  - F_{IN} = 900 N, P_{OUT} = 130 bar (torn diaphragm)
  - Reduction in m.c. pressure is 9%
- The difference between the percent reduction at low and high brake apply force of 82% and 9%, respectively is due to the sealing effect of the diaphragm supported by the front shell around the tear as illustrated in Fig. 3.

Diaphragm Tear – Risk Opinion

7. Continued



910mbar（単独）バキュームとインプットロッド作動率4.5mm/秒での亀裂ダイアフラムの返却ブースター

- 同じブースターに高バキューム（910 mbar)と作動中孤立しないバキュームソースで別のトライアルを実施。(Fig. 5)　これによりブレーキ作動中、ブースターから早く空気が排出されていることが示された。
- 低ブレーキ作動力の例 (Fig. 5):
  - F_{IN} = 300 N, P_{OUT} = 71 bar (通常ブースター)
  - F_{IN} = 300 N, P_{OUT} = 13 bar (破裂ダイアフラム)
  - m.c.圧力低下率 82%
- 低ブレーキ作動力の例 (Fig. 5):
  - F_{IN} = 900 N, P_{OUT} = 142 bar (通常ブースター)
  - F_{IN} = 900 N, P_{OUT} = 130 bar (破裂ダイアフラム)
  - m.c.圧力低下率 9%
- 低と高ブレーキ作動力低下率の82%と9%の違いは、イラスト図3のよう亀裂付近のフロントシェルで保護されているダイアフラムのそれぞれのシーリング効果によっている。

Diaphragm Tear – Risk Opinion

7. *Continued*

Conclusions:

- The helping force of a booster with a torn diaphragm in a vehicle during a braking event will be less than a normal booster without a torn diaphragm, and is dependent upon:
  - the size of the tear in the diaphragm (larger has greater effect);
  - the vacuum level within the booster at the time of the braking event (smaller initial vacuum level has greater effect);
  - the in-stop air evacuation rate of the booster (slower has greater effect);
  - the driver's apply rate of the brake pedal (faster apply rate has greater effect);
  - the driver's apply force on the brake pedal (lower apply force has greater effect).
- The condition of the diaphragms returned to TRW exhibited similar tear position and tear size characteristics, therefore it is assumed the effect of a torn diaphragm will be relatively consistent within the population of affected boosters.
- Within the input stroke of brake apply event, the diaphragm will be supported by the inner surface of the front shell diminishing or eliminating the air leak path through a tear in the diaphragm. Once the tear region of the booster is supported by the front shell, the in-stop air evacuation of the booster will increase the booster helping force. This will occur as the driver increases the braking force.

Diaphragm Tear – Risk Opinion

7. Continued

結論:

- ブレーキ作動時の亀裂が入ったダイアフラムの車両でのブースター補助力は、正常ブースター より低下。これは下記状況による:
  - ダイアフラムの亀裂サイズ (大きいほど影響有り);
  - ブレーキ作動中のブースターバキュームレベル (最初の小さいバキュームレベルほど影響有り);
  - ブースターの停止中空気排出率 (遅いほど影響有り);
  - ドライバーがブレーキペダルに力を加える率 (早いほど影響有り);
  - ドライバーがブレーキペダルに加える力(低いほど影響有り).
- 返却されたダイアフラムの状態は、破裂箇所、サイズ共類似していることから、破裂ダイアフラムは、影響したブースターの数と一貫性があると推測。ブレーキ作動時の入力ストロークにて、ダイアフラムはフロントシェルの内面で保護されており、亀裂部からの空気漏れを軽減、防止している。一度フロントシェルにより保護されると、ブースター停止中空気排出は、ブースター補助力を増加させる。これはドライバーのブレーキ踏込力増加にて発生する。

Other Mazda required

1. ***Please submit the evidence record for 8 weeks shelf life from the production history of 2006 SOP timing.***

    Response: It will take approximately two weeks to compile 2006 CY records. These records are only available in paper format and were retained offsite at the previous mixing site.
    回答:2006CY記録を収集するには約2週間必要です。この記録は書面でのみ提供可能で、最初の混合サイトで保持しています。

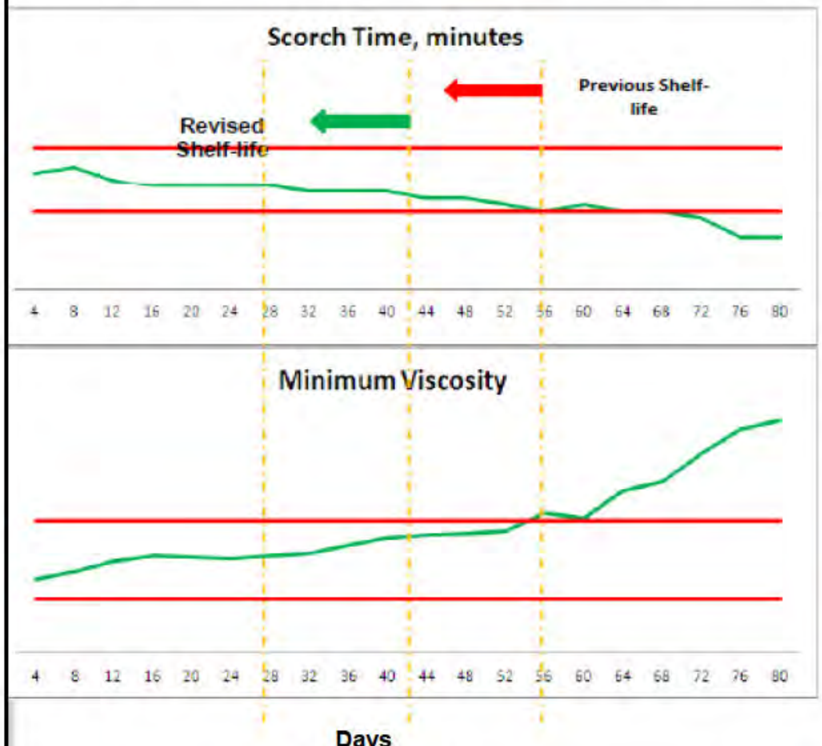
2. ***Please provide one cut diaphragm from 49 returned units. Please ship it to TAJ.***

    Response:
    Complete, shipped 10/30/2012.
    回答:
    2012/10/30発送済み

Other Mazda required cont'd

3. *Please provide G88 Compound Physicality comparison data (1 week , 2 weeks , 3 weeks, 4 weeks)*

Age Effect on Compound Rheological Properties



With the previous Shelf-life (8 weeks) was possible to use material with higher viscosity (causing more shear during the screening and injection process) and shorter scorch (time to start the cure process).

前回の保存期間(8週間)では、高い粘度(スクリーニングと注入工程にてせん断をより起こす)と短いスコーチ時間(硬化工程を開始する時間)で使用可能であった。

The red lines are Hutchinson control limits and serve as early indicators of process stability.

赤い線は工程の安定性を保持するためのHutchinsonでの管理範囲である。

The measures were done on the same batch of G88 compound stored in the cold room　低温室で保管されたG88バッチでも同様の測定を実施。

HUTCHINSON

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 2-4 Supplier Report 31 Jan 2013

COGNITIVE SAFETY SYSTEMS | TRW

Mazda J50C Booster Warranty

Update Slides

January 31, 2013
TRW Automotive

ADVANCED THINKING / SMART THINKING / GREEN THINKING

Agenda

1. Warranty Analysis of latest field returns
2. DOE results
3. Correlate between an 8wk shelf life and a 1 wk shelf life as far as the expected time these will last in the field (mileage) – Waiting on 8 wk results
4. Provide the location and particle size from all DOE parts – included in DOE results
5. Date of new tool completion at Hutchinson
6. Date when parts from new tool arrive at TRW and then to Mazda Japan
7. Thickness data on all control points on the profile of the diaphragms from new tool
8. Warranty data from other "Hot" regions
9. Service parts replacement for Saudi Arabia and UAE

Warranty Returns Analysis

(43) recent returns currently in Livonia for particle measurement and photos.

Next step send to Santa Rosa/Hutchinson for thickness and particle counts. Target completion Feb 25, 2013.

50 Warranty information

Return list of Saudi Arabia USA and other

1/29/2013

NO	Repaired Date	RW Report No	VIN	Market	Field Claim #	Mileage	Fault Description	Ship date from Japan	Analysis status and Root cause	RW Production date	Leak amount data (re produced test)	Performance DA A of input and Output (After returned)	Hutchinson Production date	Tear size	Tear picture	Tear picture	Tear picture	Location of tears (in diaphragm)	Pre cured Rubber Size	Pre cured Rubber Photo	Diaphragm thickness (mm)	Location and number of Pre cured rubber particles (in thickness)	Current Unit location	Record of Shelf life and inspection record of compound
70	10/9/2012	13-712	JM7TS1MA C[redacted]	Saudi Arabia	2CA16836 0	6396	Heavy Brake Pedal Air Leak of Brake Booster	12/26/2012	Unable to test, not stabilize vacuum, part exercised by hand and whistling noise perceived, in tear down analysis found damage in diaphragm.	December 21, 2011	Unable to test out of vacuum.	Unable to test out of vacuum.	November 2011	25 mm					175 x 236				Particle analysis at Livonia	6-8 Weeks
71	8/29/2012	13-711	JM7TS19A50[redacted]	Saudi Arabia	2C9(illegible)	222 0	Heavy Brake Force. Brake Booster	12/26/2012	Unable to test, not stabilize vacuum, part exercised by hand and whistling noise perceived, in tear down analysis found damage in diaphragm in two points.	September 21, 2011	Unable to test out of vacuum.	Unable to test out of vacuum.	August 2011	16 mm 27mm									Particle analysis at Livonia	6-8 Weeks
72	10/3/2012	13-691	JM7TS29A30[redacted]	Dominica	2CA2903(illegible)		Vacuum Leak of Brake Booster	12/26/2012	Damage in studs and in threads of tie bar, received disassembled. Unable to test, not stabilize vacuum, part exercised by hand and whistling noise perceived, in tear down analysis found damage in diaphragm in two points.	March 08, 2009	Unable to test out of vacuum.	Unable to test out of vacuum.	February, 2009	15mm (8) 18mm (3)									Particle analysis at Livonia	6-8 Weeks
73	10/8/2012	13-721	JM7TS3MAXA[redacted]	Dominica	2CA2903(illegible)		Vacuum Leak of Brake Booster	12/26/2012	Part arrived on January 11, 2013 Analysis in process	April 21, 2010	Unable to test out of vacuum.	Unable to test out of vacuum.	April 2010	30 mm									Particle analysis at Livonia	6-8 Weeks
7	10/8/2012	13-700	JM7TS19A3A[redacted]	Kuwait	2CA2 51501	31136	Heavy Brake Pedal & Squeaking Noise when applying brake	12/26/2012	Unable to test, not stabilize vacuum, part exercised by hand and whistling noise perceived, in tear down analysis found damage in diaphragm.	July 29, 2009	Unable to test out of vacuum.	Unable to test out of vacuum.	July 2009	30 mm					373 x 288				Particle analysis at Livonia	6-8 Weeks
75	9/29/2012	13-701	JM7TS19A1B[redacted]	Kuwait	2CA2 51501		Heavy Brake Pedal & Squeaking Noise when applying brake	12/26/2012	Unable to test, not stabilize vacuum, part exercised by hand and whistling noise perceived, in tear down analysis found damage in diaphragm.	August 25, 2010	Unable to test out of vacuum.	Unable to test out of vacuum.	July 2010	1 mm					233 x 185				Particle analysis at Livonia	6-8 Weeks
76	8/8/2012	13-698	JM7TS19A2A[redacted]	Kuwait	2CA2 51501	0082	Heavy Brake Pedal & Squeaking Noise when applying brake	12/26/2012	Functional test performed into spec, in tear down analysis no damage found in diaphragm.	August 10, 2009	into spec	In to spec	NA		NA	NA	NA	NA				NA	Particle analysis at Livonia	6-8 Weeks
77	7/31/2012	13-699	JM7TS19A5A[redacted]	Kuwait	2CA2 51501	37593	Heavy Brake Pedal & Squeaking Noise when applying brake	12/26/2012	Part received disassembled just one staple clinped, rear shell with one stample deformed, diaphragm checked and no damage found, part assembled and unable to hold vacuum, leak located in deformed sample. Part was repaired incorrectly.	August 18, 2008	Unable to test leak located in deformed stample.	Unable to test leak located in deformed stample.	NA		NA	NA	NA	NA				NA	Particle analysis at Livonia	6-8 Weeks
78	8/28/2012	13-717	JM7TS19A5B[redacted]	Kuwait	2CA2 51501	39182	Heavy Brake Pedal & Squeaking Noise when applying brake	12/26/2012	Unable to test, not stabilize vacuum, in tear down analysis found damage in diaphragm.	September 03, 2010	Unable to test out of vacuum.	Unable to test out of vacuum.	September 2010	32 mm									Particle analysis at Livonia	6-8 Weeks
79	8/28/2012	13-718	JM7TS19A9A[redacted]	Kuwait	2CA2 51501	3026	Heavy Brake Pedal & Squeaking Noise when applying brake	12/26/2012	Unable to test, not stabilize vacuum, in tear down analysis found damage in diaphragm.	March 11, 2010	Unable to test out of vacuum.	Unable to test out of vacuum.	February 2010	30 mm									Particle analysis at Livonia	6-8 Weeks
80	8/30/2012	13-716	JM7TS1MAXC0[redacted]	Kuwait	2CA2 51501	327 0	Heavy Brake Pedal & Squeaking Noise when applying brake	12/26/2012	Unable to test, not stabilize vacuum, in tear down analysis found damage in diaphragm.	August 30, 2011	Unable to test out of vacuum.	Unable to test out of vacuum.	August 2011	30 mm									Particle analysis at Livonia	6-8 Weeks
81	10/1 2012	13-715	JM7TS19A5B[redacted]	Kuwait	2CA2 51501		Heavy Brake Pedal & Squeaking Noise when applying brake	12/26/2012	Damage in shell near to vacuum grommet area. Unable to test, not stabilize vacuum, in tear down analysis found damage in diaphragm.	August 26, 2010	Unable to test out of vacuum.	Unable to test out of vacuum.	August 2010	3 mm									Particle analysis at Livonia	6-8 Weeks

Hutchinson Diaphragm DOE Test Timing

DOE Phase	Test Order	A: Shelf Life	B: Thickness	C: Particles / Supplier	Qty	Supplier Lead Time	Estimated Test Completed Date	Wk ending	Estimated Test Completion date as of Jan 28th
Pre-DOE	0	Current Production			4	NA	Wk 46	11-Nov	Completed Dec 12
Part 1	1	1 wk	+(Thin)	- (Hi Count) / HSM	4	1 wk	wk 47	18-Nov	Completed Jan 7
	2	1 wk	- (Thick)		4	2 wks	wk 49	2-Dec	Completed Dec 28
	3	4 wk	+(Thin)		4	5 wks	wk 2	13-Jan	75% complete, finish Feb 1
	4	4 wk	- (Thick)		4	6 wks	wk 2	13-Jan	Completed Jan 16
	5	8 wks	+(Thin)		4	9 wks	wk 3	20-Jan	Expected Feb 18
	6	8 wks	- (Thick)		4	9 wks	wk 4	27-Jan	Expected Feb 18
Part 2a	7	+(1 wk or Min)	+(Thin)	+(Lo Count)/ Rubena	4	12 wks	wk 11	17-Mar	Expected Mar 28
	8	-(30 days Max)	+(Thin)		4	16 wks	wk 15	14-Apr	Expected Apr 28
Part 2b	9	+(1 wk or Min)	+(Thin)	+(Lo Count)/ Daetwyler	4	22 wks	wk 18	5-May	Expected May 17
	10	-(6 months)	+(Thin)		4	48 wks	wk 44	3-Nov	Expected Nov 15

Notes:

1. Original DOE timing plan assumed Pre-DOE phase (Dev test) worked 1st time.
First new test method tried was not successful. Extra time to develop & evaluate a second test method delayed start of DOE testing approx. 3-4 weeks.
2. Increased Qty to test from 2 to 4.

Hutchinson Diaphragm DOE Test Plan Summary

1. Develop & evaluate accelerated evaluation test
   Test Method 1: "Air pressure cycling" approach did not work out- difficulty sealing under pressure
   Test Method 2: "Modified endurance" Successful: Replicated failure mode in short time. **COMPLETED** Dec 12.

2. Order diaphragm test configurations
   COMPLETE: All test parts have been ordered from suppliers.

3. Build booster assembles
   ONGOING: Per plan as DOE diaphragms are received.

4. Complete Part 1 Testing
   IN PROGRESS:
   1 wk "thick" parts: **COMPLETE**
   1 wk "thin" parts: **COMPLETE** (note: cracked in different position)
   4 wk "thick parts: **COMPLETE**
   4 wk "thin parts: 2 parts COMPLETE, 2 still on test expected completion Feb 1.
   8wk "thick parts" Test completion expected Feb 18
   8 wk "thin parts" Test completion expected Feb 18

5. Analyze & publish Part 1 results
   Following completion of Part 1 testing: Expected Feb 25

6. Complete Part 2a Testing & publish results
   Following completion of Part 2a testing: Expected May 3

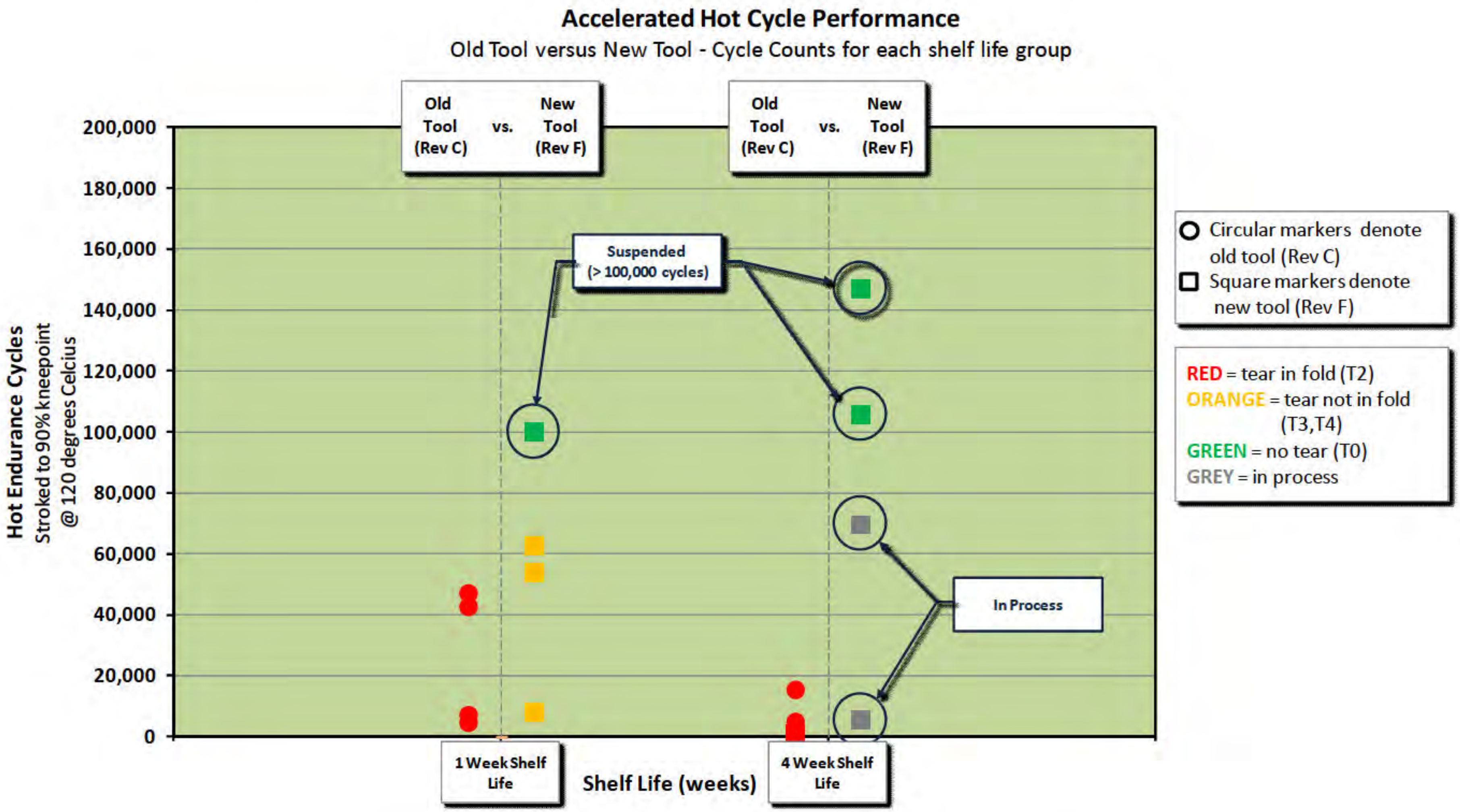
Hutchinson Diaphragm DOE Test Status

- **Diaphragms from old tool (rev C):** All have failed (1 & 4 week shelf lives)
- **Diaphragms from new tool (rev F):**
  - 3 failures (1 week shelf life)
  - 1 suspension @ 100,000 cycles (1 week shelf life)
  - 2 suspensions > 100,000 cycles (4 week shelf life)
  - 2 are in process (4 week shelf life)
- **All diaphragm failures that occurred in location T2 are similar to warranty**

Sample ID	Shelf Life	Part No	Rev Level	Status	No. of Tears	Length of Tear(mm)	Cycles @ Tear	Material Lab Request
HSM_F_08_271112	1 week	32484764	F	suspend	0	—	100,116	—
HSM_C_02_271112	1 week	32484764	C	failed	1	28	4,575	MLWR_8926
HSM_C_03_271112	1 week	32484764	C	failed	1	31	7,145	MLWR_8935
HSM_C_09_271112	1 week	32484764	C	failed	1	20	42,620	MLWR_8926
HSM_C_04_271112	1 week	32484764	C	failed	1	22	47,095	MLWR_8946
HSM_F_09_271112	1 week	32484764	F	failed	1	7	8,161	MLWR_8935
HSM_F_06_271112	1 week	32484764	F	failed	1	8	62,868	MLWR_8935
HSM_F_12_271112	1 week	32484764	F	failed	1	2	54,025	MLWR_8935
HSM_F_11_171212	4 week	32484764	F	in process	0	—	5,543	—
HSM_F_02_171212	4 week	32484764	F	in process	0	—	69,606	—
HSM_F_10_171212	4 week	32484764	F	suspend	0	—	105,609	—
HSM_F_08_171212	4 week	32484764	F	suspend	0	—	147,101	—
HSM_C_11_171212	4 week	32484764	C	failed	2	23 + 13	980	MLWR_8946
HSM_C_02_171212	4 week	32484764	C	failed	1	40	1,088	MLWR_8982
HSM_C_10_171212	4 week	32484764	C	failed	1	32	1,766	MLWR_8946
HSM_C_09_171212	4 week	32484764	C	failed	1	33	4,871	MLWR_8982
HSM_C_12_171212	4 week	32484764	C	failed	1	27	15,375	MLWR_8982

Hutchinson Diaphragm DOE Test Status

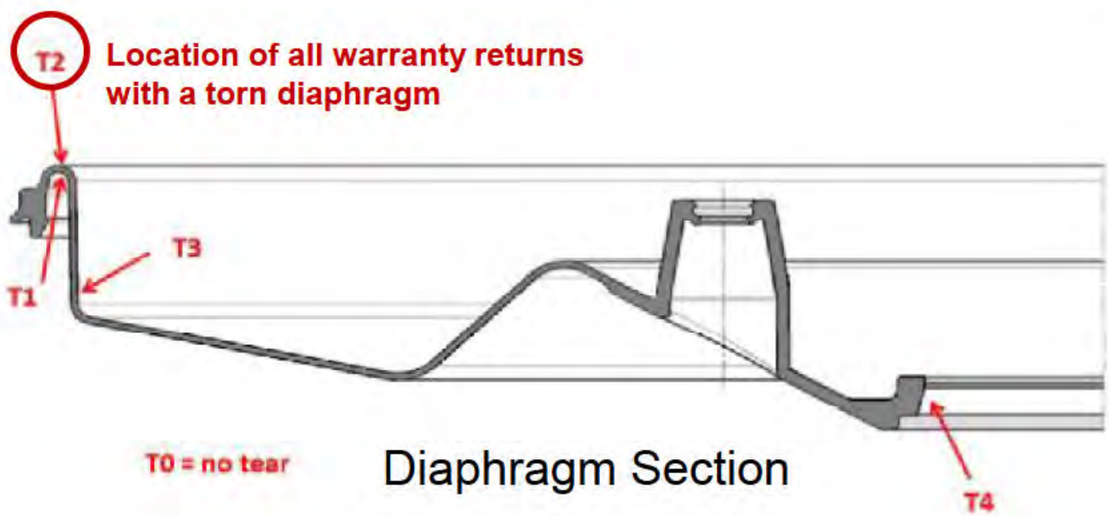
- **Hot accelerated endurance test cycles v. shelf life (1 week & 4 week)**



Hutchinson Diaphragm DOE Tear Details

- **Location Nomenclature for diaphragm tears in this DOE**

Diaphragm DOE Tear Designation Chart		
Nomenclature before 28-Jan-2013	Description	Nomenclature after 28-Jan-2013
--	No tear. No crack.	T0
A	A crack, not through tear, located in the formed radius when viewing the cross sectional area.	T1
B	A through tear located in the formed radius when viewing the cross sectional area. This is the same location noted in all warranty returns with a torn diaphragm.	T2
C	A tear located in the base of the side wall when viewing the cross sectional area.	T3
C	A tear located in the bead lock of the inner diameter when viewing the cross sectional area.	T4



Diaphragm Section

Hutchinson Diaphragm DOE Tear Details

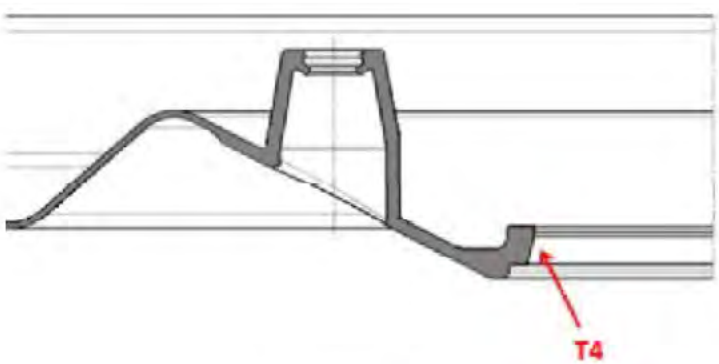
- **Diaphragms from old tool (rev C):**
  - All tears are located @ **T2** (similar to warranty) w/ non-homogeneous particle at tear origin
- **Diaphragms from new tool (rev F):**
  - 2 diaphragms have torn @ location **T3** (not similar to warranty returns), with non-homogeneous particle at tear origin
  - 1 diaphragm has torn @ location **T4**; materials report identified this tear as mechanical (no particle); likely due to prototype installation

Sample ID	Cycles	Shelf Life (weeks)	Failure Mode	Failure Location	Failure Size (mm)	Embedded Particle length (microns)	Embedded Particle height (microns)	Material Thickness (greatest) at defect site (mm)	Material Thickness at Location T2 (mm)
HSM_F_08_271112	100,116	1	—	T0	—	—	—	—	—
HSM_C_02_271112	**4,575**	**1**	**tear**	**T2**	**28**	**232**	**99**	**1.23**	**1.23**
HSM_C_03_271112	**7,145**	**1**	**tear**	**T2**	**31**	**170**	**91**	**1.1**	**1.05**
HSM_C_09_271112	**42,620**	**1**	**tear**	**T2**	**20**	**194**	**98**	**1.24**	**1.21**
HSM_C_04_271112	**47,095**	**1**	**tear**	**T2**	**22**	**147**	**79**	**1.26**	**1.15**
HSM_F_09_271112	8,161	1	tear	T3	7	87	53	0.98	0.94
HSM_F_06_271112	62,868	1	tear	T3	8	196	73	1.04	1.03
HSM_F_12_271112	54,025	1	tear	T4	2	—	—	0.98	0.94
HSM_F_11_171212	5,543	4	—	T0	—	—	—	—	—
HSM_F_02_171212	69,606	4	—	T0	—	—	—	—	—
HSM_F_10_171212	105,609	4	—	T0	—	—	—	—	—
HSM_F_08_171212	147,101	4	—	T0	—	—	—	—	—
HSM_C_11_171212	**980**	**4**	**tear***	**T2**	**43**	**177**	**76**	**1.26**	**1.23**
HSM_C_02_171212	**1,088**	**4**	**tear**	**T2**	**40**	**165**	**132**	**1.12**	**0.99**
HSM_C_10_171212	**1,766**	**4**	**tear**	**T2**	**32**	**144**	**61**	**1.24**	**1.15**
HSM_C_09_171212	**4,871**	**4**	**tear**	**T2**	**33**	**103**	**55**	**1.26**	**1.24**
HSM_C_12_171212	**15,375**	**4**	**tear**	**T2**	**27**	**106**	**87**	**1.24**	**1.22**

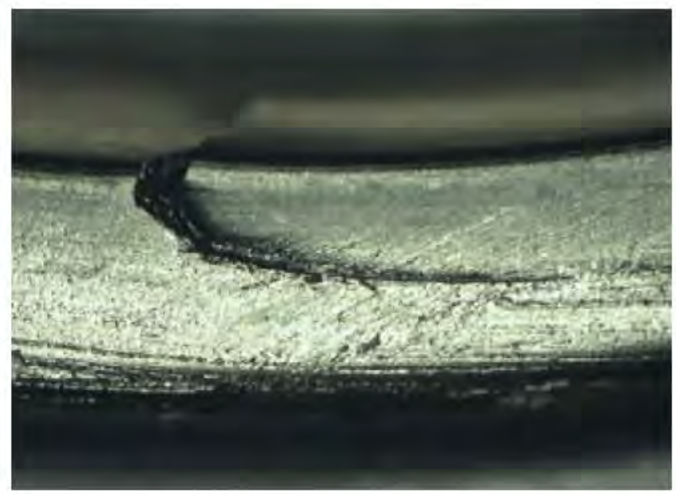
*only the larger tear identified as tear 1 in the MLWR report is used for the embedded particle size in this table.

Hutchinson Diaphragm DOE Tear Details

- **Discussion on diaphragm failure (ID HSM_F_12_271112)**
  - Diaphragm from the new tool (rev F) using 1 week shelf life material
  - Diaphragm failure noted at 54,025 cycles
  - Diaphragm failure origination at location **T4** (unique failure mode)
  - No particle noted at tear origin
  - Upon visual and microscopic examination, it was noted that the diaphragm had a 2 mm length tear. The tear appears to be from a nick in the rubber that propagated through the diaphragm section.
  - The most likely cause for the impingement in the rubber surface is the method in which the DOE diaphragms are being installed into the booster assembly prior to testing. The production process is not used for this operation on the DOE test samples.



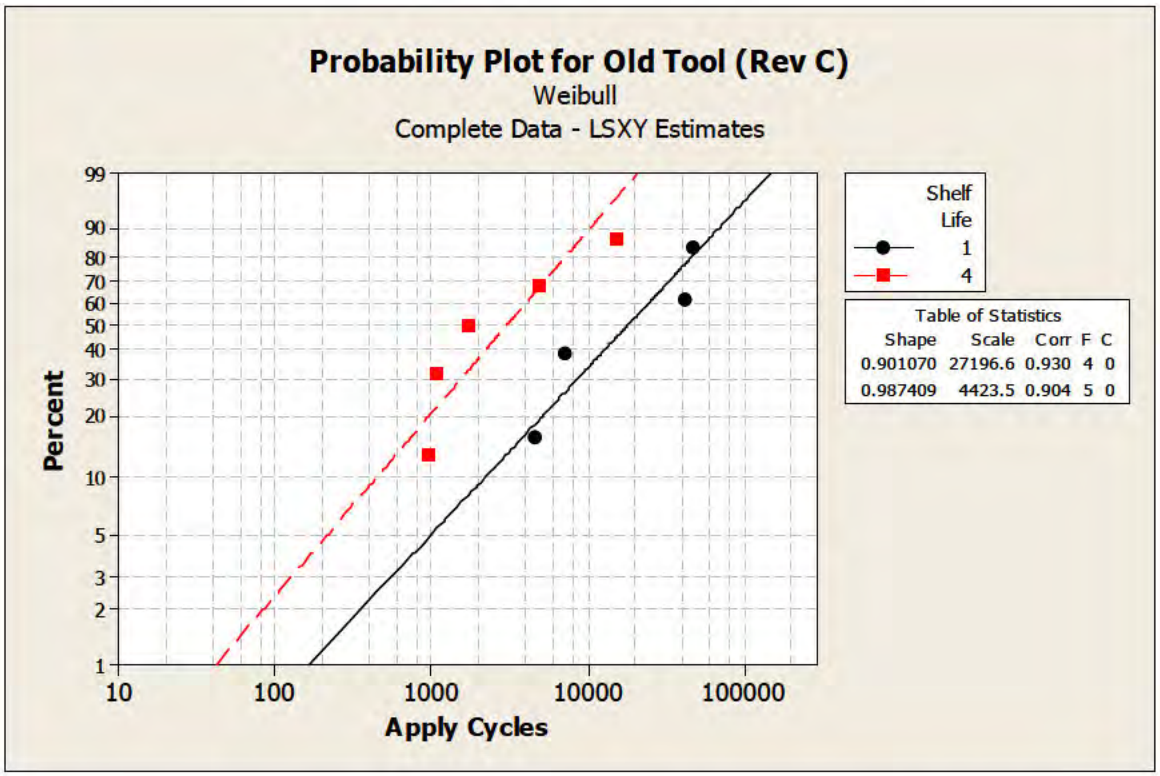
Diaphragm Section



Diaphragm HSM_F_12_27112 Tear at Location T4

Hutchinson Diaphragm DOE Est. Life Probability

- **Weibull distribution – Old tool (Rev C) with 1 week and 4 week shelf life**
  - 1 week shelf life has higher scale factor than 4 week shelf life (27,197 v. 4,424 cycles)
  - Scale parameter in a Weibull distribution predicts the 63.2 percentile failure point
- **Insufficient data to generate a Weibull distribution comparison between 1 and 4 week shelf life with diaphragms from the New tool (Rev F)**



Hutchinson Diaphragm DOE Est. Life Probability

Parametric Distribution Analysis

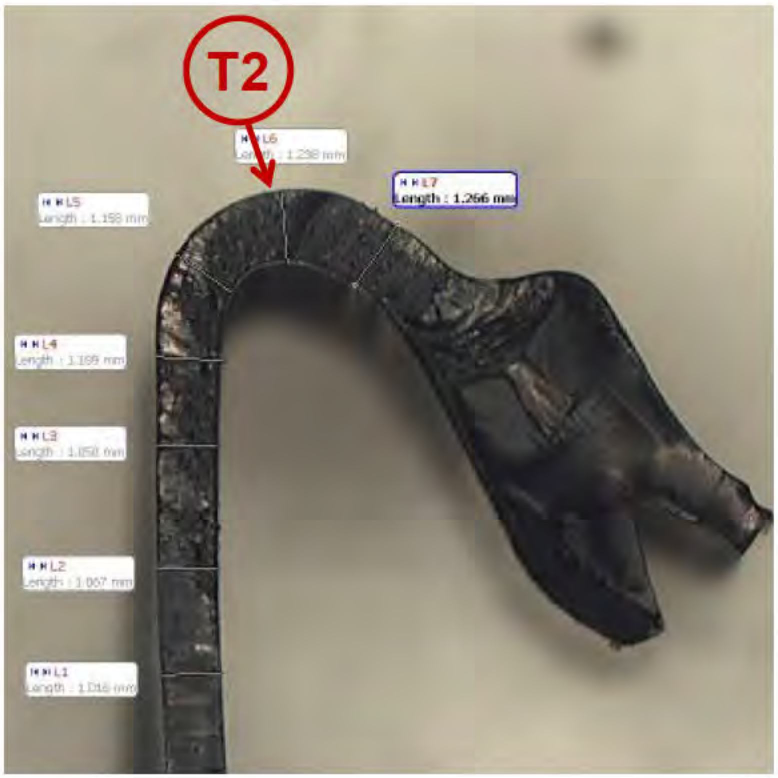
- Parametric Distribution Analysis provides estimates that describe the predicted life of a diaphragm in the accelerated test based on a distribution of failures. In this case, the failure pattern is assumed to follow a 3-parameter Weibull distribution.
- The parameter estimates (shape and scale for Weibull distribution) define the best-fitting parameter estimates based on failure and censored data.
- A least squares estimate (LSXY) of the plotted data is shown. The line is calculated by regressing log(cycles to failure) through the points in a probability plot.

Hutchinson Diaphragm DOE Est. Life Probability

- **The Weibull shape parameter defines the type of failure distribution the Weibull function represents:**
  - Infant mortality/Random failures (Shape ≤ 1)
    - Decreasing or constant hazard (instantaneous failure rate at a particular cycle count).
    - Models the useful life of the diaphragm when failures occur at random
    - May indicate multiple causes of failure
  - Early wear-out failures (1 < Shape ≤ 4)
    - Increasing hazard
    - Models the early wear-out failure of the diaphragm
  - Rapid wear-out failures (Shape > 4)
    - Increasing hazard
    - Models the final period of the diaphragm's life, when most wear-out failures occur
- **The Weibull scale parameter is the characteristic life of the distribution and defines the number of cycles where 63.2 percentile of the distribution is predicted to fail.**

DOE Results – Thickness Analysis

- **DOE diaphragm section analysis of old tool (rev C) and new tool (rev F)**



Sample HSM_C_09_171212 – Old Tool (Rev C)
Failed at 4,871 cycles (location T2)

Sample HSM_F_06_271112 – New Tool (Rev F)
Failed at 62,868 cycles (location T3)

New Tool (Tool 2) Part Inventory & Shipment

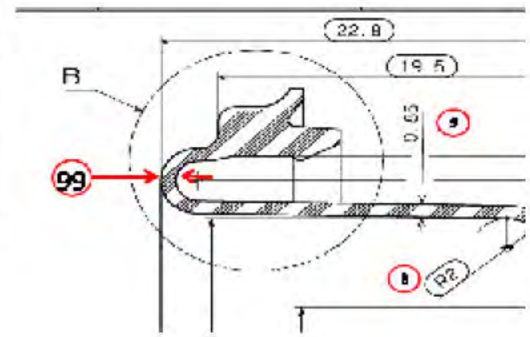
- New Tool Parts arrived at TRW Santa Rosa from Tool 2 on 11/23/12
- Date of Shipment to Mazda with parts from new diaphragm tool (Tool 2) was 11/27/12
- Date of Receipt by Mazda of parts with new diaphragm tool (Tool 2) was 12/28/12

New Tool Dimensional Control

30 pc Study from current inventory at TRW

0.957	1.139	1.025	0.946	1.088	1.042
0.976	0.999	0.991	1.03	1.047	1.05
1.104	1.04	1.016	1.039	0.992	1.01
1.109	1.001	1.018	0.996	1.008	0.983
1.178	1.094	0.938	1.02	1.066	1.031

1.031	Mean
0.055	Std. Dev
1.197	**USL**
0.850	**LSL**



- **TRW has taken the above 30 pc dimensional study of the thickness of the diaphragm at balloon 99 and determined the Std. Deviation of the sample size. We then added 3 Std. Deviations from the mean to determine the USL we will control the diaphragm thickness to.**
- **Incoming Sampling Plan at TRW will be to dimensionally layout 30 pcs from the 6000 pc shipments with a MicroView.**
  - Measurement method is a destructive method and requires the diaphragm to be sectioned for thickness results.

Hutchinson Diaphragm New Tool Update

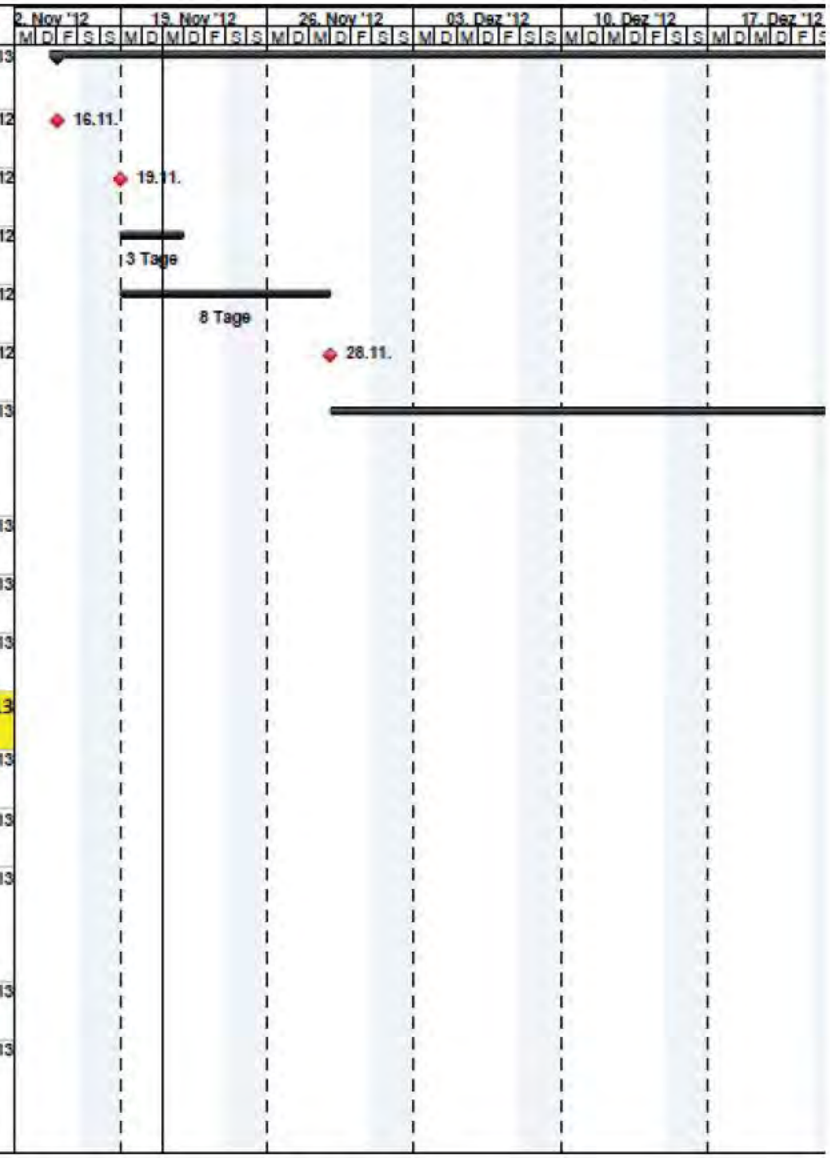
- Current Production Tool 2 was completed prior to investigation of thickness specifications.
- New tool 3 to support increased demand for CY13 scheduled for Dimensional PPAP approval from TRW on 3/4/2013. New tool will not be PPAP'd by TRW until all dimensional results are within specification.
- Both Hutchinson Tools (2 & 3) will need to be used to keep up with current demands until TRW has switched to alternative Diaphragm supplier.

Tool	Status	Remarks
Tool # 1	Out of production	Tool was worn therefore Tool 2 was kick-off
Tool # 2	Current Production	Due to OE increased requirements a third tool was kicked-off
Tool # 3	PPAP in progress	PPAP Approval Date From TRW to Hutchinson est – 3/4/13

SBR Tooling Status – Datwyler

- SBR tooling on time per schedule

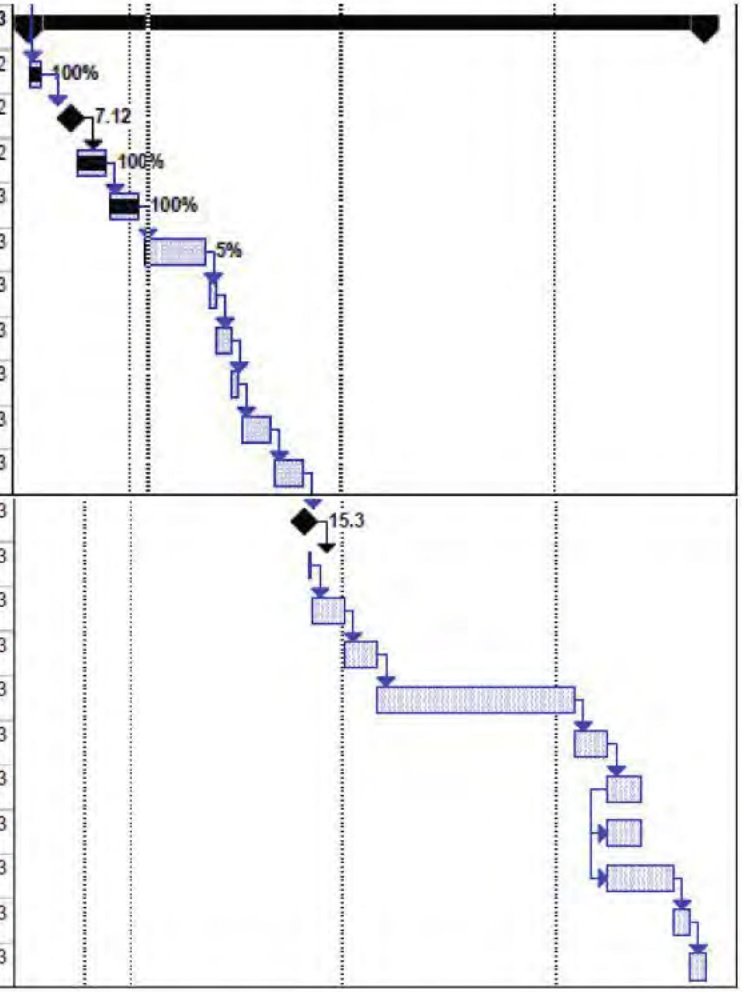
Nr.	Vorgangsname	Anfang	Ende
1	F 9211-11 / Diaphragm, 10.5" / TRW	Fr 16.11.12	Mi 10.04.13
2	Bestellung/ Order	Fr 16.11.12	Fr 16.11.12
4	Kick-Off	Mo 19.11.12	Mo 19.11.12
6	Vorbereitungs-Phase/ Preparation Phase	Mo 19.11.12	Mi 21.11.12
11	Konstruktions-Phase/ Design Phase	Mo 19.11.12	Mi 28.11.12
14	Design Review1 (DR1)	Mi 28.11.12	Mi 28.11.12
16	Werkstoff- und Werkzeugherstellungs-Phase/ Tool and compound manufacturing	Do 29.11.12	Do 28.02.13
19	Design Review2 / DR2	Do 28.02.13	Do 28.02.13
21	Herstellung Erstmuster/ Initial Samples Manufacturing	Fr 01.03.13	Fr 08.03.13
26	Design Review3 (DR3)	Fr 08.03.13	Fr 08.03.13
27	Versand Teile aus SCH / Shipment Parts from SCH	Mo 11.03.13	Fr 15.03.13
28	PPAP an SMX/ PPAP to SMX	Mo 04.03.13	Di 12.03.13
32	Verlagerung zu SMX / Transfer to SMX	Mi 13.03.13	Fr 29.03.13
36	Herstellung Erstmuster in SMX/ Initial Samples Manufacturing in SMX	Mo 01.04.13	Fr 05.04.13
40	PPAP Vorbereitung/ PPAP preparation	Mo 08.04.13	Di 09.04.13
42	Versand PPAP und Teile von SMX/ Shipment PPAP and Parts from SMX	Mi 10.04.13	Mi 10.04.13



SBR Tooling Status – Rubena

- SBR tooling on time per schedule

32		**Process Design - Diaphragm 32484764 No.1, 2**	**206 days**	**Mon 19.11.12**	**Mon 2.9.13**
33	✓	Serial Tool Design	1 wk	Mon 19.11.12	Fri 23.11.12
34	✓	Purchase order for tools – receipt	0 days	Fri 7.12.12	Fri 7.12.12
35	✓	Serial Tools Producing	2 wks	Mon 10.12.12	Fri 21.12.12
36	✓	Factory Christmas Holiday	2 wks	Mon 24.12.12	Fri 4.1.13
37		Serial Tools Producing – continue	4 wks	Mon 7.1.13	Fri 1.2.13
38		Sampling of Tools in Rubena Czech Republic	3 days	Mon 4.2.13	Wed 6.2.13
39		Internal Parts Tests	4 days	Thu 7.2.13	Tue 12.2.13
40		Hardening of tools	3 days	Wed 13.2.13	Fri 15.2.13
41		Shipment of tools to Mexico - Airtransport	2 wks	Mon 18.2.13	Fri 1.3.13
42		Resampling of Tools in Mexico and Internal Parts Tes	2 wks	Mon 4.3.13	Fri 15.3.13
43		Control Review	0 days	Fri 15.3.13	Fri 15.3.13
44		Presentation of PPAP Samples to TRW	1 day	Mon 18.3.13	Mon 18.3.13
45		PPAP Approval	2 wks	Tue 19.3.13	Mon 1.4.13
46		PV Parts Assy & Ship to Livonia	2 wks	Tue 2.4.13	Mon 15.4.13
47		TRW Testing	12 wks	Tue 16.4.13	Mon 8.7.13
48		TRW Report	2 wks	Tue 9.7.13	Mon 22.7.13
49		Assembly & Shipping	2 wks	Tue 23.7.13	Mon 5.8.13
50		Customer Approvals	2 wks	Tue 23.7.13	Mon 5.8.13
51		PTR	4 wks	Tue 23.7.13	Mon 19.8.13
52		Supplier SOP & Ship to TRW	1 wk	Tue 20.8.13	Mon 26.8.13
53		TRW SOP	1 wk	Tue 27.8.13	Mon 2.9.13



Replacement Of Service Parts

- **TRW needs Service Inventory Quantities from Middle East Region**
- **Quantity will drive ability/feasibility to replace inventory and estimated delivery date**

- **Single Booster – TRW needs address for service center and we will expedite the (1) Booster from Diaphragm Tool.**

Mazda Projected Repair Rate
J50C Booster - 2007 through 2012 MY

Country Sold	Region	1 Yr Repair %	2 Yr Repair %	3 Yr Repair %	Sales Volume
Malasia	Asia	1.28	4.66	9.76	525
Brunei	Asia	2.09	4.62	7.30	138
Saudi Arabia	Middle East	1.12	3.16	5.76	9,428
Middle East (no S.A.)	Middle East	0.85	2.82	5.62	7,207
Dominican Republic	Latin America	0.45	1.78	3.94	937
Columbia	Latin America	0.28	1.37	3.47	685
Peru	Latin America	0.47	1.59	3.23	271
Ecuador	Latin America	0.50	1.51	2.87	284
Europe (total)	Europe	0.38	0.75	1.12	2,530
North America (total)	North America	0.14	0.37	0.67	168,517
Australia	Oceania	0.07	0.20	0.35	20,311

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 2-5 Supplier Report 15 Mar 2013

Mazda J50C Warranty

Update Slides

March 15, 2013
TRW Automotive

ADVANCED THINKING / SMART THINKING / GREEN THINKING

Agenda

1. DOE Summary
2. Relationship of Hardness, Stress, and Material Aging to Diaphragm Tears
3. Why do 8 week shelf life tool 1 parts fail at T3?
4. Warranty Data Analysis
5. Validity of Thickness Specification
6. Tear Propagation
7. Warranty Location Trends
8. New Tool Validation Plan
9. Root cause
10. Control Plan
11. Capability Data
12. Supplier Timing
13. Summary

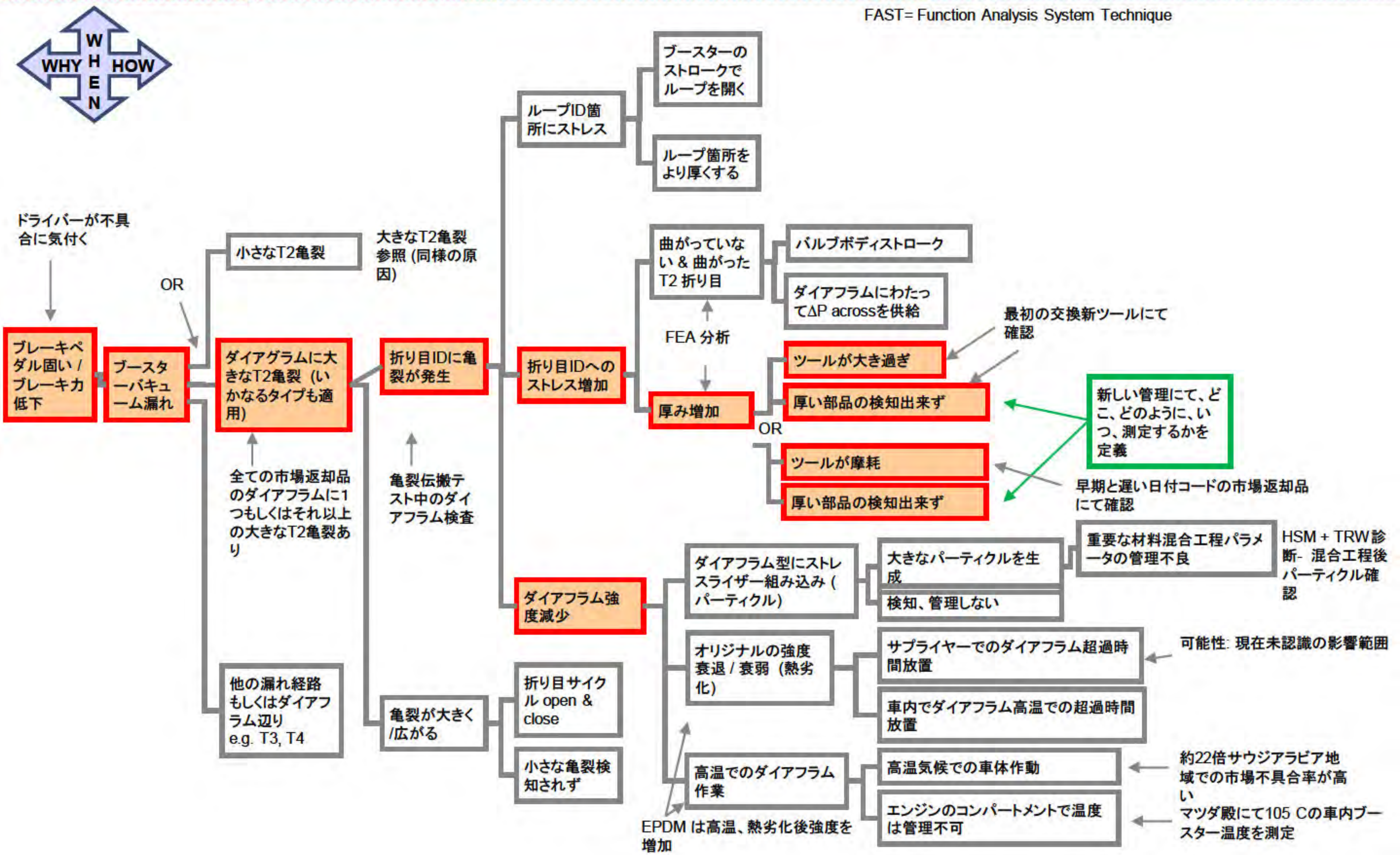
Root Cause of Diaphragm Tears
ダイアフラム亀裂原因

- **Red-X investigation – identify factors that create diaphragm tears**
  Red-X調査 – ダイアフラム亀裂を起こす因子の特定
  - Analyze diaphragms from warranty returns
    市場返却品のダイアフラム分析
  - Analyze diaphragm supplier process and controls
    ダイアフラムサプライヤーでの工程と管理の分析
  - Benchmark other TRW diaphragm suppliers (particle count)
    他TRWダイアフラムサプライヤーとのベンチマーク分析（パーティクル数)
  - Develop accelerated test – overstress new diaphragms to create tears similar to warranty returns
    加速テストの展開 – 新ダイアフラムに過度のストレスを加え市場返却品と類似の亀裂の再現
  - Run 3-factor DOE: shelf life, section thickness and particle presence – response is apply cycles to tear in accelerated test
    Run 3-因子DOE: 保存期間、厚みとパーティクルの有無- 亀裂へサイクルを加えた加速テスト反応
  - Analyze torn diaphragms for fracture mechanics　ダイアフラム亀裂破壊力学分析
- **Tear propagation study – identify tear propagation characteristics and effect of diaphragm tear on booster at various stages of propagation**
  亀裂伝搬研究 – 亀裂伝搬特徴の特定と様々なダイアフラム亀裂伝搬ステージでの影響
  - Overstress diaphragms and monitor for tear formation
    ダイアフラムに過度のストレスを加え亀裂の形成をモニター
  - Manually generate and propagate diaphragm tear
    手動でダイアフラム亀裂を発生させ広げる
  - Document effect of different size tears on booster function
    亀裂サイズによるブースター機能への影響

Root Cause of Diaphragm Tears
ダイアフラム亀裂原因

- **Red-X investigation – results**
  Red-X調査 – 結果
  - Non-random tear locations to diaphragm, booster, and in-vehicle position
    ダイアフラム、ブースター、車内の位置はランダムではない。
  - Non-homogeneous particle (cured rubber) at tear origin (100% of samples)
    亀裂開始箇所の不均質パーティクル（硬化ラバー）(100%のサンプル)
  - Worked with Hutchinson to investigate particle source:
    Hutchinsonとのパーティクル起因共同調査
    - Investigated effects at each process step on variation of particle count
      確認された様々なパーティクルのそれぞれの工程ステップの影響を調査
    - Current process produces large particle count, right from initial mixing
      現在の、最初の混合工程にてパーティクルが多く確認された。
  - Benchmark other TRW diaphragm suppliers (particle count)
    他TRWダイアフラムサプライヤーとのベンチマーク分析（パーティクル数)
  - No known recurring tear incidents with diaphragms from other suppliers
    他サプライヤーにて同ダイアフラムの事象は発生していない。
    - Some suppliers had more particles, some had much less
      他サプライヤーでは、パーティクルが多かったり少なかったりしている。
  - Accelerated high temperature endurance test developed: 加速高温耐久テストの展開：
    - Created tears similar in size to warranty returns 返却品と類似サイズの亀裂生成
    - Tears located in similar positions as warranty returns (T2 & radial) 返却品と類似箇所の亀裂生成（T2 & 放射状)
    - Tears have non-homogeneous particle at tear origin 亀裂開始箇所のパーティクルは不均質
  - Ran 1st leg of 3-factor DOE (using Hutchinson material) (Hutchinson材料使用)
    - Shelf life (1, 4, and 8-week) and section thickness (tool 1 & tool 2) 保存期間(1、4,8週間)で部分厚み(ツール1 & 2)
  - 2nd leg of 3 factor DOE (using Rubena and Daetwyler material) pending (RubenaとDaetwyler材料使用) 保留中

Root Cause of Diaphragm Tears
ダイアフラム亀裂の原因



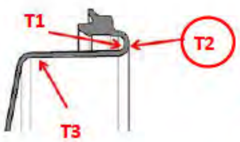
DOE Results – Test Plan

DOE Phase	Test Order	A: Shelf Life	B: Thickness	C: Particles / Supplier	Qty	Supplier Lead Time	Estimated Test Completed Date	Wk ending	Status
Pre-DOE	0	Current Production			4	NA	Wk 46	11-Nov	Completed Dec 12
Part 1	1	1 wk	+(Thin)	- (Hi Count) / HSM	4	1 wk	wk 47	18-Nov	Completed Jan 7
	2	1 wk	- (Thick)		4	2 wks	wk 49	2-Dec	Completed Dec 28
	3	4 wk	+(Thin)		4	5 wks	wk 2	13-Jan	Completed Feb 1
	4	4 wk	- (Thick)		4	6 wks	wk 2	13-Jan	Completed Jan 16
	5	8 wks	+(Thin)		4	9 wks	wk 3	20-Jan	Completed Mar 1
	6	8 wks	- (Thick)		4	9 wks	wk 4	27-Jan	Completed Mar 1
Part 2a	7	+(1 wk or Min)	+(Thin)	+(Lo Count)/ Rubena	4	12 wks	wk 11	17-Mar	Expected Apr 5
	8	-(30 days Max)	+(Thin)		4	16 wks	wk 15	14-Apr	Expected May 8
Part 2b	9	+(1 wk or Min)	+(Thin)	+(Lo Count)/ Daetwyler	4	22 wks	wk 18	5-May	Expected May 24
	10	-(6 months)	+(Thin)		4	48 wks	wk 44	3-Nov	Expected Nov 15

- Part 1 testing completed テスト完了
- Part 2a (Rubena 1 week shelf life samples) expected start 25-Mar
  3月25日開始予定（Rubena1週間保存期間サンプル）
- Part 2b (Daetwyler 1 week shelf life samples) expected start 13-May
  5月13日開始予定（Daetwyler1週間保存期間サンプル）

DOE Results – Test Plan

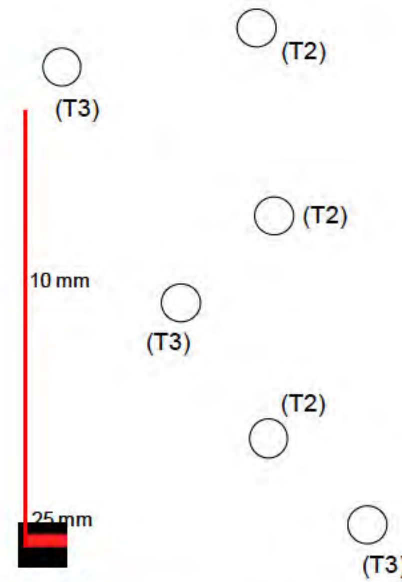
- **Location Nomenclature for diaphragm tears in this DOE**
  DOEでのダイアフラム亀裂箇所の分類



Location of all warranty returns with a torn diaphragm
全てのダイアフラム市場返却品亀裂箇所

Diaphragm DOE Tear Designation Chart	
Description	**Nomenclature after 28-Jan-2013**
No tear. No crack. 裂け目、亀裂無し	T0
A crack, not through tear, located in the formed radius when viewing the cross sectional area. 亀裂は裂け目を通っておらず放射状	T1
A through tear located in the formed radius when viewing the cross sectional area. This is the same location noted in all warranty returns with a torn diaphragm. 亀裂は裂け目を通り、放射状。全ての市場返却品と同様の状態	T2
A tear located in the base of the side wall when viewing the cross sectional area. 断面で、裂け目は側壁の基部に位置	T3
A tear located in the bead lock of the inner diameter when viewing the cross sectional area. 断面で、裂け目はビードロックに位置	T4

T4



Diaphragm Section Free State
遊離状態での
ダイアフラムセクション

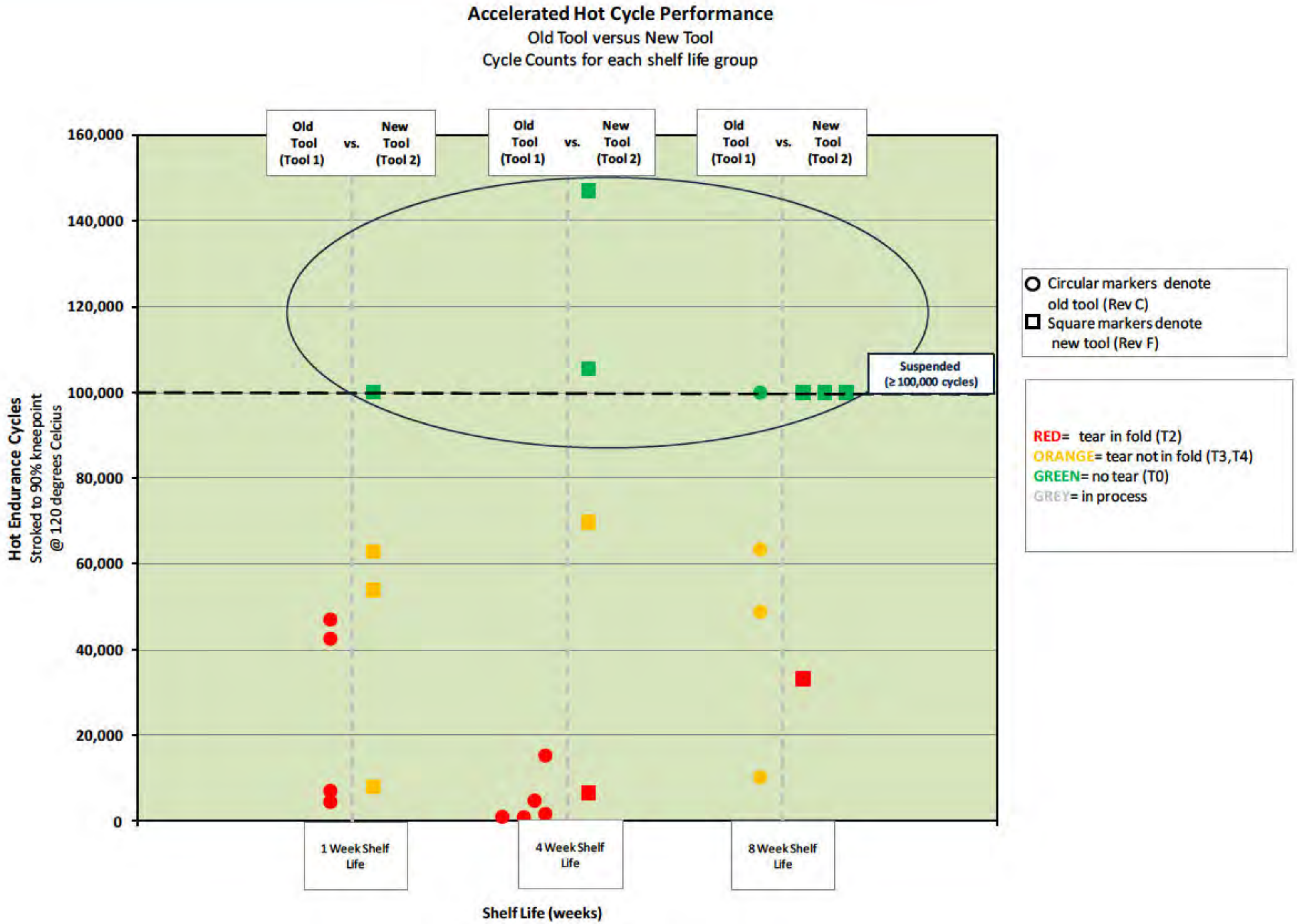
Diaphragm Section in Assembly Changes with Input Stroke
インプットストロークによって変化した
組み付けダイアフラムセクション

DOE Results – 1st Leg Section Thickness & Shelf Life

Accelerated High Temperature Endurance Test (DOE Part 1 - Section Thickness & Shelf Life)

Hutchinson Diaphragm ID	Tool	Shelf Life (weeks)	Failure Mode	Failure Location	Cycles	Failure Size (mm)	Embedded Particle length (microns)	Embedded Particle height (microns)	Material Thickness at Location T2 (mm)
HSM_C_11_171212	1	4	tear	T2	980	46	177	76	1.23
HSM_C_02_171212	1	4	tear	T2	1,088	42	165	132	0.99
HSM_C_10_171212	1	4	tear	T2	1,766	36	144	61	1.15
HSM_C_02_271112	1	1	tear	T2	4,575	27	232	99	1.23
HSM_C_09_171212	1	4	tear	T2	4,871	36	103	55	1.24
HSM_F_11_171212	2	4	tear	T2	6,693	38	215	96	0.89
HSM_C_03_271112	1	1	tear	T2	7,145	33	170	91	1.05
HSM_C_12_171212	1	4	tear	T2	15,375	30	106	87	1.22
HSM_F_06_8week	2	8	tear	T2	33,292	29	178	106	1.05
HSM_C_09_271112	1	1	tear	T2	42,620	26	194	98	1.21
HSM_C_04_271112	1	1	tear	T2	47,095	26	147	79	1.15
HSM_F_09_271112	2	1	tear	T3	8,161	7	87	53	0.94
HSM_C_05_8week	1	8	tear	T3	10,310	6	109	106	1.08
HSM_C_08_8week	1	8	tear	T3	48,909	8	106	100	1.15
HSM_F_06_271112	2	1	tear	T3	62,868	7	196	73	1.03
HSM_C_04_8week	1	8	tear	T3	63,496	7	137	58	1.10
HSM_F_02_171212	2	4	tear	T3	69,750	8	325	109	0.96
HSM_F_12_271112	2	1	tear	T4	54,025	2	—	—	0.94
HSM_C_11_8week	1	8	—	T0	100,000	—	—	—	—
HSM_F_03_8week	2	8	—	T0	100,000	—	—	—	—
HSM_F_08_8week	2	8	—	T0	100,000	—	—	—	—
HSM_F_12_8week	2	8	—	T0	100,000	—	—	—	—
HSM_F_08_271112	2	1	—	T0	100,116	—	—	—	—
HSM_F_10_171212	2	4	—	T0	105,609	—	—	—	—
HSM_F_08_171212	2	4	—	T0	147,101	—	—	—	—

DOE Results – Data Plot (section thickness & shelf life)



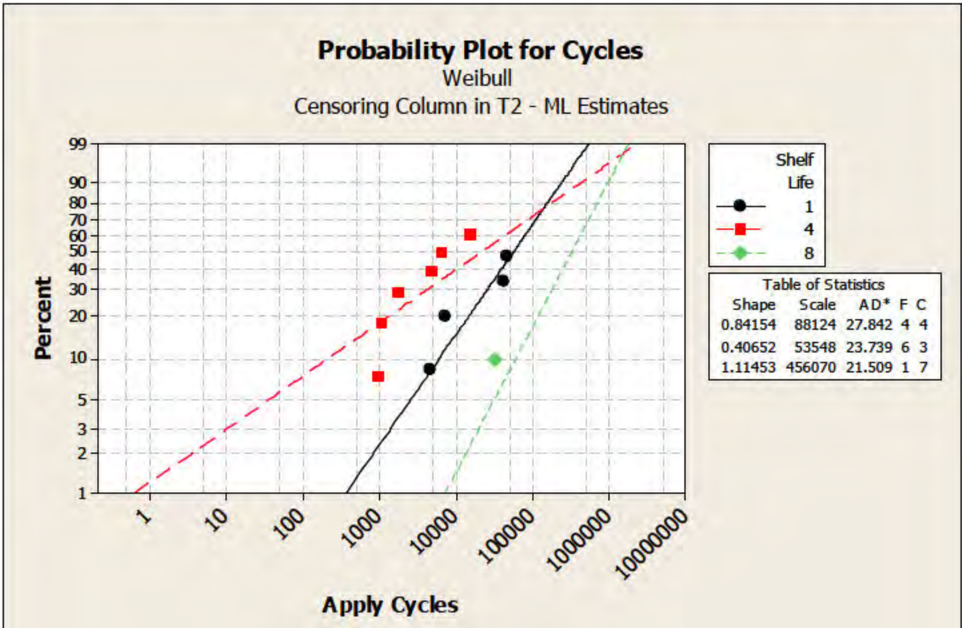
DOE Results – Impact of Shelf Life　保存期間の影響

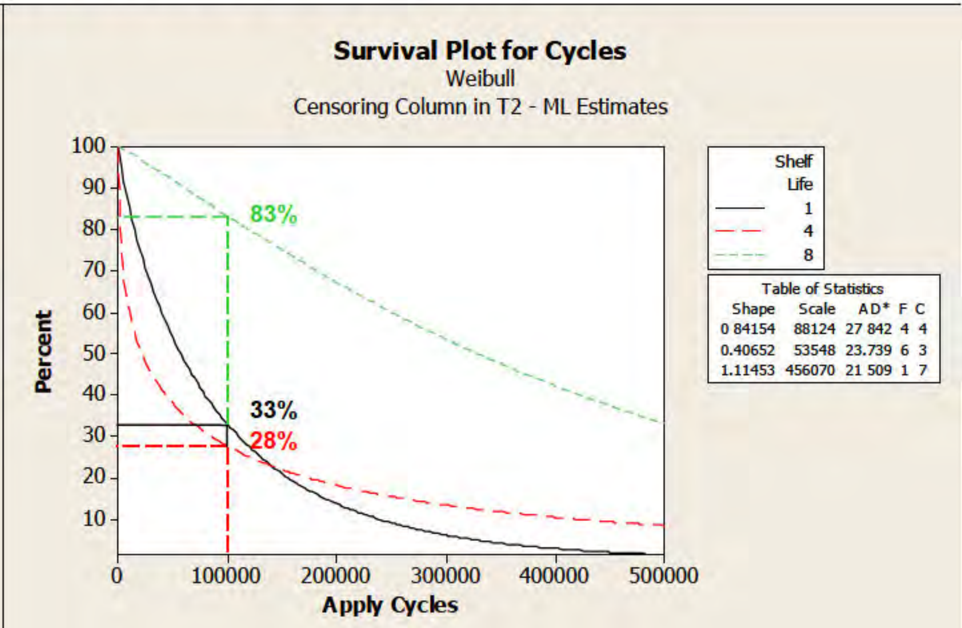
- **Weibull distribution of DOE results: 1-week, 4-week, and 8-week shelf life (T2 tear only)**
  DOE結果ワイブル分布：保存期間1,4,8週間（T2亀裂のみ)

Shelf Life	Sample Size	Number of T2 Diaphragm Tears	Number of Suspensions	Estimated Weibull Distribution		
				Shape Factor (Slope)	Scale Factor (Characteristic Life) [cycles]	Probability of Reaching 100,000 Cycles in DOE Test
1-week	8	4	4	0.84	88,124	33%
4-week	9	6	3	0.41	53,548	28%
8-week	8	1	7	1.11	456,070	83%

  - Failure = T2 Tear Suspension = 100,000 cycles or T3/T4 failure T2亀裂停止=100,000サイクルもしくはT3/T4不具合

- **Conclusion:** Unlikely correlation exists between uncured material shelf life and cycles to failure in the accelerated high temperature endurance test (DOE testing)
  加速高温耐久テストにて、未硬化材料の保存期間と不具合発生までのサイクルに相互関係は見られない。



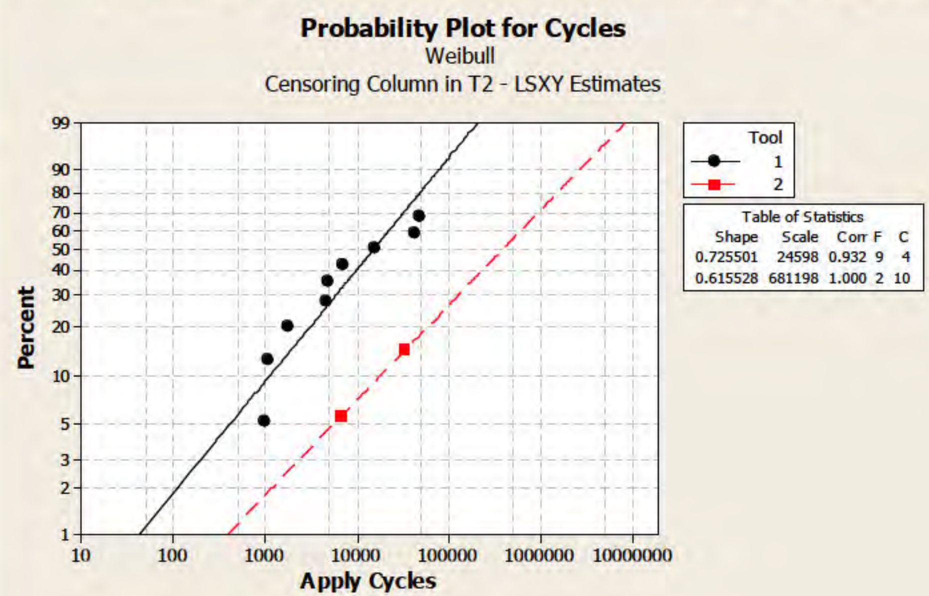


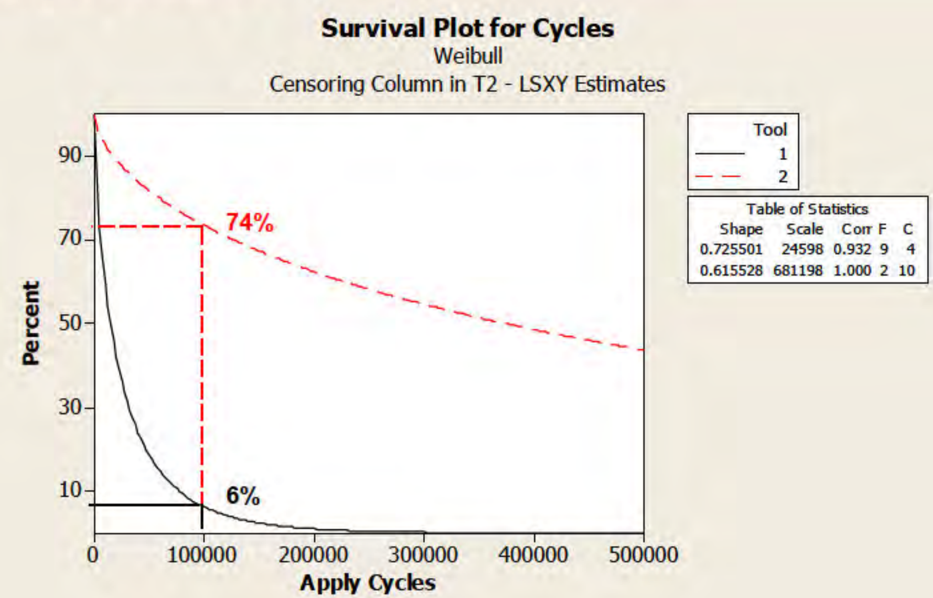
DOE Results – Impact of Tool 1 v. Tool 2 v. Tool 3 (T2 Failure)

- **Weibull distribution of DOE results: tool 1 v. tool 2 failure at location T2 (all material shelf lives)**
  DOE結果ワイブル分布：ﾂｰﾙ1 v. ツール2 T2亀裂不具合（全ての保存期間）

Tool	Sample Size	Number of T2 Diaphragm Tears	Number of Suspensions	Estimated Weibull Distribution		
				Shape Factor (Slope)	Scale Factor (Characteristic Life) [cycles]	Probability of Reaching 100,000 Cycles in DOE Test
1	13	9	4	0.73	24,589	6%
2	12	2	10	0.62	681,198	74%

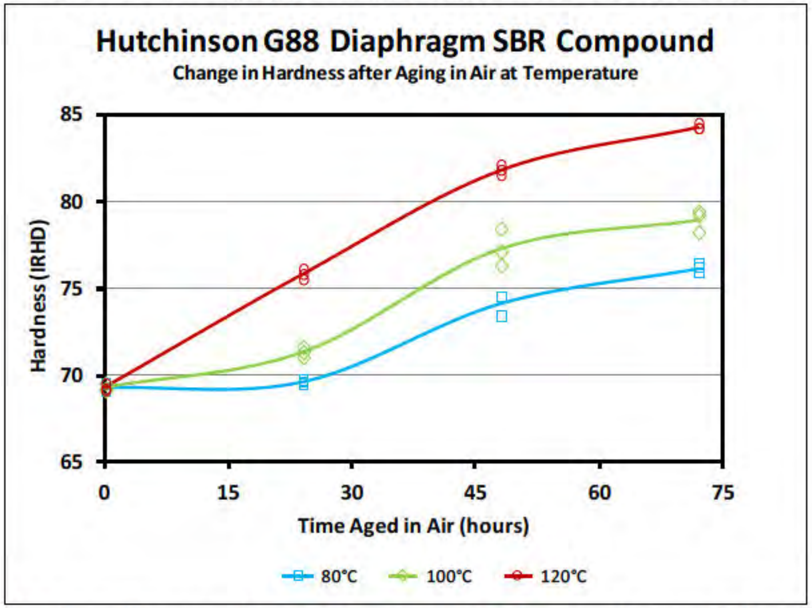
  - Failure = T2 Tear Suspension = 100,000 cycles or T3/T4 failure
- Insufficient data for tool 3 life comparison at tear location T2 (no failures in 4 samples evaluated)
  ツール3での比較にはデータ不十分(4サンプルで不具合無し)
- **Conclusion:** Diaphragms from tool 2 have a higher probability of reaching the 100,000 cycle limit in the accelerated high temperature endurance test (DOE testing) than diaphragms from tool 1
  ツール2の方がツール1に比べて、DOEテストでの限界値100,000サイクルに達する可能性が高い。





Relationship of Hardness to Diaphragm Tears
硬度とダイアフラム亀裂の関係

- **The diaphragm material hardness will change with heat aging**
  ダイアフラム材料の硬度は熱老化により変化



Air Temperature	Average Hardness (IRHD) after Aging in Air			
	0 hr	24 hr	48 hr	72 hr
80°C	69.3	69.6	74.1	76.2
100°C	69.3	71.3	77.3	78.9
120°C	69.3	75.8	81.8	84.3

- Average of 3 test pieces for each temperature
- Original hardness of material at 0 hr
- Age test pieces in air at specified temperature for specified time
- Measure rubber hardness at room temperature after samples have cooled
- 各温度での3テスト平均
- 0時間での材料オリジナル硬度
- 既定の温度と時間での外気劣化テスト部品
- サンプルを冷却後、室温でのラバー硬度測定

- As hardness changes, material toughens (elongation decreases, 100% modulus increases) and effect of stress-risers becomes more pronounced reducing fatigue life of material
  硬度の変化により、材料は強化され（延長減少、100%率の増加)、劣化期間を減少させるストレスの起因に影響する。
- Probability of diaphragm tear at T2 increases with heat aging of the material (rubber hardness increase) if a particle of sufficient size exists in the T2 region and stress from cyclic loading exceeds the reduced fatigue limit of the material in that region
  十分なサイズのパーティクルがT2に存在し、サイクルの荷重により材料の疲労限度が減少した場合、材料の熱劣化によりT2の亀裂発生の可能性は増加する。

Relationship of Stress to Diaphragm Tears
ストレスとダイアフラム亀裂の関係

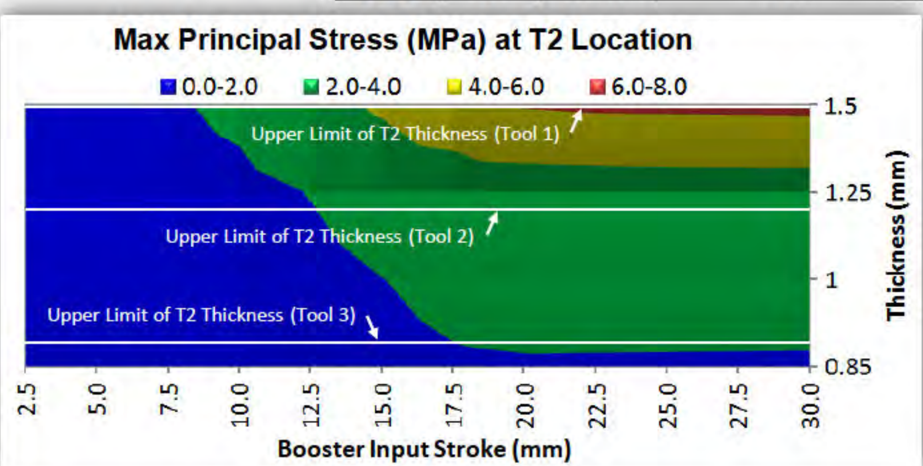
- **Tabular summary of FEA predicted maximum principal stress in diaphragm models simulating Tool 1, Tool 2 and Tool3 at locations T2 and T3**
  FEAの表形式サマリーは、ツール1.2.3のT2とT3箇所でのシミュレーションにてダイアフラムへの最大主応力を予測
  - Predicted maximum principal stress at T2 location increases with booster input stroke until diaphragm at T2 location is adequately supported by front shell, then stress remains constant with continued input stroke
    T2での予測最大主応力は、フロントシェルに十分サポートされるまで、ブースターのインプットストロークと共に増加し、その後応力は一定のインプットストロークで持続する。
  - Predicted maximum principal stress at T3 location increases steadily with booster input stroke
    T3での予測最大主応力は、ブースターのインプットストロークと着実に増加する。

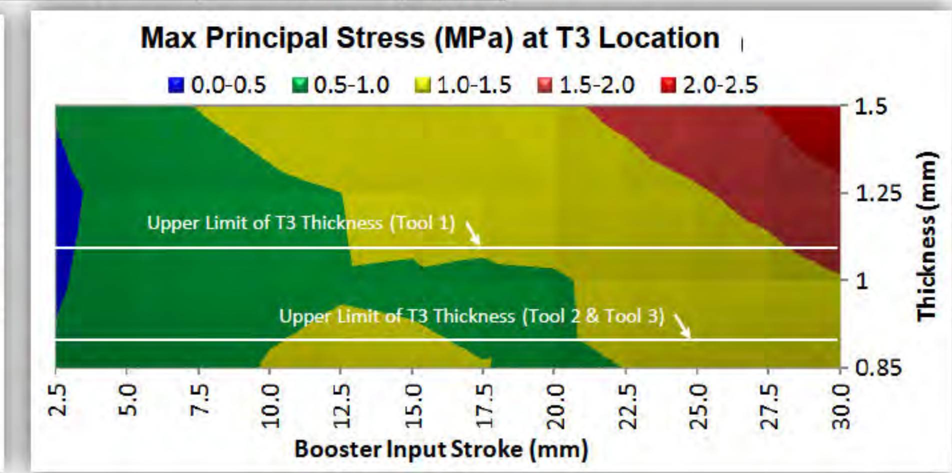
		Model 1 (tool 1)	Model 2 (tool 2)	Model 3 (tool 3)
	T2 Thickness	1.25 mm	1.00 mm	0.85 mm
	T3 Thickness	1.00 mm	0.85 mm	0.85 mm
T2 Stress	9.6mm	1.69 MPa	1.09 MPa	1.12 MPa
	25 mm	3.57 MPa	2.12 MPa	1.95 MPa
	30 mm	3.59 MPa	2.12 MPa	1.94 MPa
	35 mm	3.59 MPa	2.12 MPa	1.94 MPa
T3 Stress	9.6mm	1.01 MPa	0.97 MPa	1.00 MPa
	25 mm	1.33 MPa	1.03 MPa	1.07 MPa
	30 mm	1.66 MPa	1.27 MPa	1.31 MPa
	35 mm	2.20 MPa	1.63 MPa	1.70 MPa

Relationship of Stress to Diaphragm Tears
ストレスとダイアフラム亀裂との関係

- Graphical summary of FEA predicted maximum principal stress in diaphragm models simulating Tool 1, Tool 2 and Tool3 at locations T2 and T3
  FEAのグラフサマリーはツール1.2.3のT2とT3箇所でのシミュレーションにてダイアフラムへの最大主応力を予測
- FEA assumes material properties to be isotropic and homogeneous
  FEAは材料の特性を等方性で同質と推測する。
- Maximum principal stress predicted in T2 and T3 regions are far below the tensile stress of the material during normal operation
  T2とT3での予測最大主応力は、通常の作業中の材料引張応力をはるかに下回る。

Tool	Section Location	Section Thickness (mm)	FEA Max Principal Stress @ 30 mm Stroke (MPa)	Room Temp Tensile Strength (MPa)	Tensile Strength after 70 hr @ 100°C (MPa)	Margin
1	T2	1.50	6.4	20	15	2.3
1	T2	1.25	3.6	20	15	4.2
2	T2	1.00	2.1	20	15	7.1
3	T2	0.85	1.9	20	15	7.9
1	T3	1.00	1.7	20	15	8.8
2 & 3	T3	0.85	1.3	20	15	11.5





Relationship of Material Aging to Stress in Diaphragms
ダイアフラムへの材料劣化ストレスとの関係

- **FEA run on nominal thickness diaphragm model varying material properties 通常の厚みダイアフラムモデルにて、材料特性を検証するFEAを実施。**
  - Hutchinson G88 material　Hutchinson G88材料
  - data from test samples aged in air 外気でのテストサンプル劣化データ

Thermal Conditioning	Maximum Principal Stress @ 30 mm Input Travel			
	Predicted Value		Change from OP	
	T2 (MPa)	T3 (MPa)	T2 (MPa)	T3 (MPa)
Original Properties (OP)	1.9	1.3	–	–
Heat Aged 70 hours @ 80°C	2.5	1.6	132%	123%
Heat Aged 70 hours @ 100°C	3.3	2.3	174%	177%
Heat Aged 70 hours @ 120°C	3.9	2.9	205%	223%

  - Predicted maximum principal stress increase by up to 223% at 30 mm of stroke with change of material properties
    30mmのストロークで材料特性変化223%増加を予測

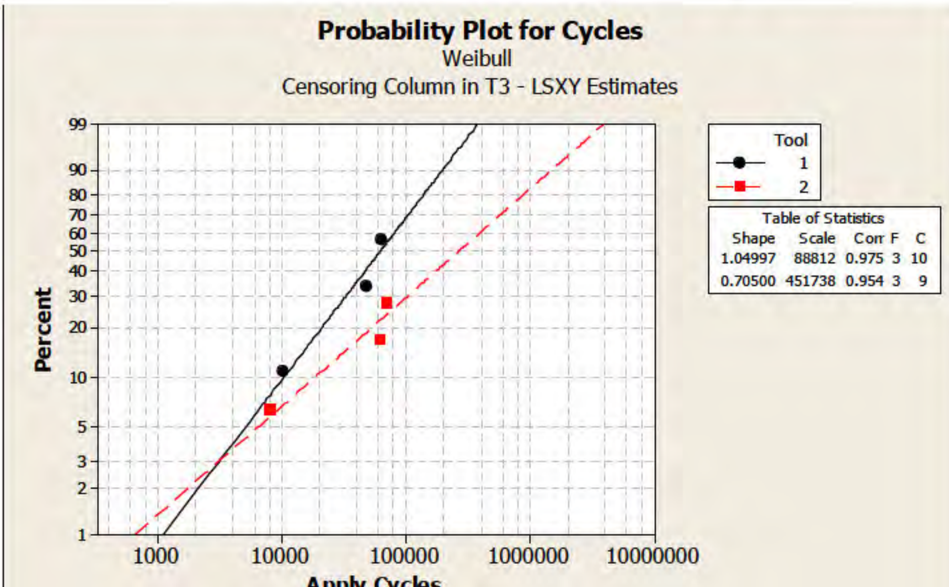
Why do 8 week shelf life tool 1 parts fail at T3?
ツール１での保存期間8週間の材料はT3で不良となるのか？
Failure Distribution T3 Failures in DOE Evaluations
DOE評価でのT3不具合分布

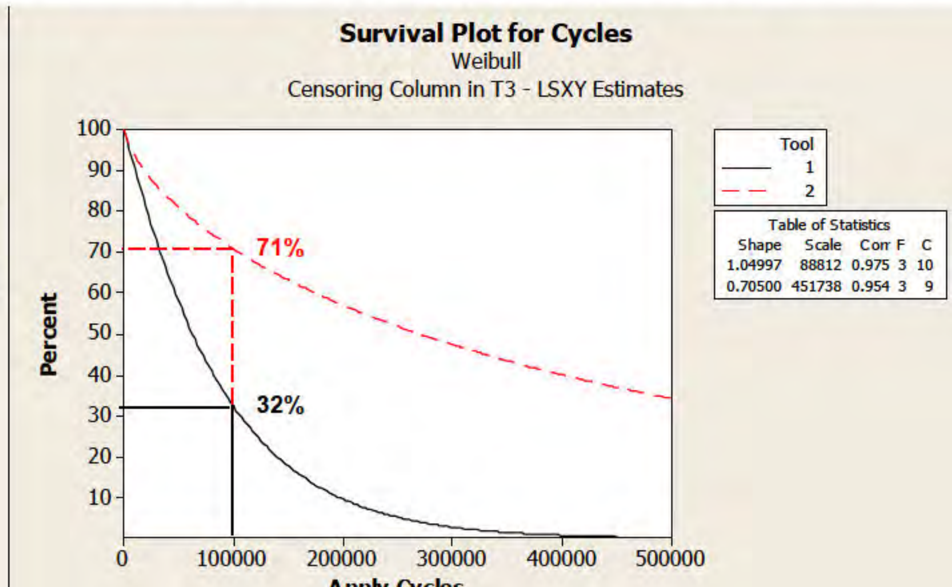
- **Weibull distribution of DOE results: tool 1 v. tool 2 failure at location T3 (all material shelf lives)**
  DEO結果ワイブル分布：ツール1 v. ツール2　T3亀裂不具合（全ての保存期間材料)

Tool	Sample Size	Number of T3 Diaphragm Tears	Number of Suspensions	Estimated Weibull Distribution		
				Shape Factor (Slope)	Scale Factor (Characteristic Life) [cycles]	Probability of Reaching 100,000 Cycles in DOE Test
1	13	3	10	1.05	88,812	32%
2	12	3	9	0.71	451,738	71%

  - Failure = T3 Tear Suspension = 100,000 cycles or T2/T4 failure

- **Conclusion:**
  - Data suggests probability of a T3 failure in a diaphragm evaluated in accelerated high temperature endurance test is higher in Tool 1 than in Tool 2
    加速高温耐久テストのデータによると、T3不具合発生の可能性は、ツール1よりツール2の方が高い。





Why do 8 week shelf life tool 1 parts fail at T3?
ツール1での保存期間8週間の材料はT3で不良となるのか？
Stringency of DOE Test is Greater than MES PA43800
DOEテストがMES PA43800より厳密な為

- **Summary of MES PA43800 Hot Cycle Test to TRW DOE Test**
  MES PA43800高温サイクルテストとTRW DOEテストのサマリー

項目	マツダ殿 MES PA 43800 高温サイクルテスト	TRW加速高温テスト (DOE)	ダイアフラムテスト厳重さ MES v DOE	ダイアフラム機能への予測影響	コメント
エンジン構成品下部をシミュレーションした作動温度	120℃ +/- 5℃	120℃ +/- 5℃	O	無	相違無し
運転席をシミュレーションした作動温度	60℃ +/- 10℃	120℃ +/- 5℃	++ DOE	材料の熱劣化増加	120℃の大気は、ダイアフラム材の熱劣化に影響する以上の高温環境
温度下での時間	約100時間（サイクル数/サイクル率）	目標102時間（サイクル数/サイクル率 + 可熱2時間）管理無し	++ DOE	材料の熱劣化増加	DOEでは温度下での時間は管理されていなかった。テストはダイアフラムの状態をチェックする為頻繁に中断され、この為ブースター組立品へストロークが加わってない時間が追加されている。
実装組立品	車両状況をシミュレーション	水平の据え付けられた固定された鉄のストロークプレート	O	無	相違無し
入力負荷	ペダルの移動角度をシミュレーションする為の明確な振りアーム	ペダルの移動角度をシミュレーションする為の明確な振りアーム	O	無	相違無し
消費者の調整（室温の調整）	70 +/- 10%効果的ストロークでの100%ブースターニーポイント	トータルストローク2/3での90%ブースターニーポイント	+ MES	ダイアフラムへのストレス増加	MESテストの消費者はTRW TS設定より約5.8%高くしている。加えるストローク/アウトプット圧力排気量のMES設定はダイアフラムへより強く負荷を加える。
ストローク	70 +/- 10%効果的ストロークローク	目標トータルストローク2/3（トータルストロークの1/2-2/3変化）	+ MES	ダイアフラムへのストレス増加	MESテストストロークは約4.9%わずかに高い。ループでのダイアフラム主応力はこれによっては変化しない。
バキューム源	66.7 +/- 2.7 kPa (667 mbar)	0.8 bar (800 mbar)	++ DOE	ダイアフラムへのストレス増加	TRW DOEテストはダイアフラムへの圧力に変化を起こす高いバキュームレベルにて作動。約20%の負荷の増加が見られる。
サイクル数	100,000	100,000	O	無	相違無し
サイクル率	1000±100 c/h	1000 c/h	O	無	相違無し

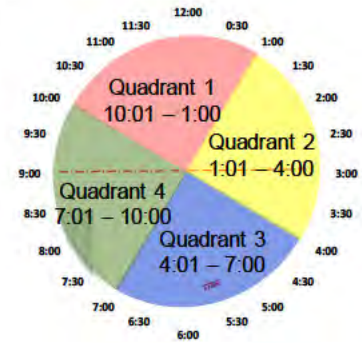
Why do 8 week shelf life tool 1 parts fail at T3?
ツール1での保存期間8週間の材料はT3で不良となるのか？
Conclusion　結論

- **Conclusion　結論**
  - DOE evaluates booster diaphragm more stringently than MES PA43800 Hot cycle test
    DOEはMES PA43800高温サイクルテストより厳しい評価
    - Material heat aging　材料熱劣化
      - Air moving through booster during evaluation is at 120°C (MES air is at 60°C)
        評価では120℃までブースター温度を上昇（MES気温は60℃）
      - Time at temperature is potentially longer due to master cylinder pressure monitoring causing frequent test interruptions (MES test is monitored, but not typically interrupted)
        マスターシリンダーのモニタリングは頻繁なテスト妨害を起こす為、潜在的に高温時での時間は長い。（MESテストのモニタリングでは妨害は通常起こらない）
    - Diaphragm loading　ダイアフラム負荷
      - Vacuum set at 17% higher level increasing pressure difference across diaphragm induces higher stress at all input strokes
        17%高いレベルでのバキューム設定で全てのインプットストロークで高いストレスを誘発するダイアフラムへの異なる圧力が増加。
    - The MES evaluation has 5% longer stroke and slightly higher brake stiffness which translates into 6% higher master cylinder pressure at a given stroke
      MES評価で、5%長いストローク、6%高いマスターシリンダー圧力に変換するわずかに高いブレーキ硬性を確認。
      - Shorter input stroke to master cylinder pressure causes diaphragm load at a given pressure to occur in shorter stroke position (T2) and diaphragm will have higher stress at T3 location due to longer input strokes
        マスターシリンダー圧力への短いインプットストロークは、ダイアフラムの短いストローク箇所(T2)に負荷を加え、長いインプットストロークによりT3へ過度のストレスが加わる。
- **T3 failures occurred in Tool 1 of DOE testing, but have not shown up in warranty – TRW believes the T3 failure is caused by overstressing the diaphragm well beyond normal operating modes and therefore T3 failures are unlikely in service**
  T3不具合はツール１でのDOEテストにて発生したが、市場で確認されていないT3での不具合はダイアフラムへの通常作動より遥かに過度なストレスが原因で発生するため、市場では発生しないと推測します。

Mazda Warranty Analysis

- **Investigate warranty – no returns with diaphragm mold date after December 2011**
  市場調査－2011年12月後のダイアフラム形成日での返却無し
- **Particles in Pre-DOE and DOE tears at T2 have smaller particle size than warranty diaphragms**
  T2亀裂のPre-DOEとDOEのパーティクルは市場品よりサイズが小さい
- **Analysis scope:分析スコープ**
  - 40 Mazda warranty returns with torn diaphragm (55 tears total at T2)
    ダイアフラム亀裂市場返却品40台(T2は55の亀裂)
  - 24 Pre-DOE and DOE diaphragms that exhibited a T2 diaphragm tear (25 tears total)
    Pre-DOEとDOEの24台のダイアフラムにてT2亀裂を確認(トータル25の亀裂)
  - Compare largest dimension of particle at tear initiation and section thickness at position 9 (T2)
    亀裂開始箇所でパーティクルの大きいサイズを99ヶ所で厚み比較(T2)
  - Looked at diaphragm mold date code (all) and vehicle mileage (warranty only)
    ダイアフラムの形成日コード(全て）と走行距離（市場品のみ）を確認

- **General results from analysis:分析からの一般的結果**
  - Correlation between changes made in Hutchinson mixing process (TCU and discharge duct improvements) and reduction in particle size Hutchinsonでの混合工程変更(TCUと放電ダクト改善)パーティクルサイズ減少の関連性
    - post-Jan 2012 mold date diaphragms (pre-DOE/DOE samples) have smaller particle at T2 tear origin than pre-Jan 2012 mold date (warranty returns)
      Pre-DOE/DOEサンプルの2012年1月の形成ダイアフラムのT2パーティクルは同時期の市場返却品より小さい。
    - average of largest particle dimension for warranty samples is 259 µm v. 168 µm for Pre-DOE/DOE samples
      市場返却品の最大パーティクルの平均は259 µm v. Pre-DOE/DOEサンプルは168 µm
  - Average section thickness at T2 for warranty samples increases from diaphragm molding dates of Jan-2010 through Dec-2011 市場サンプルのT2の厚み平均は、2010年1月から2011年12月にかけ増加している。
  - Percentage of T2 tears in warranty samples (Tool 1) have a similar radial distribution as Pre-DOE/DOE T2 tears (Tool 1 only) 市場サンプルのT2亀裂のパーセンテージは、Pre-DOE/DOEのT2(ツール1のみ)亀裂と類似分布である。



Mazda Warranty Returns thru CY2011 (Tool 1)

Quadrant	Clock Position	Tool 1 Tear Count (T2 Tears) Total	Tool 1 Largest Particle Dimension (µm) Average	Tool 1 Section Thickness @ T2 (mm) Average	Tool 1 % of Tears in Each Quadrant
1	10:01-1:00	28	236	1.17	51%
2	1:01-4:00	9	298	1.10	16%
3	4:01-7:00	14	254	1.09	25%
4	7:01-10:00	4	345	1.11	7%
Average / Total		55	259	1.15	100%

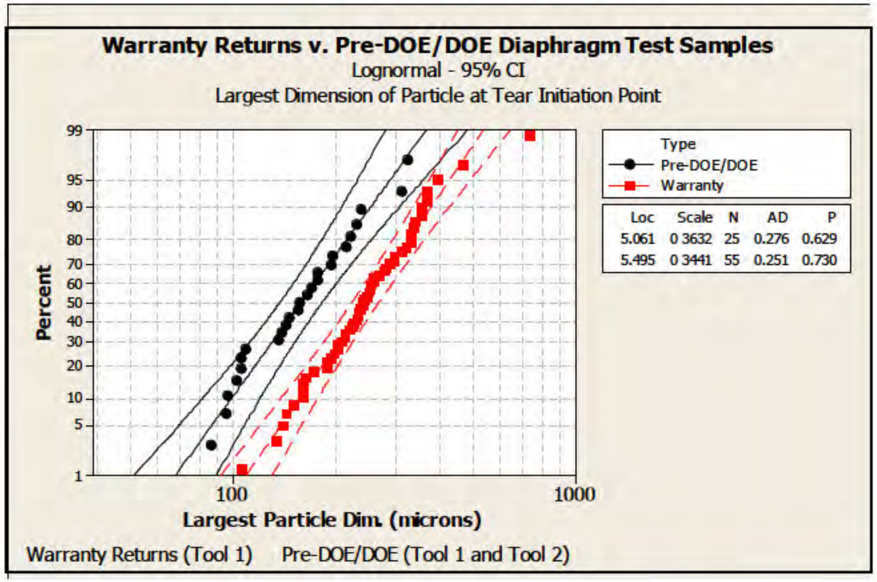
Pre-DOE & DOE Diaphragms (Tool 1 & Tool 2)

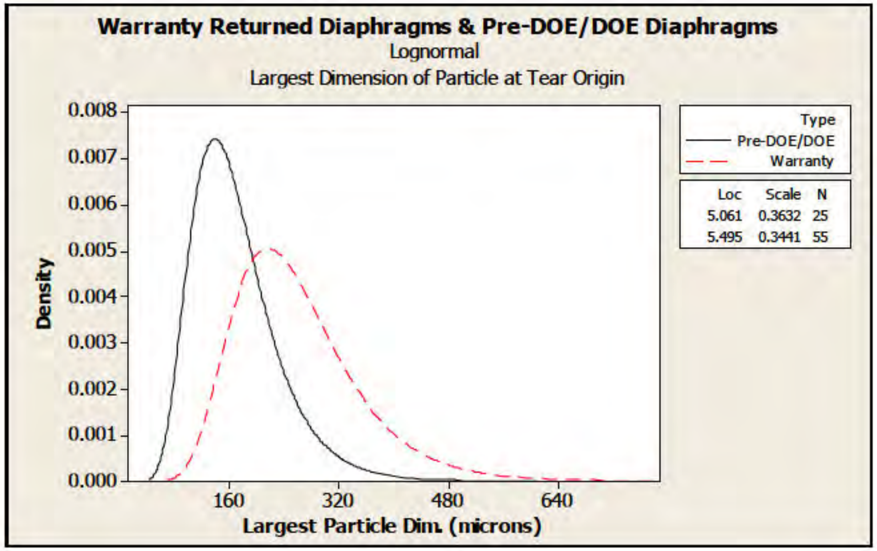
Quadrant	Clock Position	(Tool 1 & Tool 2, T2 & T3) Tear Count (T2 & T3) Total	(Tool 1 & Tool 2, T2 & T3) Largest Particle Dimension (µm) Average	(Tool 1 Only, T2 Only) Tear Count (T2 Tears) Total	(Tool 1 Only, T2 Only) Section Thickness @ T2 (mm) Average	(Tool 1 Only, T2 Only) % of Tears in Each Quadrant
1	10:01-1:00	15	170	12	1.21	67%
2	1:01-4:00	3	140	1	1.14	6%
3	4:01-7:00	3	183	2	1.02	11%
4	7:01-10:00	4	172	3	1.16	17%
Average / Total		25	168	18	1.18	100%

Mazda Warranty Analysis

- **Particle Size　パーティクルサイズ**
  - Comparing the distribution of the largest dimension of particle at tear initiation point between warranty return diaphragms and Pre-DOE/DOE diaphragms
    市場返却ダイアフラムとPre-DOE/DOEダイアフラムとの亀裂開始箇所パーティクルの最大サイズ分布比較
  - The suggested distribution is lognormal for both sets of data (α < 0.05).
    分布は両方のデータ共対数正規
  - The probability plot identifies a significant difference between the two distributions:
    確率プロットは2つの分布に大きな違いを確認
    - Pre-DOE/DOE have lower probability for a particle size than the warranty returns with 95% confidence intervals
      Pre-DOE/DOEは、95%の確信間隔でパーティクルサイズの確率が市場品より低い
    - Lognormal distribution
      対数正規分布

Population	Sample Size	Lognormal Distribution	
		Location	Scale
Pre-DOE/DOE	25	5.06	0.36
Warranty	55	5.50	0.34

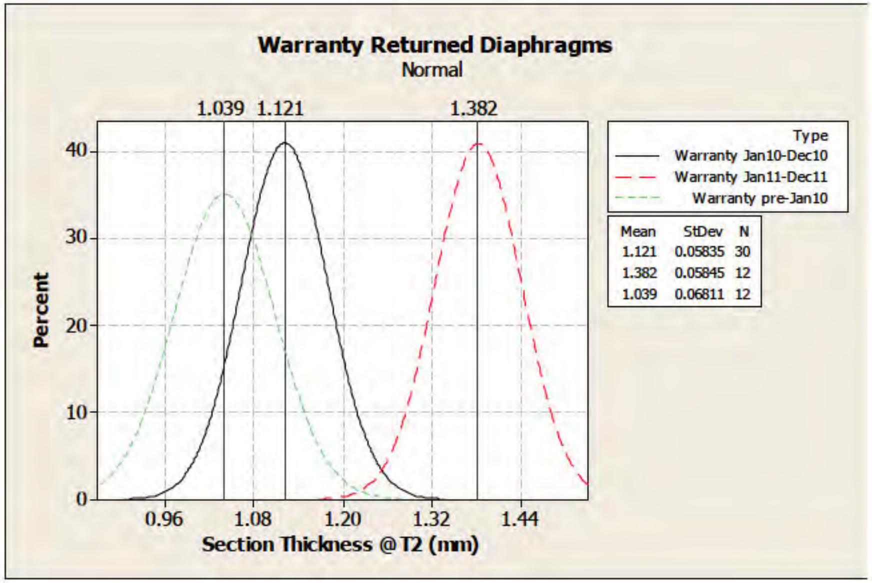




Mazda Warranty Analysis

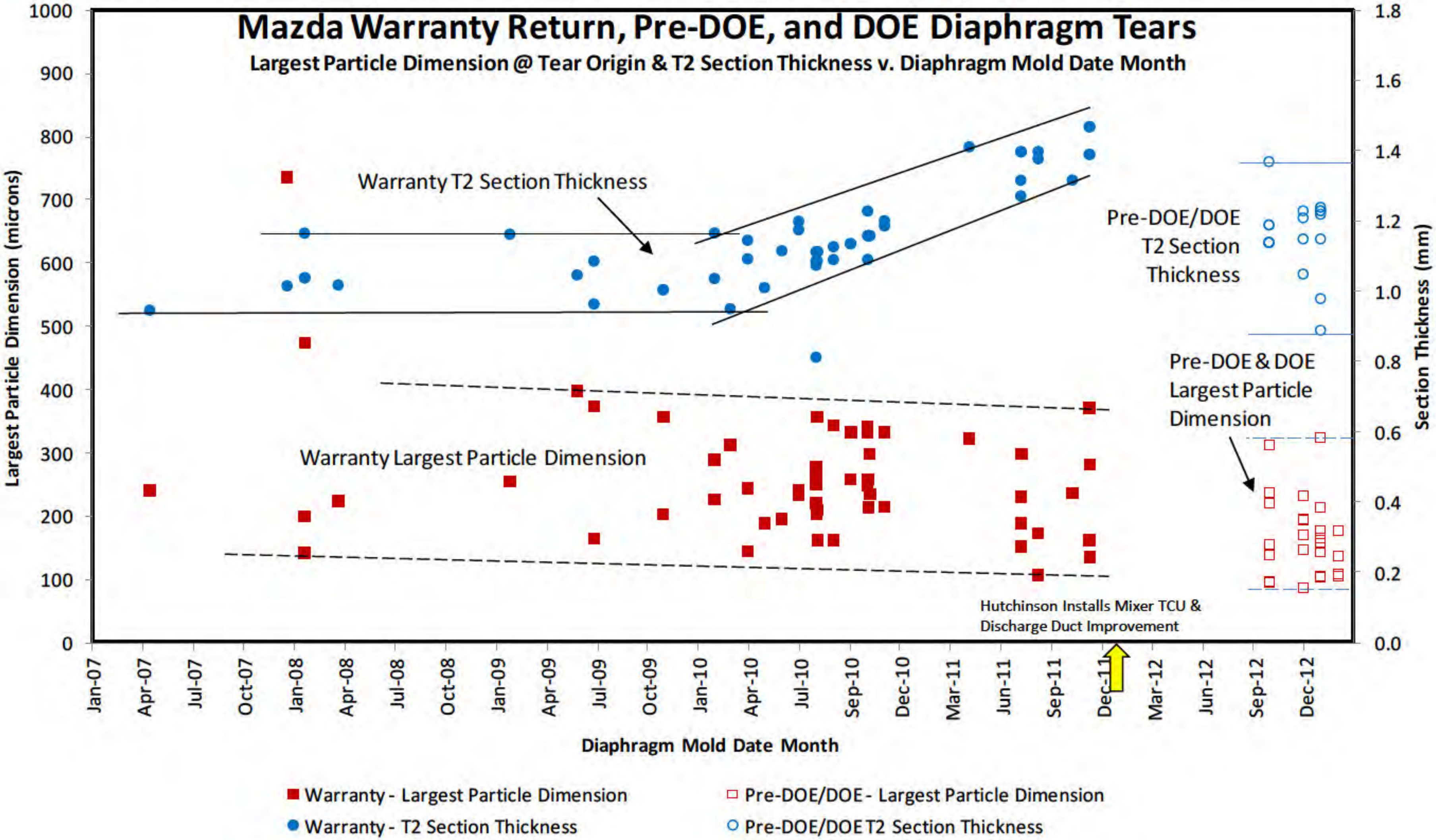
- **T2 Section Thickness　T2箇所の厚み**
  - Comparing distribution of section thickness at T2 for Tool 1 within warranty return diaphragms
    市場ダイアフラムのツール1でのT2厚み分布を比較
  - Populations are normally distributed　母集団は標準的に分布
  - Means of warranty return diaphragms are significantly different (α < 0.05) depending on the mold date codes and increasing from January 2010 through December 2011:
    市場返却ダイアフラムは形成日コードによって著しく異なっており(α<0.05)、2010年1月から2011年12月にかけ増加している。

Diaphragm Mold Date	Sample Mean (mm)	Sample Std. Dev.(mm)	Sample Size	Means Significantly Different (α < 0.05)
Pre-Jan10	1.04	0.068	12	Yes
Jan10-Dec10	1.12	0.058	30	Yes
Jan11-Dec11	1.36	0.058	12	Yes



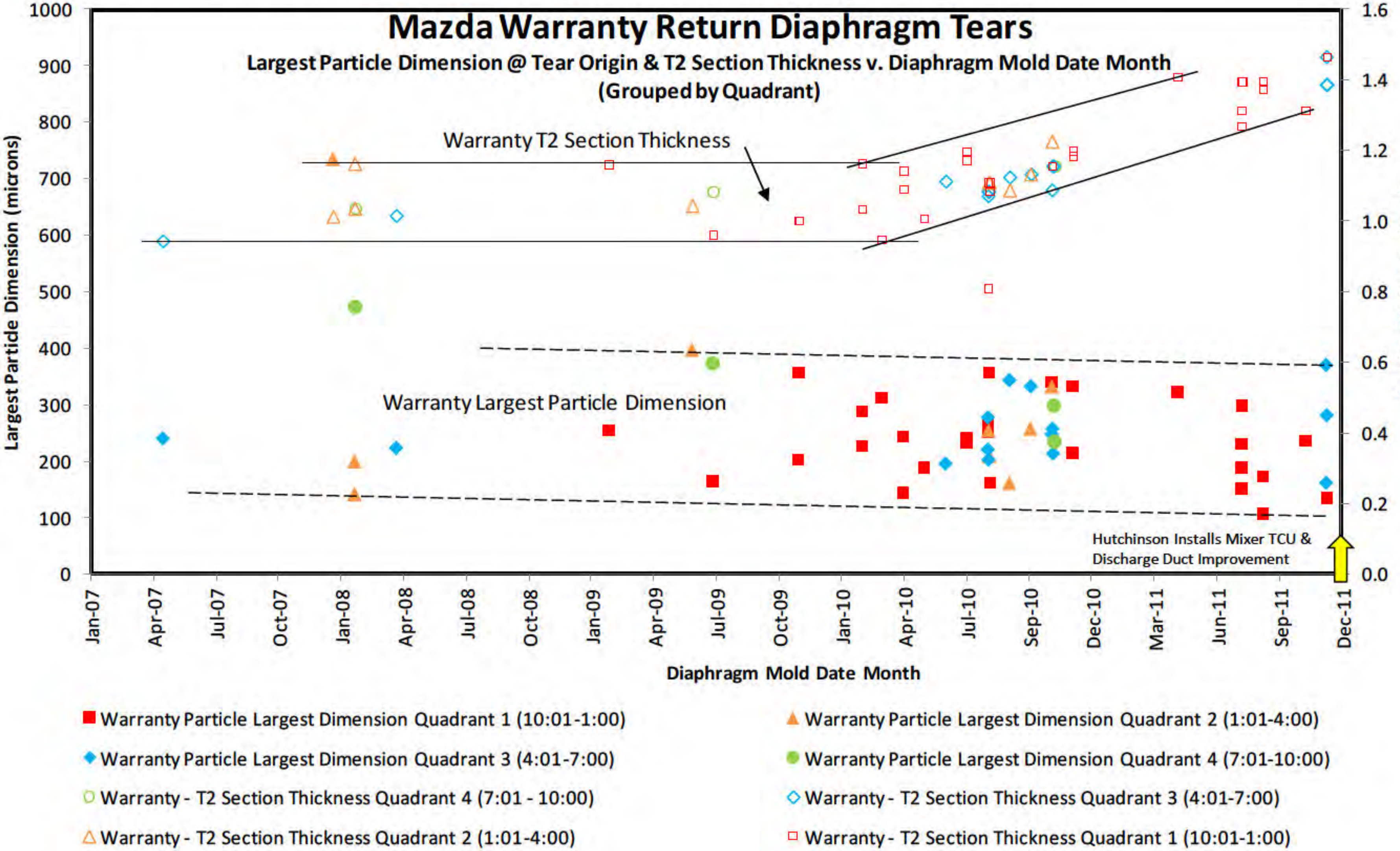
Mazda Warranty Analysis

- Data plotted v. diaphragm date code:



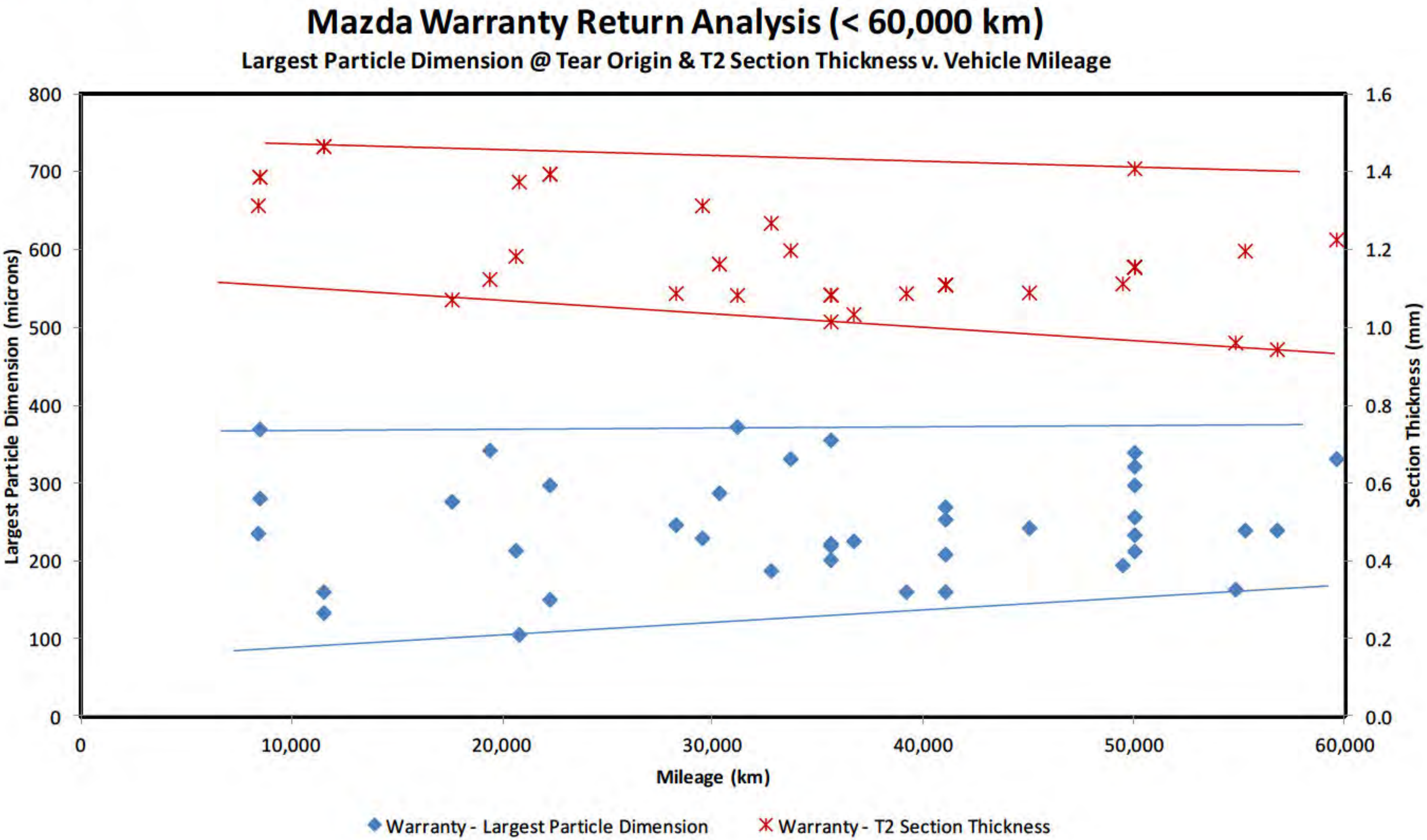
Mazda Warranty Analysis

- Data plotted v. diaphragm date code (warranty data only):



Mazda Warranty Analysis

- Data plotted v. reported vehicle mileage (warranty data only):



Mazda Warranty Analysis

- **Conclusions:結論**
  - The data suggests the probability of a smaller particle exists at the tear location of diaphragms molded after October 2012 when compared to diaphragms molded before January 2012.
    データによると、2012年1月以前と比べ2012年10月以降に形成されたダイアフラムダイアフラムの亀裂箇所に小さなパーティクルが存在する可能性がある。
    - The diaphragm molding date codes:
      ダイアフラム形成日コード

Molding Date Code Ranges

Warranty Samples	Pre-DOE /DOE Samples
May - 2007	Oct - 2012
Dec - 2011	Jan - 2013

    - The average of the largest particle dimension for warranty samples is 259 µm v. 168 µm for Pre-DOE/DOE samples.市場返却品の最大パーティクルの平均は259 µm v. Pre-DOE/DOEサンプルは168 µm
    - A partial explanation for this difference is warranty samples were selected by failing in service, whereas Pre-DOE/DOE samples were randomly selected samples from a limited batches of diaphragms.
      この違いは、市場サンプルは不具合品の中から選ばれているがPre-DOE/DOEサンプルはランダムに限定されたバッチの中から選ばれているため
    - Not all diaphragms tested in the DOE exhibited failures at T2 location and therefore it can be assumed that those that did fail have larger particles. More clear understanding of this point may be gained in the next leg of the DOE that evaluates diaphragms with presumed fewer particles.
      全てのDOEテストのダイアフラムにT２で不具合が起こったのではないため、不具合を起こしたものには大きなパーティクルが存在すると推測出来る。詳しくは次項、少ないパーティクルが推定されるダイアフラムの評価を参照。
  - The evidence supports the trend of smaller particles in recent samples
    このエビデンスにて最近のサンプルは小さなパーティクルである傾向を明確にしている。
  - Addition of TCU and mixer duct improvements at Hutchinson correspond to the last warranty returns received for torn diaphragms
    Hutchinsonで追加したTCUとミキサーダクトの改善は、最新の市場返却亀裂ダイアフラムに対応している。

Mazda Warranty Analysis

- **Conclusions (continued):結論（続き）**
  - Data suggests average section thickness at T2 for warranty samples (Tool 1) increases over time, starting with a diaphragm molding date in April 2010 and growing larger each successive year through December 2011 (the diaphragm date code of latest warranty return)
    データによると、市場サンプルT2の厚み平均は(ツール１)、2010年4月形成日のダイアフラムから始まり、時間とともに増加し、2011年12月までの継続的な年ごとに大きくなっている。(最新の市場返却品ダイアフラム日付コード)
    - The maximum section thickness at T2 prior to a molding date code of April 2010 is 1.2 mm
      2010年4月の形成日コード以前のT2最大厚みは1.2mm
    - Maximum section thickness at T2 of the data is 1.47 mm (mold date Dec-11)
      データのT2最大厚みは1.47mm（形成日2011年12月)
  - Percentage of tears (T2) in warranty samples (Tool 1) have a similar radial distribution as Pre-DOE/DOE samples (Tool 1 only)
    市場サンプルのT2亀裂のパーセンテージは、Pre-DOE/DOEのT2(ツール1のみ)亀裂と類似分布である。
  - No apparent correlation between largest particle dimension at tear origin for warranty returned boosters and reported vehicle mileage
    市場返却ブースターの亀裂部の最大パーティクルサイズと走行距離に明白な関連性はみられない。
  - Weak correlation between section thickness at T2 of warranty returned boosters and reported vehicle mileage
    市場返却ブースターのT2亀裂部の厚みと走行距離にはわずかな関連性はみられる。

Validity of T2 thickness spec for T2 & T3
T2&T3の厚み仕様の妥当性

- **Issue: 4 of the 40 warranty returns analyzed by TRW have T2 section thickness < 1.0 mm (upper specification limit). TRWで解析した市場返却品40台の内4台のT2厚みは<1.0mm (上限スペックリミット)**
  - All four samples have relatively large particles at tear origin that represent 17 – 32% of section thickness in these diaphragms: 4サンプル全てに厚みの17-32%の比較的大きなパーティクルが存在

REF	VIN	Diaphragm Mold Date	Mileage (Km)	Section Thickness (mm)	Particle Size & Orientation* (microns)	Ratio Particle Size to Section Thickness
104	JM3TB2DAXB[redacted]	May-07	56,770	0.95	240 ↔ x 165 ↕	17%
90	JM7TB19AXA[redacted]	Jul-09	54,795	0.96	[illegible]	[illegible]
85	JM7TB19A3A[redacted]	Mar-10	not provided	0.95	[illegible]	[illegible]
81	JM7TB19A6B[redacted]	Aug-10	not provided	0.81	[illegible]	[illegible]

* Section thickn[illegible]

  - Measured tensile strength of diaphragm material at [illegible] an the FEA predicted stress at T2 for specification thickness: 高温でのタ[illegible]結果は、仕様厚み、T2のFEA予測ストレスよりはるかに高かった。

T2 Thickness	FEA Predicted T2 Stress	Room Temp Tensile Strength	Margin	Tensile Strength after 70 hours @ 120°C	Margin
0.85 mm	2.0 MPa	20 MPa	10	15 MPa	7.5
1.0 mm	2.1 MPa	20 MPa	9.5	15 MPa	7.1

TRW material specification limits: 14 MPa minimum; 10.5 MPa minimum after 70 hours @ 120°C

  - Presence of a non-homogeneous particle in T2 section acts as a stress-riser; resultant high localized stress lowers fatigue life after material heat aging
    T2箇所の異種パーティクルの存在は、ストレスライザーとなり、結果、材料の熱劣化後の低い疲労寿命への局部的な高いストレスとなる。

Tear Propagation – Effect on Booster Function
亀裂伝搬 – ブースター機能への影響

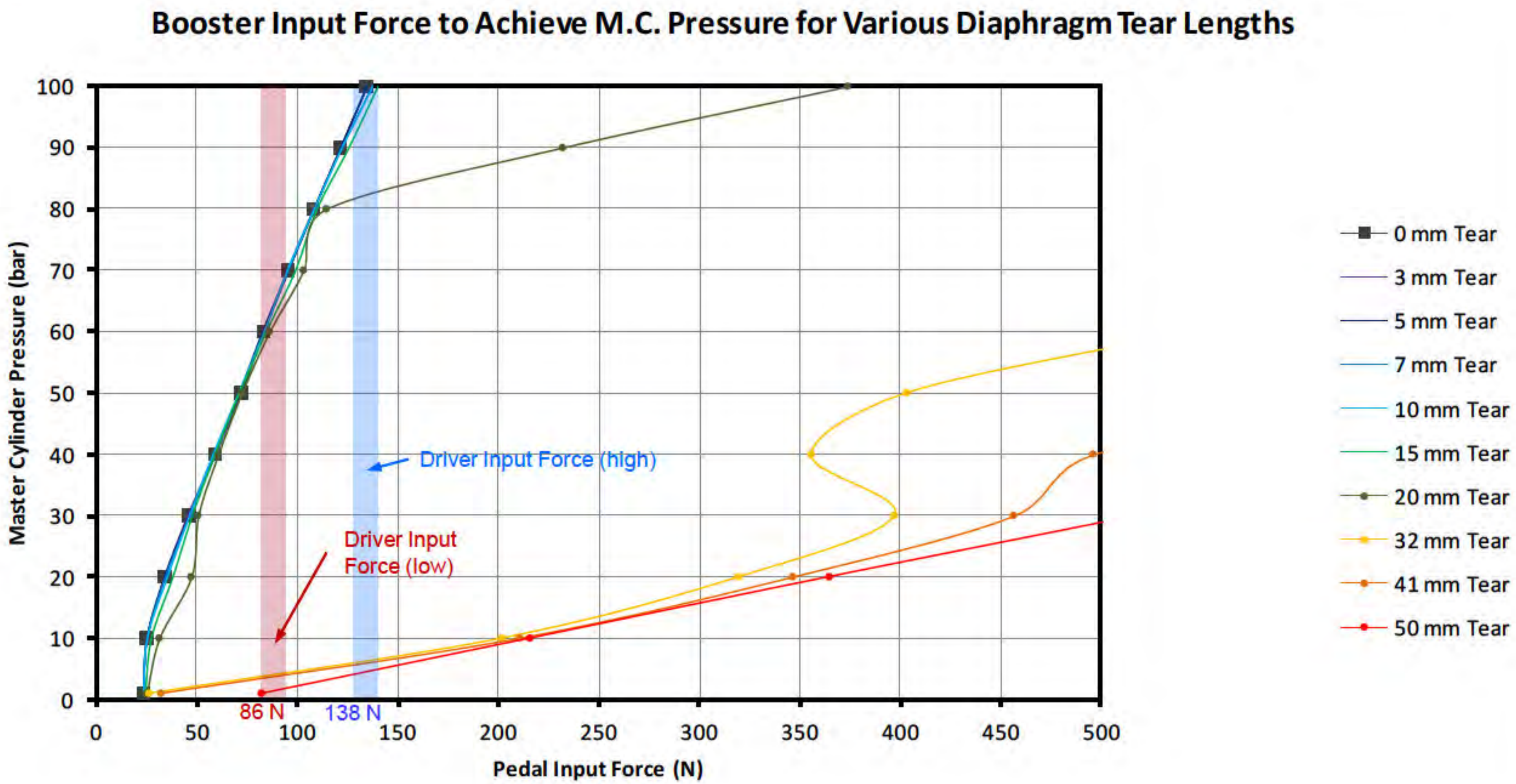
- **Tear propagation study – identify tear propagation characteristics and effect of diaphragm tear on booster at various stages of propagation**
  亀裂伝搬研究 – 亀裂伝搬特性と様々な伝搬ステージでのブースターへのダイアフラム亀裂の影響を特定
  - Tear initiation point is on the logo-side of diaphragm surface
    亀裂開始ポイントはダイアフラム表面のロゴ側
  - Fracture surfaces of tears have similar characteristics to warranty diaphragms
    亀裂表面の裂け目は、市場ダイアフラムと類似の特性
  - Tear can grow along the section before propagating through the section
    亀裂はセクションへの伝搬前に広がる
  - Tear propagation rates varied from 0.002 - 1.731 mm/apply
    亀裂伝搬率は0.002 - 1.731 mm/applyと多様
  - Tear influence on boost function of booster assembly:
    亀裂はブースターのブースト機能に影響：

亀裂長さ Tear Length	ブースターへの影響 Effect on Booster Assembly	ドライバーによる検知 Detectable by Driver	ペダル力認知/ダイアフラム亀裂無しと比べ車両の減速度、ドライバーへのインパクト Impact to driver perception of pedal force/vehicle deceleration relationship compared to no diaphragm tear
0 - 10 mm	< 10% loss of booster gain	difficult to detect independent of brake apply force ブレーキ踏込力のみでの検知は困難	· negligible ごくわずか · consistent difference regardless of apply speed スピードにかかわらず一貫して異なる
10 - 15 mm	< 65% loss of booster gain	easily detected at higher brake apply force (higher vehicle deceleration) 強いブレーキ踏込力で容易に検知(高い車両の減速度)	· increased 増加
15 - 30 mm	< 95% loss of booster gain		· difference in boost gain minimized with faster rate of apply ブースターへ加わる最小限にする速度率によって異なる
> 40 mm	100% loss of booster gain	easily detected at all apply forces (all vehicle decelerations) 全ての踏込力で容易に検知(全ての車両の減速度	· greatest 最大 · independent of rate of apply 加わる率に関連無し

- **Temperature and usage profiles significantly influence rate of tear propagation therefore it is not possible to accurately associate vehicle mileage or time in service to the rate of tear propagation**
  温度と仕様プロファイルは亀裂伝搬率に著しく影響するため、走行距離もしくは試用期間と亀裂伝搬率とを正確に関連付けるのは不可能である。

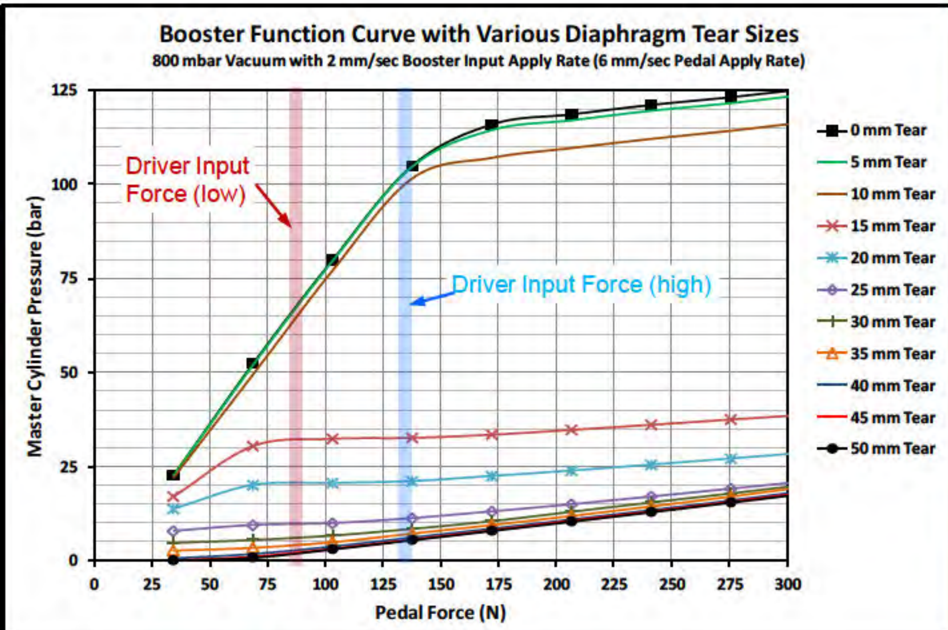
Tear Propagation – Driver Detection
亀裂伝搬 – ドライバー検知

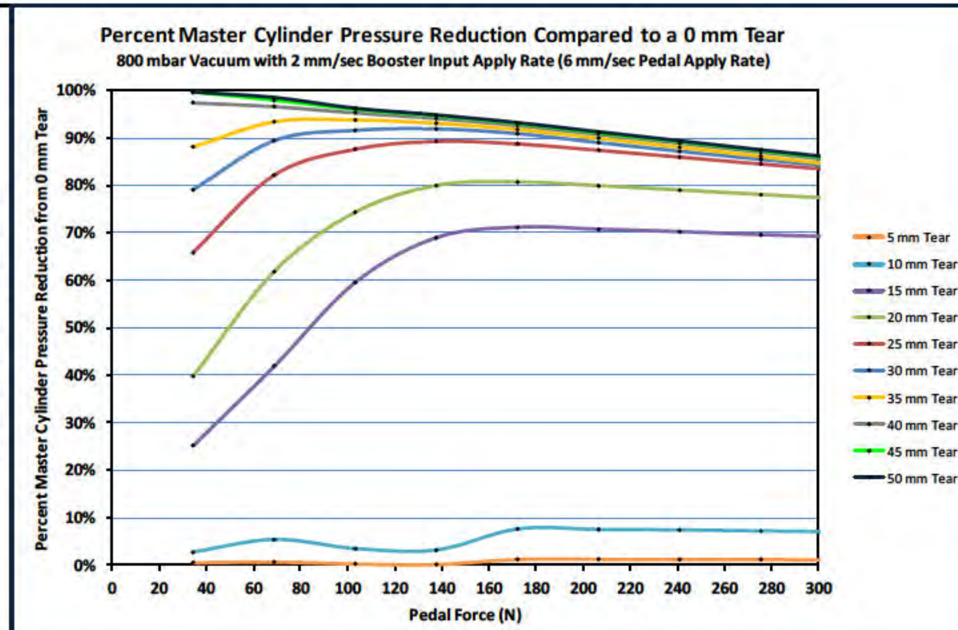
- **As T2 tear propagates, depends on the size and shape of the tear**
  T2亀裂の伝搬は亀裂サイズと形による
- **In this example, driver increase in pedal apply forces (slow apply rate < 10 mm/sec)**
  この例で、ドライバーはペダル踏込力を上げている
  - approximately 32 mm diaphragm tear light apply force (86 N pedal force) **軽い踏込力で約32mm亀裂**
  - approximately 20 mm diaphragm tear high apply force (138 N pedal force) **強い踏込力で約20mm亀裂**



Tear Propagation – Effect of Tear Shape
亀裂伝搬 – 亀裂成形の影響

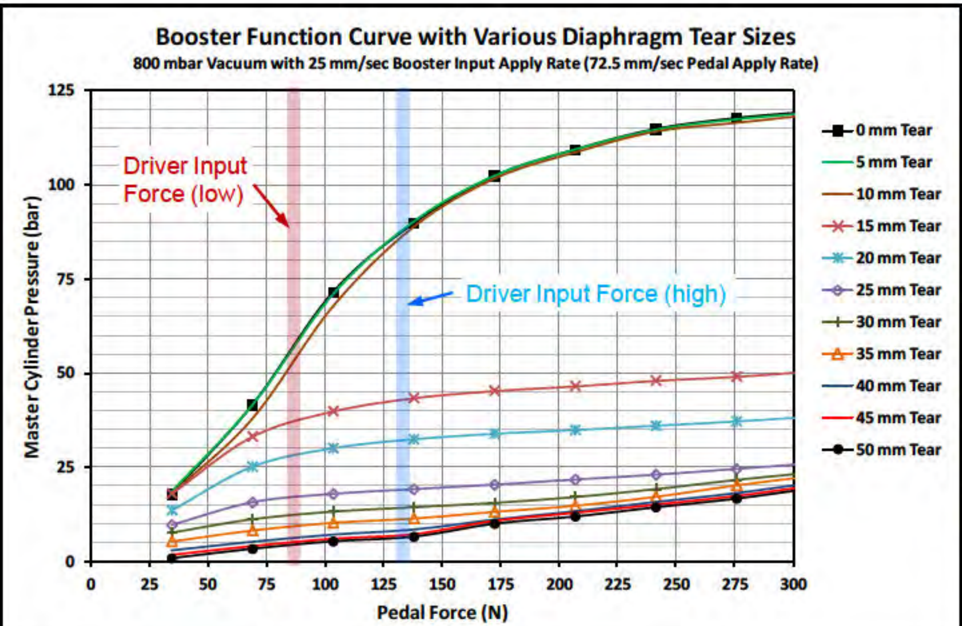
- **Another example with different shape of the tear (slow apply rate < 10 mm/sec)**
  異なる亀裂成形の他のサンプル
- **Booster tear is wider than the previous tear – no partial sealing against the front shell as the diaphragm unrolls during the forward stroke　以前の亀裂よりブースター亀裂は幅が広い –前方ストローク中のダイアフラムが展開する部分的なフロントシェルへのシーリング無し**
- **In this example, driver increase in pedal apply forces occur:　この例で、ドライバーはペダル踏込力を上げ**
  - approximately 15 mm diaphragm tear light apply force (86 N pedal force)　**軽い踏込力で約15mm亀裂**
  - approximately 15 mm diaphragm tear high apply force (138 N pedal force)　**強い踏込力で約15mm亀裂**
- **Change in booster function as a percentage of 0 mm tear with progressively larger T2 tear is shown on plot at right**
  0mm亀裂から徐々に大きくなるT2亀裂のブースター機能の変化は右のプロット

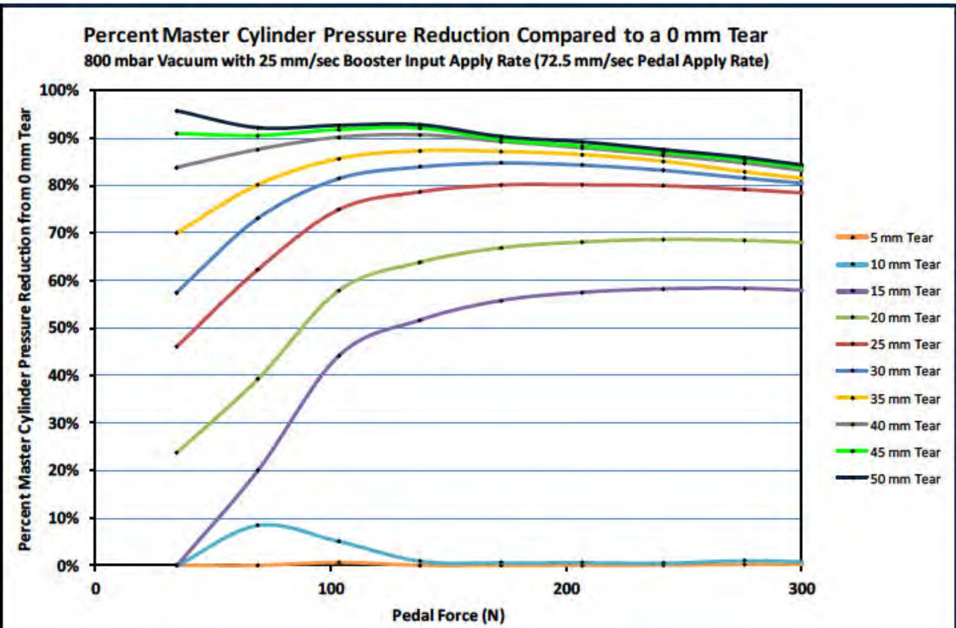




Tear Propagation – Effect of Apply Rate
亀裂伝搬 – 応力率の影響

- Same booster as previous slide, faster apply rate (72.5 mm/sec at pedal)
  全ページと同様のブースターでのより速い応力率
- In this example, driver increase in pedal apply forces occur
  この例で、ドライバーはペダル踏込力を上げ
  - approximately 20 mm diaphragm tear light apply force (86 N pedal force)　軽い踏込力で約20mm亀裂
  - approximately 15 mm diaphragm tear high apply force (138 N pedal force)　強い踏込力で約15mm亀裂
- Change in booster function as a percentage of 0 mm tear with progressively larger T2 tear is shown on plot at right
  0mm亀裂から徐々に大きくなるT2亀裂のブースター機能の変化は右のプロット
- Example shows that faster pedal apply rate reduces the difference between no tear and tear performance
  早いペダル踏込率では、亀裂無しと亀裂有りの機能差異が少ないことを示している
  - air has less time to pass through tear during fast applies
    早い踏込では空気は短い時間で亀裂を通過





Tear Propagation – Predictability
亀裂伝搬 – 予測

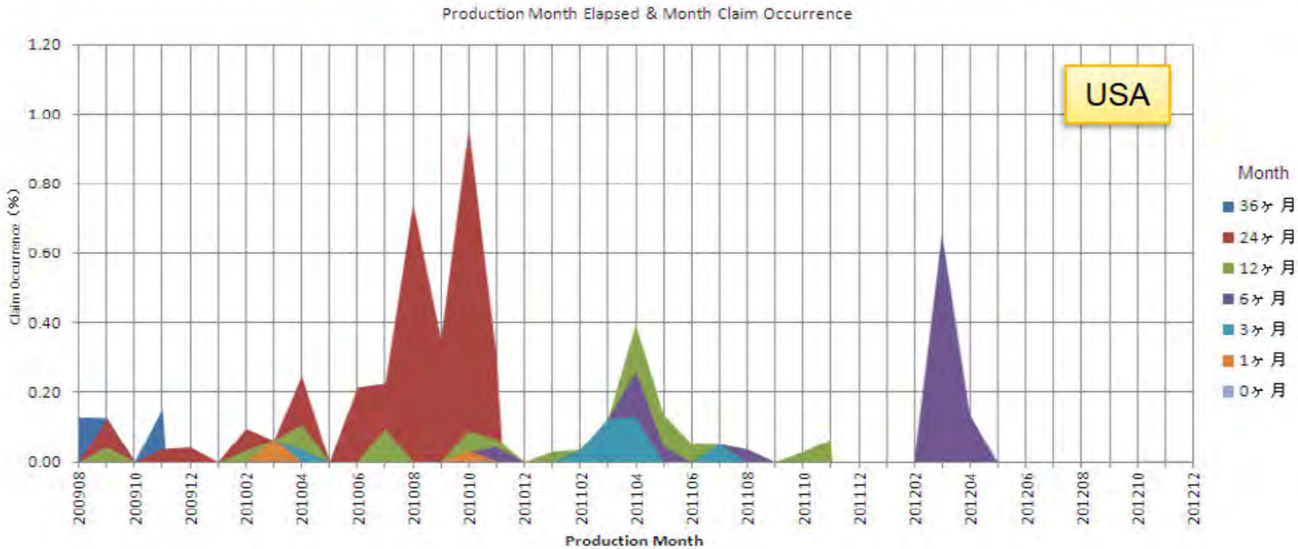
Conclusions:結論

- Helping force of a booster with a torn diaphragm in a vehicle during a braking event will be less than a normal booster without a torn diaphragm, and is dependent upon:
ブレーキ作動中の車両での亀裂ダイアフラムブースター応力は、下記次第で亀裂無しの通常ブースターより低くなる:
  - size of tear in the diaphragm (larger has greater effect) ダイアフラム亀裂サイズ(大きいほど影響)
  - vacuum level within booster at time of braking event (smaller initial vacuum level has greater effect)
  ブレーキ作動時のバキュームレベル(小さいレベルほど影響)
  - in-stop air evacuation rate of booster (slower has greater effect)
  ブースターのin-stop空気排気率(遅いほど影響)
  - driver's apply rate of brake pedal (faster apply rate has less effect)
  ドライバーのブレーキペダル踏込率(早い率ほど影響無し)
  - driver's apply force on brake pedal (higher apply force has greater effect)
  ドライバーのブレーキペダル踏込力(強い力ほど影響)
- Shape of diaphragm tear has an influence on whether diaphragm can partially seal on front shell as it unrolls during forward input stroke
ダイアフラム亀裂成形は、ダイアフラムが前方インプットストローク中に展開するフロントシェルを部分的にシール出来るかに影響する。
  - in some instances booster will partially recover boost with increased input stroke
  いくつかのブースターでは、インプットストロークの増加でブーストが部分的に復帰する。
  - in some instances booster will not recover boost with increased input stroke
  いくつかのブースターでは、インプットストロークの増加でブーストが部分的に復帰しない。
- Heat history of the material has a large influence on tear formation and propagation
材料の熱履歴は亀裂の形成と伝搬に強く影響する。
- Driver usage profile has a large influence on tear formation and propagation
ドライバーの使用プロファイルは亀裂の形成と伝搬に強く影響する。
- **Accurate predictions of tear propagation for diaphragms in service is not possible considering all possible variables that influence the tear size, shape, and propagation rate**
亀裂サイズ、成形、伝搬率が影響する様々な可能性を考慮しなければならない為、市場でのダイアフラム亀裂伝搬の正確な予測は不可能である。

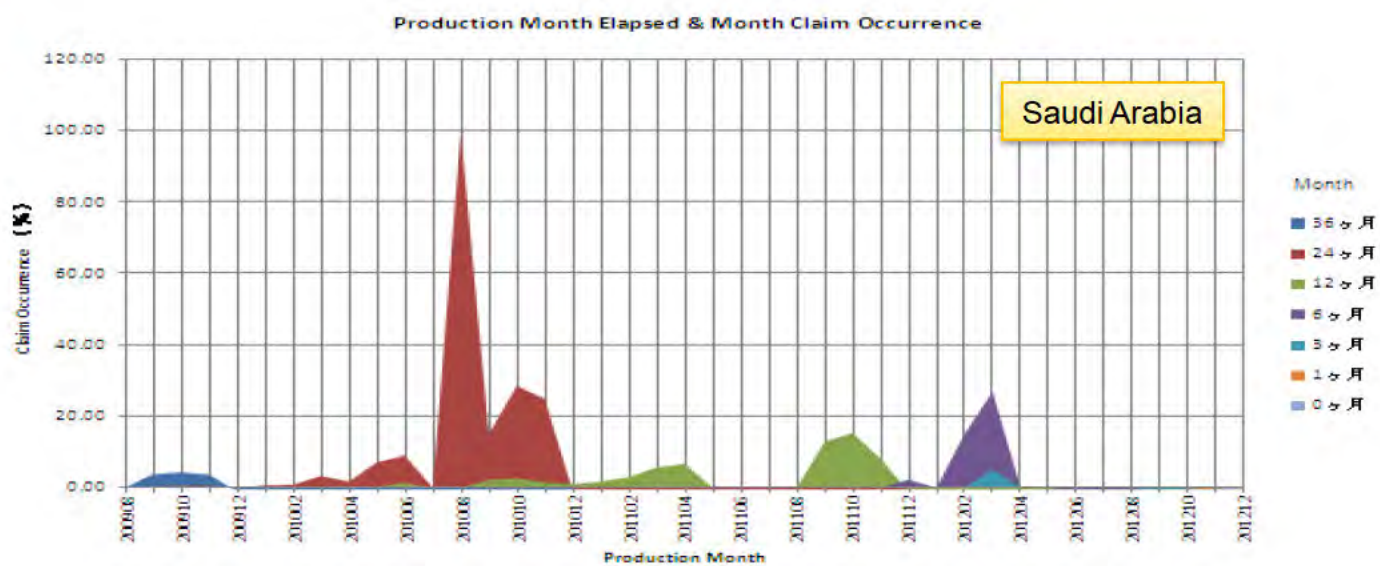
Warranty – Effect of Location (North/South)
市場 – 場所の影響（北/南）

- **Factors that influence the tear that may give variation in time in service to diaphragm tear at T2: T2のダイアフラム亀裂に影響する要因は変動がある**
  - Particle size　パーティクルサイズ
  - Diaphragm section thickness (T2)　ダイアフラム厚み
  - Heat history of the material (heat aging)　材料の熱履歴（熱劣化）
  - User load profile　ユーザー荷重プロファイル
- **Of these factors, heat history of the material is the most significant relating to location of affected diaphragms**
  これらの要因より、材料の熱履歴が最もダイアフラムに影響する場所との関連がある。
- **Warranty in regions with prolonged periods of elevated temperatures have much higher incident rates than regions that have either shorter periods or cooler temperatures**
  長期に渡る気温の上昇が起こる地域の市場では、短期の気温上昇もしくは低温地域と比べ発生率が高い。

J50C Booster Warranty Trends



Scale difference due to high temperature Factor
スケールは高温のため異なっている



Mazda J50C New Diaphragm Tool Validations
新ダイアフラムツール検証

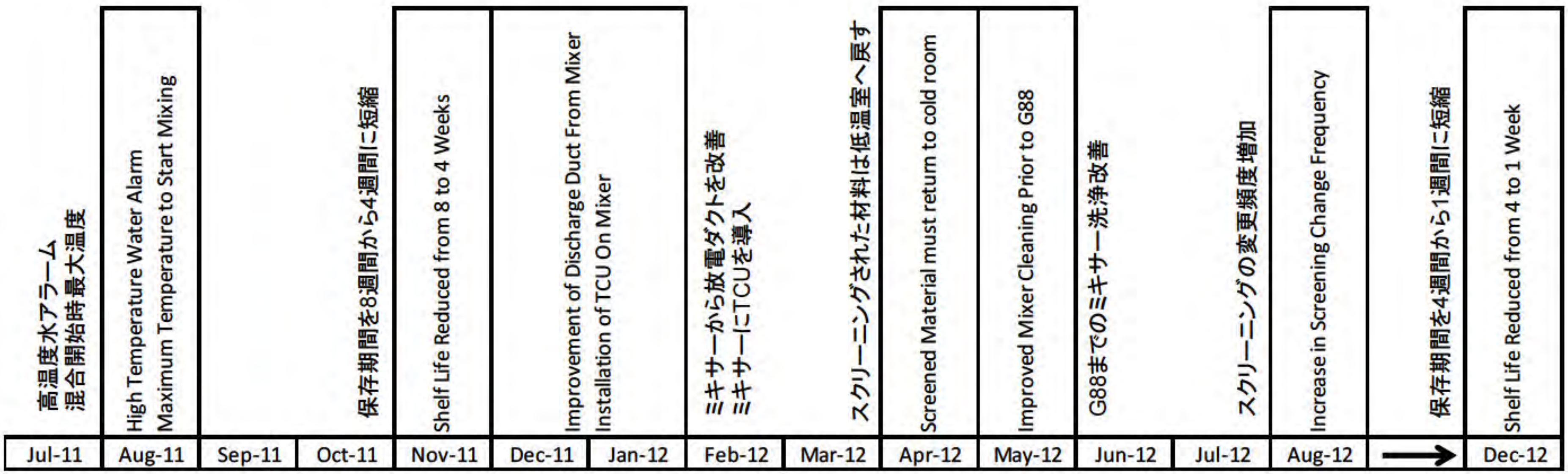
- **Diaphragms from each new tool will be validated to Mazda Spec (PA43800C): 新ツールそれぞれのダイアフラムをマツダ殿のスペックにて検証**
  - Durability:耐久性
    - 7.4.1 Room Temp Durability　室温での耐久性
    - 7.4.2 High Temp Durability　高温での耐久性
    - 7.4.3 Low Temp Durability　低温での耐久性
- **Validation report submission estimates:検証報告書提出予定**
  - Hutchinson Tool 3: 15-Apr-2013
  - Rubena Tool: 24-May-2013
  - Daetwyler Tool: 30-July-2013

Root Cause Of Thickness Out Of Specification
厚みスペック外の原因

- **Tool Number 1 (Warranty Return Parts) became dimensionally incorrect due to tool wear from material movement removing tooling material detail.**
  ツール番号1（市場返却品）は、ツール材の細部を取り除く材料の移動によるツール摩耗のため寸法が正確ではなくなった。
- **Tool Number 2 manufactured towards USL in bend area due to the fact that dimensions in this area was not known to be out of specification during time of manufacture of the tool.**
  ツール番号2は、ツール製造時に曲がった箇所がスペック外との認識が無かったため、そのUSLに面して製造されていた。
- **Supplier did not control area for thickness until TRW notified supplier of out of spec condition and Tool #3 was built to the thickness specification.**
  サプライヤーはTRWがスペック外である状況を告知するまで、厚み管理をしていなかった。ツール#3は厚みスペック内で製造。

Hutchinson Improvements　Hutchinsonでの改善

Hutchinson Manufacturing Improvements



Particles

Particle count and size cannot be controlled any better than current Hutchinson controls with TCU on mixer, this is the reason TRW is changing suppliers.
パーティクル数とサイズの管理は、現状のミキサーTCUの管理以上はHutchinsonでは不可能なためTRWはサプライヤーを変更。

Hutchinson Diaphragm

Root Cause Of Thickness Out Of Specification
厚みスペック外の原因

Daetwyler Diaphragm

Rubena Diaphragm

Above analyses shows the homogenous compound of Datwyler and Rubena with significant decrease in particles.
上記分析が示すよう、DatwylerとRubenaでの同種の合成物でのパーティクルは著しく減少している。

Hutchinson Control Plan – Material Properties

PART PROCESS NUMBER	PROCESS NAME / OPERATION DESCRIPTION	MACHINE, DEVICE, JIG, TOOL FOR MFG.	CHARACTERISTICS			SPECIAL CHAR. CLASS.	METHODS				RESPONSIBLE DEPARTMENT	REACTION PLAN
			No.	PRODUCT	PROCESS		PRODUCT/PROCESS SPECIFICATION TOLERANCE	EVALUATION MEASUREMENT TECHNIQUE	SAMPLE SIZE AND FREQUENCY	CONTROL METHOD		
8	Control Lab Test	**Various:** Tensometer, Shore "A", Analytical Balance, Rheometer	8A		**Physical and Chemical Properties:** Tensile Modulus, Elongation, Hardness, Sp. Gravity, Rate or Cure.	3	Batch Control Limits	Lab Test: ASTM D1414/D412 ASTM D1414/D412 ASTM D1414/D412 ASTM D2240 ASTM D297 Rheometer Standard/ Lab Technician	Each Batch. All Recipes	Batch Control Testing Procedure Physical properties result. Rheometer chart. WI 10.06.26	Laboratory	Tag. Material Rejected. Batch report is submitted to chemist for disposition. Inform chemist and request disposition. Batch repair WI 10.02.03
26	Quality Department	Hardness gage Shore M	26.01	hardness Test			65 +/- 5 Shore M	TS2-18-74	1 part per batch number	Lab test sheet	Quality Department.	Inform Quality Engineer isolate and tag nonconform products According to MRB Hold procedure
Note: This test is done before shipping the parts to customer		Tensometer	26.02	Tension Test		3	14.0 N/mm² Min.	TS2-18-74	1 part per batch number	Lab test sheet	Quality Department.	Inform Quality Engineer isolate and tag nonconform products According to MRB Hold procedure
			26.03	Elongation Test		3	250 % Min.	TS2-18-74	1 part per batch number	Lab test sheet	Quality Department.	Inform Quality Engineer isolate and tag nonconform products According to MRB Hold procedure
			26.04	Modulus at 100% Test		3	2.0 N/mm² Min.	TS2-18-74	1 part per batch number	Lab test sheet	Quality Department.	Inform Quality Engineer isolate and tag nonconform products According to MRB Hold procedure
27	Production Part Approval Process Revalidation		27.01			3	AIAG PPAP Manual		Annually	AIAG PPAP Manual	QA Dept.	

Control plan showing in process material properties controls in Hutchinson process

Hutchinson Control Plan – Tool 3

CONTROL PLAN

	Customer: TRW Automotive (Chassis Systems)	Company: Hutchinson Seal de México	Date (Orig): 18-Nov-03	Process Type: 1	Prototype ☐
	Mold No: 5721-3	Part No: 32484764	Last Rev: 30-Jan-13		Pre-Launch ☐
	BluePrint Rev: F	Part Name: Diaphragm 10.5"	Customer Approval:		Production ☒
Core Team: J.C. Gomez / J. Villalba / Mario G. D. Cortarelli / D. Lopez / A. Avalos		Key Contact/Phone: [redacted]	Prepared By J.C. Gomez / J. Villalba		

PART PROCESS NUMBER	PROCESS NAME OPERATION DESCRIPTION	MACHINE DEVICE, JIG, TOOL FOR MFG.	CHARACTERISTICS No.	CHARACTERISTICS PRODUCT	CHARACTERISTICS PROCESS	SPECIAL CHAR. CLASS.	METHODS PRODUCT/PROCESS SPECIFICATION TOLERANCE	METHODS EVALUATION MEASUREMENT TECHNIQUE	METHODS SAMPLE SIZE AND FREQUENCY	METHODS CONTROL METHOD	RESPONSIBLE DEPARTMENT	REACTION PLAN
			21.05	Thickness cross section Item # 7		BT2	0.85 +/- 0.15 mm	Dimensional Check using Thickness gauge / Quality Auditor	2 parts per run (6 000 pieces aprox.)	Measure report sheet 10.11.03-13 / Dimensional Control chart WI 20.01.01-2	Production Dept.	Inform supervisor Isolate and tag nonconforming product. According to MRB Hold procedure.
			21.06	Item # 28		BT2	4.45 ± 0.15 mm	Dimensional Control Chart using Vertex during Annual Revalidation	100 % Inspection	Dimensional Control chart WI 20.01.01-2	Quality Department	Inform Quality Engineer Isolate and tag nonconform products According to MRB Hold procedure
			21.07	Item # 29		BT2	3.3 ± 0.1 mm	Dimensional Check using Vertex / Quality Auditor	2 parts per month (36 000 pieces aprox)	Dimensional Control chart WI 20.01.01-2	Quality Department	Inform Quality Engineer Isolate and tag nonconform products According to MRB Hold procedure
			21.08	Item # 45		BT2	5.5 ±0.1	Dimensional Check using Vertex / Quality Auditor	2 parts per month (36 000 pieces aprox)	Dimensional Control chart WI 20.01.01-2	Quality Department	Inform Quality Engineer Isolate and tag nonconform products According to MRB Hold procedure
			21.09	Item # 49		BT2	3.3 ± 01 mm	Dimensional Check using Vertex / Quality Auditor	2 parts per month (36 000 pieces aprox)	Dimensional Control chart WI 20.01.01-2	Quality Department	Inform Quality Engineer Isolate and tag nonconform products According to MRB Hold procedure
			21.10	Item # 99		----	Control limits 0.85 ± 0.15	Dimensional Check using Optical Comparator / Quality Auditor	1 part per shift 4 points (480 pieces aprox.)	Dimensional Control WI 20.01.01-2 / Not SPC	Quality Department	Inform supervisor Isolate and tag nonconforming product. According to MRB Hold procedure.

- **SDE is working with Hutchinson to include T3 area as part of control plan inspection, but Hutchinson is non responsive to any requests lately. Escalation process has been followed.**

TRW Control Plan

Control Plan

r:	ES6-002-CP-J50CLH-J50CRH-MAZDA-2009	Prototype Pre-Launch **Production X**	**Date Orig.:** 4-Dec-07
Part Number / Latest change level:	32068913 / Level "B" 32069456 / Level "B"	**Key Contact / Phone:** Eduardo Santana [redacted]	**Date Rev.:** 26-Feb-13
Customer part number:	TD11-43950-E TD84-43950	**Core Team:** P. Verduzco(Quality), G. Edwards (AME), V. Camarena (AME), A. Saucedo(Product), G.	**Customer Engineering Approval / Date (If req'd):**
Part Name Description / Model Year:	MAZDA J50C (RH) / (LH) 2009	**Supplier / Plant Approval / Date:**	**Customer Quality Approval / Date (If req'd):**
Supplier/Plant:	TRW Santa Rosa Plant	**Other Approval /**	**Other Approval / Date (If req'd):**
Supplier Code:	N10DE		

Part/ Process Number	Process Name/ Operation Description	Machine, Device, Jig, Tools For Mfg.	Characteristics			Special Char. Class	Methods					Reaction Plan
			No.	Product	Process		Prod./Process Specification/ Tolerance	Evaluation Measurement Technique	Sample		Control Method	
									Size	Frequency		
	Diaphragm 10'		Gen-01	Diaphragm Thinkness			0.85 ± 0.15 mm	Gage Location 0, 90, 180, & 270 degrees at Loc 99 T2 & T3	Sample table	Prior to Production	Acceptance criteria: no non-conforming material in sample (0, zero). Material is inspected according to inspection sheets, supplier reliability, and sample tables (variable). Work instruction SR-E120-2-01	Segregate material and notify to supplier. All batches must be inspected and identified until corrective actions are implemented.
	Setup		Gen-02		Set Up		Confirm set-up Y/N (appropiate work instruction)	Verify mistake proofing	Each Station	Prior to Production	Any set up or change over is made until pallets are complete and there are no subassemblies in production line. If set up or change over is not done correctly, assemblies would be rejected.	Segregate material and notify to supplier. All batches must be inspected and identified until corrective actions are implemented.
	Change Over		Gen-03		Change		Confirm change	Verify mistake	Each Station	Prior to	Any set up or change over	Segregate material and

TRW Inspection Process

TRW

Frenos y Mecanismos, S. A. de C. V.

SISTEMAS DE CALIDAD

INSPECCION RECIBO

REPORTE DE INSPECCION

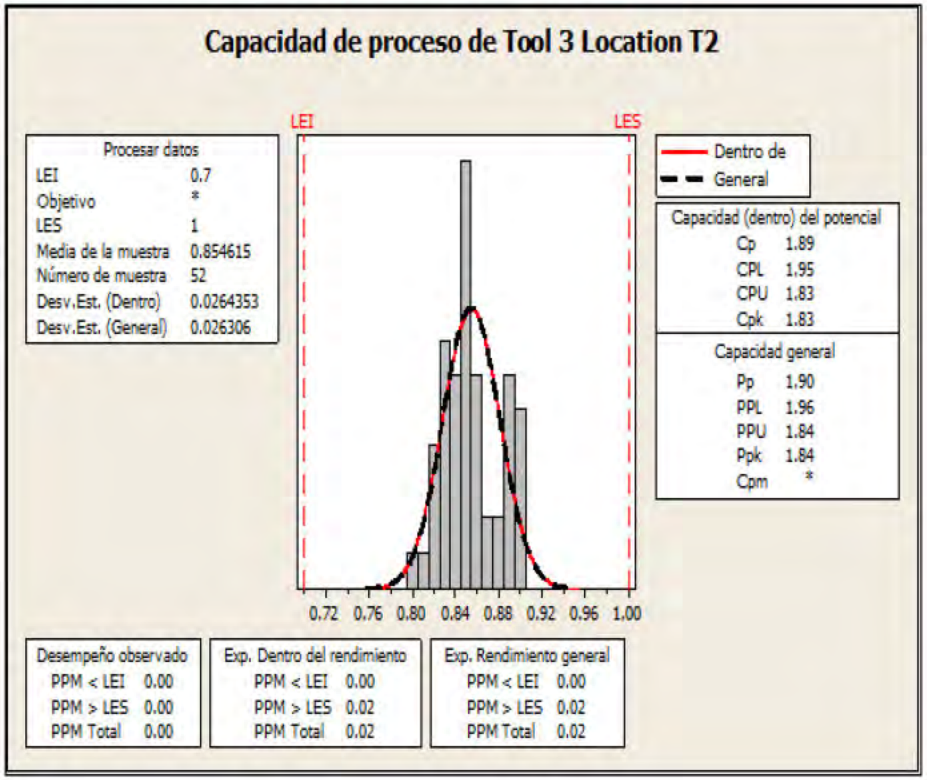
PROVEEDOR: HUTCHINSON SEAL PARTE No: 32484764 REV : C DESCRIPCION: DIAPHRAGM 10.5

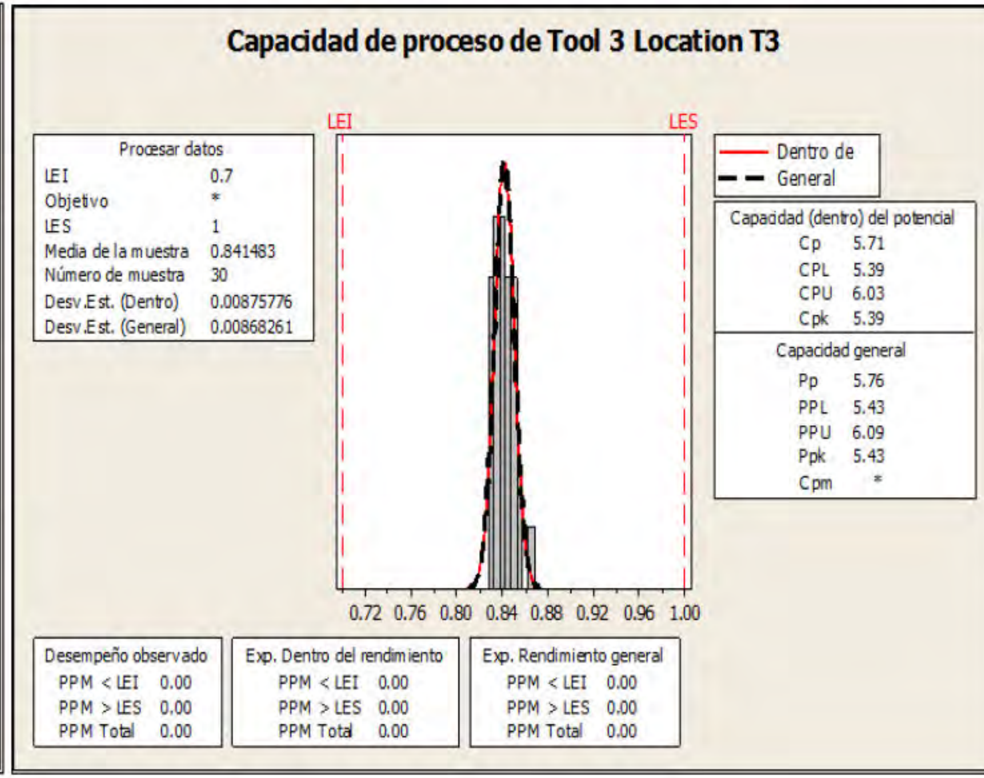
INSPECTOR: ______ LOTE PROV. No : ______ LOTE TRW : ______

CANTIDAD: ______ ACEPTADO ☐ RECHAZADO ☐ SORTEADO/RETRAB. ☐ FECHA : ______

ITEM #	LOC	ESPECIFICACION	METODO	MUESTRAS								
				1	2	3	4	5	6	7	8	9
1	-----	Verificar Nivel de Revision de Ingenieria	Visual									
2	N04	Libre de flash, particulas y marcas de herramienta	Visual									
3	N08	Area de sellado limpia y sin fisuras	Visual									
4	N10	Impreso "TRW", fecha de prod. y "32484764"	Visual									
5	C8	Diametro de 50.00 - 50.30 mm <I>	Proyector de sombra									
6	-----	Espesor del Diafragma (0.85 ± 0.15)mm Location 0, 90, 180, & 270 degrees at Loc 99 T2	Gage									
7	-----	Espesor del Diafragma (0.85 ± 0.15)mm Location 0, 90, 180, & 270 degrees at Loc 99 T3	Gage									
8	-----	Falta de material	Visual									

Tool 3 CPK Data





Tool 3 T2 Cpk: 1.83

Tool 3 T3 Cpk: 5.39

Alternative SBR Supplier Tooling Status
代替えSBRサプライヤーツーリングステータス

	32484764 Daetwyler	253 days	11/22/12
✓	Tool Drawing	2 wks	11/22/12
✓	Tool Production	12 wks	12/06/12
	Sampling & Measuring	2 wks	02/28/13
	Shipping Tool	2 wks	03/14/13
	PPAP	2 wks	03/28/13
	PPAP Approval	2 wks	04/11/13
	PV Parts Assy & Ship to Livonia	2 wks	04/30/13
	TRW Testing	16 wks	05/14/13
	TRW Report	2 wks	09/03/13
	TRW PPAP to Customer	2 wks	09/17/13
	Customer Engrg Approval	2 wks	09/17/13
	PTR	4 wks	10/01/13
	Supplier SOP & Ship to TRW	1 wks	10/29/13
	TRW SOP	1 wks	11/05/13

	32484764 Rubena	236 days	11/22/12
✓	Tool Drawing	2 wks	11/22/12
✓	Tool Production	8 wks	12/06/12
✓	Sampling & Measuring	1 wks	01/31/13
✓	Rubena CZ in house tests	4 days	02/07/13
✓	Hardening	3 days	02/13/13
	Shipping Tool	2 wks	02/18/13
	PPAP	2 wks	03/04/13
	PPAP submission	1 days	03/18/13
	PPAP Approval	2 wks	03/19/13
	PV Parts Assy & Ship to Livonia	2 wks	04/05/13
	TRW Testing	16 wks	04/19/13
	TRW Report	2 wks	08/09/13
	TRW PPAP to Customer	2 wks	08/23/13
	Customer Engrg Approval	2 wks	08/23/13
	PTR	4 wks	09/06/13
	Supplier SOP & Ship to TRW	1 wks	10/04/13
	TRW SOP	1 wks	10/11/13

Currently On-Time as per previously shown timing
現在、前もって提示した期限通りで進行中

EPDM Material Change　EPDM材料変更

- **TRW is awaiting a response from Mazda on official RFQ submission to pursue a change from SBR to EPDM**
  TRWはSBRからEPDMへ変更するためのマツダ殿からの正式RFQ提出を待機中

TRW Summary Of J50C Warranty

- TRW's opinion based on current DOE results, TRW's Engineering Risk Assessment and current warranty trends; is that the risk to the end user is minimal and believe no field action is warranted at this time. If the diaphragm is going to fail in the hot regions of the world, it is expected to fail within the warranty coverage time period.
  最新のDOE結果、エンジニアのリスクアセスメント、最新の市場傾向に基づくと、エンドユーザーへのリスクは最小で現時点での市場措置は必要ではないと考えます。ダイアフラムが高温地域で不良となる場合、ワランティー保証期間内であると予測します。
- Based on Mazda Warranty data received by TRW to date, the likelihood occurrence rate outside of the Middle East region is minimal.
  マツダ殿の市場データーに基づくと、中東地域外での発生率はわずかです。
- Based on the DOE and Dimensional results this issue was caused by Hutchinson. TRW's component drawing included a homogenous thickness of 0.85 +/- 0.15 in the fold area and identified this area as a significant characteristic.
  DOEと寸法結果に基づくと、この事案はHutchinsonが原因で発生しています。折り目箇所と特定された箇所の同種厚み0.85+/-0.15を含むTRWの構成部品図面は独持のものです。
- Current Hutchinson Build Dates based on warranty returns indicate issue has been corrected with the installation of the TCU to reduce particle size in December 2011.
  市場返却品に基づいた最新のHutchinsonの製造部品は、2011年12月にパーティクルサイズを減少させるために導入したTCUにより修正しています。

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 2-6 Supplier Report 2

Diaphragm板厚寸法不良対策

- Diaphragm板厚寸法不良対策
- HSM製造日:2013/2/4
- TRW製造日:2013/2/20
- Booster Serial: TD11 (LHD) WY47129MA6
  TD84 (RHD) AY48620MB6
- Mazda 様納入日: ①TD11-43-950:2013/04/25
  ②TD84-43-950:2013/05/08

板厚管理

ツール3寸法管理方法
How to control tool 3 dimensions

Q1: Mazda is asking how to control of tool 3 dimension: Needs guarantee of tool life , maintenance plan and guarantee of shot.

質問1: どのようにしてツール3の寸法を管理するのか:ツール寿命の保証、メンテナンスプラン、ショットの保証

Answer: Tool life will be monitored through the following dimensional controls on the part:

1. Inner Diameter - SPC
2. Wall thickness in two places including radius - SPC
3. Inner bead thicknesses in two places - SPC
4. Distance of the outer bead - SPC
5. Thickness on the outer bead
6. Flash inspection at five places

Trends are observed on the increase of thickness through above controls which would indicate the tool trend.

Preventative maintenance is performed at every 10,000 shots. PM includes thorough cleaning of the mold, mold cavities, venting and parting lines. The dimensions of the tool cavities are not exactly the same as the part, due to material shrinkage.

回答:ツール寿命は下記部品の寸法管理に沿ってモニタリングされる:

1. 内径ーSPC
2. 半径を含めた2ヵ所での板厚ーSPC
3. 2ヵ所での内部ビード厚ーSPC
4. 外部ビードの距離ーSPC
5. 外部ビード厚
6. 5ヵ所でのフラッシュ検査

傾向は、上記管理にて、ツールの傾向を示す板圧の増加が監視される。

モールド、モールド空洞、排出口、ライン分離部の洗浄を含む防止メンテナンスは10,000ショット毎に実施。ツール空洞の寸法は材料の縮小の為、部品とは完全に一致していない。

板厚管理

Thickness Controls　板厚管理

Q: What is significant characteristic (SC/CC) for diaphragm manufacture? How to control?

質問：ダイアフラム製造における重要な特性（SC/CC)は何か？どのように管理するか？

Answer: Viscosity and scorch are significant characteristics during diaphragm manufacturing. These are controlled with rheological testing as per control plan.

答え：粘度とスコーチは、ダイアフラム製造時の重要な特性である。これらは管理プランごとのレオロジーテストで管理されている。

Q: How to control for thickness by production conditions? (Without measurement, focus on the method of manufacture)

質問：どのような製造条件で板厚を管理しているのか？（測定以外、製造方法に焦点）

Answer: Per Hutchinson, thickness is primarily dependent upon tool geometry. With the construction of correct geometry and on-going tooling preventative maintenance , thickness is monitored and controlled.
Rubena's response - We have control with the wear pins in the mould by monitoring dimensional in four points of membrane, 12, 03, 06 and 09 O´clock

答え：Hutchinsonでは、板厚は主としてツール形状が影響する。正しい形状でのツール構造と継続中の防止メンテナンスで板厚はモニタリングされ管理されている。
Rubenaでは - メンブレインの12.03.06.09時4か所の寸法をモニタリングしモールドの摩耗ピンで管理している。

Control plan HSM

TRW

Hutchinson Control Plan – Tool 3

TRW

CONTROL PLAN

	Customer: TRW Automotive (Chassis Systems)	Company: Hutchinson Seal de México	Date (Orig): 18-Nov-03	Process Type 1	Prototype ☐
	Mold No: 5721-3	Part No: 32484764	Last Rev: 30-Jan-13		Pre-Launch ☐
	BluePrint Rev: F	Part Name: Diaphragm,10.5"	Customer Approval:		Production ☒
Core Team: J.C. Gomez / J. Villalba / Mario G. D. Cortarelli / D. Lopez / A. Avalos		Key Contact/Phone: Jenipher Villalba [redacted]	Prepared By J.C. Gomez / J. Villalba		

PART PROCESS NUMBER	PROCESS NAME OPERATION DESCRIPTION	MACHINE DEVICE, JIG, TOOL FOR MFG.	CHARACTERISTICS			SPECIAL CHAR. CLASS.	METHODS				RESPONSIBLE DEPARTMENT	REACTION PLAN
			No.	PRODUCT	PROCESS		PRODUCT/PROCESS SPECIFICATION TOLERANCE	EVALUATION MEASUREMENT TECHNIQUE	SAMPLE SIZE AND FREQUENCY	CONTROL METHOD		
			21.05	Thickness cross section Item # 7		BT2	0.85 +/- 0.15 mm	Dimensional Check using Thickness gauge / Quality Auditor	2 parts per run (6 000 pieces aprox.)	Measure report sheet 10.11.03-13 / Dimensional Control chart WI 20.01.01-2	Production Dept.	Inform supervisor Isolate and tag nonconforming product. According to MRB Hold procedure.
			21.06	Item # 28		BT2	4.45 ± 0.15 mm	Dimensional Control Chart using Vertex during Annual Revalidation	100 % Inspection	Dimensional Control chart WI 20.01.01-2	Quality Department	Inform Quality Engineer Isolate and tag nonconform products According to MRB Hold procedure
			21.07	Item # 29		BT2	3.3 ± 0.1 mm	Dimensional Check using Vertex / Quality Auditor	2 parts per month (36 000 pieces aprox)	Dimensional Control chart WI 20.01.01-2	Quality Department.	Inform Quality Engineer Isolate and tag nonconform products According to MRB Hold procedure
			21.08	Item # 45		BT2	5.5 ±0.1	Dimensional Check using Vertex / Quality Auditor	2 parts per month (36 000 pieces aprox)	Dimensional Control chart WI 20.01.01-2	Quality Department	Inform Quality Engineer Isolate and tag nonconform products According to MRB Hold procedure
			21.09	Item # 49		BT2	3.3 ± 01 mm	Dimensional Check using Vertex / Quality Auditor	2 parts per month (36 000 pieces aprox)	Dimensional Control chart WI 20.01.01-2	Quality Department	Inform Quality Engineer Isolate and tag nonconform products According to MRB Hold procedure
			21.10	Item # 99		—	Control limits 0.85 ± 0.15	Dimensional Check using Optical Comparator / Quality Auditor	1 part per shift 4 points (480 pieces aprox.)	Dimensional Control WI 20.01.01-2 / Not SPC	Quality Department	Inform supervisor Isolate and tag nonconforming product. According to MRB Hold procedure.

Control Plan TRW

TRW Control Plan

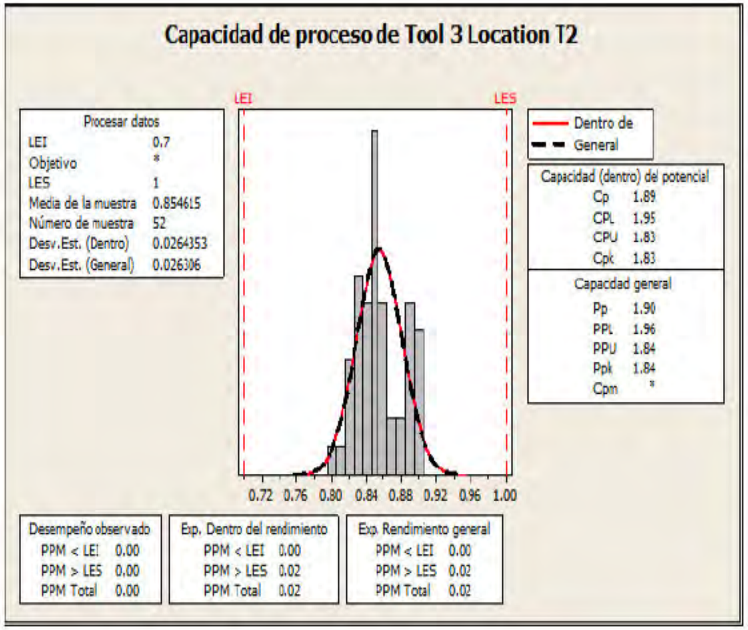
Control Plan

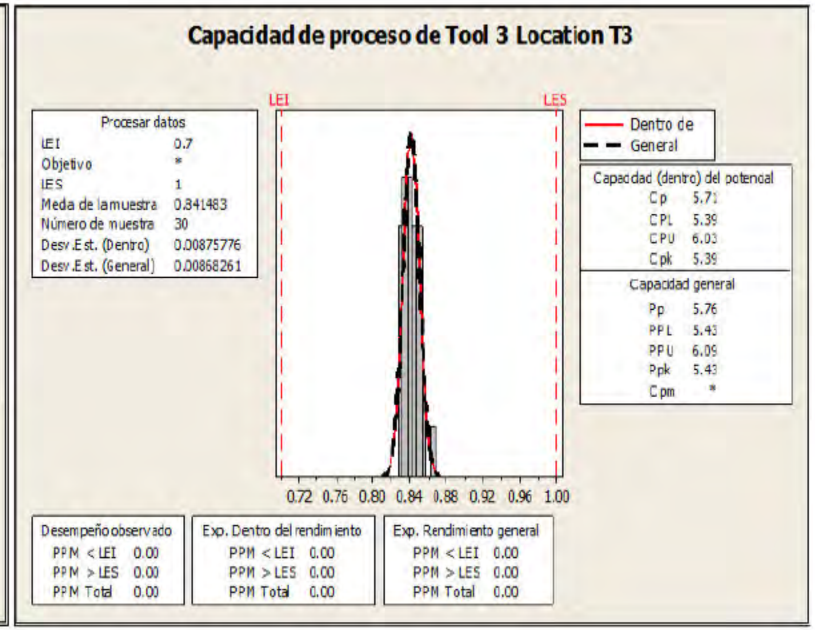
r:	ES6-002-CP-J50CLH-J50CRH-MAZDA-2009	Prototype	Pre-Launch	**Production X**	**Date Orig.:** 4-Dec-07
Part Number / Latest change level:	32068913 / Level "B" 32069456 / Level "B"	**Key Contact / Phone:**	Eduardo Santana [redacted]		**Date Rev.:** 26-Feb-13
Customer part number:	TD11-43950-E TD84-43950	**Core Team:**	P. Verduzco(Quality), G. Edwards (AME), V. Camarena (AME), A. Saucedo(Product), G.		**Customer Engineering Approval / Date (If req'd):**
Part Name Description / Model Year:	MAZDA J50C (RH) / (LH) 2009	**Supplier / Plant Approval / Date:**			**Customer Quality Approval / Date (If req'd):**
Supplier/Plant:	TRW Santa Rosa Plant	**Other Approval /**			**Other Approval / Date (If req'd):**
Supplier Code:	N10DE				

Part/ Process Number	Process Name/ Operation Description	Machine, Device, Jig, Tools For Mfg.	Characteristics			Special Char. Class	Methods					Reaction Plan
			No.	Product	Process		Prod./Process Specification/ Tolerance	Evaluation Measurement Technique	Sample		Control Method	
									Size	Frequency		
	Diaphragm 10'		Gen-01	Diaphragm Thinkness			0.85 ± 0.15 mm	Gage Location 0, 90, 180, & 270 degrees at Loc 99 T2 & T3	Sample table	Prior to Production	Acceptance criteria: no non-conforming material in sample (0, zero). Material is inspected according to inspection sheets, supplier reliability, and sample tables (variable). Work instruction SR-E120-2-01	Segregate material and notify to supplier. All batches must be inspected and identified until corrective actions are implemented.
	Setup		Gen-02		Set Up		Confirm set-up Y/N (appropiate work instruction)	Verify mistake proofing	Each Station	Prior to Production	Any set up or change over is made until pallets are complete and there are no subassemblies in production line. If set up or change over is not done correctly, assemblies would be rejected.	Segregate material and notify to supplier. All batches must be inspected and identified until corrective actions are implemented.
	Change Over		Gen-03		Change		Confirm change	Verify mistake	Each Station	Prior to	Any set up or change over	Segregate material and

Cpk Tool 3 T2,T3 area

Tool 3 CPK Data





Tool 3 T2 Cpk: 1.83

Tool 3 T3 Cpk: 5.39

板厚管理

- HSM 4point 測定T2部・CMM・Shift 毎・2013/2/4~
- HSM 過去測定ポイントT3部・ロット毎
- TRW T2部は専用Gageにて測定・ロット毎10個・2013/2/26~

- 金型の摩耗/寸法精度バラツキのコントロール特性と管理方法。
- 金型メンテ周期（摩耗確認)10万ショット/毎
- コントロールプラン追加内容：10万ショット毎に30個ダイアフラム板厚測定OK確認
- メンテナンス追加内容：10万ショット毎に型内径・ビート部測定
- 基準：0.85±0.15（TRW　社内図）
- 確認方法：ダイアフラムをカットし測定

TRW受け入れ検査

TRW

ダイアフラム測定ゲージ

Diaphragm Measurement Gage

TRW

目的: ループエリアでのダイアフラム厚み測定の方法展開

Objective: Develop a method to measure thickness of the diaphragm in the loop area (position 99)

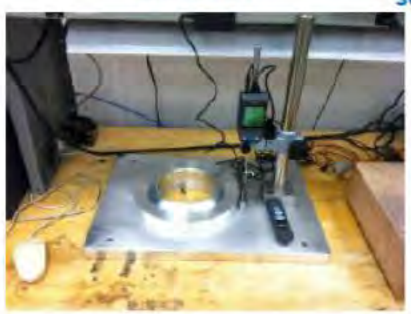
Digital Indicator

Diaphragm Fixture

Indicator Spindle Lift Handle

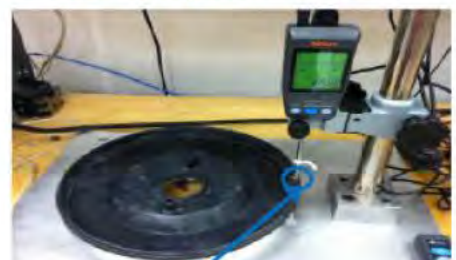
Remote Control

Laptop Computer with USB port and Microsoft Excel software



デジタル測定器ー材料上部で0に設定

Digital Indicator - The digital indicator is zeroed on top of the mandrel.



Digital Indicator– contacts the diaphragm during measurement.

デジタル測定器ー測定時、ダイアフラムに接触

パーティクル管理

- パーテクルの管理基準:300ミクロン以下
- 確認方法:ダイアフラムごとに24箇所カットして測定(マイクロスコープ)した最大10個のパーティクルの平均を計算
- 実施日：2013/7/15
- 検査周期：ロット毎 3 Diaphragm
- 現行品の大きさ：176~265ミクロン
- パーテクルの数管理基準：無し

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 2-6_P7

Thickness control

- HSM 4point measurement T2 point, CMM, Shift, it is 2013/2/4~
- HSM past measurement point T3 point, per lot
- TRW measure T2 point by exclusive gage, 10 item per lot, 2013/2/26~
- Control properties and administration method for the mold abrasion / dimension precision variation of the mold.
- Mold maintenance period (abrasion confirmation) in every 100,000 shot
- Additional contents for control plan: Measure 30 diaphragm thickness measurement and OK confirmation every 100,000 shots
- Added contents to maintenance: Measure the model inside diameter, beat in every 100,000 shots
- Criteria: 0.85+-0.15 (schematic in TRW)
- Confirmation method: Cut and measure a diaphragm

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 2-6_P9

Particle control

- Control measure: 300 microns or less
- Confirmation method: Cut 24 points of a diaphragm and calculate the average of the maximum 10 particles measured (by microscope) per a diaphragm.
- Conducted day: 2013/7/15
- Inspection period: 3 diaphragms per lot
- Size of the current parts: 176~265 micron
- Control measure for Number of particle: No

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 2-7 Supplier Report 11 Jan 2013

COGNITIVE SAFETY SYSTEMS | TRW

Mazda J50C Booster Warranty

Update Slides

January 11, 2013
TRW Automotive

ADVANCED THINKING / SMART THINKING / GREEN THINKING

Agenda

1. Status of Root Cause Investigation/DOE
2. Accelerated Endurance Test Results and Performance Summary
3. TRW Position
4. EPDM change update
5. SBR tools update
6. Warranty Return Analysis Status
7. Details on accident and availability of returned part

RedX DOE Plan with 4wk shelf life added

	Factors	Description	Level 1	Level 2	Level 3	units	Supporting Evidence
Diaphragm Strength Factors	A	Shelf Life	Max (8)	4	Min (1)	Weeks	Hutchinson Experience
	B	Thickness	>1.3		<1.1	mm	TRW FEA analysis
	C	Particles	Hi (>90) HSM		Low (<10) New Suppliers	Count	Particles always present in tear surface
Energy Factors	D	Temperature	120 deg C			Celsius	Much higher failure rate in hot climates
	Noise	Unknown cause of non-random tear position					Tear angular position is non-random.

Plan from before

	Plan
1	Develop & evaluate accelerated evaluation test
2	Order diaphragm test configuration
3	Build booster assemblies
4	Complete Part 1 testing
5	Analyze & Publish Part 1 results
6	Complete Part 2 testing & publish results

		'A' Level 3 Min Shelf Life	A' Level 2 4 wk Shelf Life	'A' Level 1 Max Shelf Life	
-C HSM Current Particles	-B Thick	2.1	4.1	6.1	DOE Part 1
		2.2	4.2	6.2	
	+B Thin	1.1	3.1	5.1	
		1.2	3.2	5.2	
+C Rubena Few Particles	+B	7.1		8.1	DOE Part 2a
		7.2		8.2	
+C Daetwyler Few Particles	+B	9.1		10.1	DOE Part 2b
		9.2		10.2	

DOE Response is test time to initiate tear using new designed accelerated endurance test

Particles to be counted on additional samples from test parts batches, and on tested diaphragms post test

DOE Timing

DOE Phase	Test Order	A: Shelf Life	B: Thickness	C: Particles / Supplier	Qty	Supplier Lead Time	Estimated Test Completed Date	Wk ending	Estimated Test Completion date as of Jan 8th
Pre-DOE	0	Current Production			4	NA	Wk 46	11-Nov	Completed Dec 12
Part 1	1	1 wk	+(Thin)	- (Hi Count) / HSM	2	1 wk	wk 47	18-Nov	Completed Jan 7
	2	1 wk	- (Thick)		2	2 wks	wk 49	2-Dec	Completed Dec 28
	3	4 wk	+(Thin)		2	5 wks	wk 2	13-Jan	Parts starting test
	4	4 wk	- (Thick)		2	6 wks	wk 2	13-Jan	Parts starting test
	5	8 wks	+(Thin)		2	9 wks	wk 3	20-Jan	Expected Feb 18
	6	8 wks	- (Thick)		2	9 wks	wk 4	27-Jan	Expected Feb 18
Part 2a	7	+(1 wk or Min)	+(Thin)	+(Lo Count)/ Rubena	2	12 wks	wk 11	17-Mar	Expected Mar 28
	8	-(30 days Max)	+(Thin)		2	16 wks	wk 15	14-Apr	Expected Apr 28
Part 2b	9	+(1 wk or Min)	+(Thin)	+(Lo Count)/ Daetwyler	2	22 wks	wk 18	5-May	Expected May 17
	10	-(6 months)	+(Thin)		2	48 wks	wk 44	3-Nov	Expected Nov 15

Original DOE timing plan assumed Pre-DOE phase (Dev test) worked 1st time.
First new test method tried was not successful. Extra time to develop & evaluate a second test method delayed start of DOE testing approx. 3-4 weeks.

Summary: DOE Test Plan Status:

1. Develop & evaluate accelerated evaluation test
   Test Method 1: "Air pressure cycling" approach did not work out- difficulty sealing under pressure
   Test Method 2: "Modified endurance" Successful: Replicated failure mode in short time. **COMPLETED** Dec 12.

2. Order diaphragm test configurations
   COMPLETE: All test parts have been ordered from suppliers.

3. Build booster assembles
   ONGOING: Per plan as DOE diaphragms are received.

4. Complete Part 1 Testing
   IN PROGRESS:
   1 wk "thick" parts: **COMPLETE**
   1 wk "thin" parts: **COMPLETE** (note: cracked in different position)
   4 wk "thick parts: HSM shipped Jan 7, test completion expected Jan 16
   4 wk "thin parts: HSM shipped Jan 7, test completion expected Jan 16
   8wk "thick parts" Test completion expected Feb 18
   8 wk "thin parts" Test completion expected Feb 18

5. Analyze & publish Part 1 results
   Following completion of Part 1 testing: Expected Feb 25

6. Complete Part 2a Testing & publish results
   Following completion of Part 2a testing: Expected May 3

Accelerated Endurance Test Description

Test Details:

1. DOE diaphragm assembled into production booster at Livonia prototype
2. Assembled booster mounted vertically to test stand
3. Adjustable volume absorber connected to master cylinder
4. Vacuum source is 0.8 bar
5. The volume absorption characteristic for endurance testing is set so that 90% of the performance curve kneepoint occurs during 2/3 of the total stroke, with 0.8 bar vacuum. This adjustment takes place at test temperature.
6. Test Temperature is 120° C
7. Actuation frequency is 800 - 1200 cycles/hour.
8. Test automated with a programmable controller capable of setting the input force of the test stand, monitoring the output pressure of the duplex, tracking the cycle count of a single test, and suspending the test based on an output pressure fault exceeding a pre-determined limit (>=10 bar drop below target output pressure for 5 applies).

Booster mounted

Booster actuation

Test chamber

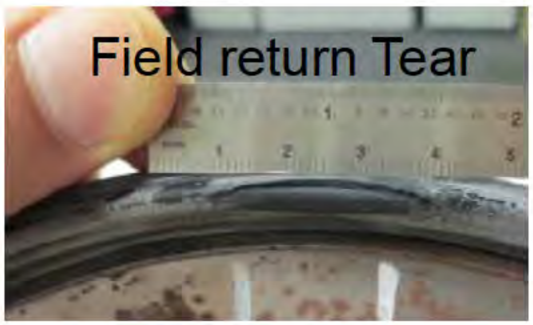
Accelerated Endurance Test- Baseline Results

Lab Accelerated Endurance test replicated field failure mode:

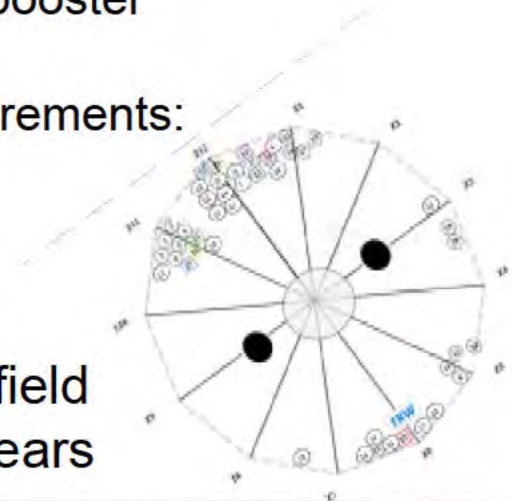
- Tear is in same region (on the highest stressed bend radius)
- Tears are in similar angular “clock” position relative to booster
- Similar tear lengths

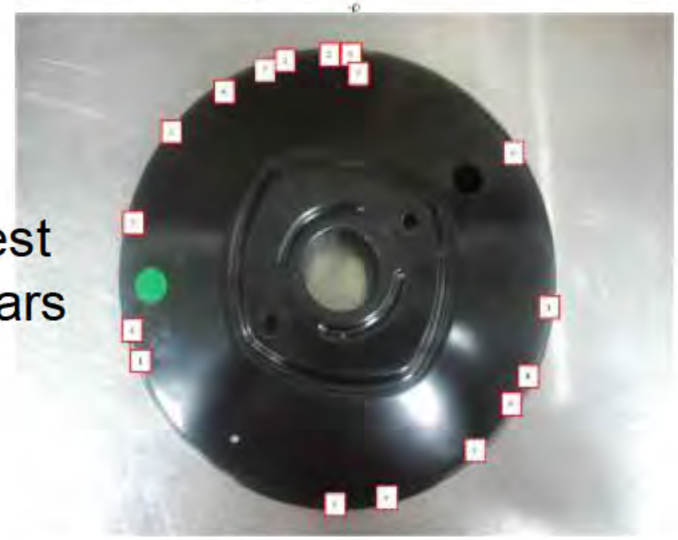
<u>Conclusion:</u> Lab Accelerated Endurance test meets requirements:

A. Accurately reproduces field return conditions
B. Can quickly produce tears (within 48 hours)


Field return Tear


Test produced Tear

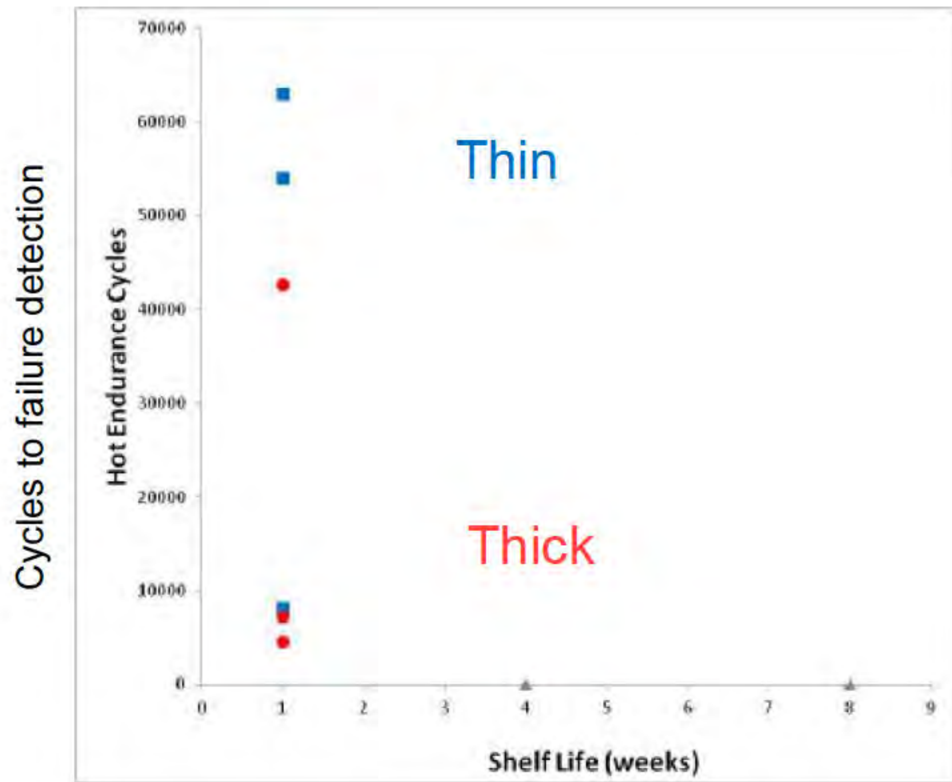

Position of field produced Tears


Position of test produced Tears

DOE Results - To Date

		'A' Level 3 Min Shelf Life	A' Level 2 4 wk Shelf Life	'A' Level 1 Max Shelf Life	
-C HSM Current Particles	-B Thick	4,575 cycles 7,145 cycles 42,629 cycles	Just Starting		DOE Part 1
	+B Thin	62,868 cycles * 54,025 cycles * 8,161 cycles *	Just Starting		

* Cracked near valve body



Tear Propagation Study

- **The intended objective of this testing is to provide evidence to answer the following questions:**
  - How does the tear in the booster diaphragm propagate?
  - What force change will the driver of the Mazda J50 experience to achieve a desired deceleration as a diaphragm tear propagates?
- **The approach to gather objective evidence is:**
  - Overstressing new diaphragms in a booster assembly by repeated input stroking at high input force with vacuum and at high temperature until tears form in the diaphragm and propagate. (Program A & B)
  - As the diaphragm tear propagates, the length of the tear is recorded and the associated booster performance is documented.
  - Additionally as reference samples, a tear in the diaphragm is manually generated in the region of the diaphragm where tears form and the associated booster performance is documented. (Program C)

Evaluation Procedure

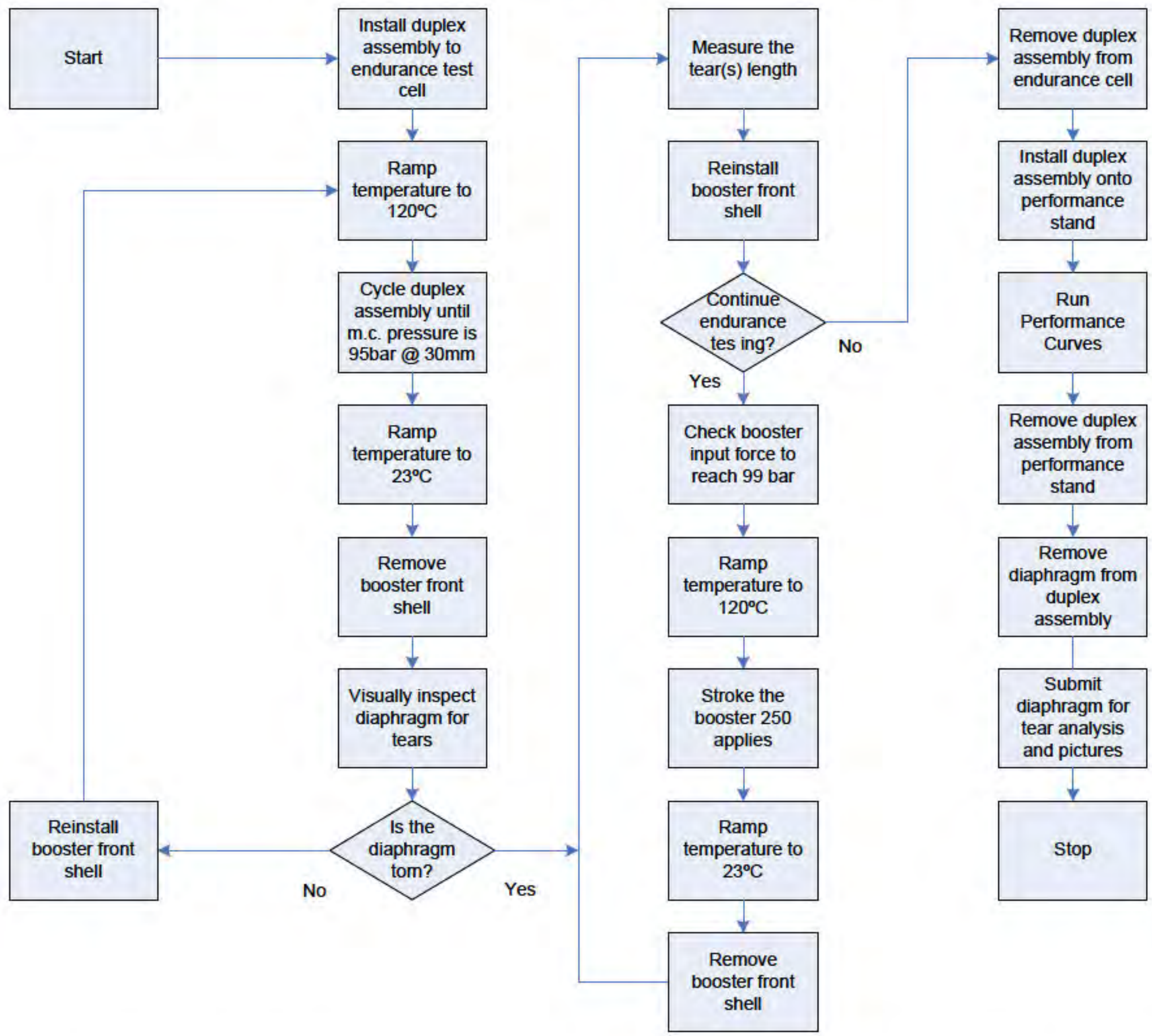
TRW

Program A: Accelerated High Temperature Test

- Mount duplex assembly on a suitable stroking test fixture that simulates vehicle brake pedal articulation angle
- Set brake fluid volume absorbers to achieve 90% of booster kneepoint pressure at 2/3 total master cylinder stroke (99 bar at 30 mm input stroke)
- Regulate vacuum source to booster at 800 mbar with 40 l reservoir
- Preheat environment chamber to a temperature of 120 +/- 5°C
- Apply input stroke at a rate of 20 +/- 10 bar/sec
- Run test at an apply cadence of 1000 +/- 100 cycles per hour
- Monitor master cylinder pressure; halt test once master cylinder pressure drops to 95 bar at 30 mm input stroke; visually inspect diaphragm
- Once a pressure drop is detected, reduce brake apply to 250 cycles visually inspecting diaphragm for tears every 250 brake applies
- Once diaphragm tear is visually confirmed, measure diaphragm tear length and input force to 99 bar master cylinder pressure

Evaluation Procedure

Program A: Accelerated High Temperature Test



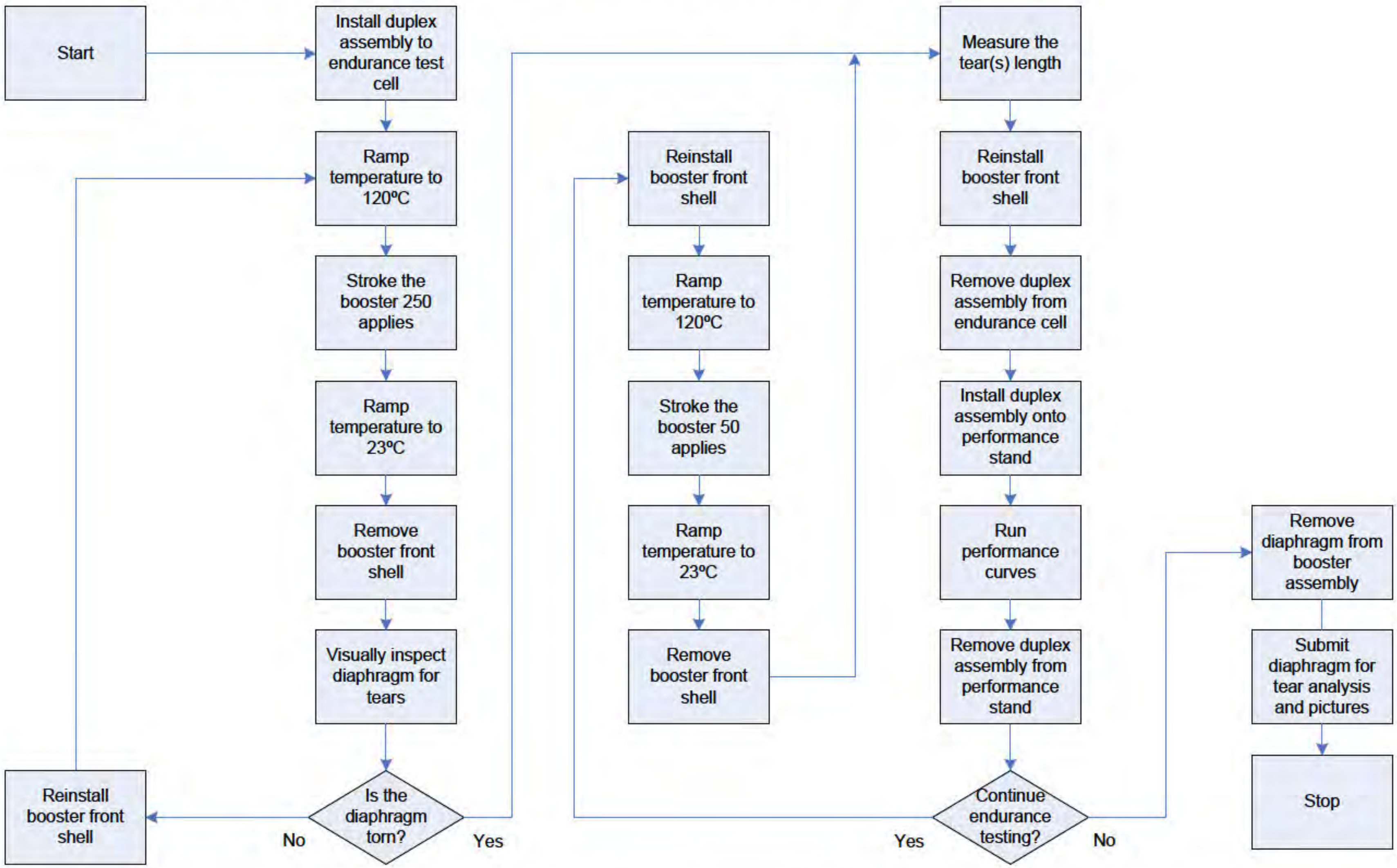
Evaluation Procedure

Program B: Accelerated High Temperature Test

- Retain test set up and parameters as in test program A
- *Delete*: halt test once master cylinder pressure drops to 95 bar at 30 mm input stroke and begin visual inspection of diaphragm
- *Add*: visually inspect diaphragm every 250 brake applies
- *Add*: once a diaphragm tear is visually confirmed, measure tear length and increase inspection frequency to every 50 brake applies.
- *Add*: after visual confirmation that a diaphragm tear has propagated through diaphragm section, remove the booster from the endurance stroking fixture, mount to the performance stand, and run a performance curve after each visual inspection

Evaluation Procedure

Program B: Accelerated High Temperature Test



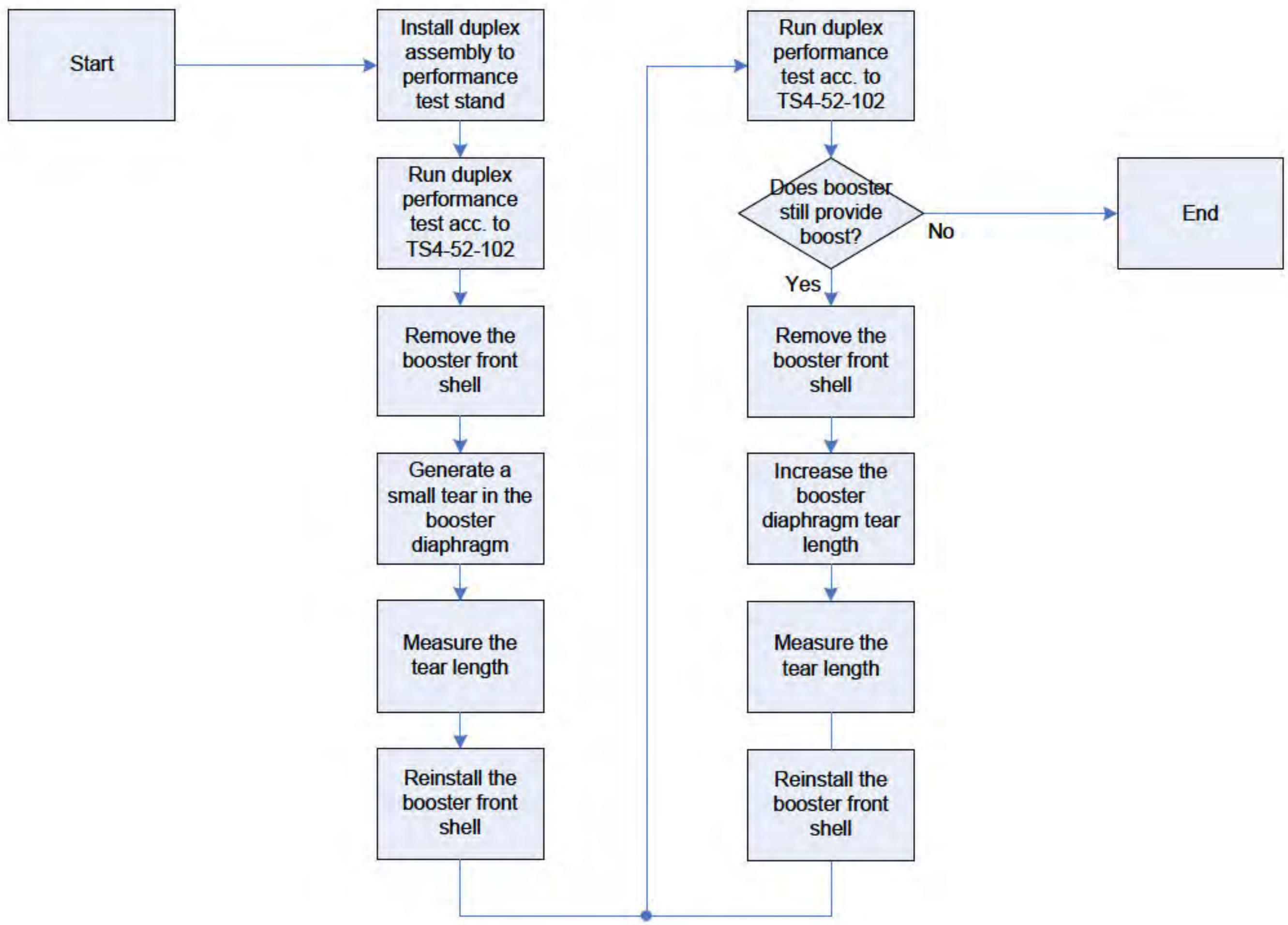
Evaluation Procedure

Program C: Manually Accelerated Test (Reference)

- Attach a duplex (booster and master cylinder assembly) containing a booster with a new diaphragm to the performance test rig and run a performance curve according to TS4-52-102.
- Remove the front shell from the booster assembly and create a small tear in the diaphragm using a sharp knife.
- Measure and record the length of the tear.
- Reinstall the booster front shell and re-run the performance curve according to TS4-52-102.
- Continue increasing the length of the tear at small increments, documenting the length, and repeating the performance measurement at each new tear length.
- Halt the test when the booster no longer has enough vacuum differential across the diaphragm to boost output.

Evaluation Procedure

Program C: Manually Accelerated Test (Reference)



Tear Propagation Study

- **Test Sample Summary:**

Sample ID	Part No	Rev Level	Section	Test Program	Status	Diaphragm Tears (Through Diaphragm Section)
0777-01	32484764	C	Thick	A*	halted	1 tear (28 mm) @ 2609 applies; submitted for material analysis
0777-02	32484764	C	Thick	A*	halted	2 tears (9, 34 mm) @ 17073 applies; submitted for material analysis
0800-01	32484764	C	Thick	A	halted	2 tears (16, 23 mm) @ 10000 applies; (19, 33 mm) @ 12271 applies
0800-02	32484764	C	Thick	A	halted	4 tears (9, 13, 13, 9 mm) @ 1038 applies; (19, 19, 15, 10 mm) @ 3309 applies
0800-03	32484764	F	Thin	A	halted	0 tears @ 4995 applies
0800-04	32484764	F	Thin	A	halted	0 tears @ 2518 applies
0800-05	32484764	C	Thick	A	halted	1 large tear (45 mm) @ 2030 applies
0800-06	32484764	C	Thick	B	halted	1 tear (15 mm) @ 1365 applies
0800-07	32484764	C	Thick	B	halted	1 tear (20 mm) @ 1182 applies

* Samples 0777-01 and 0777-02 were run to Test Program A, except halted after first visual inspection of diaphragm.

- **Program B:**
  - Master cylinder pressure drop from 99 to 95 bar prior to inspections did not allow for early detection of diaphragm tears when cycling at 1000 applies per hour.
  - After visually confirming initial diaphragm tear through the diaphragm section, the rate of diaphragm tear propagation requires smaller intervals (50 brake applies) to capture small changes in diaphragm tear length.

Tear Propagation Study

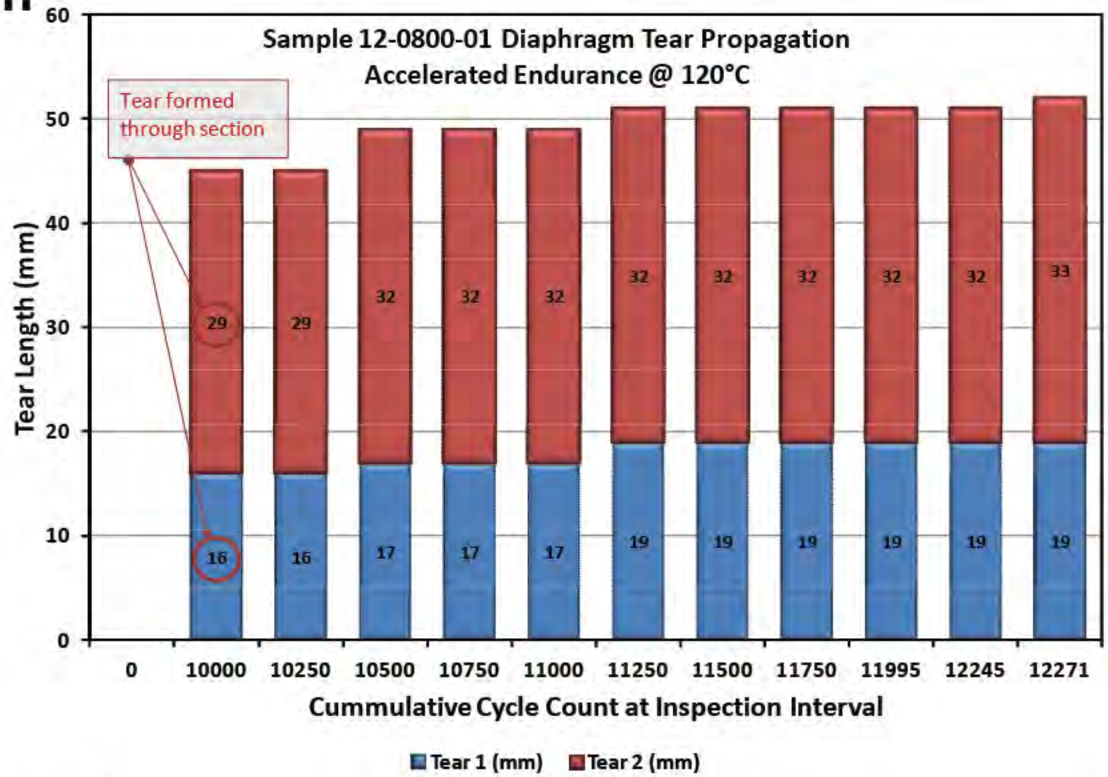
- **Diaphragm tear propagation summary**
  - Evaluation to determine propagation of diaphragm tears in accelerated endurance testing at 120°C
  - Hutchinson diaphragms, 32484764 Revision C, Tool 1 only)
  - Test programs A and B

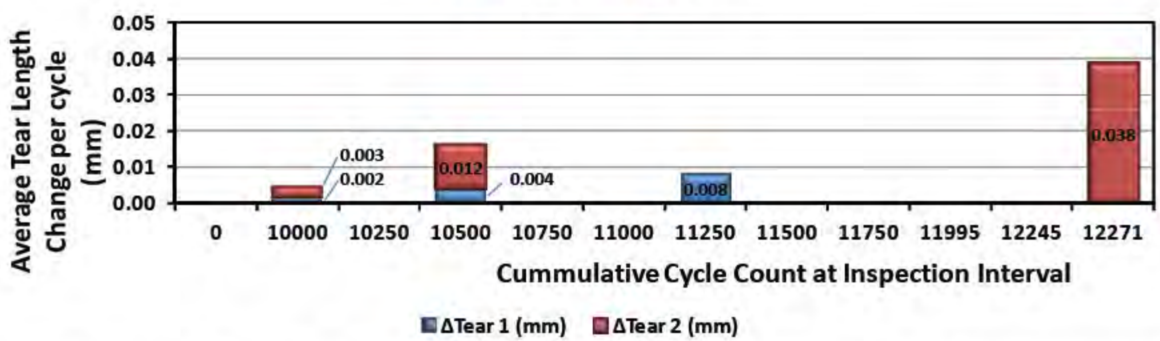
TRW Sample Number	Test Program	Tear Type	Observed Initial Tear Length (mm)	Tear Length at Test Conclusion (mm)	Max Tear Propagation Rate Noted (Average) (mm/cycle)	Apply Cycles When Initial Tear Noted (cycles)	Apply Cycles When Test Halted (cycles)
12-0800-01	A	Through	16	19	0.002 - 0.008	10000	12271
		Through	29	33	0.003 - 0.038	10000	12271
12-0800-02	A	Through	9	19	0.004 - 0.115	1038	3309
		Through	13	19	0.004 - 0.038	1038	3309
		Through	13	15	0.004 - 0.013	1038	3309
		Through	9	10	0.004 - 0.009	1038	3309
		Surface	1	1	0.004	1538	3309
12-0800-05	A	Through	45	45	1.731	2030	2030
12-0800-06	B	Surface	2	5	0.040 - 0.027	850	1365
		Surface	6	6	0.133	1365	1365
		Through	15	15	0.333	1365	1365
		Surface	7	7	0.156	1365	1365
12-0800-07	B	Through	20	20	0.444	1182	1182
		Surface	3	3	0.067	1182	1182

Tear Propagation Study

- **Diaphragm tear propagation**
  - Sample 12-0800-01
  - Test Program A
  - 2 through tears formed

Sample 12-0800-01		Diapharagm Tear Length		Change per Inspection Interval	
Type of Diaphragm Tear →		*Through*	*Through*	*Through*	*Through*
Inpspection Interval	Cummulative Cycles	Tear 1 (mm)	Tear 2 (mm)	ΔTear 1 (mm)	ΔTear 2 (mm)
0	0	0	0	–	–
10000	10000	16	29	0.002	0.003
250	10250	16	29	–	–
250	10500	17	32	0.004	0.012
250	10750	17	32	–	–
250	11000	17	32	–	–
250	11250	19	32	0.008	–
250	11500	19	32	–	–
250	11750	19	32	–	–
245	11995	19	32	–	–
250	12245	19	32	–	–
26	12271	19	33	–	0.038



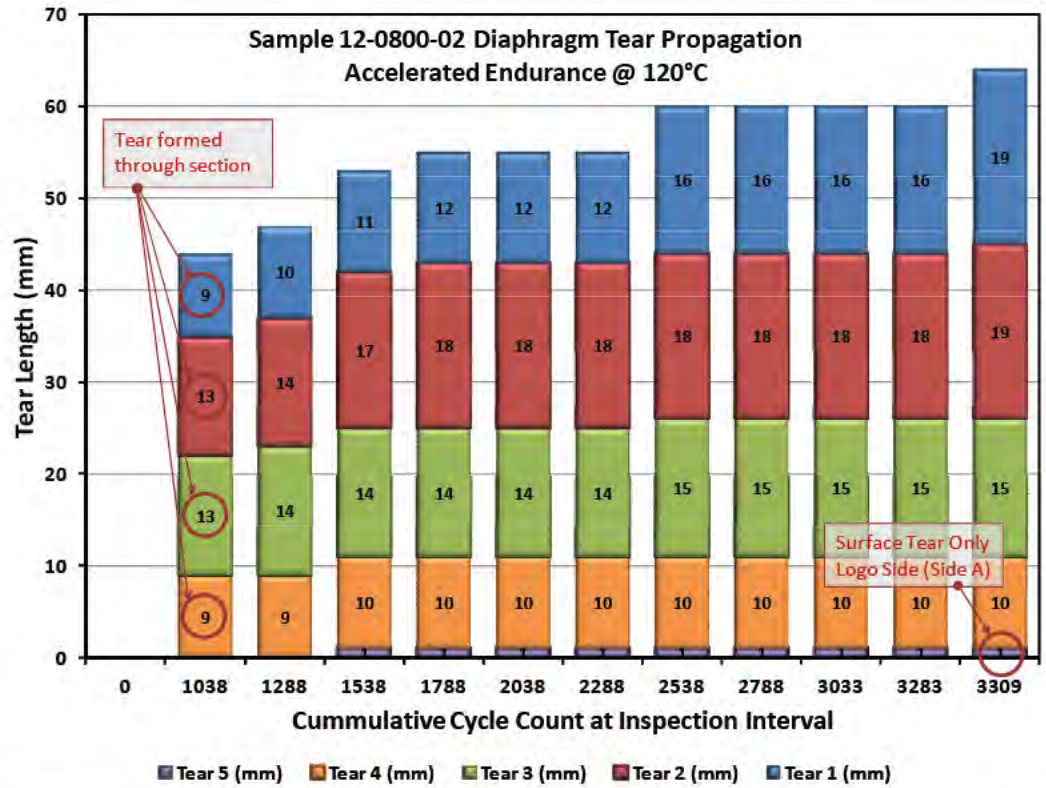


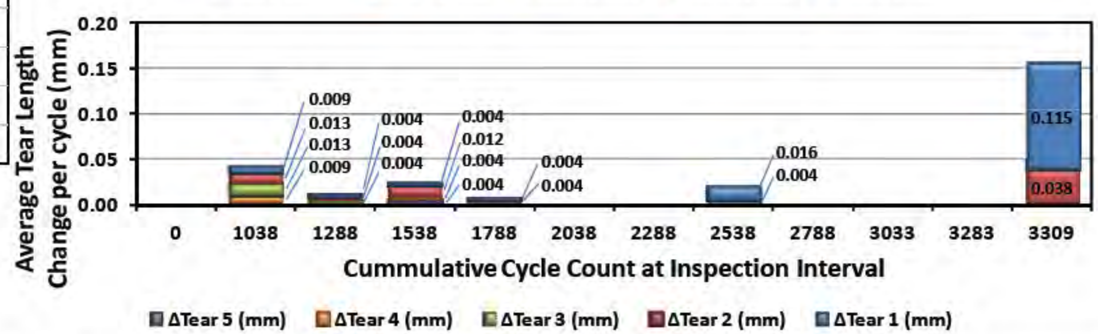
Tear Propagation Study

- **Diaphragm tear propagation**
  - Sample 12-0800-02
  - Test Program A
  - 4 through tears formed
  - 1 surface tear formed

Sample 12-0800-02

		Diapharagm Tear Length					Change per Inspection Interval				
Type of Diaphragm Tear →		*Through*	*Through*	*Through*	*Through*	*Surface*	*Through*	*Through*	*Through*	*Through*	*Surface*
Inpspection Interval	Cummulative Cycles	Tear 1 (mm)	Tear 2 (mm)	Tear 3 (mm)	Tear 4 (mm)	Tear 5 (mm)	ΔTear 1 (mm)	ΔTear 2 (mm)	ΔTear 3 (mm)	ΔTear 4 (mm)	ΔTear 5 (mm)
0	0										
1038	1038	9	13	13	9		0.009	0.013	0.013	0.009	
250	1288	10	14	14	9		0.004	0.004	0.004		
250	1538	11	17	14	10	1	0.004	0.012		0.004	0.004
250	1788	12	18	14	10	1	0.004	0.004			
250	2038	12	18	14	10	1					
250	2288	12	18	14	10	1					
250	2538	16	18	15	10	1	0.016		0.004		
250	2788	16	18	15	10	1					
245	3033	16	18	15	10	1					
250	3283	16	18	15	10	1					
26	3309	19	19	15	10	1	0.115	0.038			



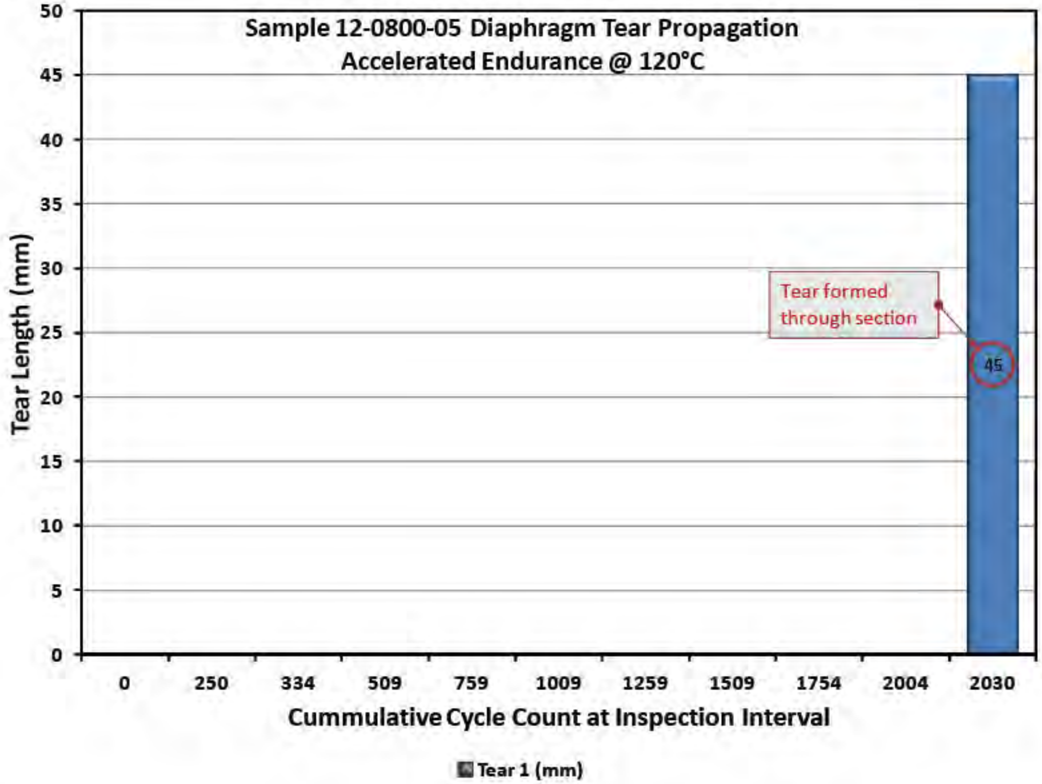


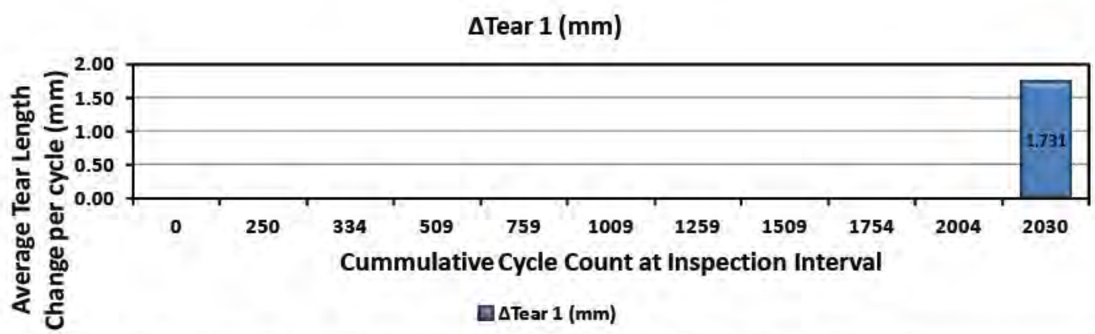
Tear Propagation Study

- **Diaphragm tear propagation**
  – Sample 12-0800-05
  – Test Program A
  – 1 through tear formed

Sample 12-0800-05

		Diaphragm Tear Length	Change per Insper
Type of Diaphragm Tear →		*Through*	*Through*
Inpspection Interval	Cummulative Cycles	Tear 1 (mm)	ΔTear 1 (mm)
0	0	–	–
250	250	–	–
84	334	–	–
175	509	–	–
250	759	–	–
250	1009	–	–
250	1259	–	–
250	1509	–	–
245	1754	–	–
250	2004	–	–
26	2030	45	1.731

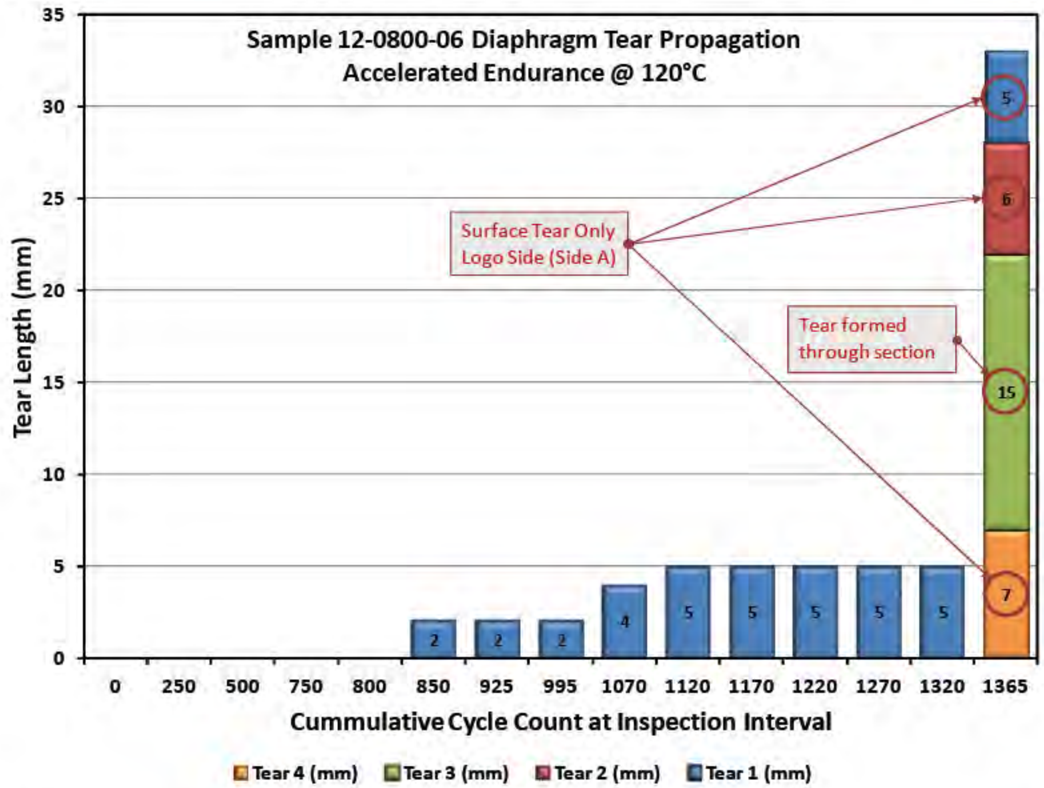


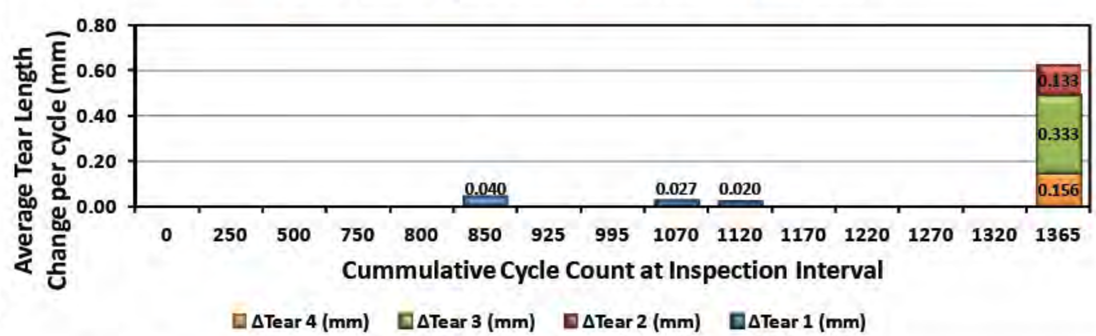


Tear Propagation Study

- **Diaphragm tear propagation**
  - Sample 12-0800-06
  - Test Program B
  - 1 through tear formed
  - 3 surface tears formed

Sample 12-0800-06		Diaphragm Tear Length				Change per Inspection Interval			
Type of Diaphragm Tear →		*Surface*	*Surface*	*Through*	*Surface*	*Surface*	*Surface*	*Through*	*Surface*
Inpspection Interval	Cummulative Cycles	Tear 1 (mm)	Tear 2 (mm)	Tear 3 (mm)	Tear 4 (mm)	ΔTear 1 (mm)	ΔTear 2 (mm)	ΔTear 3 (mm)	ΔTear 4 (mm)
0	0	–	–	–	–	–	–	–	–
250	250	–	–	–	–	–	–	–	–
250	500	–	–	–	–	–	–	–	–
250	750	–	–	–	–	–	–	–	–
50	800	–	–	–	–	–	–	–	–
50	850	2	–	–	–	0.040	–	–	–
75	925	2	–	–	–	–	–	–	–
70	995	2	–	–	–	–	–	–	–
75	1070	4	–	–	–	0.027	–	–	–
50	1120	5	–	–	–	0.020	–	–	–
50	1170	5	–	–	–	–	–	–	–
50	1220	5	–	–	–	–	–	–	–
50	1270	5	–	–	–	–	–	–	–
50	1320	5	–	–	–	–	–	–	–
45	1365	5	6	15	7	–	0.133	0.333	0.156

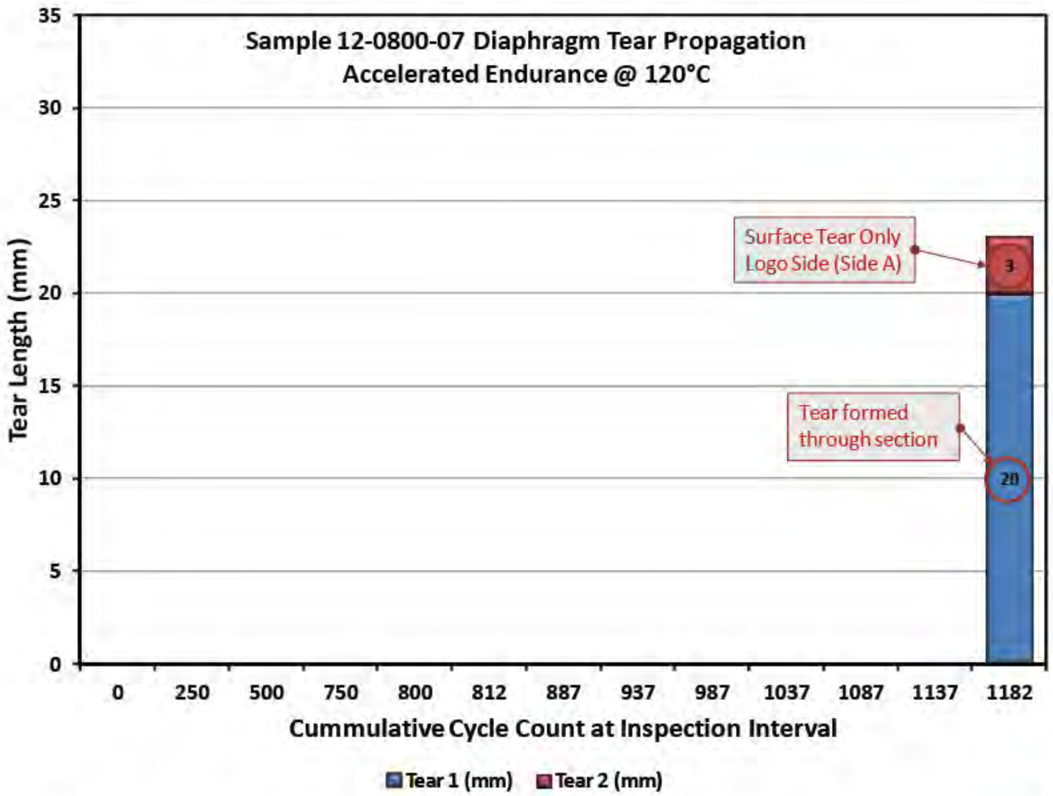


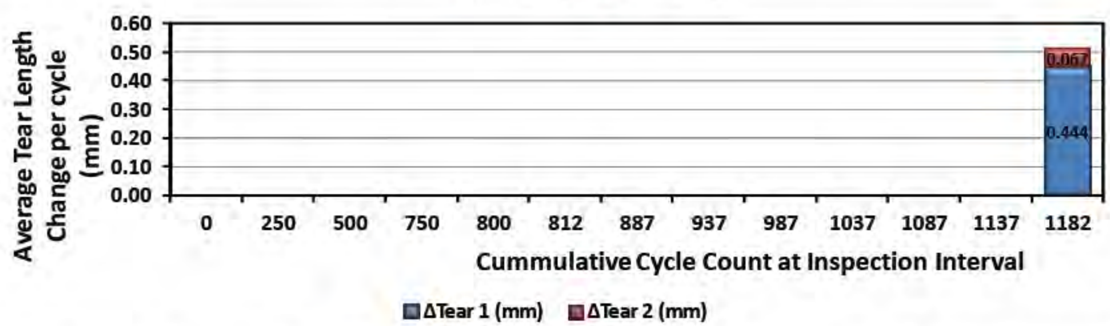


Tear Propagation Study

- **Diaphragm tear propagation**
  - Sample 12-0800-07
  - Test Program B
  - 1 through tear formed
  - 1 surface tear formed

Sample 12-0800-07		Diaphragm Tear Length		Change per Inspection Interval	
Type of Diaphragm Tear →		*Through*	*Surface*	*Through*	*Surface*
Inpspection Interval	Cummulative Cycles	Tear 1 (mm)	Tear 2 (mm)	ΔTear 1 (mm)	ΔTear 2 (mm)
0	0	–	–	–	–
250	250	–	–	–	–
250	500	–	–	–	–
250	750	–	–	–	–
50	800	–	–	–	–
12	812	–	–	–	–
75	887	–	–	–	–
50	937	–	–	–	–
50	987	–	–	–	–
50	1037	–	–	–	–
50	1087	–	–	–	–
50	1137	–	–	–	–
45	1182	20	3	0.444	0.067

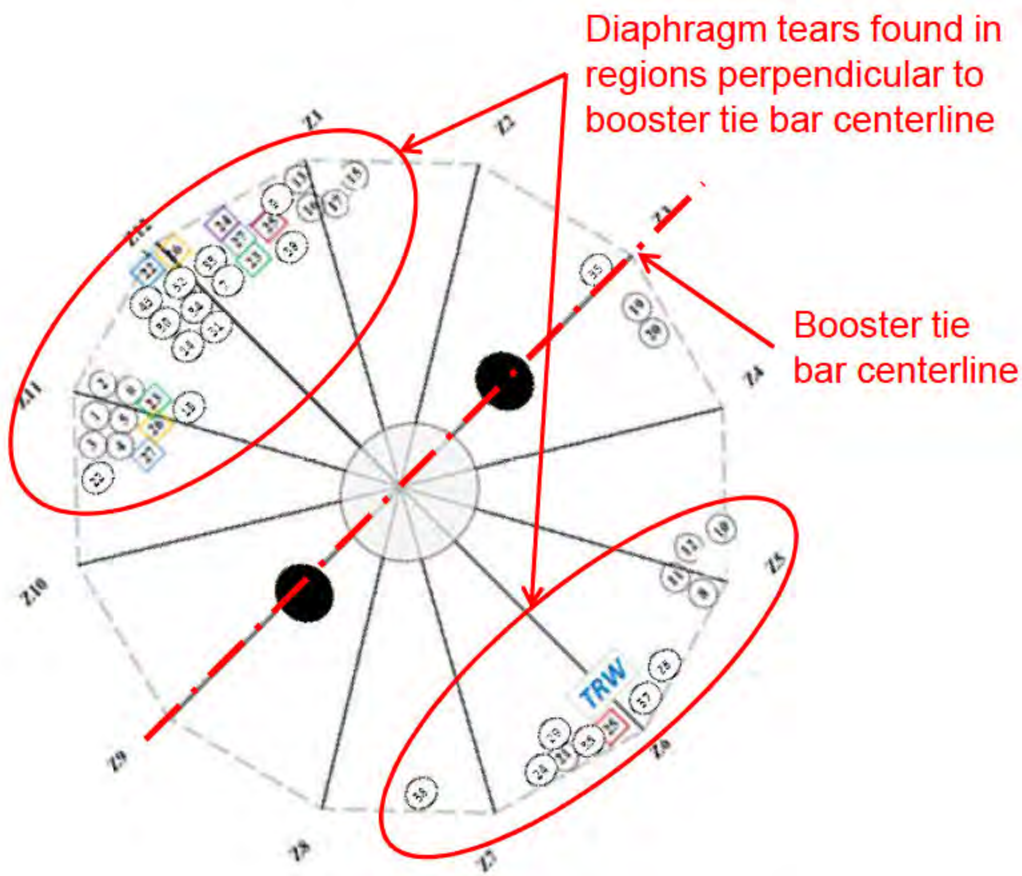




Tear Propagation Study

- **Diaphragm tear concentration diaphragm (warranty returns)**

Item	TRW reference Number	Failure legth mm
1	12-20581	32
2	12-21079	25
3	12-22470	25
4	12-23029	25
5	12-21238	25
6	12-20580	22
7	12-26042	35
8	12-20577	32
9	12-26055	25
10	12-21243	25
11	12-21242	25
12	12-21237	36
13	12-22478	25
14	12-26051	23
15	12-20579	27
16	12-21080	30
17	12-22474	31
18	12-26060	25
20	12-21241	21
21	12-22476	35
22	12-26049	24
23	12-21078	33/3
24	12-26052	34
25	12-20578	30/12
26	12-21244	20/24
27	12-22477	24/14
28	12-26038	26
29	12-26058	32
30	12-26048	24
31	12-26059	33
32	12-26040	25
33	12-26041	33
34	12-26061	30
35	12-26054	16
36	12-26043	24
37	12-26050	30
38	12-26053	25
39	12-26039	28



Location of tear relative to diaphragm shown

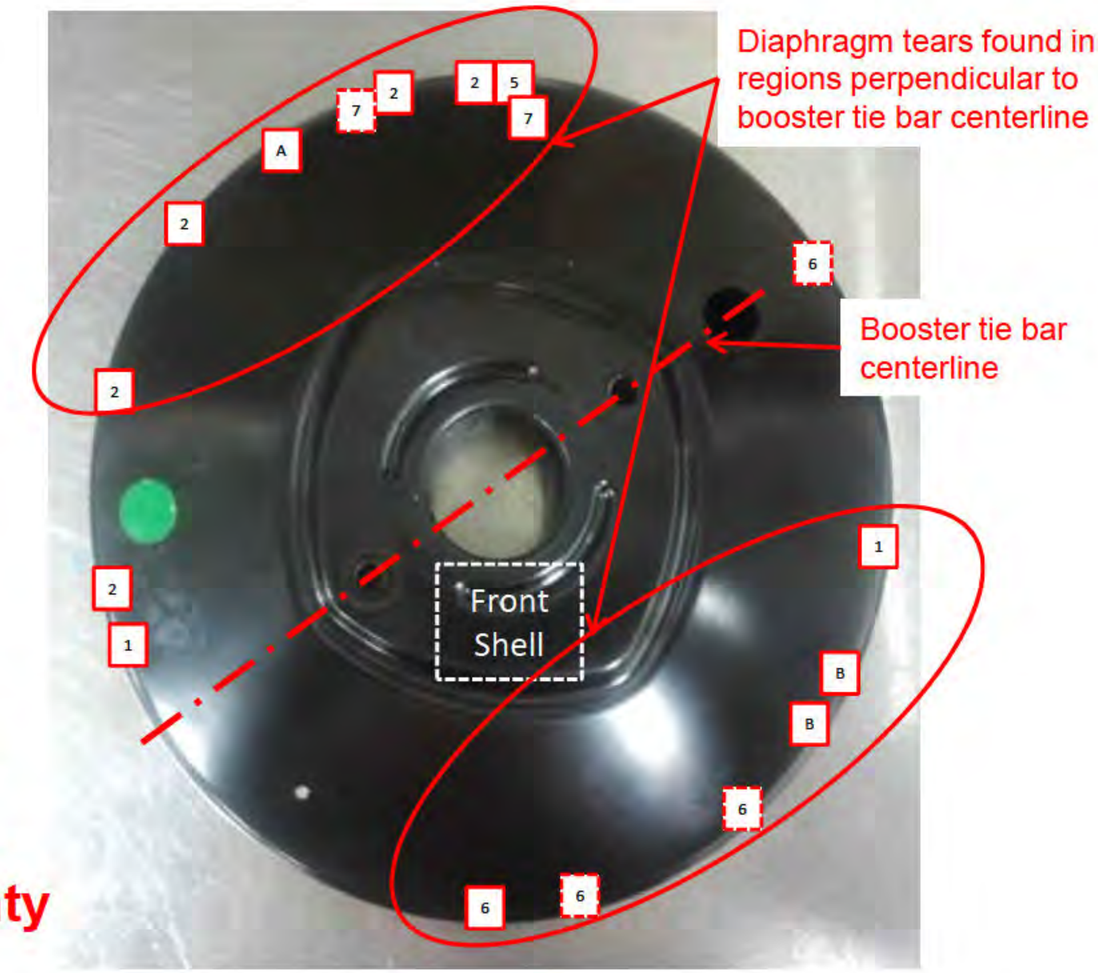
Tear Propagation Study

- **Diaphragm tear concentration diaphragm (from Tear Propagation Study)**

Legend

- A side (logo) only tear (dashed box)
- B side tear (solid box)

Label	Test Diaphragm ID	No. of Tears
A	12-0777-01	1
B	12-0777-02	2
1	12-0800-01	2
2	12-0800-02	5
5	12-0800-05	1
6	12-0800-06	1
7	12-0800-07	0



- **Conclusion: Diaphragm tear locations induced in propagation study mimic those found in the warranty return diaphragms.**

Tear Propagation Study

- **Shelf life of un-cured rubber for diaphragms used in this evaluation:**

Sample ID	Date Code	Shelf Life Range (Days)
0777-01	Oct-11	22 - 41
0777-02	Jun-11	13 - 29
0800-01	Oct-12	3 - 22
0800-02	Oct-12	3 - 22
0800-05	Oct-12	3 - 22
0800-06	Oct-12	3 - 22
0800-07	t.b.d.	t.b.d.

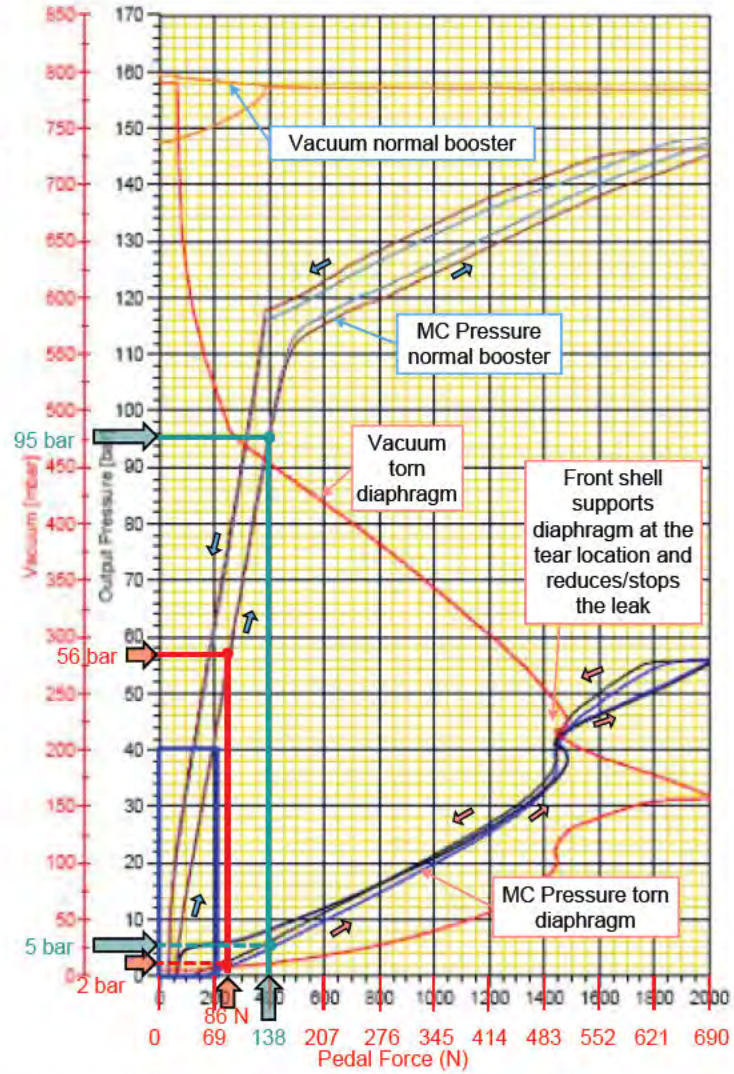
- **These parts have been received from different Santa Rosa production lots. It is possible to estimate shelf life range from the date code information on the diaphragms.**

Tear Propagation Study

- **Duplex performance with diaphragm 12-0800-01:**
  - 19 mm and 33 mm (through) tear lengths
  - Cumulative tear length (through) 52 mm

Apply Type	Pedal Force	Booster Input Force	Master Cylinder Pressure Torn Diaphragm	Master Cylinder Pressure Normal Booster	Pressure Reduction	Pressure Reduction
Low Force	86 N	200 N	2 bar	56 bar	54 bar	96%
High Force	138 N	450 N	5 bar	95 bar	90 bar	95%

Booster12-0800-01 with 800 mbar vacuum (isolated) and apply rate 4.5 mm/sec at input rod

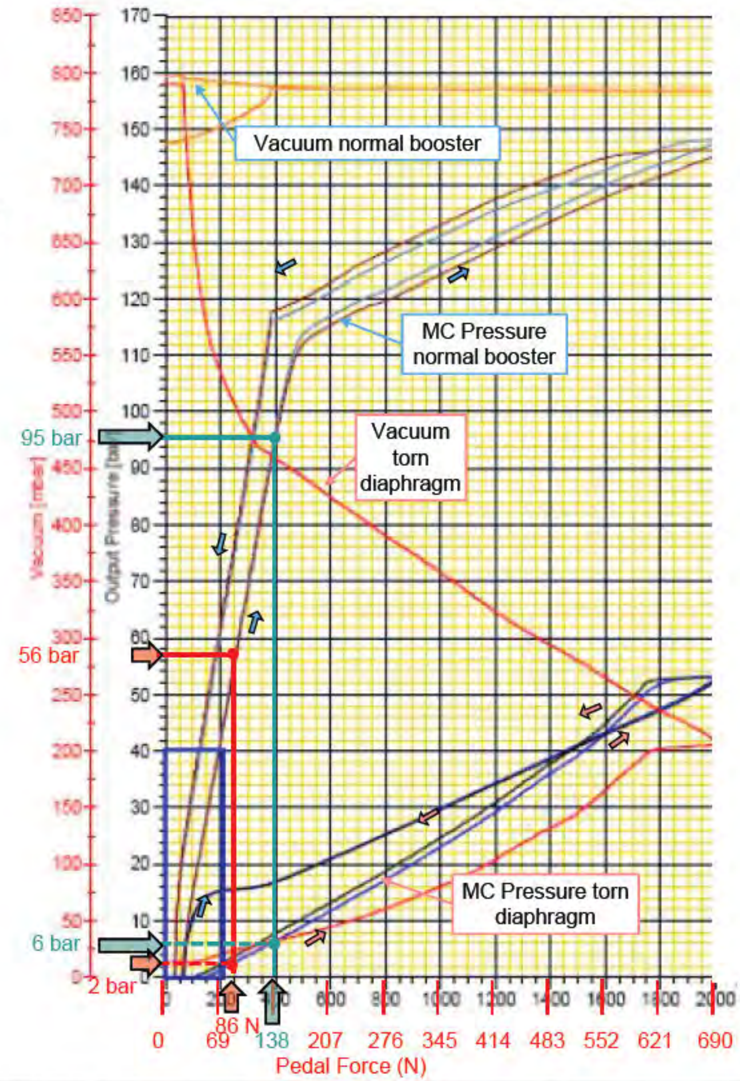


Tear Propagation Study

- **Duplex performance with diaphragm 12-0800-02:**
  - 10 mm, 15 mm, 19 mm, and 19 mm (through), and 1 mm (surface) tear lengths
  - Cumulative tear length (through) 63 mm

Apply Type	Pedal Force	Booster Input Force	Master Cylinder Pressure Torn Diaphragm	Master Cylinder Pressure Normal Booster	Pressure Reduction	Pressure Reduction
Low Force	86 N	200 N	2 bar	58bar	54bar	96%
High Force	138 N	450 N	6 bar	95 bar	89 bar	93%

Booster12-0800-02 with 800 mbar vacuum (isolated) and apply rate 4.5 mm/sec at input rod

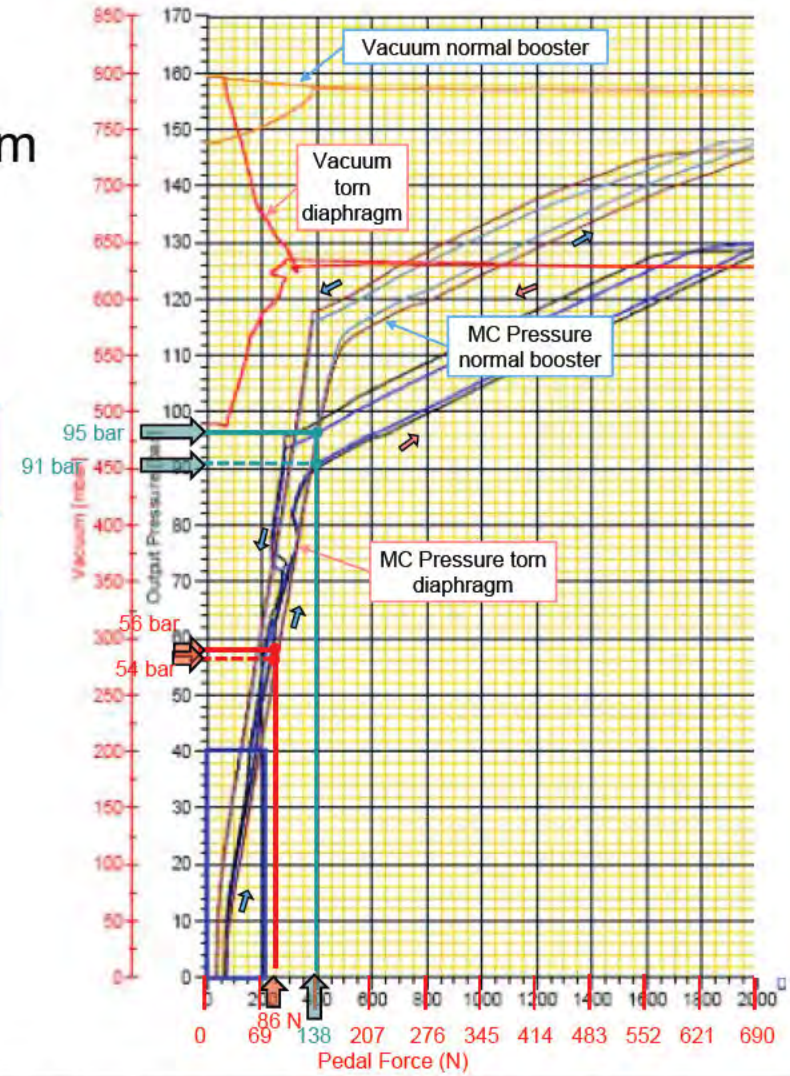


Tear Propagation Study

- **Duplex performance with diaphragm 12-0800-06:**
  - 16 mm (through), 6 mm, 7 mm, and 8 mm (surface) tear lengths
  - Cumulative tear length (through) 16 mm

Apply Type	Pedal Force	Booster Input Force	Master Cylinder Pressure Torn Diaphragm	Master Cylinder Pressure Normal Booster	Pressure Reduction	Pressure Reduction
Low Force	86 N	200 N	54 bar	56bar	2bar	4%
High Force	138 N	450 N	91 bar	95 bar	4 bar	4%

Booster12-0800-06 with 800 mbar vacuum (isolated) and apply rate 4.5 mm/sec at input rod

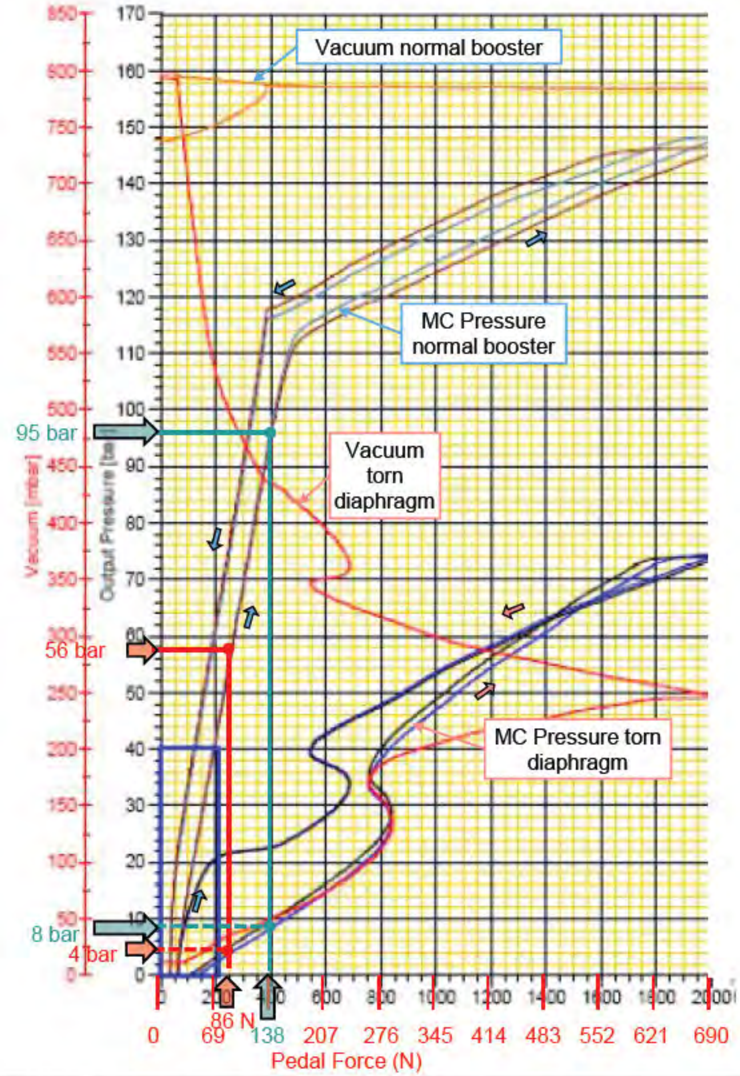


Tear Propagation Study

- **Duplex performance with diaphragm 12-0800-07:**
  - 20 mm (through), 3 mm (surface) tear lengths

Apply Type	Pedal Force	Booster Input Force	Master Cylinder Pressure Torn Diaphragm	Master Cylinder Pressure Normal Booster	Pressure Reduction	Pressure Reduction
Low Force	86 N	200 N	4 bar	58bar	52 bar	93%
High Force	138 N	450 N	8 bar	95 bar	87 bar	92%

Booster12-0800-07 with 800 mbar vacuum (isolated) and apply rate 4.5 mm/sec at input rod



Tear Propagation Study

- **Conclusions**
  - Overstressing new diaphragms in a booster assembly by repeated input stroking at high input force with vacuum and at high temperature until tears form in the diaphragm and propagate produces diaphragm tears similar to those found in warranty returns and in similar locations on the diaphragm.
  - Diaphragm tears tend to form and propagate along surface of the diaphragm before propagating through the section of the diaphragm:
    - Tear #1 in sample 12-0800-06 propagated from 2 mm to 5 mm without propagating through the section with approximately 600 brake applies under test conditions.
  - Variation in tear propagation rates is significant in the samples evaluated in this procedure:
    - Tear propagation rates were between 0.002 and1.731 mm/apply.

Tear Propagation Study

- **Results from Program C (reference)**
  - Manual diaphragm tear propagation
  - Evaluation to identify driver force input change as diaphragm tear propagates
  - Tear initiated manually from 3 mm to 50 mm

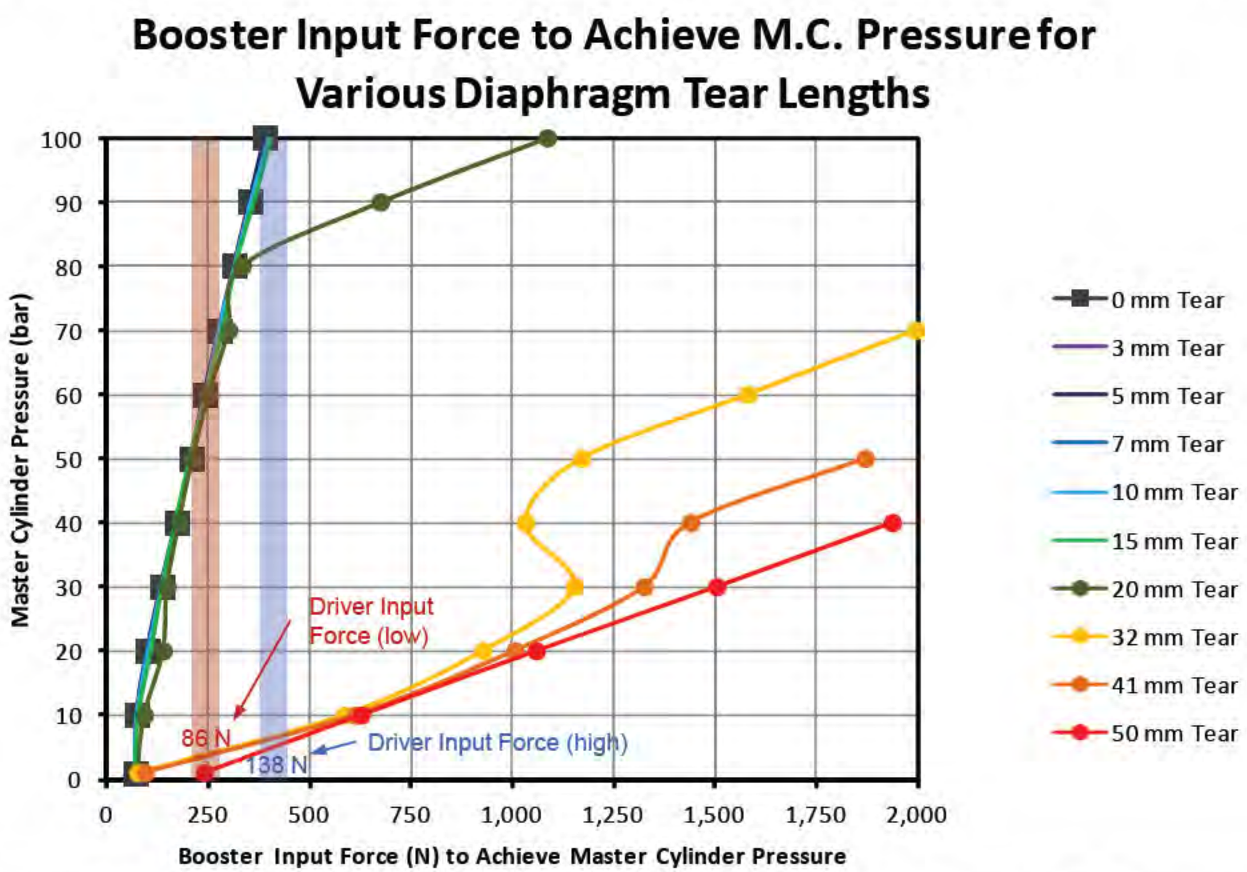
Tear Length (mm)	Vacuum Level @ F_{IN_0} (mbar)	Vacuum Level @ F_{IN_250} (mbar)	Vacuum Level @ F_{IN_400} (mbar)	Vacuum Level @ F_{IN_KP} (mbar)	Pressure @ $F_{IN\ 250}$ (bar)	Pressure @ $F_{IN\ 400}$ (bar)	$F_{IN\ KP}$ (N)	Pressure @ $F_{IN\ KP}$ (bar)	$F_{IN\ THRES}$ @ 1 bar MC Pressure (N)	F_{IN} to Achieve 30 bar M.C. Pressure (N)	F_{IN} to Achieve 60 bar M.C. Pressure (N)	F_{IN} to Achieve 100 bar M.C. Pressure (N)
0	795	788	785	783	63	102	457	117.7	68.5	134	242	390
3	794	787	784	783	63	102	457	117.8	67.9	132	241	391
5	799	789	786	785	63	102	457	117.7	68.7	134	240	390
7	793	780	777	776	63	102	453	116.3	68.6	135	242	398
10	798	776	773	772	62	102	453	116.5	67.5	134	242	398
15	797	729	720	719	61	100	420	106.2	70.0	138	245	406
20	797	592	581	580	61	84	545	88.0	72.3	147	250	1085
32	794	486	447	234	6	8	1080	46.6	76.2	1152	1580	–
41	791	461	421	191	3	6	960	38.6	93.4	1324	–	–
50	794	443	385	0	1	6	238	11.7	238.4	1503	–	–

2 mm Tear

50 mm Tear

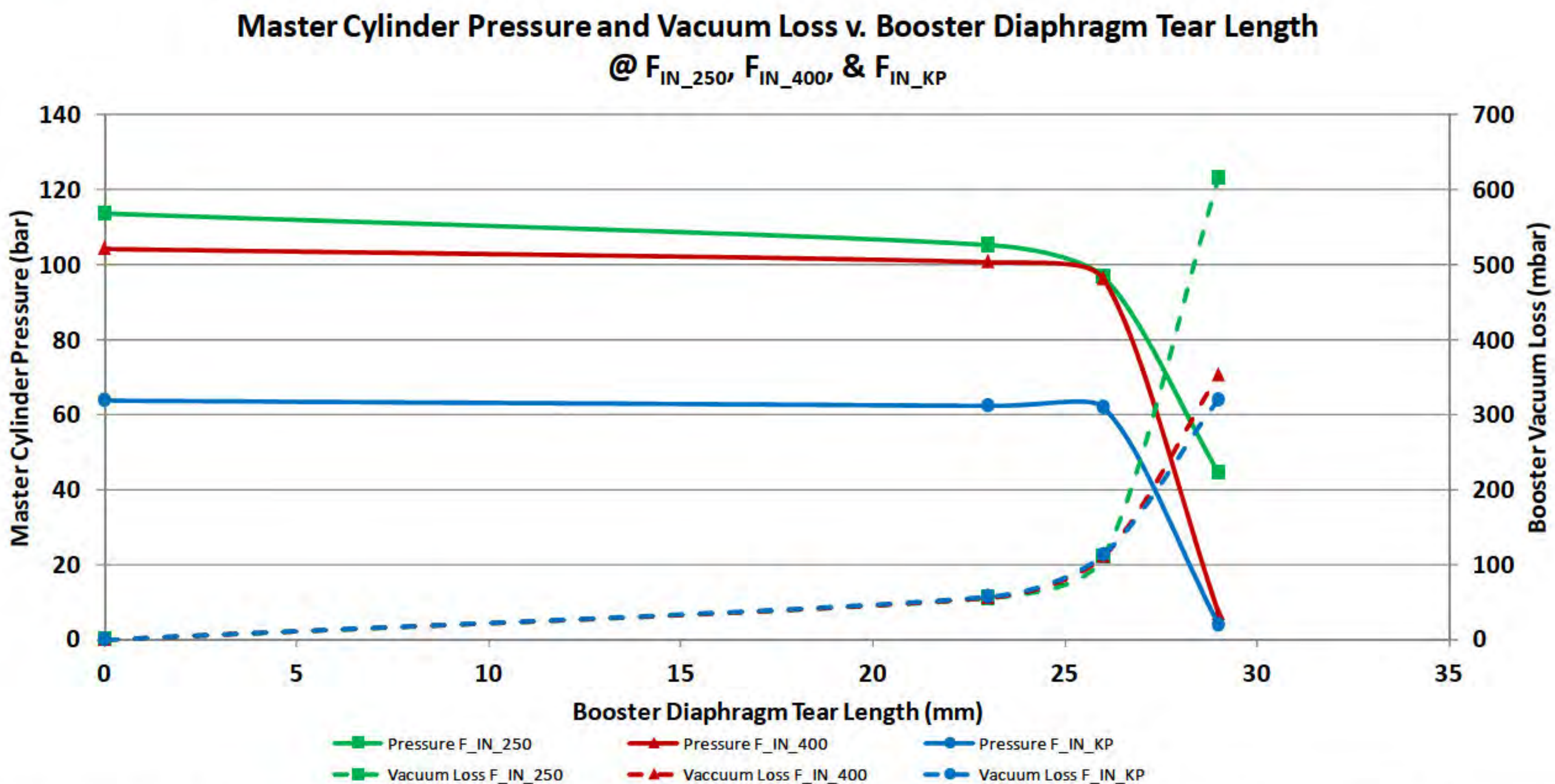
Tear Propagation Study

- **Results from Program C (reference)**
  - Driver notices increase in pedal apply forces
    - ~ 32 mm diaphragm tear light apply force (86 N pedal force)
    - ~ 20 mm diaphragm tear high apply force (138 N pedal force)



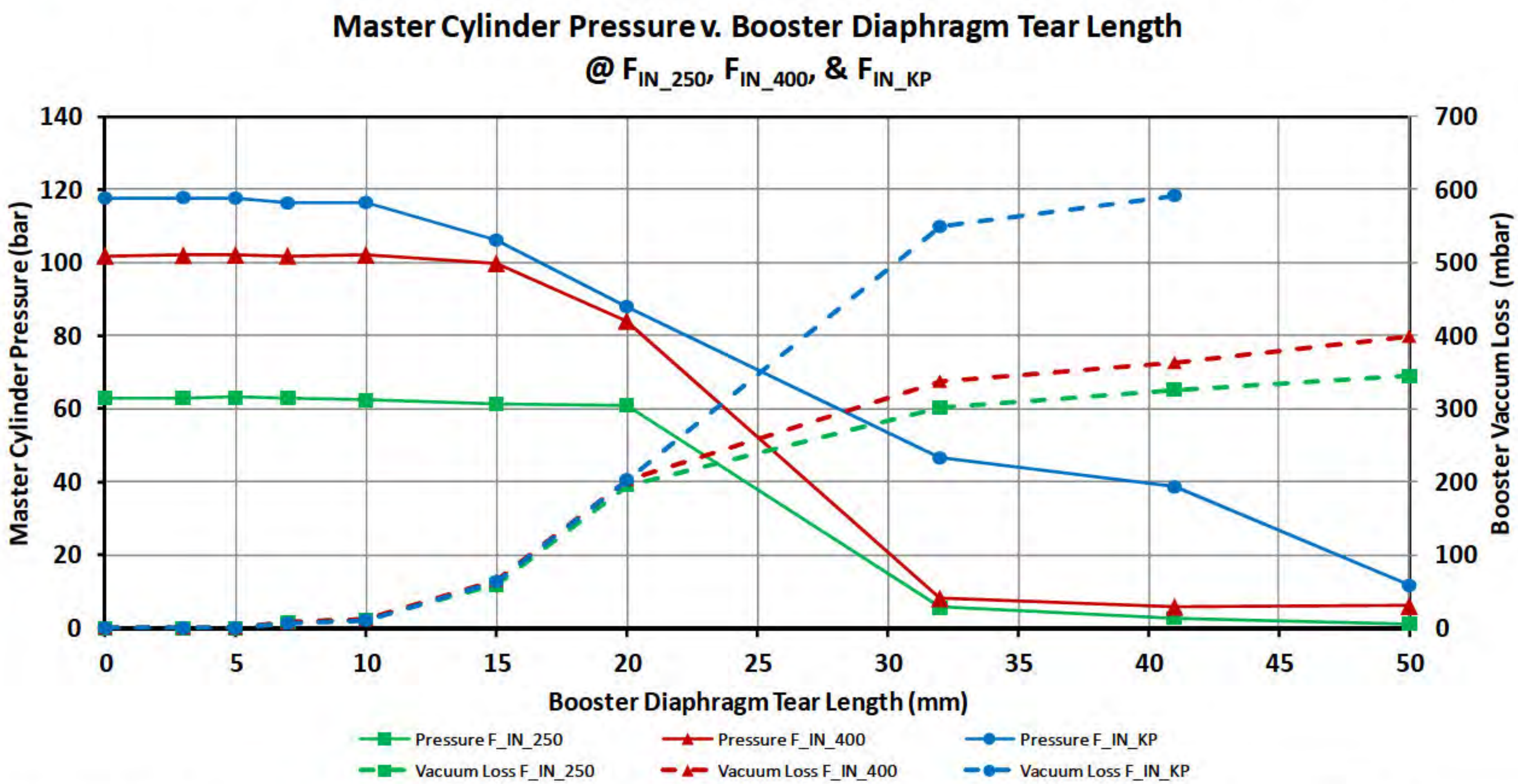
Tear Propagation Study

- **Results from Program C (reference)**
  - Manual diaphragm tear propagation
  - Diaphragm tear between 20 mm and 29 mm
  - Low force apply 250 N (86 N Pedal) and high force apply 400 N (138 N Pedal)



Tear Propagation Study

- **Results from Program C (reference)**
  - Manual diaphragm tear propagation
  - Diaphragm tear lengths from 0 mm to 50 mm
  - Low force apply 250 N (86 N Pedal) and high force apply 400 N (138 N Pedal)

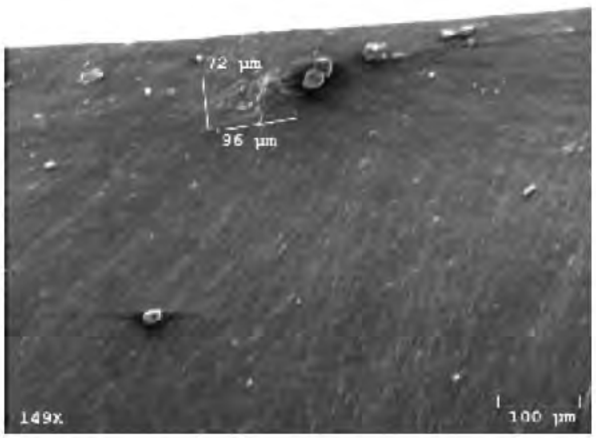


Tear Propagation Study

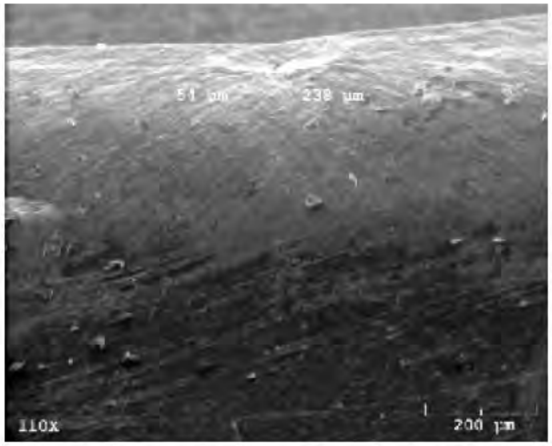
- **Conclusions from manual tear propagation**
  - Diaphragm tears up to 15 mm in length have minimal influence on the booster assembly boost function.
  - Diaphragm tears over 15 mm and under 30 mm in length:
    - Affect the booster assembly boost function.
    - Can be detected with an increase in braking force to achieve a master cylinder pressure under low and high brake force applications.
  - Diaphragm tears over 40 mm in length result in total loss of booster assembly boost function.

Tear Propagation Study

- **Tear Analysis: Particle Sizes Located at Tear Origins**
  - Diaphragm 12-0800-01
  - 19 mm and 33 mm (through) tear lengths



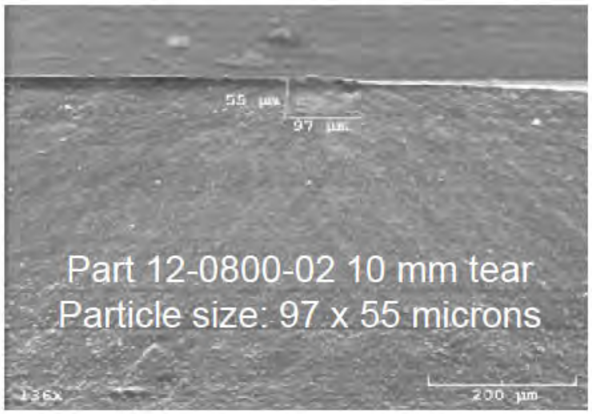
Part 12-0800-01 19 mm tear
Particle size: 96 x 72 microns

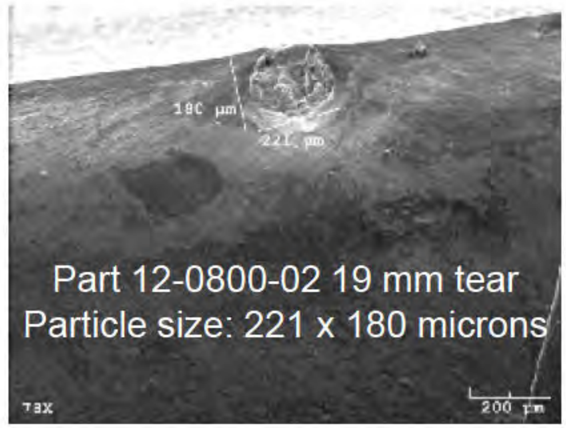


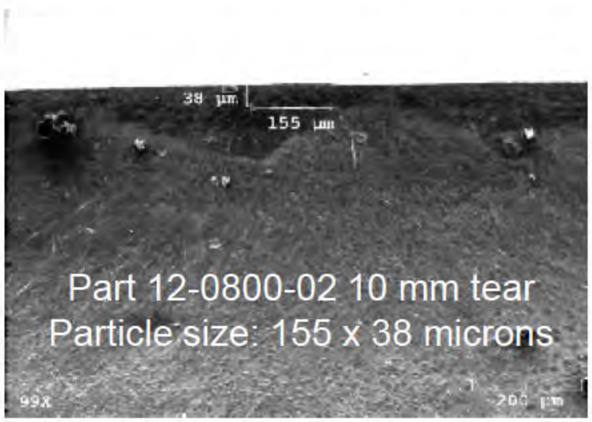
Part 12-0800-01 33 mm tear
Particle size: 238 x 54 microns

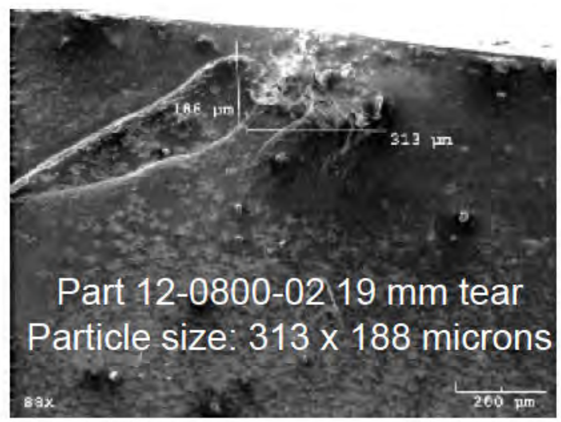
Tear Propagation Study

- **Tear Analysis: Particle Sizes Located at Tear Origins**
  - Diaphragm 12-0800-02
  - 10, 15, 19, and 19 mm (through), and 1 mm (surface) tear lengths



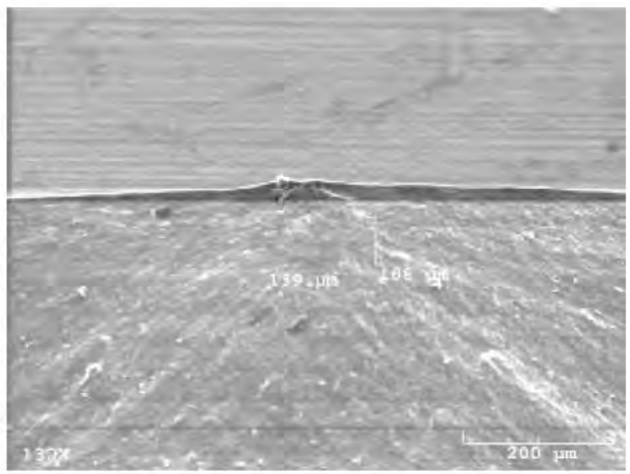






Tear Propagation Study

- **Tear Analysis: Particle Sizes Located at Tear Origins**
  - Diaphragm 12-0800-05
  - 45 mm (through) tear length



Part 12-0800-05 45 mm tear
Particle size: 139 x 108 microns

TRW Position and Warranty Extension

- Based on the TRW Engineering Analysis, TRW believes that diaphragm tears are not a safety critical issue. The driver will become aware of a hard pedal feel, which will give sufficient warning of an issue with the brake actuation.

As a gesture of good will and to cover any potential additional costs associated with a tear in the diaphragm;

TRW will increase warranty coverage to 3 years / 60k km for the following claim conditions:

- Vehicle: J50C
- Warranty Claim: Booster Diaphragm Tear
- Region: Middle East (specifically Saudi Arabia, Iran, Kuwait, United Arab Emirates, Oman, Qatar, Syria, Sri Lanka, Bahrain, Jordan, Lebanon, Nepal, Turkey, Cyprus, Israel)
- MY 2012 Spike Months: July 2011 thru March 2012 Vehicle Build

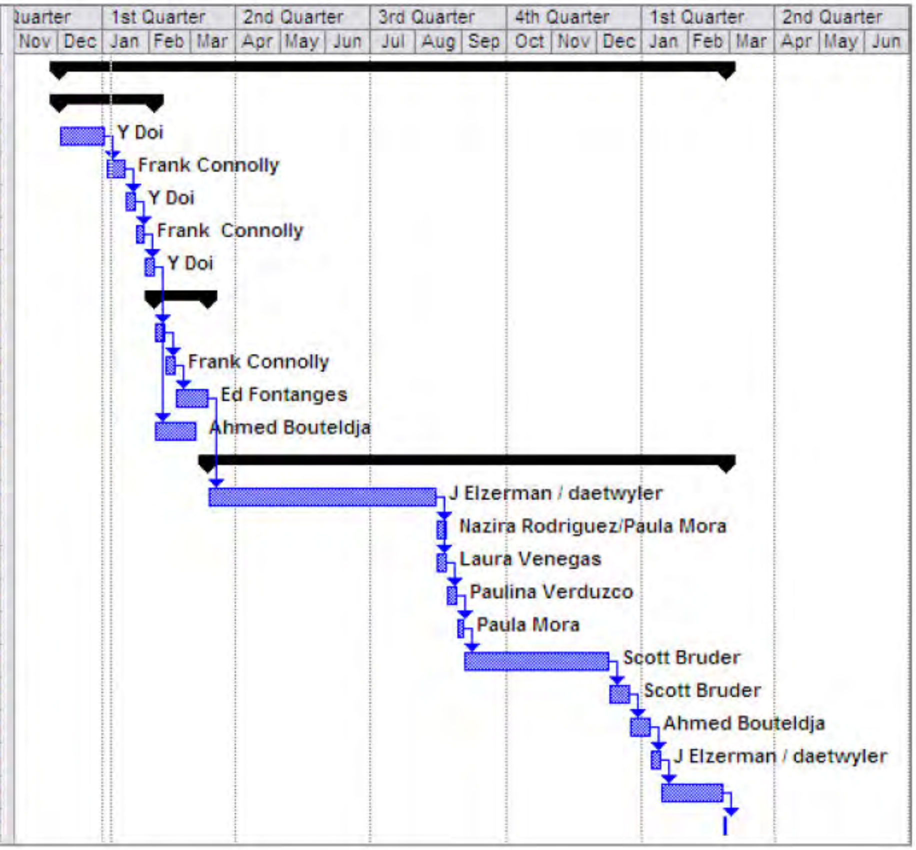
Material Property Change: EPDM vs. SBR Rubber Heat Aging 70 hours at 120ºC

Material Property	Hutchinson SBR Change After Heat Aging	Rubena SBR Change After Heat Aging	Daetwyler 440351 SBR Change After Heat Aging	Daetwyler EPDM Change After Heat Aging
Hardness (IRHD)	+6.9	+8.1	+7.7	+0.2
Tensile Strength	-18%	+3%	-5%	-4%
Elongation	-48%	-33%	-33%	+2%
20% Modulus	+75%	+71%	+59%	-2%
50% Modulus	+87%	+87%	+77%	-2%
100% Modulus	+109%	+95%	+87%	-2%

EPDM Change

- Timing driven by three items: Tool production (22 wks), PV testing (14 wks), and parts shipment (6 wks)
- Current status-Cost and timing submitted to TRW Sales (Y. Doi)
- Plan for SOP at Mazda 27Feb 2014

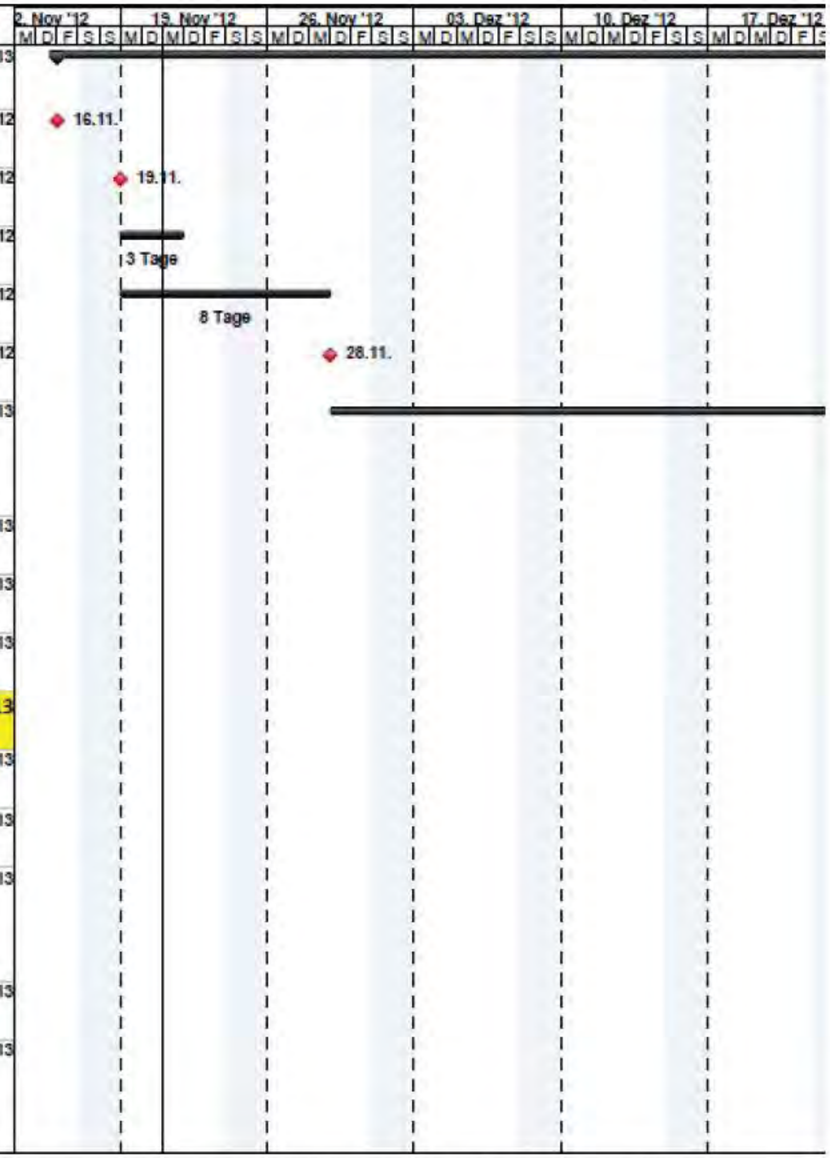
		Task Name	Duration	Start	Finish
1		- EPDM Diaphragm	323.5 days	Mon 12/3/12	Thu 2/27/14
2		- Quoting	45.5 days	Mon 12/3/12	Mon 2/4/13
3		RFQ from Mazda	4.5 wks	Mon 12/3/12	Wed 1/2/13
4		Quote to Mazda	2 wks	Wed 1/2/13	Wed 1/16/13
5		Mazda review and response	1 wk	Wed 1/16/13	Wed 1/23/13
6		TRW review	3 days	Wed 1/23/13	Mon 1/28/13
7		Mazda agrement	1 wk	Mon 1/28/13	Mon 2/4/13
8		- Kick off	27 days	Mon 2/4/13	Wed 3/13/13
9		receive tooling PO from Mazda	1 wk	Mon 2/4/13	Mon 2/11/13
10		Approval of funding / Account No	1 wk	Mon 2/11/13	Mon 2/18/13
11		Issue POCN / PO & Provide 3 D Model	17 days	Mon 2/18/13	Wed 3/13/13
12		CR for diapgragm and duplexes	4 wks	Mon 2/4/13	Mon 3/4/13
13		- Productionization	251 days	Wed 3/13/13	Thu 2/27/14
14		Tool Production & Sample Production	22 wks	Wed 3/13/13	Wed 8/14/13
15		Sample Shipment	1 wk	Wed 8/14/13	Wed 8/21/13
16		PPAP Approval	1 wk	Wed 8/14/13	Wed 8/21/13
17		Build Assemblies at SR	1 wk	Wed 8/21/13	Wed 8/28/13
18		Ship to Livonia	3 days	Wed 8/28/13	Mon 9/2/13
19		PV Testing & Paperwork	14 wks	Mon 9/2/13	Mon 12/9/13
20		Test Report	2 wks	Mon 12/9/13	Mon 12/23/13
21		Customer Approval	2 wks	Mon 12/23/13	Mon 1/6/14
22		Production SOP On New Tool	1 wk	Mon 1/6/14	Mon 1/13/14
23		Shipment to Mazda	6 wks	Mon 1/13/14	Mon 2/24/14
24		SOP at Mazda	3 days	Mon 2/24/14	Thu 2/27/14



SBR Tooling Status – Datwyler

- SBR tooling on time per schedule

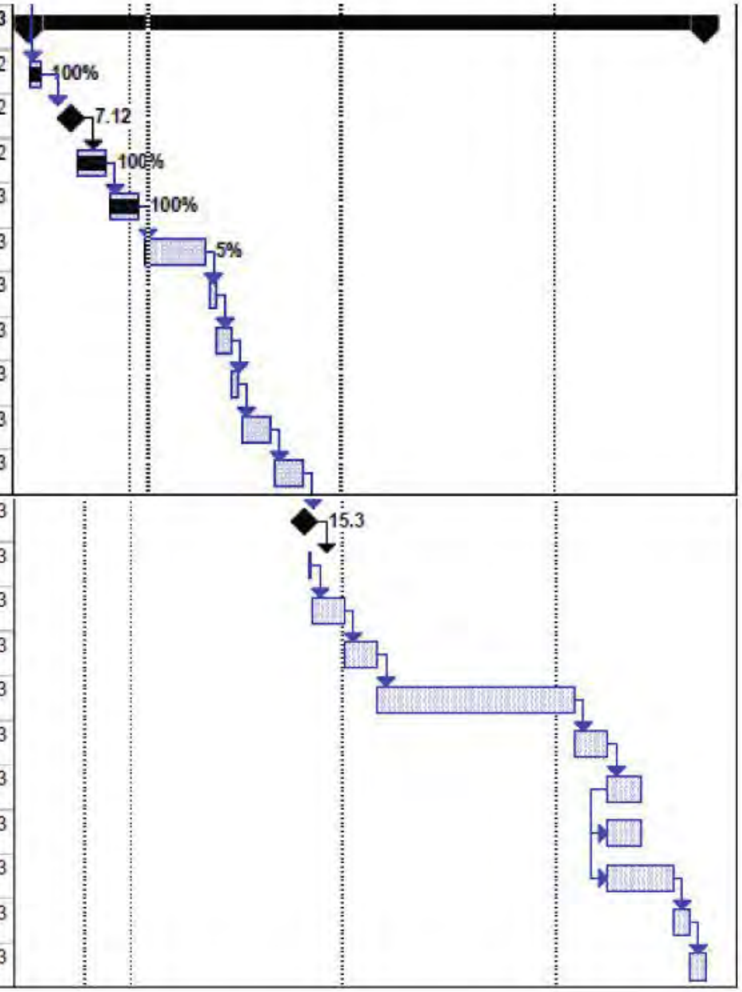
Nr.	Vorgangsname	Anfang	Ende
1	F 9211-11 / Diaphragm, 10.5" / TRW	Fr 16.11.12	Mi 10.04.13
2	Bestellung/ Order	Fr 16.11.12	Fr 16.11.12
4	Kick-Off	Mo 19.11.12	Mo 19.11.12
6	Vorbereitungs-Phase/ Preparation Phase	Mo 19.11.12	Mi 21.11.12
11	Konstruktions-Phase/ Design Phase	Mo 19.11.12	Mi 28.11.12
14	Design Review1 (DR1)	Mi 28.11.12	Mi 28.11.12
16	Werkstoff- und Werkzeugherstellungs-Phase/ Tool and compound manufacturing	Do 29.11.12	Do 28.02.13
19	Design Review2 / DR2	Do 28.02.13	Do 28.02.13
21	Herstellung Erstmuster/ Initial Samples Manufacturing	Fr 01.03.13	Fr 08.03.13
26	Design Review3 (DR3)	Fr 08.03.13	Fr 08.03.13
27	**Versand Teile aus SCH / Shipment Parts from SCH**	**Mo 11.03.13**	**Fr 15.03.13**
28	PPAP an SMX/ PPAP to SMX	Mo 04.03.13	Di 12.03.13
32	Verlagerung zu SMX / Transfer to SMX	Mi 13.03.13	Fr 29.03.13
36	Herstellung Erstmuster in SMX/ Initial Samples Manufacturing in SMX	Mo 01.04.13	Fr 05.04.13
40	PPAP Vorbereitung/ PPAP preparation	Mo 08.04.13	Di 09.04.13
42	Versand PPAP und Teile von SMX/ Shipment PPAP and Parts from SMX	Mi 10.04.13	Mi 10.04.13



SBR Tooling Status – Rubena

- SBR tooling on time per schedule

32		**Process Design - Diaphragm 32484764 No.1, 2**	**206 days**	**Mon 19.11.12**	**Mon 2.9.13**
33	✓	Serial Tool Design	1 wk	Mon 19.11.12	Fri 23.11.12
34	✓	Purchase order for tools – receipt	0 days	Fri 7.12.12	Fri 7.12.12
35	✓	Serial Tools Producing	2 wks	Mon 10.12.12	Fri 21.12.12
36	✓	Factory Christmas Holiday	2 wks	Mon 24.12.12	Fri 4.1.13
37		Serial Tools Producing – continue	4 wks	Mon 7.1.13	Fri 1.2.13
38		Sampling of Tools in Rubena Czech Republic	3 days	Mon 4.2.13	Wed 6.2.13
39		Internal Parts Tests	4 days	Thu 7.2.13	Tue 12.2.13
40		Hardening of tools	3 days	Wed 13.2.13	Fri 15.2.13
41		Shipment of tools to Mexico - Airtransport	2 wks	Mon 18.2.13	Fri 1.3.13
42		Resampling of Tools in Mexico and Internal Parts Tes	2 wks	Mon 4.3.13	Fri 15.3.13
43		Control Review	0 days	Fri 15.3.13	Fri 15.3.13
44		Presentation of PPAP Samples to TRW	1 day	Mon 18.3.13	Mon 18.3.13
45		PPAP Approval	2 wks	Tue 19.3.13	Mon 1.4.13
46		PV Parts Assy & Ship to Livonia	2 wks	Tue 2.4.13	Mon 15.4.13
47		TRW Testing	12 wks	Tue 16.4.13	Mon 8.7.13
48		TRW Report	2 wks	Tue 9.7.13	Mon 22.7.13
49		Assembly & Shipping	2 wks	Tue 23.7.13	Mon 5.8.13
50		Customer Approvals	2 wks	Tue 23.7.13	Mon 5.8.13
51		PTR	4 wks	Tue 23.7.13	Mon 19.8.13
52		Supplier SOP & Ship to TRW	1 wk	Tue 20.8.13	Mon 26.8.13
53		TRW SOP	1 wk	Tue 27.8.13	Mon 2.9.13



Warranty Returns Analysis

- **43 recent returns in transit from Japan to Santa Rosa for analysis, arrive Jan 8th, analysis by Jan 15th.**

J50 Warranty information
Return list of Saudi Arabia ,USA and other

1/7/2013

NO.	Repaired Date	VIN	Market	Field Claim #	Mileage (km)	Fault Description	Analysis status and Root cause	TRW Production date	Leak amount data (re produced test)	Performance DATA of Input and Output (After returned)	Hutchinson Production date	Tear size with picture	Location and number of Pre cured rubber particles (in thickness)	Location and number of Pre cured rubber particles (in Diaphragm)	Current Unit location	Record of Shelf life and inspection record of compound
70		JM7TB1MA4C [redacted]	Saudi Arabia	2CA1663948		Heavy Brake Pedal (Air Leak of Brake Booster)	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
71		JM7TB19A5B [redacted]	Saudi Arabia	2C90502902		Heavy Brake Force. Brake Booster	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
72		JM3TB28A38 [redacted]	Dominica	2CA2963602		Vacuum Leak of Brake Booster	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15 2013								In transit to Santa Rosa	
73		JM3TB3MAXA [redacted]	Dominica	2CA2963602		Vacuum Leak of Brake Booster	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
74		JM7TB19A0A [redacted]	Kuwait	2CA2451501		Heavy Brake Pedal & Squeaking Noise when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
75		JM7TB19A1B [redacted]	Kuwait	2CA2451501		Heavy Brake Pedal & Squeaking Noise when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
76		JM7TB19A2A [redacted]	Kuwait	2CA2451501		Heavy Brake Pedal & Squeaking Noise when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15 2013								In transit to Santa Rosa	
77		JM7TB19A5A [redacted]	Kuwait	2CA2451501		Heavy Brake Pedal & Squeaking Noise when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
78		JM7TB19A6B [redacted]	Kuwait	2CA2451501		Heavy Brake Pedal & Squeaking Noise when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
79		JM7TB19A9A [redacted]	Kuwait	2CA2451501		Heavy Brake Pedal & Squeaking Noise when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
80		JM7TB1MAXC [redacted]	Kuwait	2CA2451501		Heavy Brake Pedal & Squeaking Noise when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15 2013								In transit to Santa Rosa	
81		JM7TB19A6B [redacted]	Kuwait	2CA2451501		Heavy Brake Pedal & Squeaking Noise when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
82		JM7TB19A4A [redacted]	Qatar	2CB1201503		Heavy Brake Pedal when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
83		JM7TB19A0A [redacted]	Qatar	2CB1201503		Heavy Brake Pedal when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
84		JM7TB19A29 [redacted]	Qatar	2CB1201503		Heavy Brake Pedal when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15 2013								In transit to Santa Rosa	
85		JM7TB19A3A [redacted]	Qatar	2CB1201503		Heavy Brake Pedal when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
86		JM7TB19A7A [redacted]	Qatar	2CB1201503		Heavy Brake Pedal when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
87		JM7TB19AXA [redacted]	Saudi Arabia	2C72563752		Air Leak from Brake Booster	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
88		JM7TB19A5B [redacted]	Saudi Arabia	2CB0605412		Brake Fluid Leak & Heavy Brake Pedal when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15 2013								In transit to Santa Rosa	
89		JM7TB19A3B [redacted]	Saudi Arabia	2CB1201736		Heavy Brake Pedal & Whooshing Noise when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
90		JM7TB1MA9C [redacted]	Saudi Arabia	2CB1201736		Heavy Brake Pedal & Whooshing Noise when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
91		JM7TB19AXA [redacted]	Saudi Arabia	2CB1201736		Heavy Brake Pedal & Whooshing Noise when applying brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
92		JM7TB1MAXC [redacted]	Saudi Arabia	2CA2451408		Brake is not working well	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
93		JM3TB3MA6B [redacted]	Colombia	2CB0551544		Heavy Brake Pedal	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
94		JM3TB3MAXB [redacted]	Colombia	2CB0551544		Heavy Brake Pedal	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
95		JM3TB3MA5B [redacted]	Colombia	2CB0551544		Heavy Brake Pedal	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15 2013								In transit to Santa Rosa	
96		JM3TB3MA9B [redacted]	Colombia	2CB0551544		Heavy Brake Pedal	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
97		JM7TB19A5B [redacted]	Saudi Arabia	2CB1305613		Vacuum Leak of Brake Booster, Heavy Brake Pedal and Whooshing Noise	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
98		JM7TB19A0A [redacted]	Saudi Arabia	2CB1305613		Vacuum Leak of Brake Booster, Heavy Brake Pedal and Whooshing Noise	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
99		JM7TB19A2B [redacted]	Saudi Arabia	2CB1305613		Vacuum Leak of Brake Booster, Heavy Brake Pedal and Whooshing Noise	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15 2013								In transit to Santa Rosa	
100		JM7TB19A8A [redacted]	Saudi Arabia	2CB1305613		Vacuum Leak of Brake Booster, Heavy Brake Pedal and Whooshing Noise	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
101		JM7TB19A69 [redacted]	Qatar	2CC0404613		Whooshing Noise during brake	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	
109		JM3TB28A38 [redacted]	Dominica	2CA2963602		Vacuum Leak of Brake Booster	Part wil l arrive on January 08, 2013 Estimated completion date of analysis January 15, 2013								In transit to Santa Rosa	

Details on accident

- **Information available?**

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 2-8 Supplier Report 16 Jan 2013

Mazda Diaphragm J50C New Tool Detail

January 16, 2013

ADVANCED THINKING / SMART THINKING / GREEN THINKING

DOE Status Update　DOEステータスアップデート

- **1 week and 4 week shelf life samples only**　保存期間、1週間と4週間のサンプルのみ

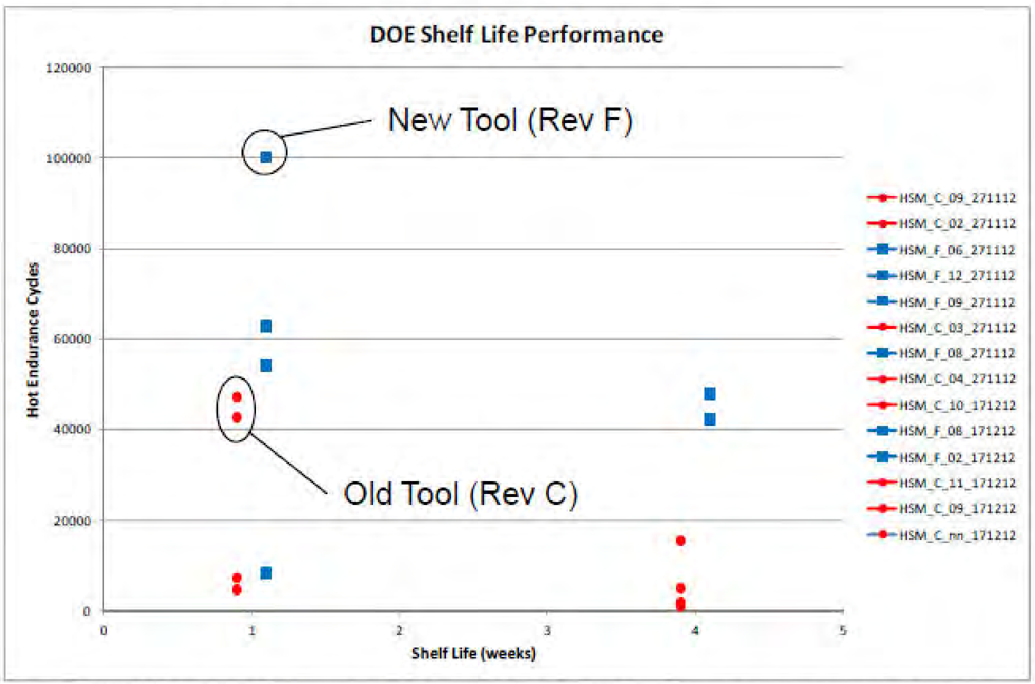
Sample ID	Shelf Life	Part No	Rev Level	Comments
HSM_C_09_271112	1 week	32484764	C	1 tear (26-B mm) @ 42,620 applies; submitted for material analysis
HSM_C_02_271112	1 week	32484764	C	1 tear (27-B mm) @ 4,575 applies; submitted for material analysis
HSM_F_06_271112	1 week	32484764	F	1 tear (7-C mm) @ 62,868 applies
HSM_F_12_271112	1 week	32484764	F	1 tear (2-C mm) @ 54,025 applies [split of ID bead lock - not common tear]
HSM_F_09_271112	1 week	32484764	F	1 tear (7-C mm) @ 8,161 applies
HSM_C_03_271112	1 week	32484764	C	1 tear (33-B mm) @ 7,145 applies
HSM_F_08_271112	1 week	32484764	F	0 tears @ 100,116 applies
HSM_C_04_271112	1 week	32484764	C	1 tears @ 47,095 applies
HSM_C_10_171212	4 week	32484764	C	1 tears @ 1,766 applies
HSM_F_08_171212	4 week	32484764	F	0 tears @ 47,883 applies
HSM_F_02_171212	4 week	32484764	F	0 tears @ 42,308 applies
HSM_C_11_171212	4 week	32484764	C	2 tears @ 980 applies [23 + 13 mm tears]
HSM_C_09_171212	4 week	32484764	C	x tears @ 4,871 applies
HSM_C_nn_171212	4 week	32484764	C	0 tears @ 15,375 applies

材料分析中
材料分析中
IDビードロックの分裂
通常とは違う亀裂

- **Tool Rev. C is old tool (thick section)**　Rev.Cは古いツール（厚い部分）
- **Tool Rev. F is new tool (thin section)**　Rev.Fは新しいツール（薄い部分）

DOE Shelf Life Performance　DOE保存期間性能

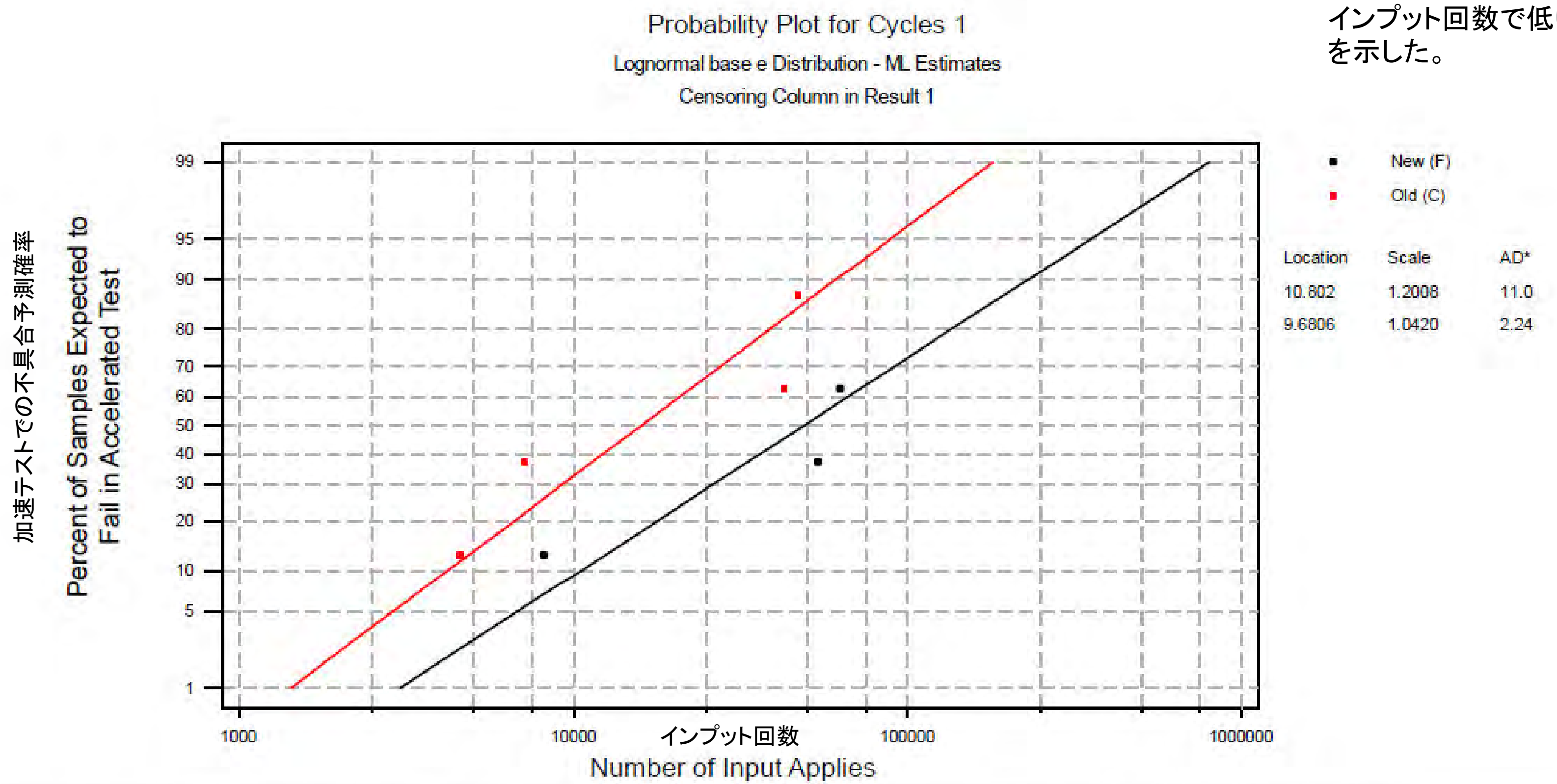
- The below represents accelerated testing results that do not represent real life field exposure. The results are a standard representation between the Old Tool and New Tool to give a representation of potential life performance. 下記は、実際の市場環境での結果ではなく加速テストでの結果を示しており、旧ツールと新ツール間での潜在的性能を表している。
- DOE Results to date
  - New tool (Rev F) is denoted by blue squares 新ツール（Rev F)は青四角
  - Old Tool (Rev C) is denoted by red circles 旧ツール（Rev C)は赤丸



保存期間1週間での推定確率
1 week Shelf Life Estimated Life Probability

- Old tool (Rev C) has lower expected input applies to failure than new tool (Rev F) in the accelerated testing utilized for the DOE portion of the diaphragm investigation.
  - Assume Lognormal base e failure distribution
    対数正規基準での不具合分布仮定

ダイアフラム調査のDOEでの加速テストにて、旧ツール（Rev C）は新ツール(Rev F)より不具合に至るインプット回数で低い予測を示した。



新ツール部品の在庫と発送
New Tool Part Inventory & Shipment

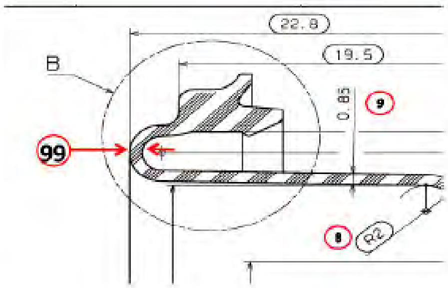
- New Tool Parts arrived at TRW Santa Rosa from Tool 2 on 11/23/12
  ツール2での新ツール部品はTRW Santa Rosaに2012年11月23日到着
- Date of Shipment to Mazda with parts from new diaphragm tool was 11/27/12
  新ダイアフラムツールでの部品は2012年11月27日にマツダ殿発送
- Date of Receipt by Mazda of parts with new diaphragm tool was 12/28/12
  マツダ殿での部品受取り日は2012年12月28日

Dimensional Control 寸法管理

30 pc Study from current inventory at TRW
現在のTRW在庫品30台調査

0.957	1.139	1.025	0.946	1.088	1.042
0.976	0.999	0.991	1.03	1.047	1.05
1.104	1.04	1.016	1.039	0.992	1.01
1.109	1.001	1.018	0.996	1.008	0.983
1.178	1.094	0.938	1.02	1.066	1.031

1.031	Mean
0.055	Std. Dev
1.197	**USL**
0.850	**LSL**



上記30台にて、サンプルサイズの基準偏差値を推定する為、丸99箇所でのダイアフラムの厚み調査を実施。
USLを推測するため、平均値から3つの基準偏差値を追加し、ダイアフラムの厚みを管理。

- **TRW has taken the above 30 pc dimensional study of the thickness of the diaphragm at balloon 99 and determined the Std. Deviation of the sample size. We then added 3 Std. Deviations from the mean to determine the USL we will control the diaphragm thickness to.**
- **Incoming Sampling Plan at TRW will be to dimensionally layout 30 pcs from the 6000 pc shipments with a MicroView.**
  到着サンプルの6000台から30台を顕微鏡で寸法的レイアウトの確認。
  – Measurement method is a destructive method and requires the diaphragm to be sectioned for thickness results.
  測定方法は破壊方式で、ダイアフラムの各セクションでの厚み結果を要する。

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 2-9 Supplier Report 12 Feb 2013

Mazda J50C Booster Warranty

Update Slides

February 12, 2013

TRW Automotive

ADVANCED THINKING / SMART THINKING / GREEN THINKING

Agenda

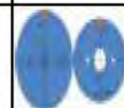
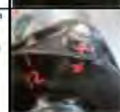
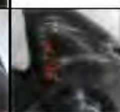
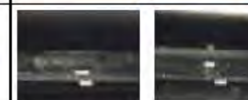
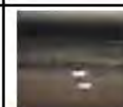
1. Warranty return and thickness analysis
2. Warranty return to Livonia—in analysis
3. Has Hutchinson done everything possible to reduce thickness in the tear area for Tool 2?
4. Updated timing on Rubena and Datwyler tools
5. DOE Update
6. Thickness correlation of bend area to other area to promote 100% inspection
7. Non-destructive thickness measurements for 100% inspection
8. TRW position on replacement of ~300 actuators for ME

Warranty Returns Analysis

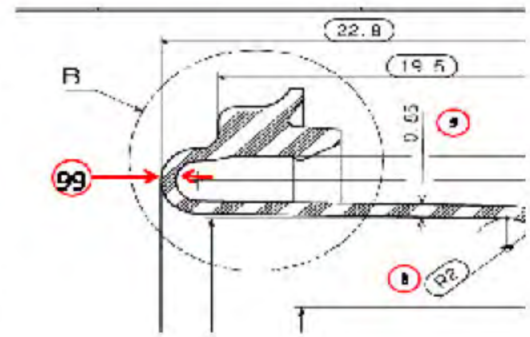
(43) recent returns, currently at Hutchinson, thickness measurements complete at Santa Rosa. Next step particle counts. Target completion at Hutchinson 28th February.

J50 Warranty Information
Return list of Saudi Arabia ,USA and other

2/12/2013

NO	Repaired Date	RW Report No	VN	Market	RW Production date	Leak amount data (re produced est)	Performance DA A of Input and Output (After returned)	Hutchinson Production date	ear size	ear picture	ear picture	ear picture	Location of tears (in diaphragm)	Pre cured Rubber S ze	Pre cured Rubber Photo	Diaphragm hickness (mm)	Location and number of Pre cured rubber partic es (in thickness)
70	10/9 2012	13-712	JM7TB1MA C[redacted]	Saudi Arabia	Dcember 21, 2011	Unabe to test lost of vacuum.	Unabe to test lost of vacuum.	November 2011	25 mm					175 x 236		1.315	
71	8/29 2012	13-711	JM7TB19A5B[redacted]	Saudi Arabia	September 21, 2011	Unabe to test lost of vacuum.	Unabe to test lost of vacuum.	August 2011	16 mm 27mm					1. 151 x 89 2. 298 x 113		1.396	
72	10/3 2012	13-691	JM8TB28A38 [redacted]	Dominica	March 06, 2008	Unabe to test lost of vacuum.	Unabe to test lost of vacuum.	February, 2008	15mm (6) 16mm (3)					1. 199 x 137 2. 73 x 316		1.037	
73	10/8 2012	13-721	JM8TB3MAXA[redacted]	Dominica	April 21, 2010	Unabe to test lost of vacuum.	Unabe to test lost of vacuum.	April 2010	32 mm					1 x 117		1.1	
7	10/8 2012	13-700	JM7TB19A0A[redacted]	Kuwait	July 29, 2009	Unabe to test lost of vacuum.	Unabe to test lost of vacuum.	July 2009	30 mm					373 x 268		1.085	
75	9/29 2012	13-701	JM7TB19A1B[redacted]	Kuwait	August 25, 2010	Unabe to test lost of vacuum.	Unabe to test lost of vacuum.	July 2010	1 mm					233 x 165		1.17	
76	8/8/2012	13-698	JM7TB19A2A[redacted]	Kuwait	August 10, 2009	Into spec	Into spec	NA		NA	NA	NA	NA				NA
77	7/31 2012	13-699	JM7TB19A5A[redacted]	Kuwait	August 18, 2008	Unabe to test leak ocated in deformed stample.	Unabe to test leak located in deformed stample.	NA		NA	NA	NA	NA				NA
78	8/28 2012	13-717	JM7TB19A6B[redacted]	Kuwait	September 03, 2010	Unabe to test lost of vacuum.	Unabe to test lost of vacuum.	September 2010	32 mm					161 x 127		1.089	
79	8/28 2012	13-718	JM7TB19A9A[redacted]	Kuwait	March 11, 2010	Unabe to test lost of vacuum.	Unabe to test lost of vacuum.	February 2010	26 mm					288 x 165		1.165	

Thickness Analysis



30 pc Study from Tool 2, current inventory at TRW

0.957	1.139	1.025	0.946	1.088	1.042
0.976	0.999	0.991	1.03	1.047	1.05
1.104	1.04	1.016	1.039	0.992	1.01
1.109	1.001	1.018	0.996	1.008	0.983
1.178	1.094	0.938	1.02	1.066	1.031

1.031	Mean
0.055	Std. Dev

30 pc Study from Tool 1, warranty returns

1.315	1.396	1.037	1.144	1.085	1.174
1.089	1.165	1.270	0.811	1.045	1.009
1.161	0.949	1.114	1.227	1.200	1.467
0.962	1.315	1.126	1.089	1.185	1.073
1.111	1.134	1.198	1.035	1.397	1.164

1.148	**Mean**
0.141	**Std. Dev**

Reduce Thickness in Tear Area

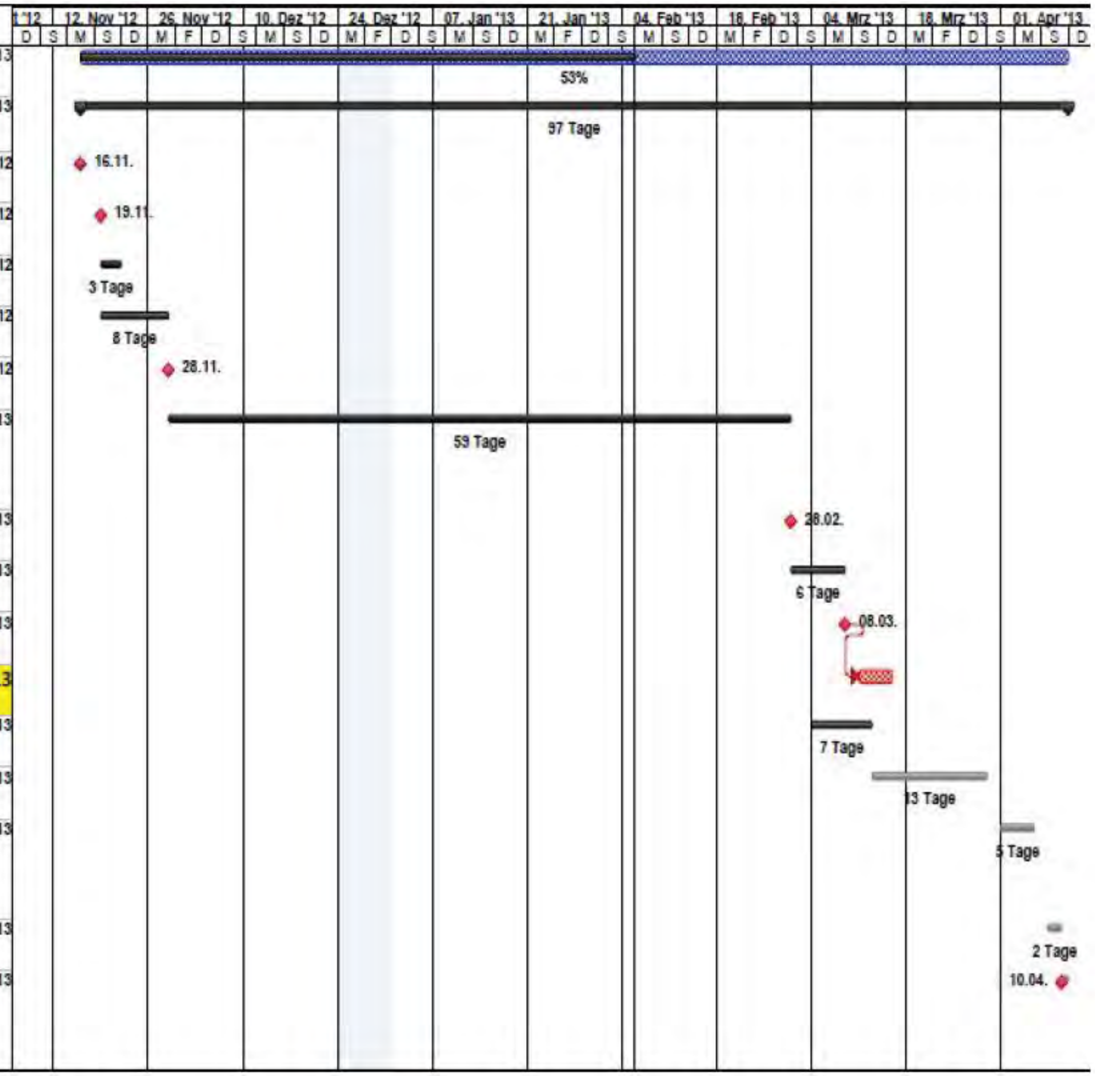
Has Hutchinson done everything possible to reduce thickness in tear area for Tool 2?

- **Tool correction is required upon releasing new tool# 3 into production.**

SBR Tooling Status – Datwyler

- SBR tooling on time per schedule

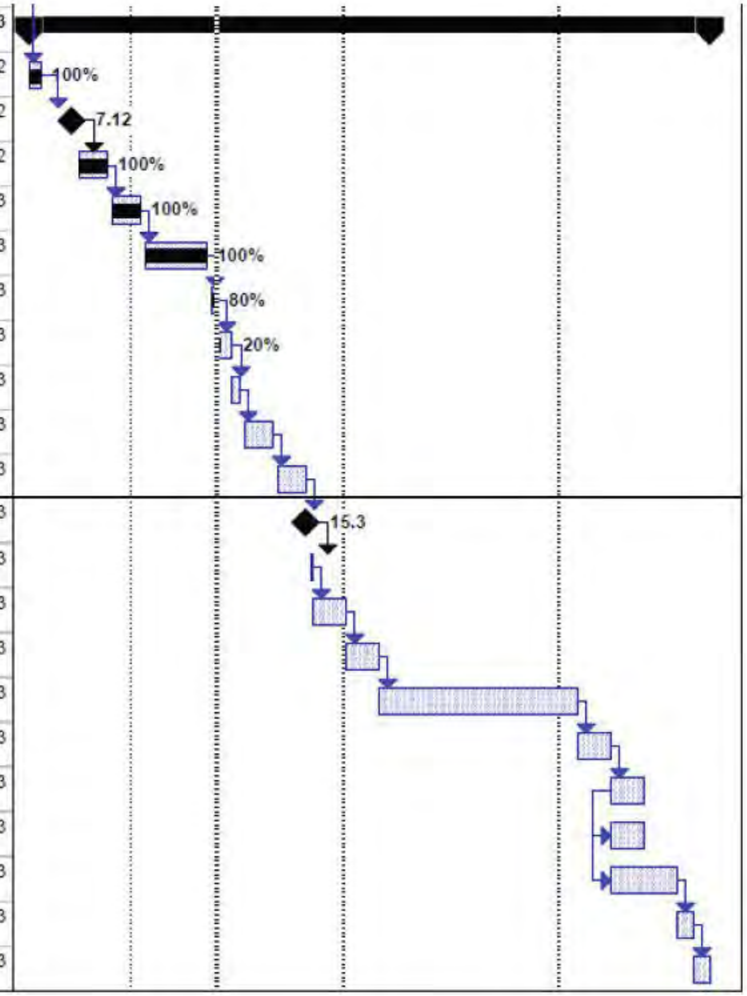
Nr.	Vorgangsname	Anfang	Ende
1	Project-Status	Fr 16.11.12	Mi 10.04.13
2	F 9211-11 / Diaphragm, 10.5" / TRW	Fr 16.11.12	Mi 10.04.13
3	Bestellung/ Order	Fr 16.11.12	Fr 16.11.12
5	Kick-Off	Mo 19.11.12	Mo 19.11.12
7	Vorbereitungs-Phase/ Preparation Phase	Mo 19.11.12	Mi 21.11.12
12	Konstruktions-Phase/ Design Phase	Mo 19.11.12	Mi 28.11.12
15	Design Review1 (DR1)	Mi 28.11.12	Mi 28.11.12
17	Werkstoff- und Werkzeugherstellungs-Phase/ Tool and compound manufacturing	Do 29.11.12	Do 28.02.13
20	Design Review2 / DR2	Do 28.02.13	Do 28.02.13
22	Herstellung Erstmuster/ Initial Samples Manufacturing	Fr 01.03.13	Fr 08.03.13
27	Design Review3 (DR3)	Fr 08.03.13	Fr 08.03.13
28	**Versand Teile aus SCH / Shipment Parts from SCH**	**Mo 11.03.13**	**Fr 15.03.13**
29	PPAP an SMX/ PPAP to SMX	Mo 04.03.13	Di 12.03.13
33	Verlagerung zu SMX / Transfer to SMX	Mi 13.03.13	Fr 29.03.13
37	Herstellung Erstmuster in SMX/ Initial Samples Manufacturing in SMX	Mo 01.04.13	Fr 05.04.13
41	PPAP Vorbereitung/ PPAP preparation	Mo 08.04.13	Di 09.04.13
43	Versand PPAP und Teile von SMX/ Shipment PPAP and Parts from SMX	Mi 10.04.13	Mi 10.04.13



SBR Tooling Status – Rubena

- SBR tooling on time per schedule

32		**Process Design - Diaphragm 32484764 No.1, 2**	**206 days**	**Mon 19.11.12**	**Mon 2.9.13**
33	✓	Serial Tool Design	1 wk	Mon 19.11.12	Fri 23.11.12
34	✓	Purchase order for tools – receipt	0 days	Fri 7.12.12	Fri 7.12.12
35	✓	Serial Tools Producing	2 wks	Mon 10.12.12	Fri 21.12.12
36	✓	Factory Christmas Holiday	2 wks	Mon 24.12.12	Fri 4.1.13
37	✓	Serial Tools Producing – continue	4 wks	Mon 7.1.13	Fri 1.2.13
38		Sampling of Tools in Rubena Czech Republic	3 days	Mon 4.2.13	Wed 6.2.13
39		Internal Parts Tests	4 days	Thu 7.2.13	Tue 12.2.13
40		Hardening of tools	3 days	Wed 13.2.13	Fri 15.2.13
41		Shipment of tools to Mexico - Airtransport	2 wks	Mon 18.2.13	Fri 1.3.13
42		Resampling of Tools in Mexico and Internal Parts Tes	2 wks	Mon 4.3.13	Fri 15.3.13
43		Control Review	0 days	Fri 15.3.13	Fri 15.3.13
44		Presentation of PPAP Samples to TRW	1 day	Mon 18.3.13	Mon 18.3.13
45		PPAP Approval	2 wks	Tue 19.3.13	Mon 1.4.13
46		PV Parts Assy & Ship to Livonia	2 wks	Tue 2.4.13	Mon 15.4.13
47		TRW Testing	12 wks	Tue 16.4.13	Mon 8.7.13
48		TRW Report	2 wks	Tue 9.7.13	Mon 22.7.13
49		Assembly & Shipping	2 wks	Tue 23.7.13	Mon 5.8.13
50		Customer Approvals	2 wks	Tue 23.7.13	Mon 5.8.13
51		PTR	4 wks	Tue 23.7.13	Mon 19.8.13
52		Supplier SOP & Ship to TRW	1 wk	Tue 20.8.13	Mon 26.8.13
53		TRW SOP	1 wk	Tue 27.8.13	Mon 2.9.13



Hutchinson Diaphragm DOE Test Timing

DOE Phase	Test Order	A: Shelf Life	B: Thickness	C: Particles / Supplier	Qty	Supplier Lead Time	Estimated Test Completed Date	Wk ending	Estimated Test Completion date as of Jan 28th
Pre-DOE	0	Current Production			4	NA	Wk 46	11-Nov	Completed Dec 12
Part 1	1	1 wk	+(Thin)	- (Hi Count) / HSM	4	1 wk	wk 47	18-Nov	Completed Jan 7
	2	1 wk	- (Thick)		4	2 wks	wk 49	2-Dec	Completed Dec 28
	3	4 wk	+(Thin)		4	5 wks	wk 2	13-Jan	75% complete, finish Feb 1
	4	4 wk	- (Thick)		4	6 wks	wk 2	13-Jan	Completed Jan 16
	5	8 wks	+(Thin)		4	9 wks	wk 3	20-Jan	Expected Feb 18
	6	8 wks	- (Thick)		4	9 wks	wk 4	27-Jan	Expected Feb 18
Part 2a	7	+(1 wk or Min)	+(Thin)	+(Lo Count)/ Rubena	4	12 wks	wk 11	17-Mar	Expected Mar 28
	8	-(30 days Max)	+(Thin)		4	16 wks	wk 15	14-Apr	Expected Apr 28
Part 2b	9	+(1 wk or Min)	+(Thin)	+(Lo Count)/ Daetwyler	4	22 wks	wk 18	5-May	Expected May 17
	10	-(6 months)	+(Thin)		4	48 wks	wk 44	3-Nov	Expected Nov 15

New date: Feb. 25

Notes:

1. Original DOE timing plan assumed Pre-DOE phase (Dev test) worked 1st time.
First new test method tried was not successful. Extra time to develop & evaluate a second test method delayed start of DOE testing approx. 3-4 weeks.
2. Increased Qty to test from 2 to 4.

Hutchinson Diaphragm DOE Test Plan Summary

1. Develop & evaluate accelerated evaluation test
   Test Method 1: "Air pressure cycling" approach did not work out- difficulty sealing under pressure
   Test Method 2: "Modified endurance" Successful: Replicated failure mode in short time. **COMPLETED** Dec 12.

2. Order diaphragm test configurations
   COMPLETE: All test parts have been ordered from suppliers.

3. Build booster assembles
   ONGOING: Per plan as DOE diaphragms are received.

4. Complete Part 1 Testing
   IN PROGRESS:
   1 wk "thick" parts: **COMPLETE**
   1 wk "thin" parts: **COMPLETE** (note: cracked in different position)
   4 wk "thick parts: **COMPLETE**
   4 wk "thin parts: **COMPLETE**
   8wk "thick parts" Test completion expected ~~Feb 18~~ Feb 25
   8 wk "thin parts" Test completion expected ~~Feb 18~~ Feb 25

5. Analyze & publish Part 1 results
   Following completion of Part 1 testing: Expected ~~Feb 25~~ Mar 4

6. Complete Part 2a Testing & publish results
   Following completion of Part 2a testing: Expected May 3

Hutchinson Diaphragm DOE Test Status

- **Diaphragms from old tool (rev C) – 1 & 4 week shelf life:**
  - 9 failures due to diaphragm tear
- **Diaphragms from new tool (rev F) – 1 week shelf life:**
  - 3 failures due to diaphragm tear
  - 1 suspension @ 100,000 cycles
- **Diaphragms from new tool (rev F) – 4 week shelf life:**
  - 2 failures due to diaphragm tear
  - 2 suspensions > 100,000 cycles

Sample ID	Shelf Life	Part No	Rev Level	Status	No. of Tears	Length of Tear(mm)	Cycles @ Tear	Material Lab Request
HSM_F_08_271112	1 week	32484764	F	suspend	0	—	100,116	—
HSM_C_02_271112	1 week	32484764	C	failed	1	27	4,575	MLWR_8926
HSM_C_03_271112	1 week	32484764	C	failed	1	33	7,145	MLWR_8935
HSM_C_09_271112	1 week	32484764	C	failed	1	26	42,620	MLWR_8926
HSM_C_04_271112	1 week	32484764	C	failed	1	26	47,095	MLWR_8946
HSM_F_09_271112	1 week	32484764	F	failed	1	7	8,161	MLWR_8935
HSM_F_06_271112	1 week	32484764	F	failed	1	7	62,868	MLWR_8935
HSM_F_12_271112	1 week	32484764	F	failed	1	2	54,025	MLWR_8935
HSM_F_10_171212	4 week	32484764	F	suspend	0	—	105,609	—
HSM_F_08_171212	4 week	32484764	F	suspend	0	—	147,101	—
HSM_C_11_171212	4 week	32484764	C	failed	2	23 + 13	980	MLWR_8946
HSM_C_02_171212	4 week	32484764	C	failed	1	42	1,088	MLWR_8982
HSM_C_10_171212	4 week	32484764	C	failed	1	36	1,766	MLWR_8946
HSM_C_09_171212	4 week	32484764	C	failed	1	36	4,871	MLWR_8982
Update → HSM_F_11_171212	4 week	32484764	F	failed	1	38	6,693	MLWR_8998
HSM_C_12_171212	4 week	32484764	C	failed	1	30	15,375	MLWR_8982
Update → HSM_F_02_171212	4 week	32484764	F	failed	1	8	69,750	MLWR_8998

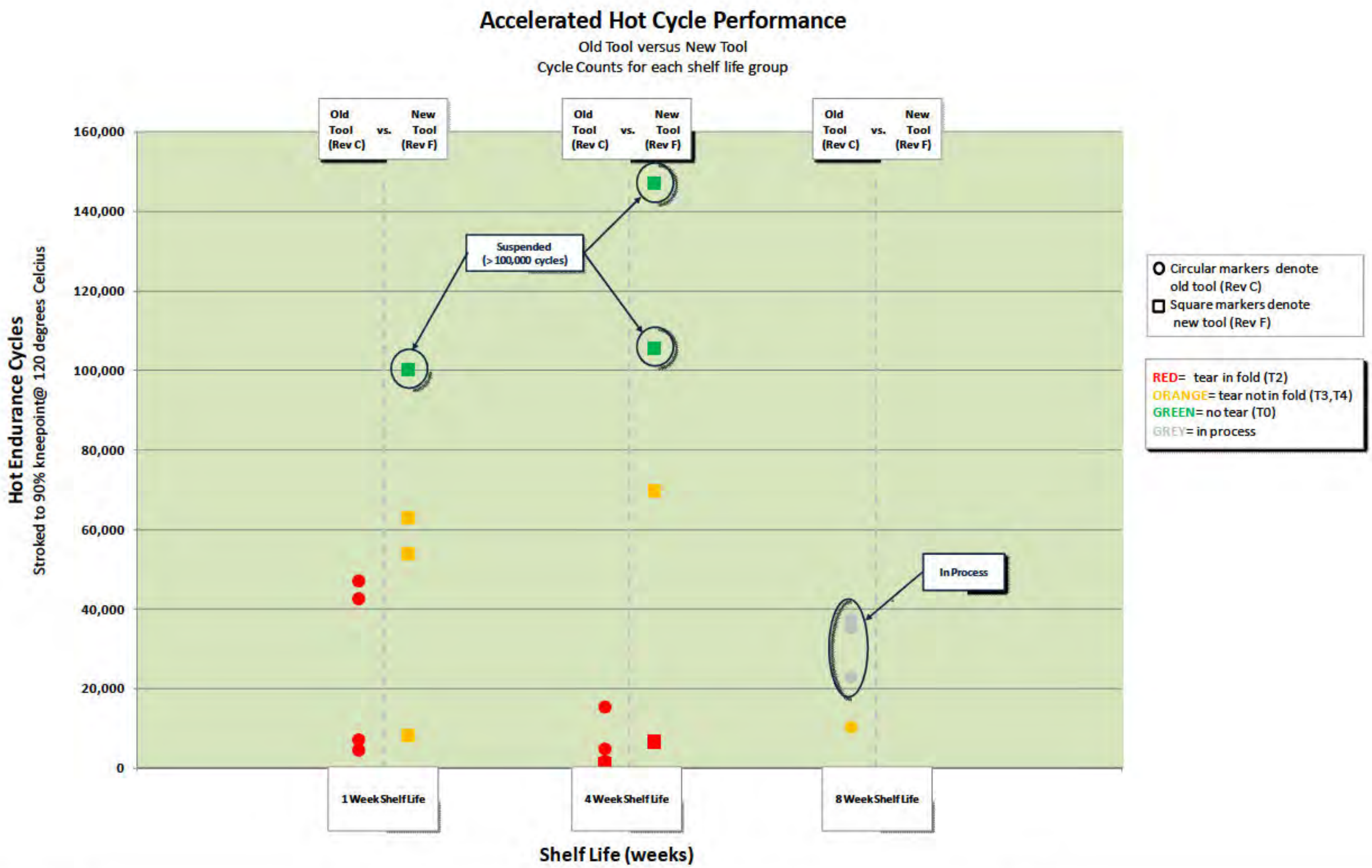
Hutchinson Diaphragm DOE Test Status

- **Diaphragms from old tool (rev C) – 8 week shelf life:**
  - 1 failed due to diaphragm tear
  - 3 in process
- **Diaphragms from new tool (rev F) – 8 week shelf life:**
  - Pending

Sample ID	Shelf Life	Part No	Rev Level	Status	No. of Tears	Length of Tear(mm)	Cycles @ Tear	Material Lab Request
HSM_C_08_8week	8 week	32484764	C	in process	0	—	22,925	—
HSM_C_04_8week	8 week	32484764	C	in process	0	—	35,147	—
HSM_C_11_8week	8 week	32484764	C	in process	0	—	37,481	—
HSM_C_05_8week	8 week	32484764	C	failed	1	8	10,310	—

Hutchinson Diaphragm DOE Test Status

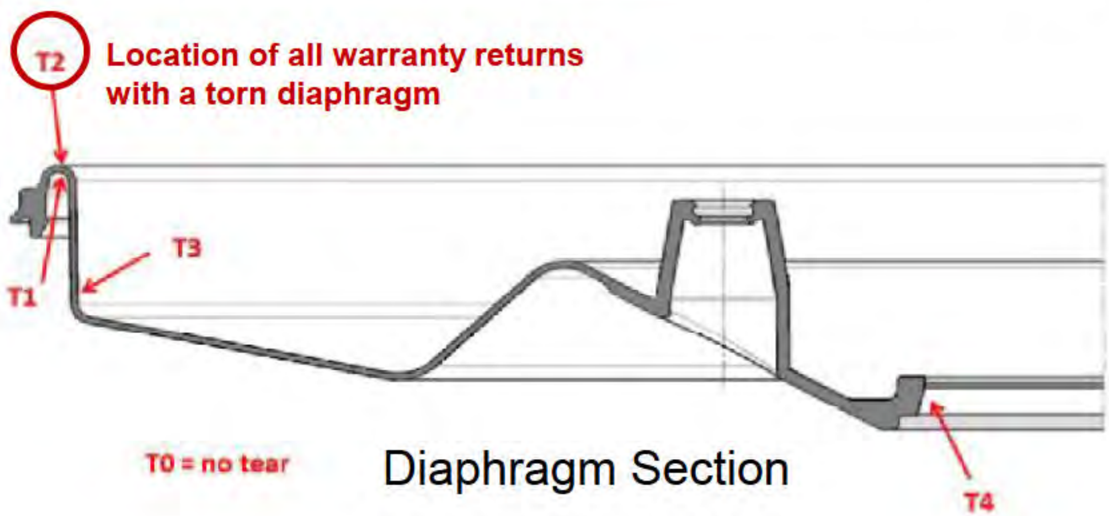
- Hot accelerated endurance test cycles v. shelf life (1 week, 4 week, 8 week)



Hutchinson Diaphragm DOE Tear Details

- **Location Nomenclature for diaphragm tears in this DOE**

Diaphragm DOE Tear Designation Chart		
Nomenclature before 28-Jan-2013	Description	Nomenclature after 28-Jan-2013
--	No tear. No crack.	T0
A	A crack, not through tear, located in the formed radius when viewing the cross sectional area.	T1
B	A through tear located in the formed radius when viewing the cross sectional area. This is the same location noted in all warranty returns with a torn diaphragm.	T2
C	A tear located in the base of the side wall when viewing the cross sectional area.	T3
C	A tear located in the bead lock of the inner diameter when viewing the cross sectional area.	T4



Diaphragm Section

Hutchinson Diaphragm DOE Tear Details

- **Diaphragms from old tool (rev C) – 1 week & 4 week shelf life:**
  - 9 diaphragm tears @ location **T2** (similar to warranty); non-homogeneous particle at tear origin
- **Diaphragms from new tool (rev F) – 1 week & 4 week shelf life:**
  - 3 diaphragms with no tears **T0**, evaluations suspended > 100,000 cycles
  - 1 diaphragm tear @ location **T2** (similar to warranty); non-homogeneous particle at tear origin
  - 3 diaphragm tears @ location **T3** (not similar to warranty); non-homogeneous particle at tear origin
  - 1 diaphragm tear @ location **T4**; materials report identified this tear as mechanical (no particle – not similar to warranty); likely due to prototype installation

	Sample ID	Cycles	Shelf Life (weeks)	Failure Mode	Failure Location	Failure Size (mm)	Embedded Particle length (microns)	Embedded Particle height (microns)	Material Thickness (greatest) at defect site (mm)	Material Thickness at Location T2 (mm)
	HSM_F_08_271112	100,116	1	—	T0	—	—	—	—	—
	HSM_C_02_271112	**4,575**	**1**	**tear**	**T2**	**27**	**232**	**99**	**1.23**	**1.23**
	HSM_C_03_271112	**7,145**	**1**	**tear**	**T2**	**33**	**170**	**91**	**1.1**	**1.05**
	HSM_C_09_271112	**42,620**	**1**	**tear**	**T2**	**26**	**194**	**98**	**1.24**	**1.21**
	HSM_C_04_271112	**47,095**	**1**	**tear**	**T2**	**26**	**147**	**79**	**1.26**	**1.15**
	HSM_F_09_271112	8,161	1	tear	T3	7	87	53	0.98	0.94
	HSM_F_06_271112	62,868	1	tear	T3	7	196	73	1.04	1.03
	HSM_F_12_271112	54,025	1	tear	T4	2	—	—	0.98	0.94
	HSM_F_10_171212	105,609	4	—	T0	—	—	—	—	—
	HSM_F_08_171212	147,101	4	—	T0	—	—	—	—	—
	HSM_C_11_171212	**980**	**4**	**tear***	**T2**	**46**	**177**	**76**	**1.26**	**1.23**
	HSM_C_02_171212	**1,088**	**4**	**tear**	**T2**	**42**	**165**	**132**	**1.12**	**0.99**
	HSM_C_10_171212	**1,766**	**4**	**tear**	**T2**	**36**	**144**	**61**	**1.24**	**1.15**
	HSM_C_09_171212	**4,871**	**4**	**tear**	**T2**	**36**	**103**	**55**	**1.26**	**1.24**
Update	**HSM_F_11_171212**	**6,693**	**4**	**—**	**T2**	**38**	**215**	**96**	**0.92**	**0.89**
	HSM_C_12_171212	**15,375**	**4**	**tear**	**T2**	**30**	**106**	**87**	**1.24**	**1.22**
Update	HSM_F_02_171212	69,750	4	—	T3	8	325	109	0.96	0.96

*only the larger tear identified as tear 1 in the MLWR report is used for the embedded particle size in this table.

Hutchinson Diaphragm DOE Tear Details

- **Diaphragms from old tool (rev C) – 8 week shelf life:**
  - 1 diaphragm tear @ location **T3** (not similar to warranty); tear analysis pending
- **Diaphragms from new tool (rev F) – 8 week shelf life:**
  - No data

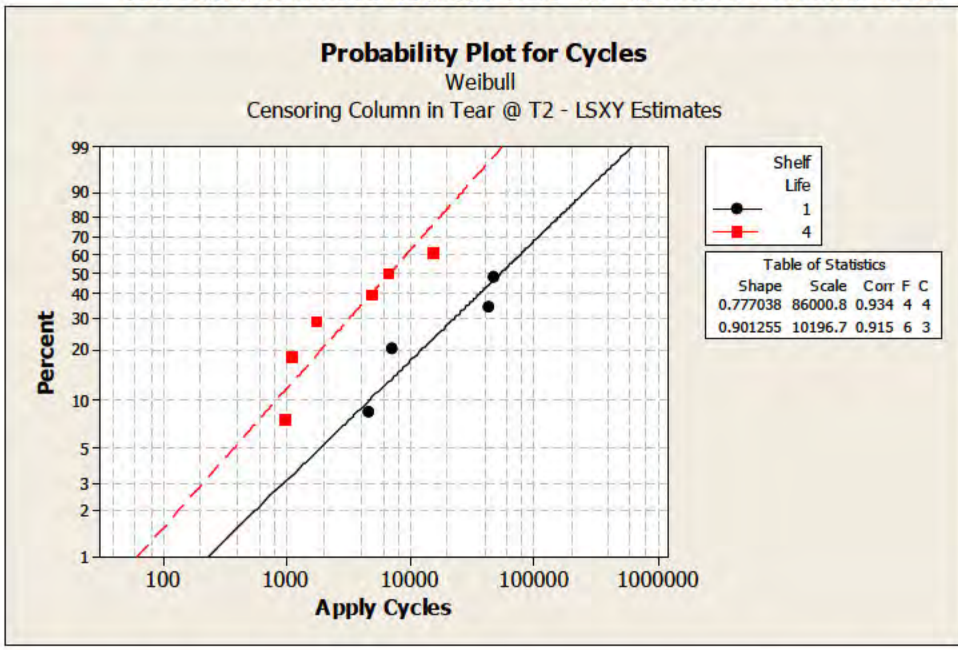
Sample ID	Cycles	Shelf Life (weeks)	Failure Mode	Failure Location	Failure Size (mm)	Embedded Particle length (microns)	Embedded Particle height (microns)	Material Thickness (greatest) at defect site (mm)	Material Thickness at Location T2 (mm)
HSM_C_08_8week	22,925	8	—	T0	—	—	—	—	—
HSM_C_04_8week	35,147	8	—	T0	—	—	—	—	—
HSM_C_11_8week	37,481	8	—	T0	—	—	—	—	—
HSM_C_05_8week	10,310	8	tear	T3	—	—	—	—	—

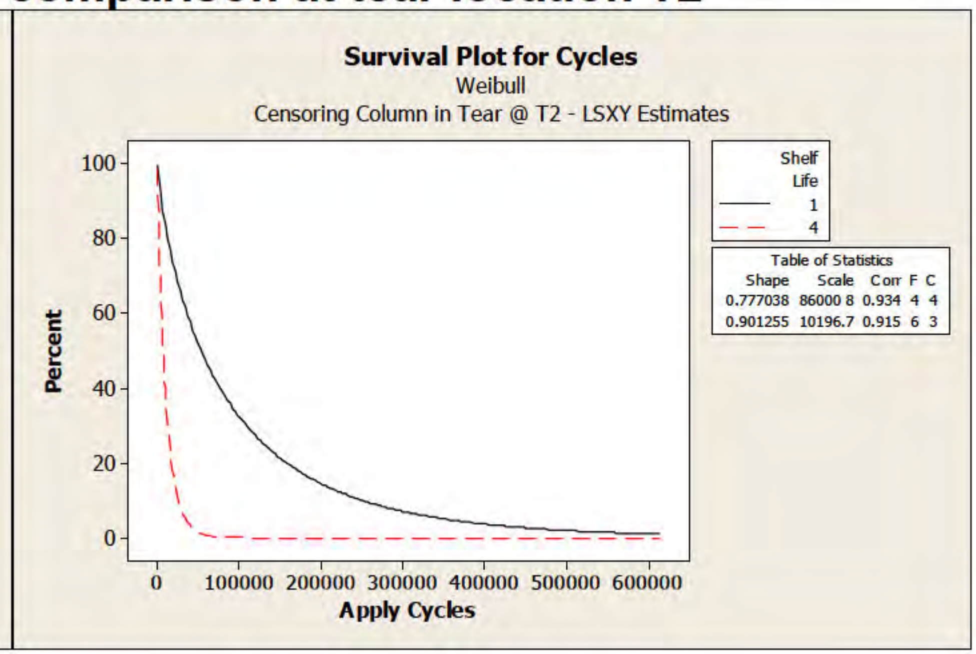
*only the larger tear identified as tear 1 in the MLWR report is used for the embedded particle size in this table.

Hutchinson Diaphragm DOE Est. Life Probability

TRW

- **Weibull distribution all samples with 1 week and 4 week shelf life for tear location T2**
  - Diaphragms with material from the 1 week shelf life batch have a longer predicted life than diaphragms with material from the 4 week shelf life batch: Weibull scale factor 86,001 v. 10,197 cycles (predicts the 63.2 percentile failure point)
  - Diaphragms with material from the 1 week shelf life batch have a more narrow failure distribution than diaphragms with material from the 4 week shelf life batch: Weibull shape factor 0.901 v. 0.777 (defines the shape of the failure distribution)
- **Insufficient data for 8 week shelf life comparison at tear location T2**





Diaphragm Measurement Gage

Objective: Develop a method to measure thickness of the diaphragm in the loop area (position 99)

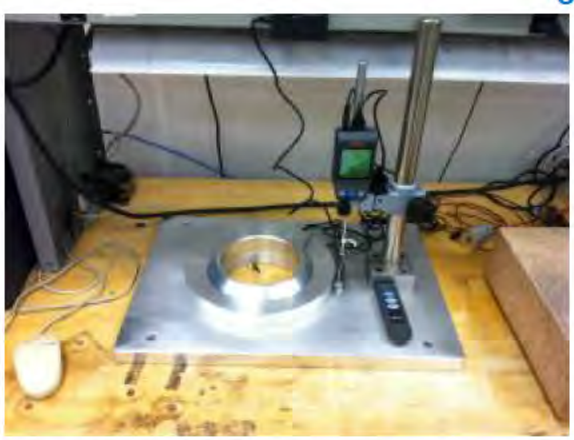
Digital Indicator

Diaphragm Fixture

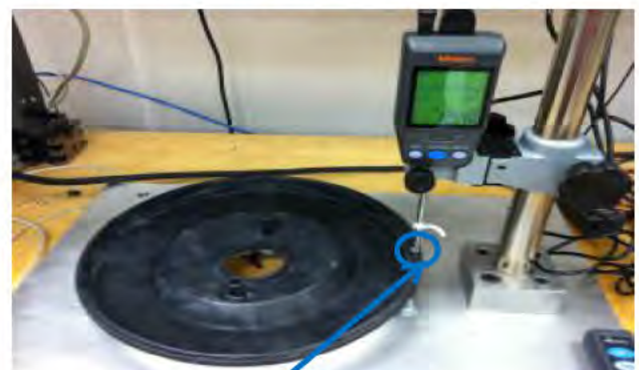
Indicator Spindle Lift Handle

Remote Control

Laptop Computer with USB port and Microsoft Excel software



Digital Indicator - The digital indicator is zeroed on top of the mandrel.



Digital Indicator– contacts the diaphragm during measurement.

Diaphragm Measurement Gage R&R Study

Gage R&R Study – Setup

- **3 Operators**
- **9 Parts total**
  - **3 "C" Samples from Tool 1, Cavity 1 (Gage R&R Parts 1, 2, 3)**
  - **3 "F" Samples from Tool 2, Cavity 3 (Gage R&R Parts 4, 5, 6)**
  - **3 "F" Samples from Tool 3, Cavity 4 (Gage R&R Parts 7, 8, 9)**
- **A total of 1 measurement location (12 o'clock position) was used as defined by the TRW logo near the 6 o'clock position and the tie bar nipple locations at 3 and 9 o'clock position.**

Gage R&R Results

- **% R&R = 3.56% (Desired) (OK)**
  - 0 – 10% is Desired
  - 10 – 20% is Acceptable
  - 20 – 30% is Borderline
  - 30% or greater is Unacceptable
- **Number of Distinct Categories = 39 (OK)**
  - Must be greater than 4 for a healthy measurement system
- **R-chart by operator = stable (OK)**
  - Must be stable, insures there are no special causes affecting calculations
- **Conclusions**
  - Measurement system variation is low, allowing good sensitivity to part variation
  - Measurement system has very capable to detect part to part variation
  - Measurement system Repeatability and Reproducibility are quite good
  - Next Step is to determine Accuracy, testing in-process

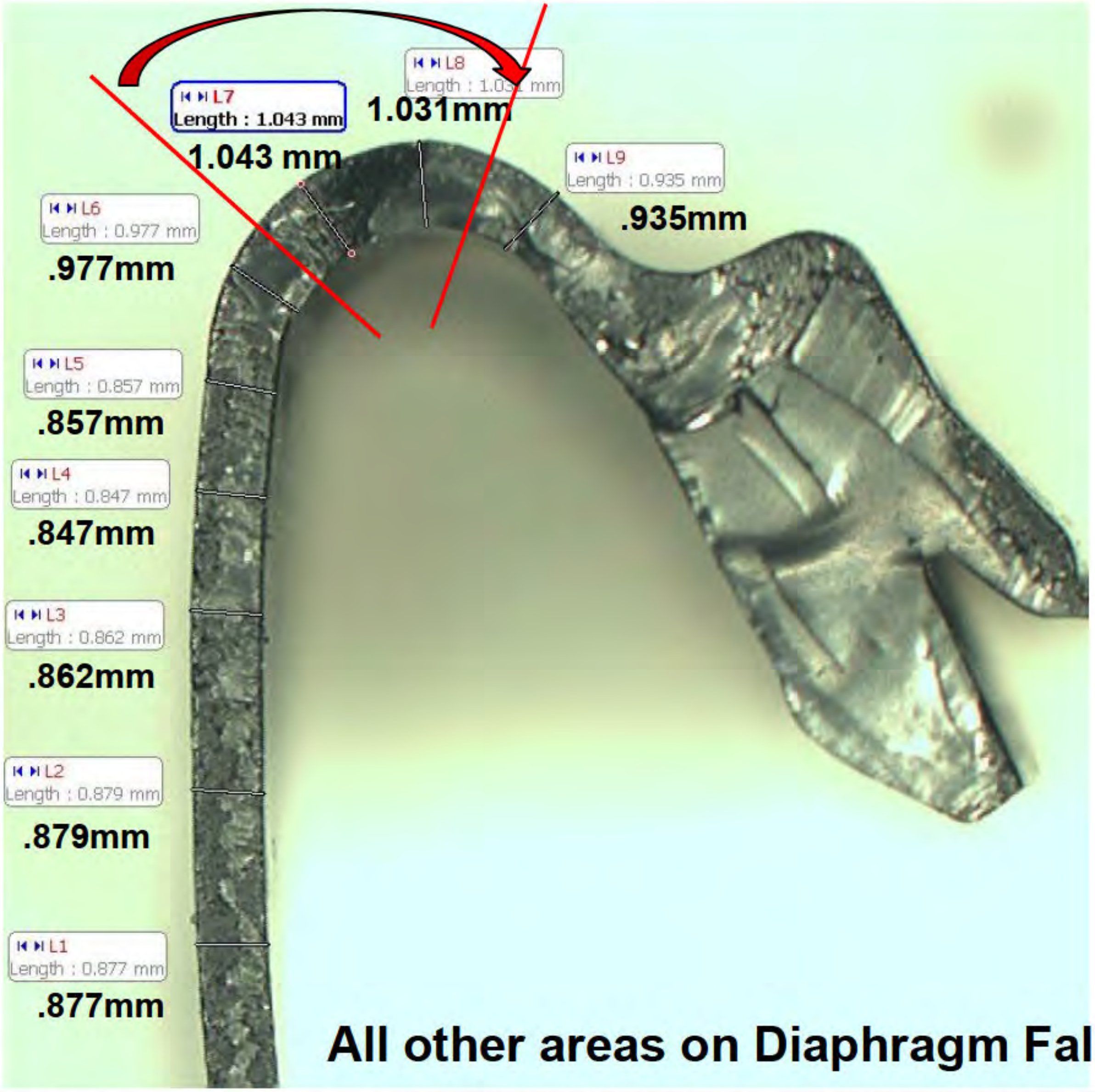
Service Part Replacement

- **Upon receipt of Engineering Designed Measurement Gage**
  - TRW will certify 389 Diaphragms for In-Specification Thickness
  - Expedite replacement of those 389 Diaphragms to Mazda for Middle East region service only

- **TRW at this moment cannot maintain current production and service requirements with 100% inspection for thickness.**

- **TRW will evaluate certifying small quantities of Tool #2 stock as required.**

Diaphragm Thickness Tool 2



All other areas on Diaphragm Fall within Specification

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 3-1 Evaluation Result

Mazda Motor Corporation
Chassis Dynamics Development Dept.
Brake Performance Development Gr.

Document No.: **BPD-Q002-146-0003**

CONFIDENTIAL

[redacted]

Address :TRW Automotive Japan Corporation

CX-9 Suudi Arabia
Evaluation Result of Brake Fluid Leak from M/C

Revision History		Date	Prepared	Approved	Comment
Revised	△1				
	△2				
	△3				
	△4				

	Date	Name
Approved	2012/3/22	Adachi
Reviewed	2012/3/21	Eguchi
Reviewed		
Created	2012/3/19	Metsugi/Uno

CX-9 Brake Fluid Le k fr m Ma t r C linder(S u i Ar bia)

<B >
B S
D

<P >
C P P S

<C >
B
2 R

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D R ⇒R P R R ⇒R P
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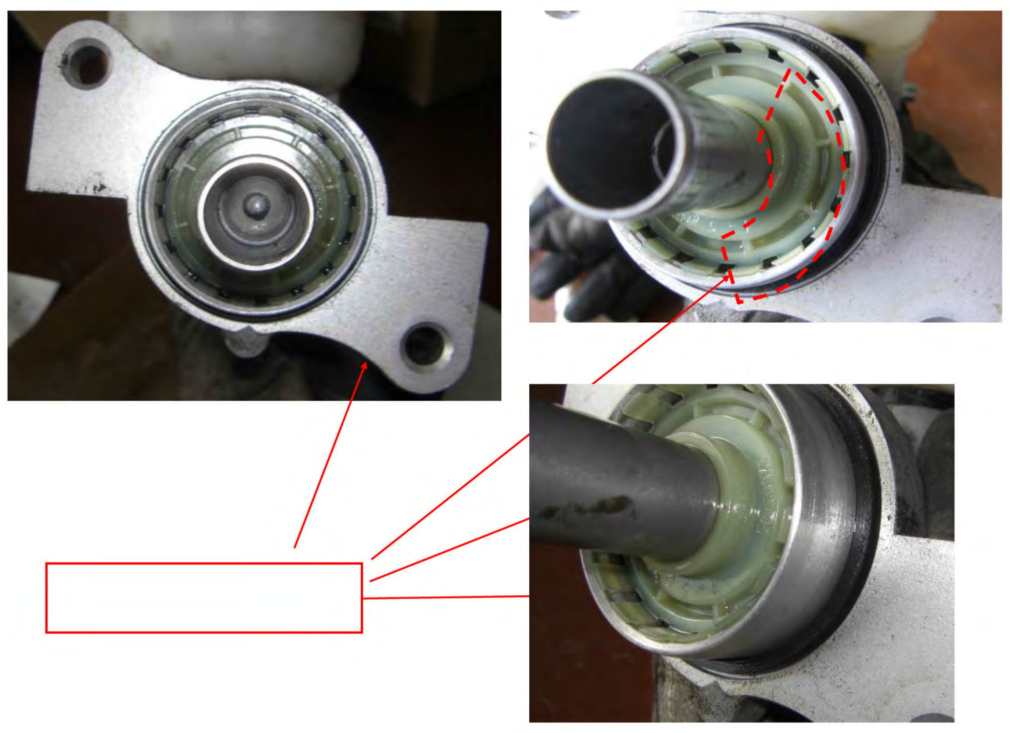
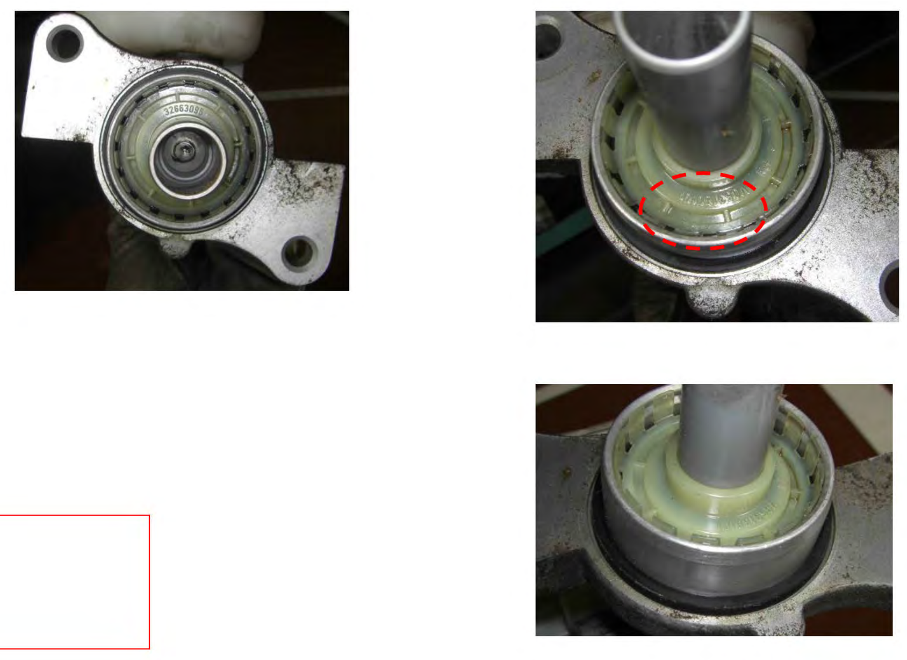
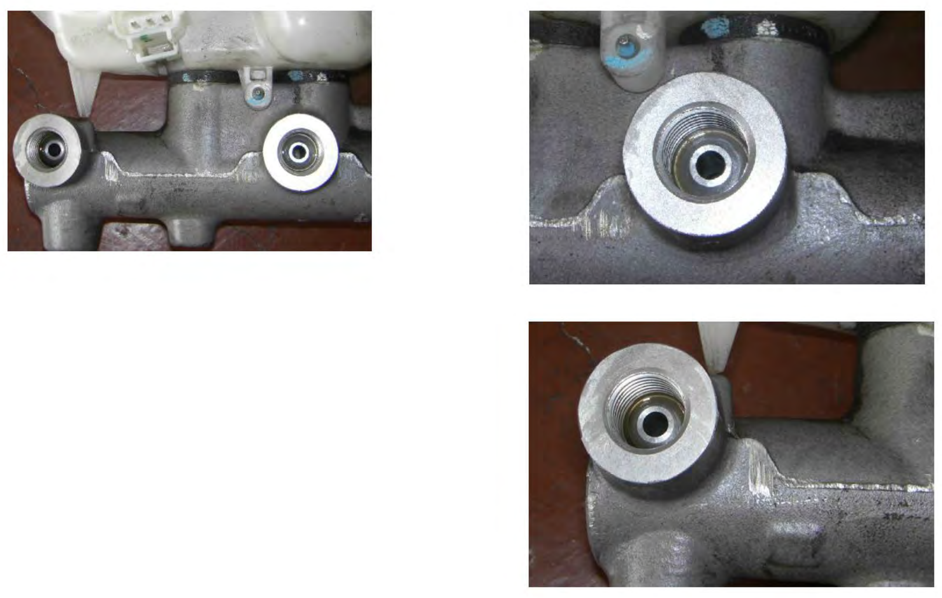
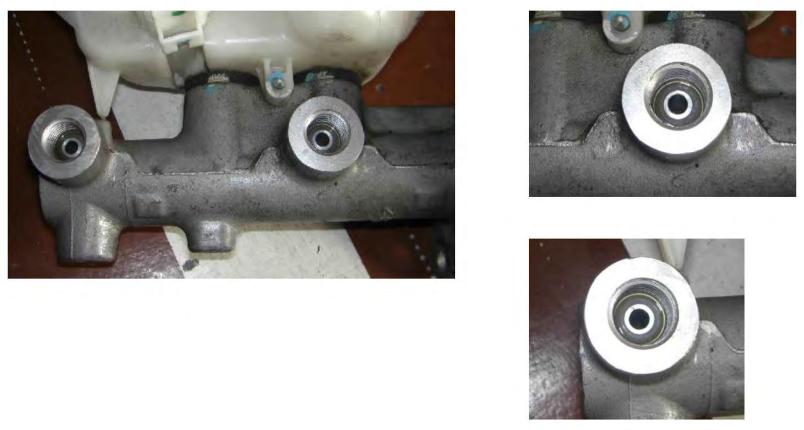
Ma t r Cyi der			
[redacted]		[redacted]	
	B R P V N		C B S R
	B P		B P
			C
V B t			
	C V		M C V
			
	C		C

CX-9 Brake Fluid Leak of Master Cylinder(Saudi Arabia)

Brake Performance Development Group UNO/METSUGI

(2)Reappearing Evaluation Result

We attached V/B from Saudi to the test vench, and carried out the following test. We used the vacuum pump to produce vacuum.

①Vacuum Leak and Stable Vacuum confirmation

In the state of V/B as no load, We operate the vacuum pump, and measured the atable vacuum. Following it, we turn off the pump, and confirm wheter there is the leak.

②Operation Check

In the state of V/B as stable vacuum, We step on the brake pedal and measure pedal forth, pedal stroke,brake fluid pressure(Pri,Sec),booster vacuum.

VIN:304178

Report Matter: Fluid leak from Master Cylinder, increased pedal forth, poor brake effect, cralinetist sound when pedal step on.

Evaluation Result:

①Stable Vacuum=;66.2kPa (Low) There was a leak.

②stepping on the pedal, vacuum decreased. More strongly stepping successively, vaccuum is restored and clarinetist sound is generated.

VIN:303009

Report Matter: increased pedal forth, poor brake effect, shoo sound occurs when brake operating.

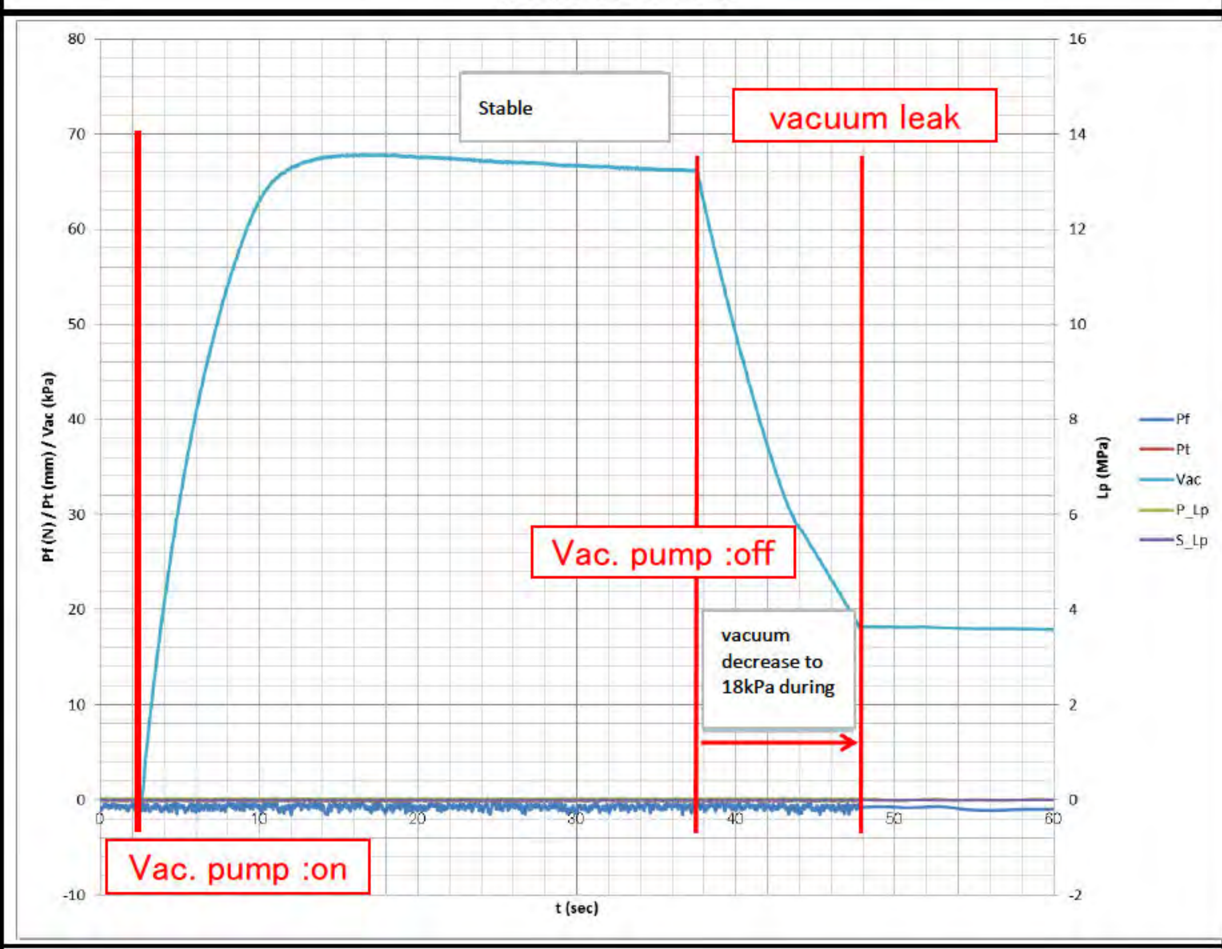
Evaluation Result:

①Stable Vacuum=61.1kPa (Low) Confirmed shoo sound.

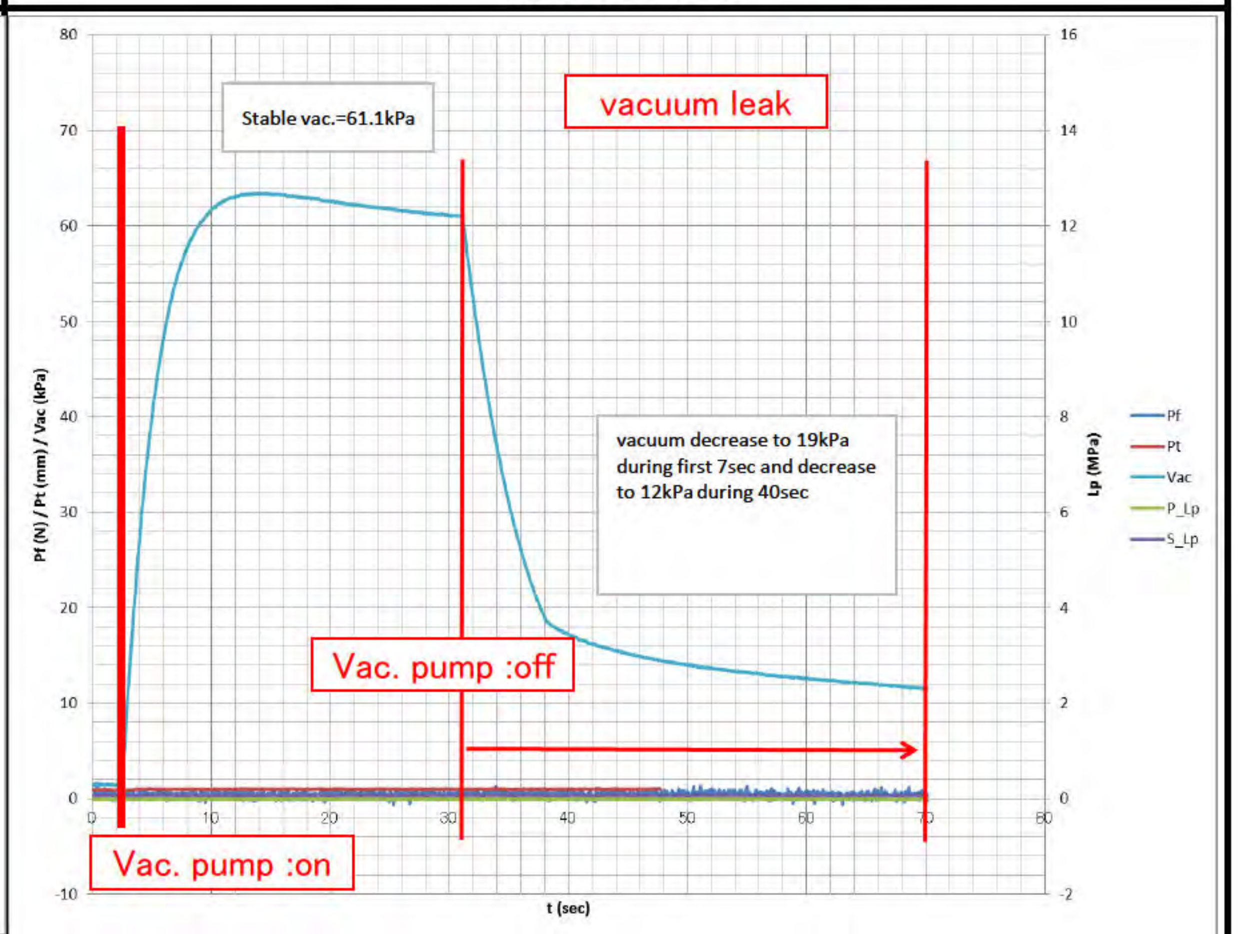
②When brake is operated, vacuum is restored.

Leak chesk & stable Vacuum

VIN:304178

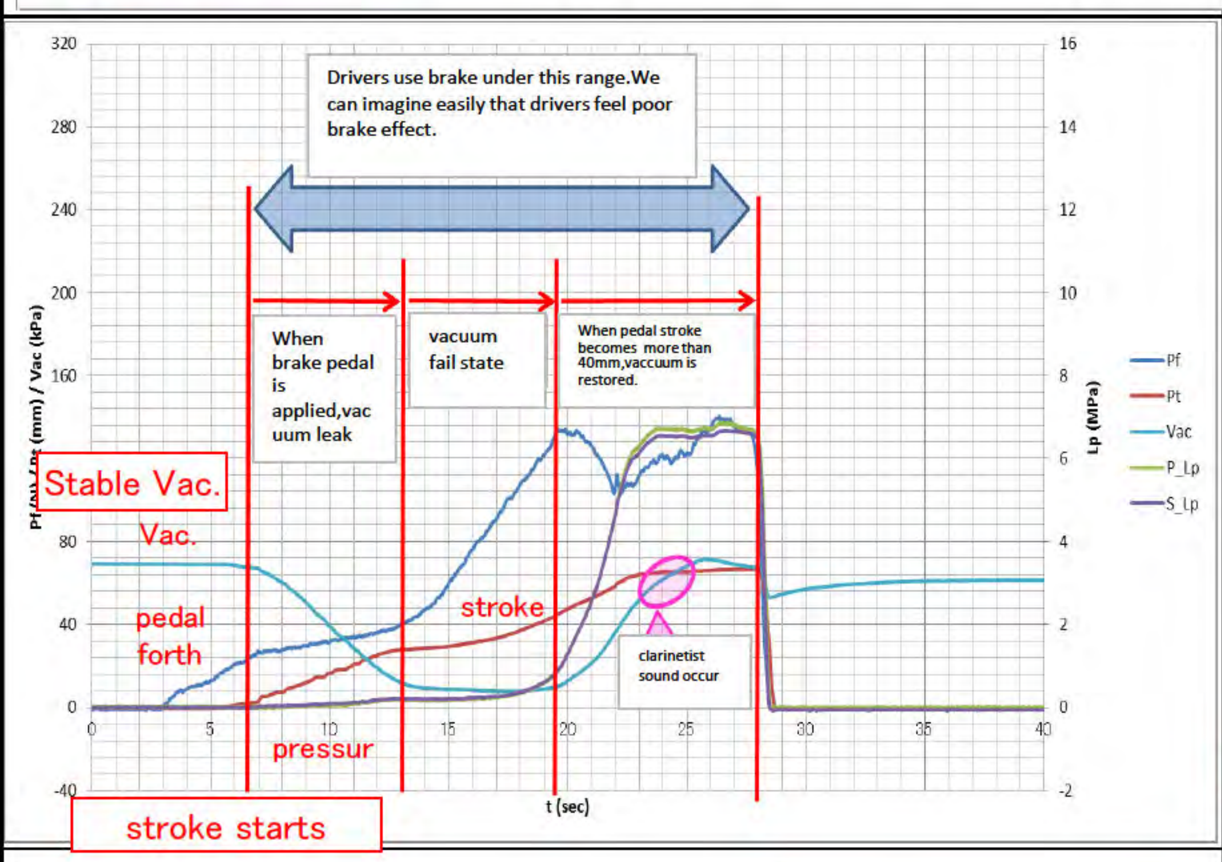


VIN:303009



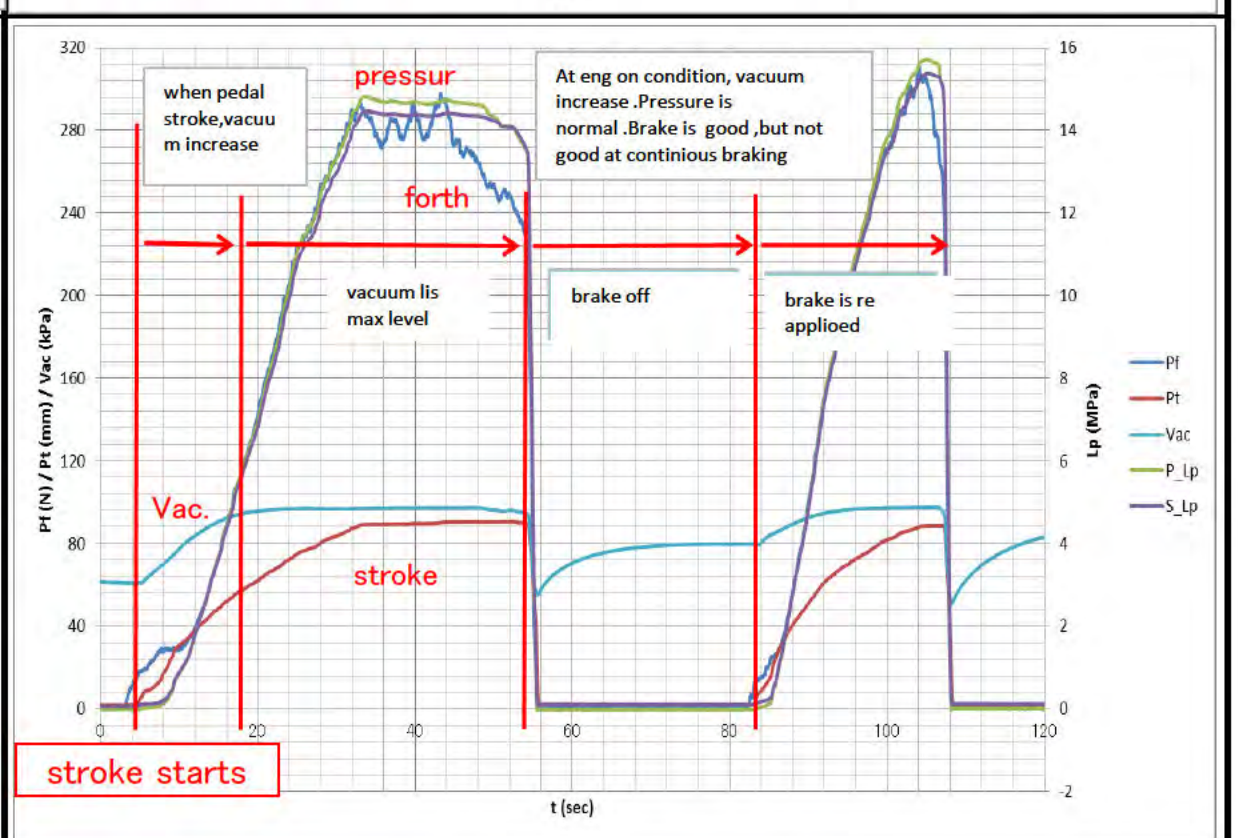
operation

VIN:304178



Re

VIN:303009



check before and after test

VIN:304178

before test

after test

VIN:303009

before test

can't confirm fluid blur

after test

comment

VIN:304178

Vacuum level is satulated at around 67kPa. We confirmed shoo sound from V/B. When pedal is applied, vacuum level become around zero.Additionaly applying the padal,vacuum level is increased again.cralinetist sound occurs at around 67kPa.Above reason, we think driver's report matter is reappeared.Reserve tunk level is 0.5〜10mm down by around 20 times braking.

VIN:303009

We confirmed Airtightness is bad,and vacuum level is not kept. Shoo sound is confirmed.too.When brake pedal is applied,vacuum level is increased for some reason. At this condition, as pressure level is normal, brake effect is good. But, when pedal is operated continiouly, we think driver feel firm brake.

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 3-2 Supplier Report 7 May 2013

Mazda J50C Warranty

Update Slides

May 7, 2013
TRW Automotive

ADVANCED THINKING / SMART THINKING / GREEN THINKING

Agenda

1. Mold dimensional data (Tool 3) and shrink ratio
2. TCU temperature limits
3. Injection parameters in relation to thickness
4. Temperature limits
5. Particle size and quantity guideline
6. Current particle size and quantity data
7. Warranty return analysis results
8. Updated Weibull analysis - Available May 24th
9. Overall summary - Available May 24th

Mold dimension and TCU limits

Q1: Mazda is asking mold dimension data (Tool 3) and shrink ratio after molding of diaphragm

Answer: Per Hutchinson, the dimensional data on the tool and compound shrinkage factors are confidential information for our design.

Q2: Current TCU temperature control 15-20 deg C, How to found out that temperature limits? Hutchinson did any evaluation?

Answer: Per Hutchinson, the 15-20 deg. C is the temperature required for the oil pumps to be in working order in order to expedite the start of the production. The 15-20 deg.C is not a process limit. These values are not meant to affect the process. These values are meant to accelerate the start up of the process. In this way, the time it takes to heat the water is shorter. The correct way to read these numbers are 15°C and 20°C, not from 15°C thru 20°C . Temperature limits are established based upon rubber processing expertise including Hutchinson R & D and manufacturing teams.

Injection parameters and temperature limits

TRW

Q3: Hutchinson's answer on Injection speed, Injection pressure for the thickness deviation.

Answer: Per Hutchinson, if the parameters are changed to be out of established range it impacts dimensions. If injection pressure and speed increased to extreme levels and out of established range, the part will be thicker. The major outcome will be that the whole part will be thicker not just the bend area and it will cause the whole part to be out of spec. This defect will be very obvious and can be easily detected with the current inspection controls.

Q4: Mazda is asking temperature limits of mixing , screening, molding and shelf life.

Answer: Temperature limits for mixing, screening and molding are considered confidential by Hutchinson. For shelf life the maximum temperature allowed is 70°F.

Item 5: Draft guideline for Particle size & quantity

Particle Size Guideline and measurements Process & Next Steps:

1. TRW created guidelines (draft) on how & when to measure particles (Complete- see next pages))
2. TRW send out guidelines draft to suppliers to review & provide feedback on understanding and agreement to implement (Mid May)
3. Review suppliers feedback & discussions / negotiations with suppliers about implementing guidelines as means to monitor & control process (End May)
4. TRW pilot use of procedure to collect information on for HSM parts and use this data to establish recommended particle limits for HSM process (See measurement plan on later page: April – May 17)
5. Discussions & negotiations with HSM about agreement to use established limits for production monitoring & control. (End May)

TRW will work hard to get support and agreement from our suppliers, however after we complete the above steps, there is no guarantee that suppliers will agree to a new requirement and specification.

Potential Issues:

- Every diaphragm we have measured has some particles, & suppliers don't know how to make parts without any particles.
- It is difficult to establish a reliable OK limit because in addition to particles size, particle location, section thickness, operating temperature & temperature history have also been found to affect the durability of the same material / process from the same supplier (HSM).
- It is unknown how stable suppliers processes are over a long time and if they would be capable to the new limits
- If a process changes, the reactions / adjustment that are needed to correct the drift are uncertain and not proven.
- Additional cost for additional new measurements, increased scrap, & any reactionary actions.
- How to contain any suspect parts if they exceed limits & still maintain delivery.
- How to establish long term limits for new suppliers that we have little data on.

Item 5: Draft guideline for Particle size & quantity

We have developed a guideline for evaluating particles in the rubber part. The guideline is currently in the DRAFT state. The guideline will be reviewed with suppliers in May.

Summary of Guideline:

Procedure:

- The sample part is divided into about 24 equal parts around the perimeter:

Rubber Particle Guideline (Draft)

•Each section is then cut from the diaphragm, nicked with a razor and torn

Rubber Particle Guideline (Draft)

- The tear surfaces are then inspected. Particles in the tear surfaces are identified, measured, and recorded.

Tear surface of section

Example of particle

Rubber Particle Guideline (Draft)

For each part evaluated, the 10 largest particle sizes observed are averaged together. The part is then graded using the following criteria:

Level 1: 50 microns or less

Level 2: 50 to 100 microns in size

Level 3: 100 to 200 microns in size

Level 4: 200 to 400 microns in size

Level 5: 400 microns or greater in size

Draft particle Guideline

Item 6: Current particles size and quantity data by cutting diaphragms (N=20 or 30)

#	Type	Part History	Shelf Life	Mold Date	Cav #	Approx Measurement Date	TRW Count >0.1mm	Ave of 10 largest	Status
1	Field- tear	Warranty	Unknown	Jan-10	1	Jul-12	11	895	Complete
2	Field- tear	Warranty	Unknown	May-10	1	Apr-13	24	209	Complete
3	Field- tear	Warranty	Unknown	May-10	1	Apr-13	23	232	Complete
1	Tested- no tear	DOE Suspension	8 week	Jan-13	3	Mar-13	2	50.7	Complete
2	Tested- no tear	DOE Suspension	8 week	Jan-13	3	Apr-13	9	149.5	Complete
3	Tested- no tear	DOE Suspension	8 week	Jan-13	3	Apr-13	8	156.9	Complete
4	Tested- no tear	Passed 100K DOE		Jan-13	4	May-13	TBD	TBD	In lab
5	Tested- no tear	Passed 100K DOE		Jan-13	4	May-13	TBD	TBD	In lab
1	New- Not tested	DOE Samples	1 week	11/27/2012	2	Jan-13	17	TBD	Complete
2	New- Not tested	DOE Samples	1 week	11/27/2012	3	Jan-13	22	TBD	Complete
3	New- Not tested	Production New	1 wk max	Jan-13	4	May-13	TBD	TBD	In lab
4	New- Not tested	Production New	1 wk max	Jan-13	4	May-13	TBD	TBD	In lab
5	New- Not tested	Production New	1 wk max	Feb-10	4	May-13	TBD	TBD	In lab
6	New- Not tested	Production New	1 wk max	Feb-10	4	May-13	TBD	TBD	In lab
7	New- Not tested	Production New	1 wk max	Feb-10	4	May-13	TBD	TBD	In lab
8	New- Not tested	Production New	1 wk max	Mar-13	3	May-13	TBD	TBD	In transit
9	New- Not tested	Production New	1 wk max	Mar-13	3	May-13	TBD	TBD	In transit
10	New- Not tested	Production New	1 wk max	Mar-13	3	May-13	TBD	TBD	In transit
11	New- Not tested	Production New	1 wk max	Mar-13	3	May-13	TBD	TBD	In transit
12	New- Not tested	Production New	1 wk max	Mar-13	3	May-13	TBD	TBD	In transit
13	New- Not tested	Production New	1 wk max	Apr-13	4	May-13	TBD	TBD	In transit
14	New- Not tested	Production New	1 wk max	Apr-13	4	May-13	TBD	TBD	In transit
15	New- Not tested	Production New	1 wk max	Apr-13	4	May-13	TBD	TBD	In transit
16	New- Not tested	Production New	1 wk max	Apr-13	4	May-13	TBD	TBD	In transit
17	New- Not tested	Production New	1 wk max	Apr-13	4	May-13	TBD	TBD	In transit

- TRW measurement status: Expect completion May 17th.
- 25 parts in total (3 warranty, 5 DOE no tear, 17 new production)
- Results will be plotted when completed

Warranty Analysis Results

- **General test set up**
  - 670 mbar vacuum applied to vacuum booster (non-isolated)
  - One master cylinder used for all evaluations
  - System stiffness set at 99 bar pressure at 30 mm master cylinder input stroke
  - 3 input apply speeds
    - 2 mm/sec @ input rod = 6 mm/sec @ pedal
    - 8 mm/sec @ input rod = 23 mm/sec @ pedal
    - 25 mm/sec @ input rod = 73 mm/sec @ pedal
  - Ambient room temperature
- **One reference booster evaluated for base line performance (no-tear diaphragm)**
- **13 warranty return boosters evaluated for performance (14 total returns received)**
- **After performance evaluations**
  - Remove diaphragms and inspect for
    - Date code
    - Tear (size and location)
- **Diaphragms with tears sent to materials group for tear analysis and inspected**
  - Presence of non-homogenous particle (recorded 2-dimensional size)
  - Thickness of T2 section near tear

Warranty Analysis Results

- **All 14 warranty returns have T2 type tears with pre-cured rubber particle at tear origin**
  - Diaphragm mold date codes range from July 2007 to December 2011
  - Composite tear lengths range from 24 mm to 70 mm (individual tear lengths range from 24 mm to 32 mm)
  - T2 section thickness near tear range from 0.99 mm to 1.41 mm
  - Booster 124704 (Field No. 2D32071032) not tested – disassembled prior to TRW receipt

No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (Sorted) (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin: Dimension 1 (micron)	Particle at Tear Origin: Dimension 2 (micron)	Particle at Tear Origin: Composition	T2 Thickness Near Tear (mm)
4	124699	Aug-11	2D32805305	JM7TB1MA8C[redacted]	14,851	Saudi Arabia	T2	6:30	25	25	266	200	Pre-cured Rubber	1.15
6	124701	Dec-11	2D32212729	JM3TB3DV8C[redacted]	18,335	U.S.A.	T2	4:30	32	32	371	276	Pre-cured Rubber	1.27
7	124702	Jul-10	2D30864905	JM7TB19A6B[redacted]	20,500	Saudi Arabia	Tear 1 T2	11:00	24	70	157	130	Pre-cured Rubber	1.34
							Tear 2 T2	12:00	22		244	163	Pre-cured Rubber	
							Tear 3 T2	0:30	24		155	114	Pre-cured Rubber	
8	124703	Sep-11	2D30864905	JM7TB1MA1C[redacted]	23,013	Saudi Arabia	T2	6:00	27	27	122	39	Pre-cured Rubber	1.32
13	124708	Aug-11	2D32805305	JM7TB19A3B[redacted]	24,866	Saudi Arabia	T2	6:00	32	32	159	123	Pre-cured Rubber	1.18
3	124692	Sep-10	2D32805305	JM7TB19A0B[redacted]	30,889	Saudi Arabia	Tear 1 T2	12:00	27	42	131	104	Pre-cured Rubber	1.11
							Tear 2 T2	11:30	15		165	104	Pre-cured Rubber	
11	124706	Aug-10	2D32071032	JM7TB19A9B[redacted]	35,375	Saudi Arabia	T2	4:00	29	29	106	71	Pre-cured Rubber	1.05
12	124707	Nov-10	2D32071032	JM7TB19A3B[redacted]	41,813	Saudi Arabia	T2	6:30	30	30	190	104	Pre-cured Rubber	1.11
2	124392	May-10	2D30110345	JM7TB19A5A[redacted]	50,629	Taiwan	T2	2:00	32	32	149	87	Pre-cured Rubber	1.11
5	124700	Apr-10	2D40854749	JM7TB19A2A[redacted]	54,966	Saudi Arabia	T2	12:00	29	29	166	103	Pre-cured Rubber	1.11
10	124705	Jul-11	2D32071032	JM7TB19AXA[redacted]	56,545	Saudi Arabia	T2	10:00	28	28	138	110	Pre-cured Rubber	1.41
1	124391	May-10	2D21465749	JM3B3MA4A[redacted]	61,362	Dominica	T2	0:30	25	25	103	53	Pre-cured Rubber	1.04
9	124704	Jul-07	2D32071032	JM7TB19AXA[redacted]	76,219	Saudi Arabia	T2	4:00	26	26	160	68	Pre-cured Rubber	0.99
14	124709	Jan-10	2D31311741	JM7TB19A98[redacted]	84,306	Saudi Arabia	T2	10:00	24	24	152	144	Pre-cured Rubber	1.13

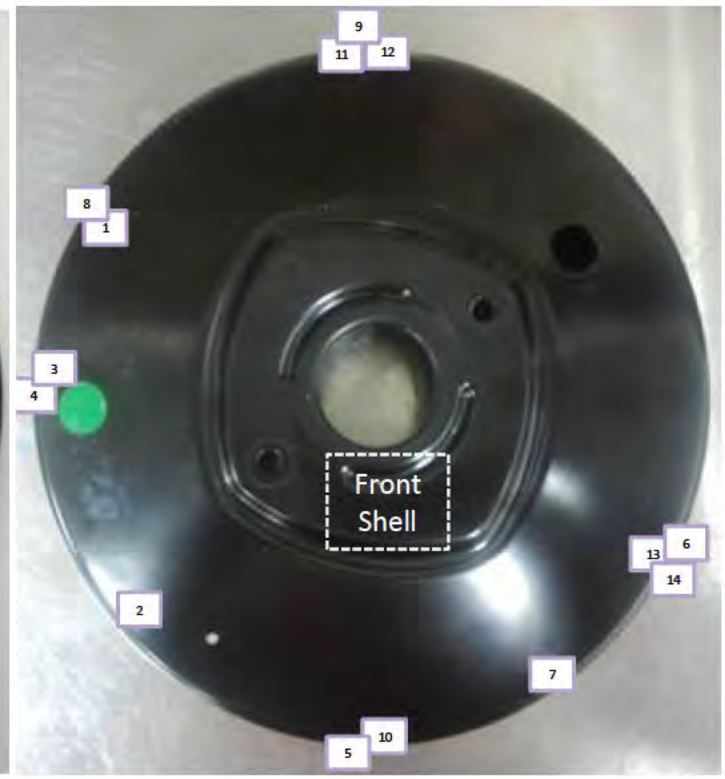
Warranty Analysis Results

- **Tear concentration diagram for location on diaphragm and location in booster assembly**

Legend

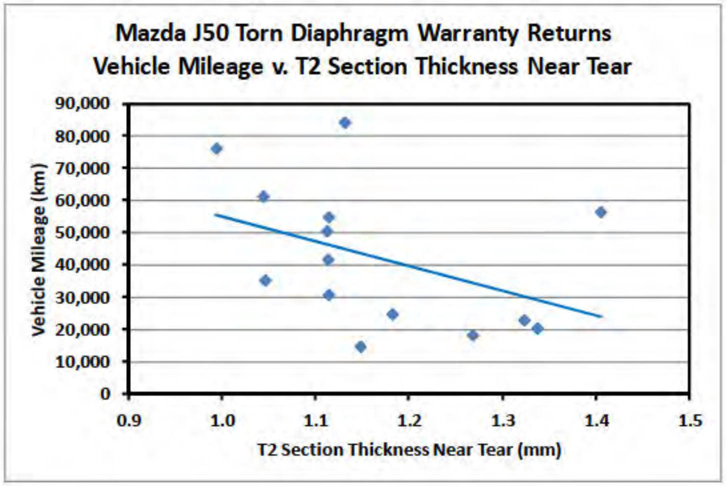
Tear from Field Warranty Return

Label	Diaphragm ID	No. of Tears
1	124391	1
2	124392	1
3	124692	2
4	124699	1
5	124700	1
6	124701	1
7	124702	3
8	124703	1
9	124704	1
10	124705	1
11	124706	1
12	124707	1
13	124708	1
14	124709	1

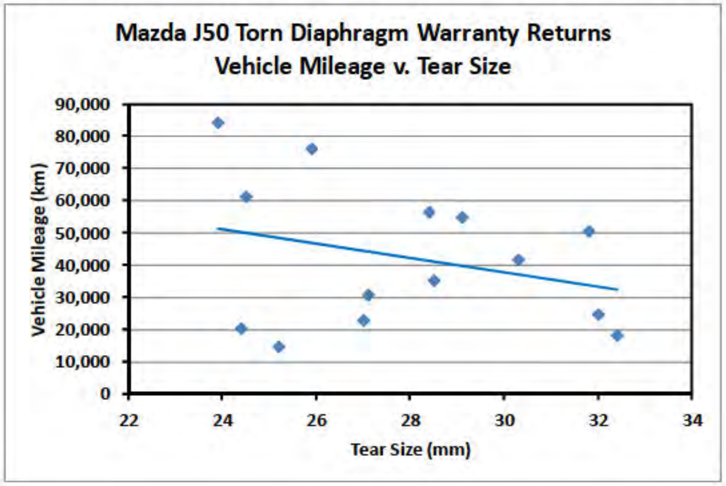


Warranty Analysis Results

- **Warranty return reported vehicle mileage v. T2 section thickness (linear regression line)**



- **Warranty return reported vehicle mileage v. diaphragm tear size (linear regression line)**

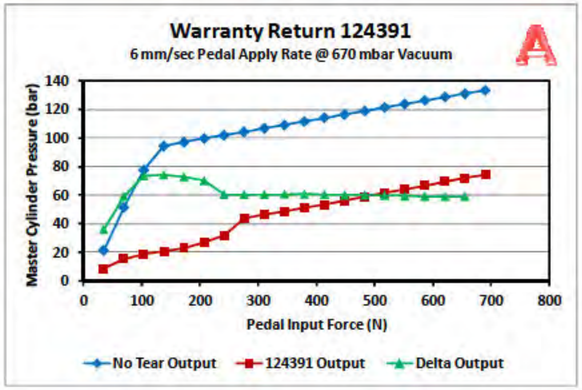


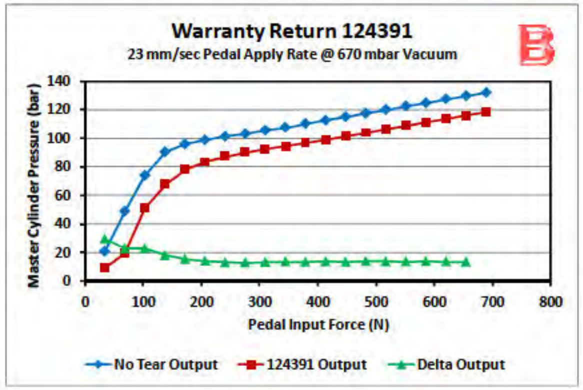
Warranty Analysis Results

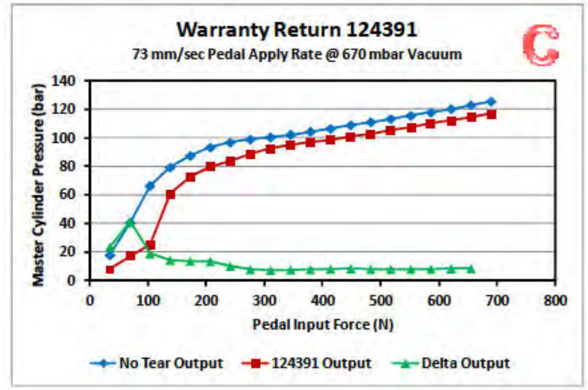
- **Graphical representations on following pages illustrate the performance of 13 warranty return boosters with torn diaphragms evaluated:**
  - Master cylinder (output) pressure v. input pedal force at 3 pedal apply speeds compared to no-tear (reference) booster performance
    - Plots: **A** 6 mm/sec pedal apply rate
      B 23 mm/sec pedal apply rate
      C 73 mm/sec pedal apply rate
      D comparison of master cylinder output with each pedal apply speed
    - Difference between warranty booster performance and no-tear booster performance decreases with faster pedal apply speed
    - Each warranty return booster attains 80% of no-tear booster performance at 23 mm/sec or greater pedal apply speed
  - Pedal input force v. pedal input travel at 3 pedal apply speeds compared to no-tear (reference) booster performance
    - Plot: **E** comparison of performance with each pedal apply speed
    - Pedal feel (input force v. input travel) changes with pedal apply speed
    - Warranty booster pedal feel approaches no-tear booster pedal feel with greater pedal apply speed

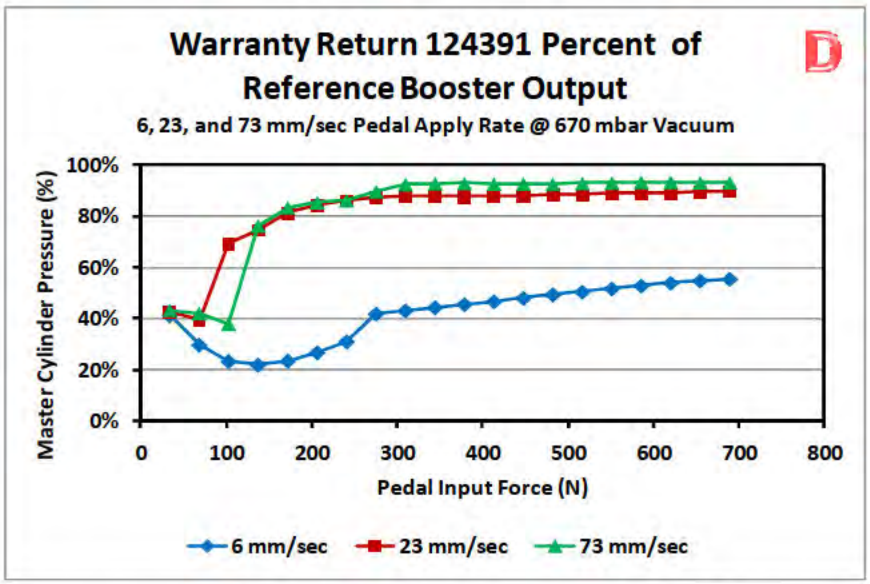
Diaphragm 124391 (VIN JM3B3MA4A0231052)

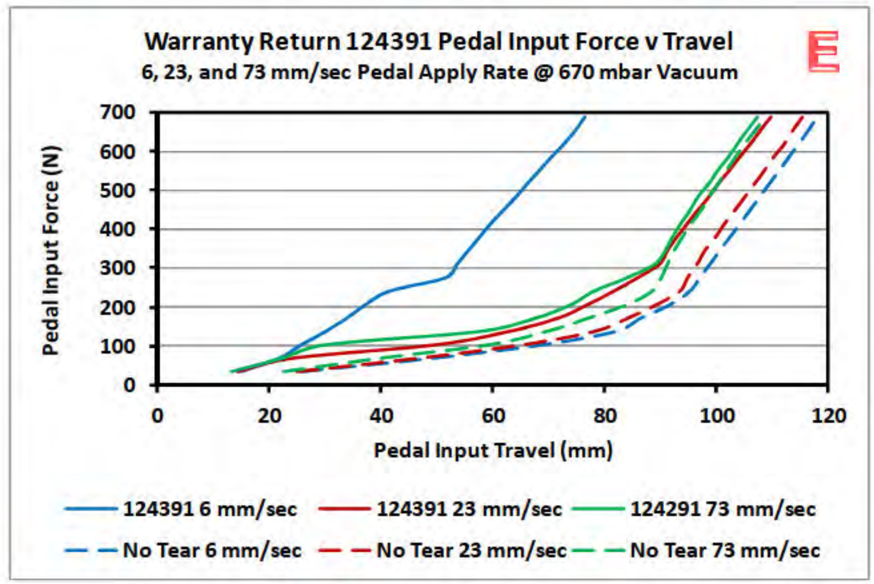
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin			T2 Thickness Near Tear (mm)
											Dimension 1 (micron)	Dimension 2 (micron)	Composition	
1	124391	May-10	2D21465749	JM3B3MA4A[redacted]	61,362	Dominica	T2	0:30	25	25	103	53	Pre-cured Rubber	1.04





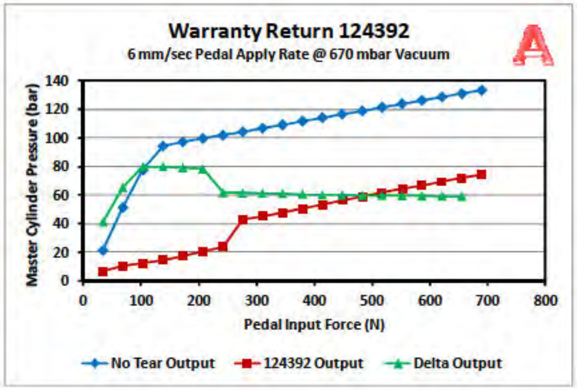


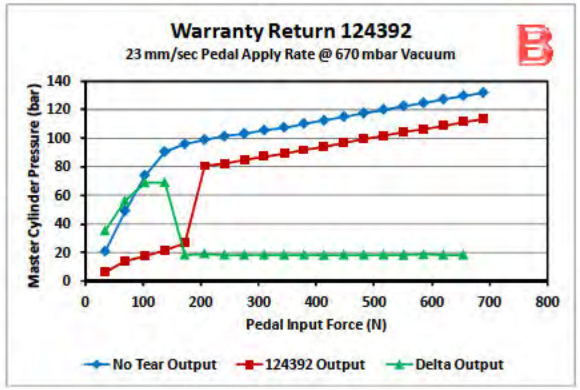


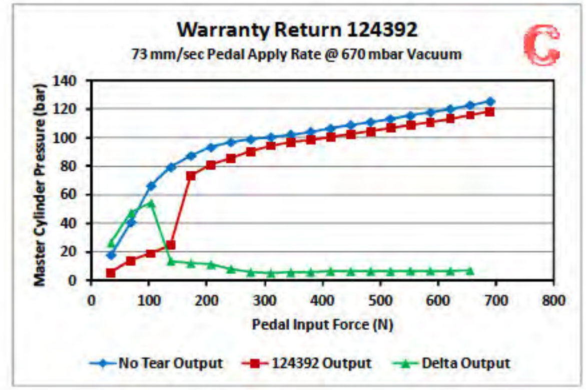


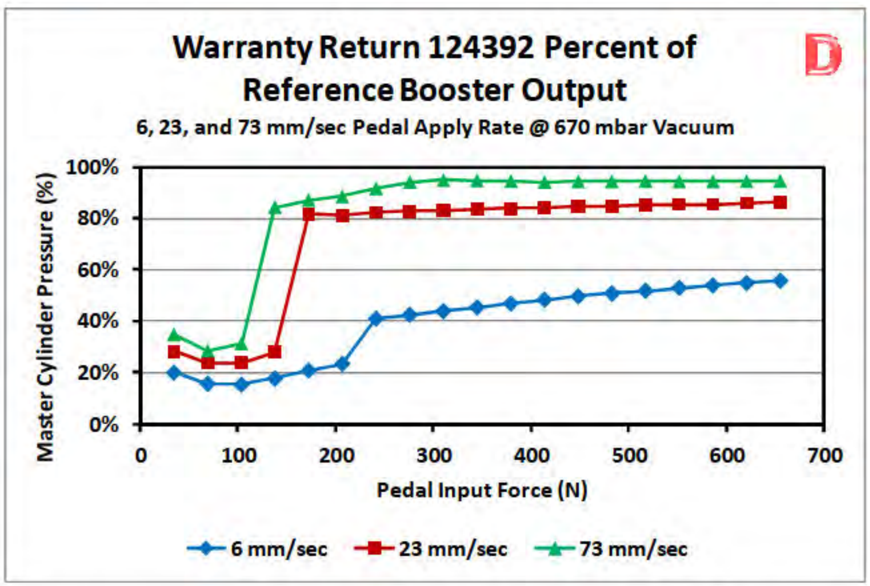
Diaphragm 124392 (VIN JM7TB19A5A0209704)

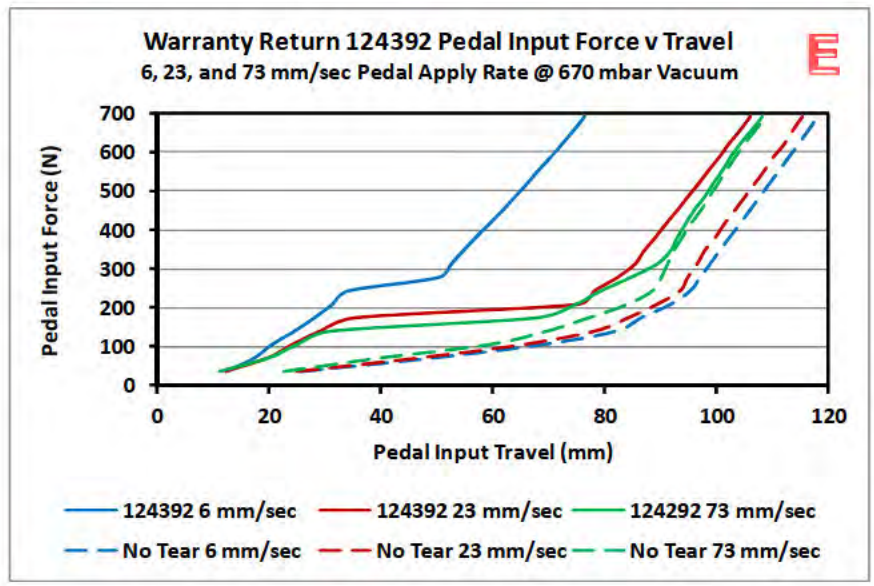
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin			T2 Thickness Near Tear (mm)
											Dimension 1 (micron)	Dimension 2 (micron)	Composition	
2	124392	May-10	2D30110345	JM7TB19A5A[redacted]	50,629	Taiwan	T2	2:00	32	32	149	87	Pre-cured Rubber	1.11





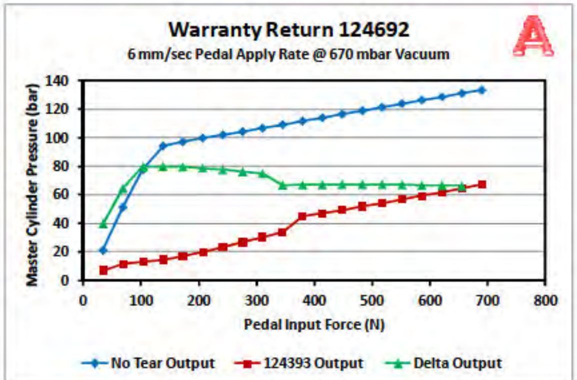


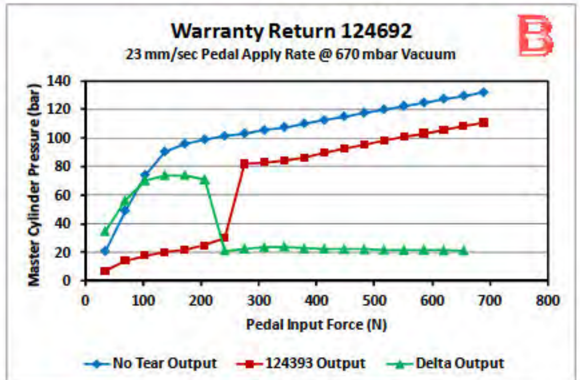


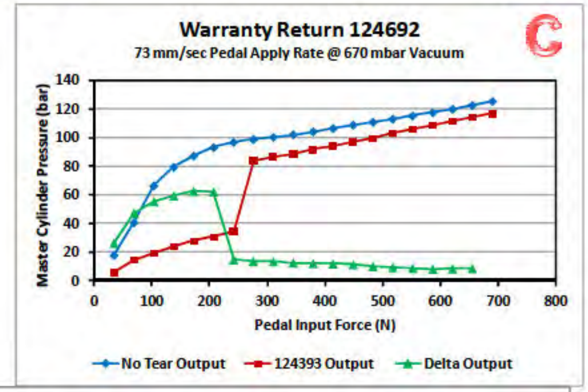


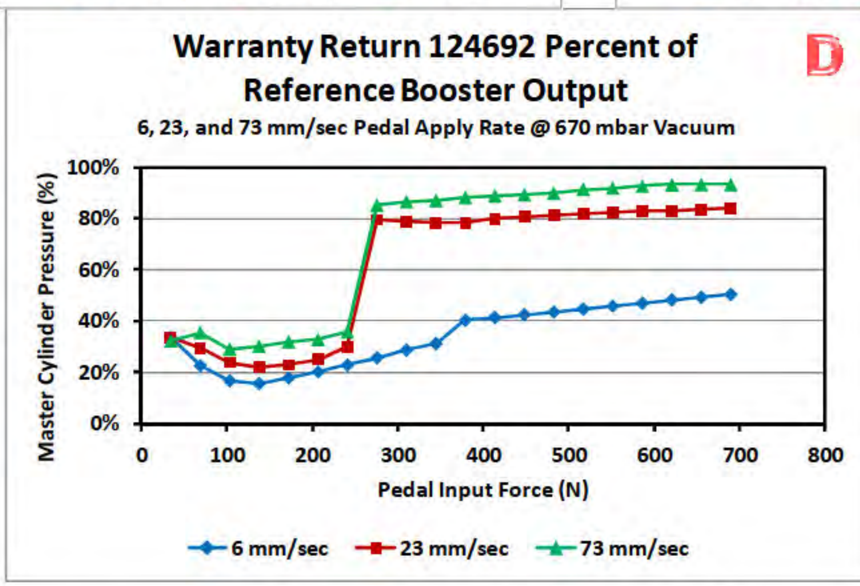
Diaphragm 124692 (VIN JM7TB19A0B0302874)

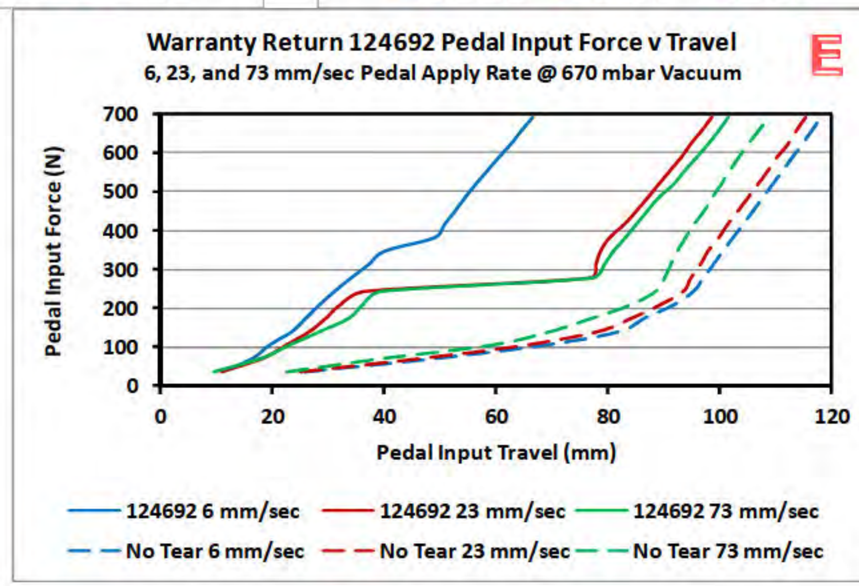
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin Dimension 1 (micron)	Particle at Tear Origin Dimension 2 (micron)	Particle at Tear Origin Composition	T2 Thickness Near Tear (mm)
3	124692	Sep-10	2D32805305	JM7TB19A0[redacted]	30,889	Saudi Arabia	Tear 1 T2	12:00	27	42	131	104	Pre-cured Rubber	1.11
							Tear 2 T2	11:30	15		165	104	Pre-cured Rubber	





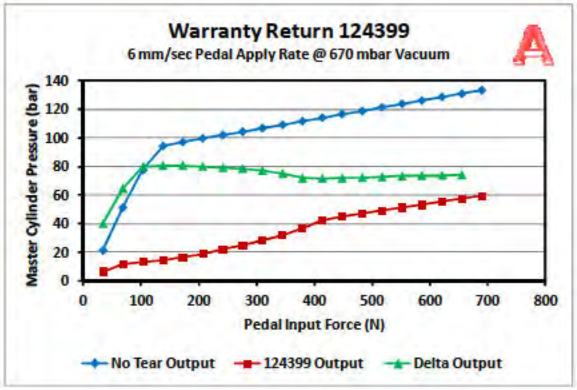


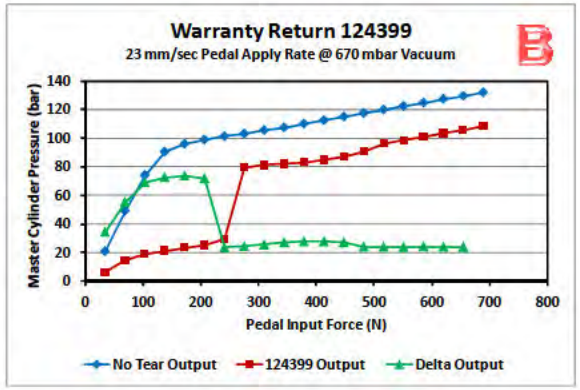


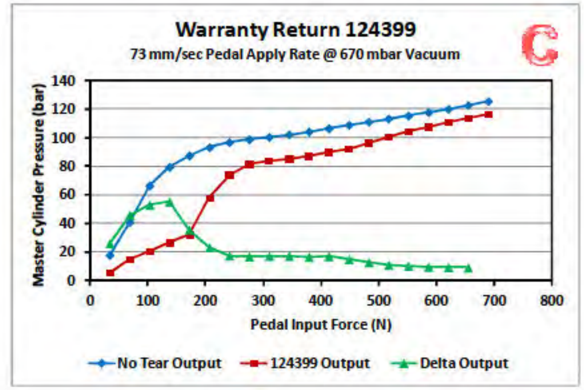


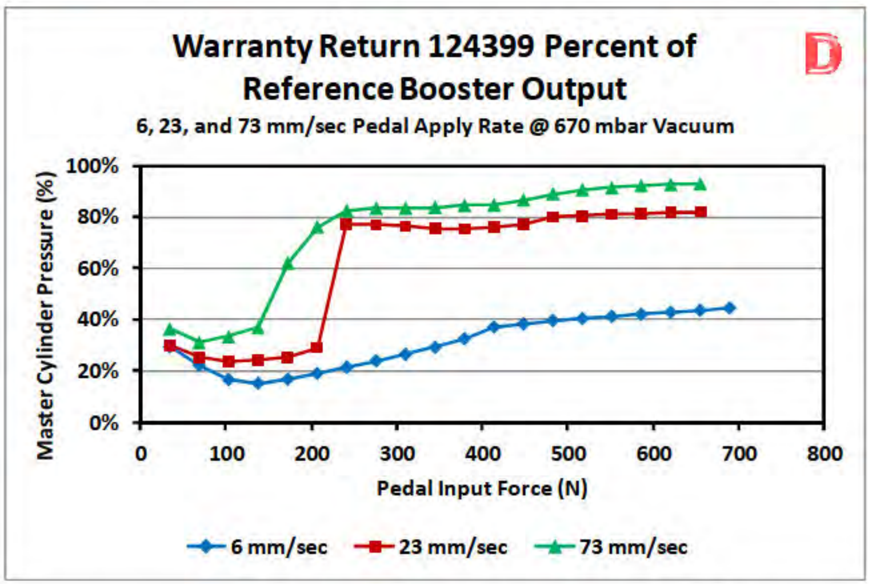
Diaphragm 124699 (VIN JM7TB1MA8C0310326)

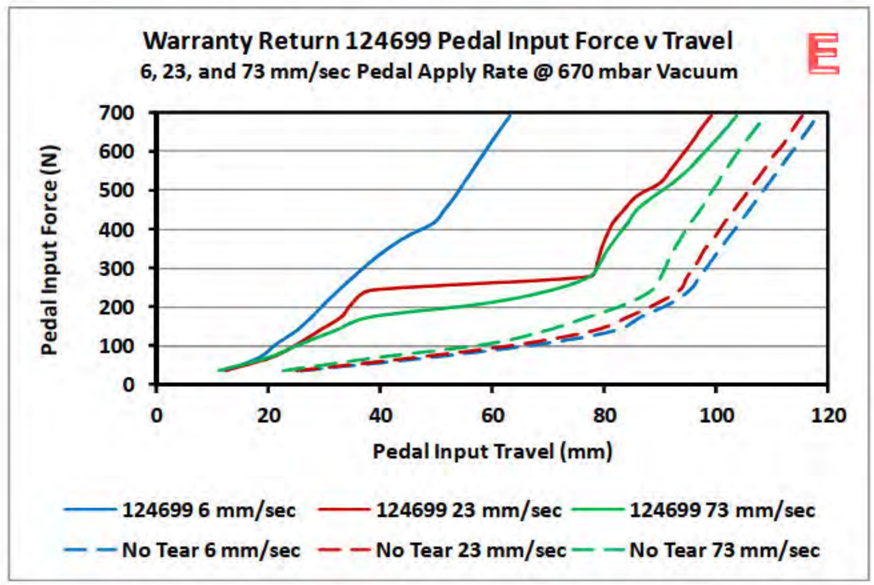
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin			T2 Thickness Near Tear (mm)
											Dimension 1 (micron)	Dimension 2 (micron)	Composition	
4	124699	Aug-11	2D32805305	JM7TB1MA8[redacted]	14,851	Saudi Arabia	T2	6:30	25	25	266	200	Pre-cured Rubber	1.15





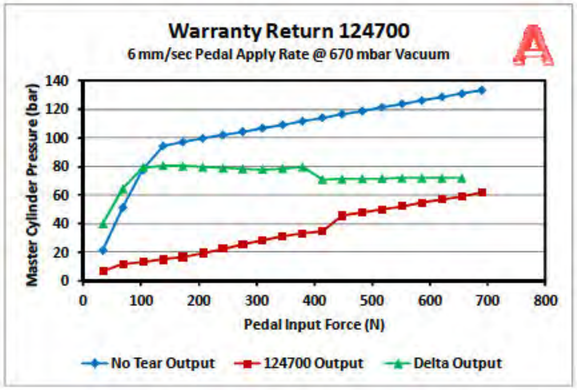


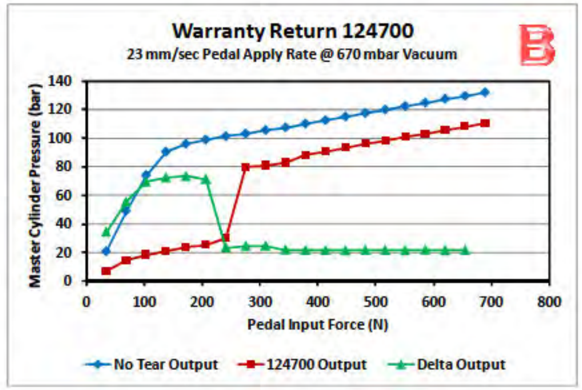


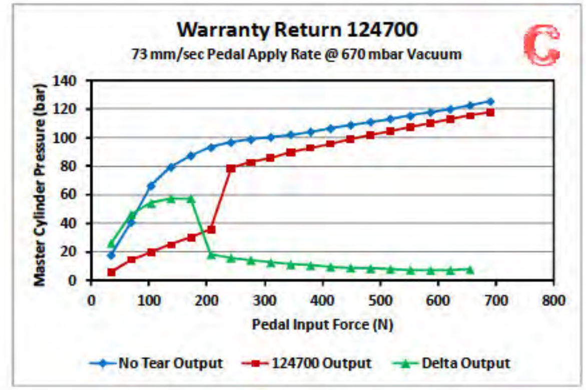


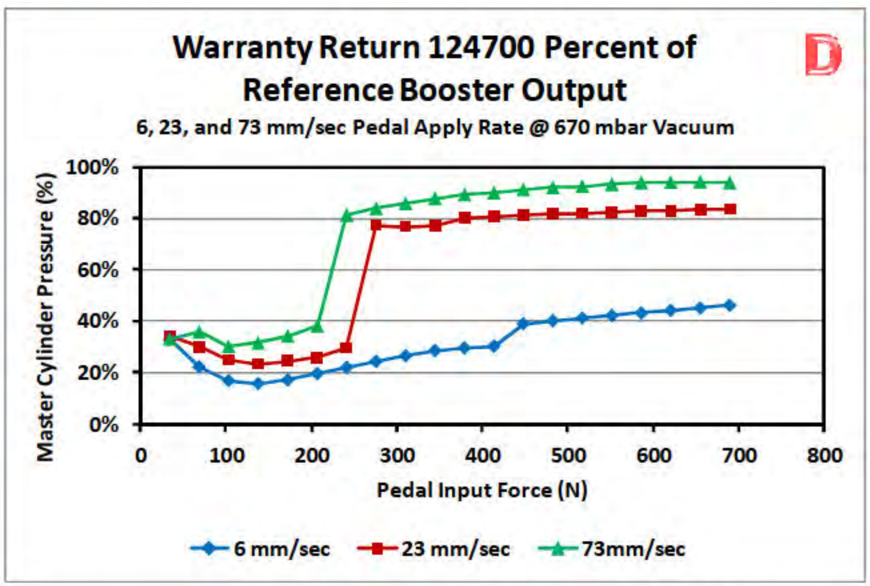
Diaphragm 124700 (VIN JM7TB19A2A0206629)

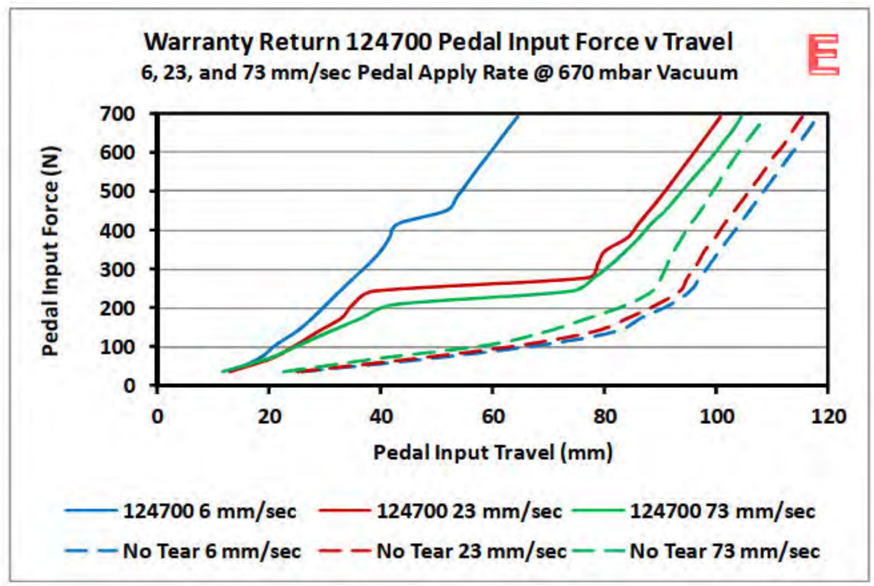
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin			T2 Thickness Near Tear (mm)
											Dimension 1 (micron)	Dimension 2 (micron)	Composition	
5	124700	Apr-10	2D40854749	JM7TB19A2[redacted]	54,966	Saudi Arabia	T2	12:00	29	29	166	103	Pre-cured Rubber	1.11





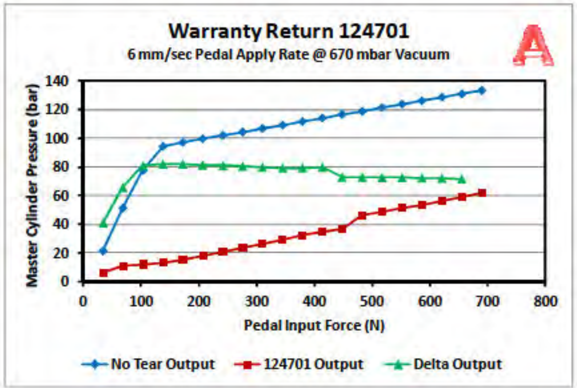


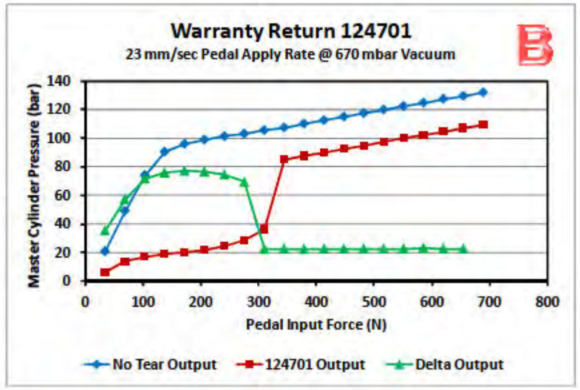


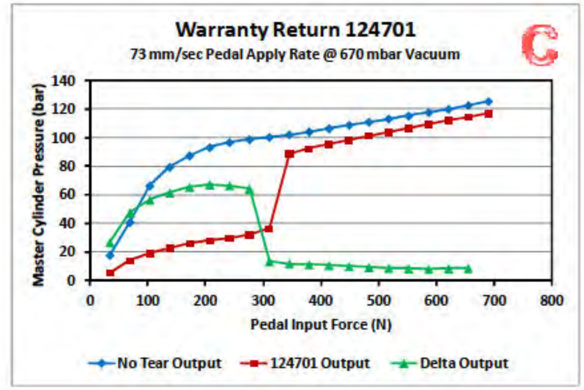


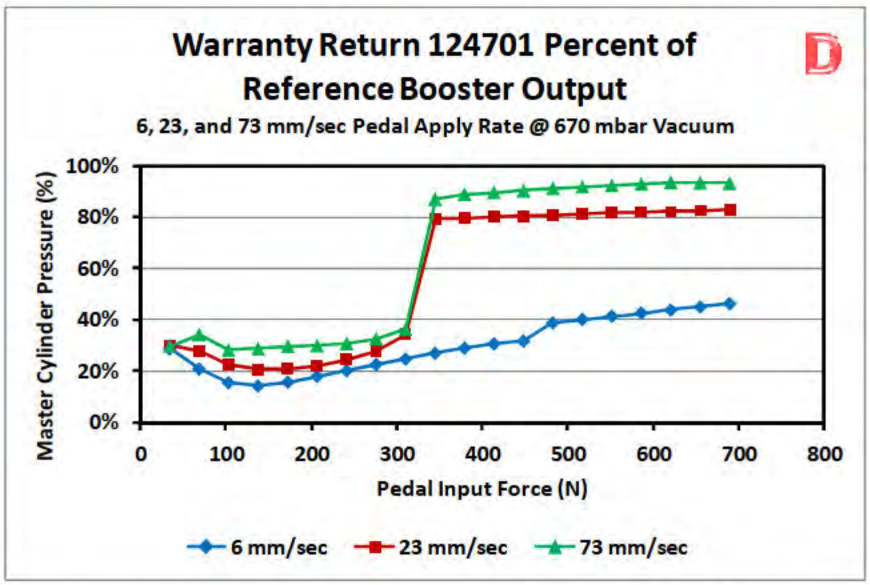
Diaphragm 124701 (VIN JM3TB3DV8C0355962)

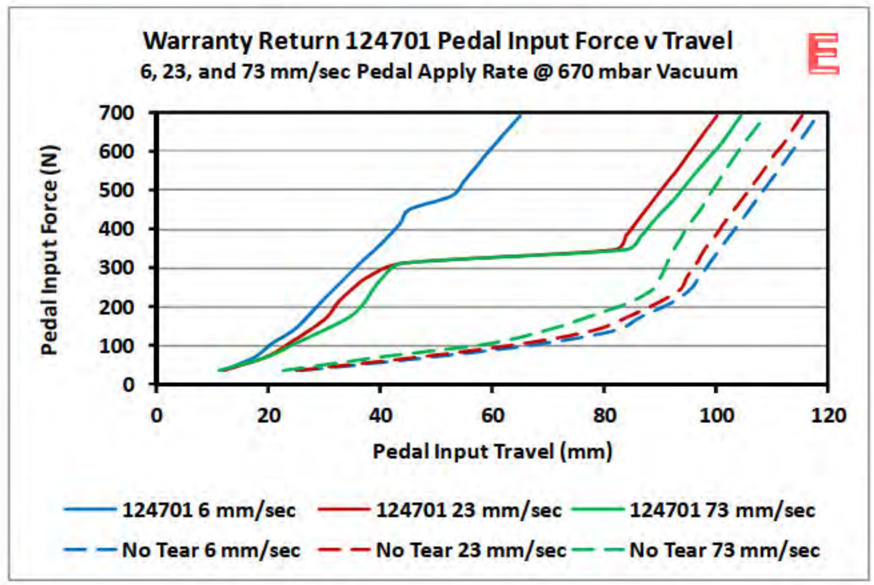
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin			T2 Thickness Near Tear (mm)
											Dimension 1 (micron)	Dimension 2 (micron)	Composition	
6	124701	Dec-11	2D32212729	JM3TB3DV8[redacted]	18,335	U.S.A.	T2	4:30	32	32	371	276	Pre-cured Rubber	1.27





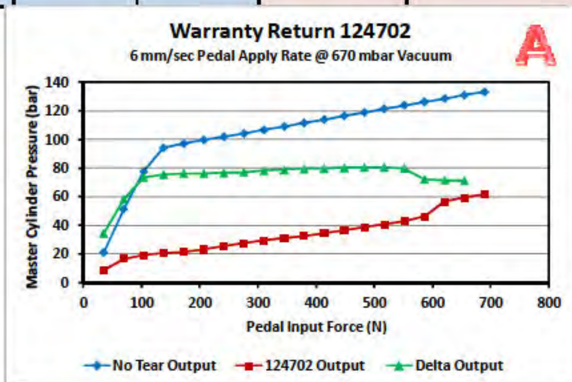


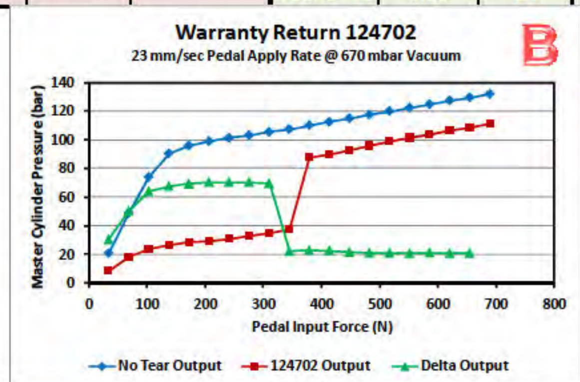


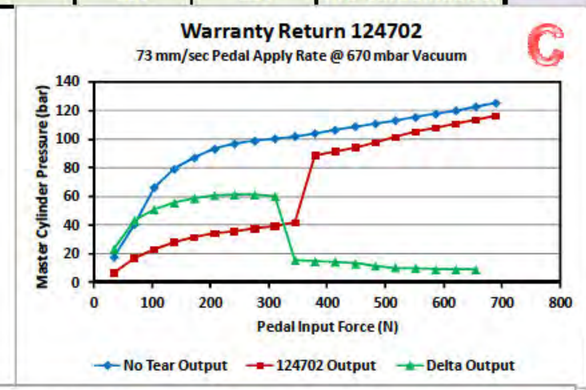


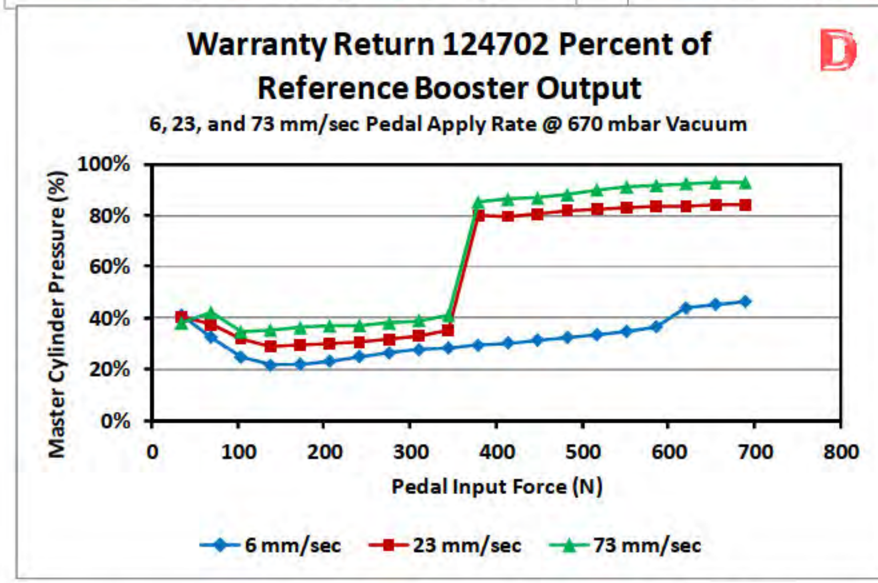
Diaphragm 124702 (VIN JM7TB19A6B0300966)

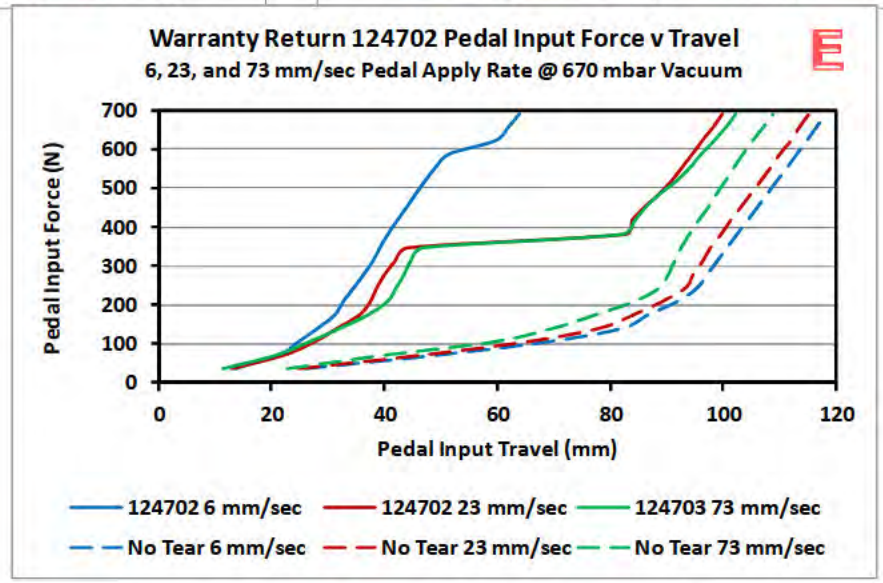
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin Dimension 1 (micron)	Dimension 2 (micron)	Composition	T2 Thickness Near Tear (mm)
7	124702	Jul-10	2D30864905	JM7TB19A6B[redacted]	20,500	Saudi Arabia	Tear 1 T2	11:00	24	70	157	130	Pre-cured Rubber	1.34
							Tear 2 T2	12:00	22		244	163	Pre-cured Rubber	
							Tear 3 T2	0:30	24		155	114	Pre-cured Rubber	





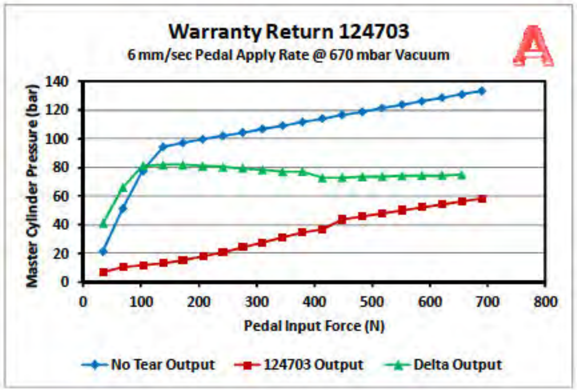


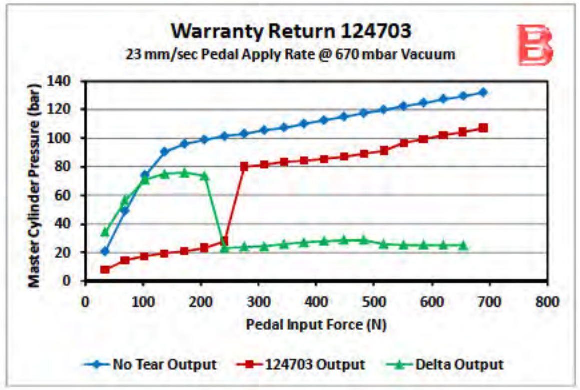


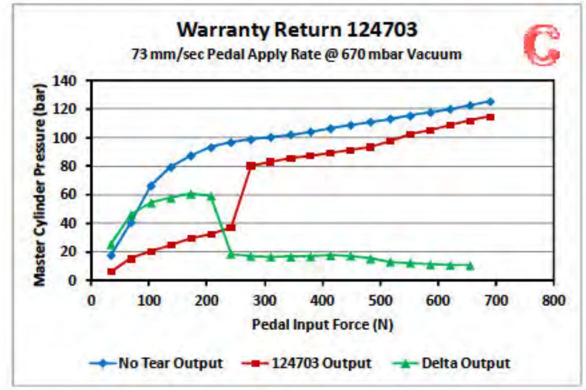


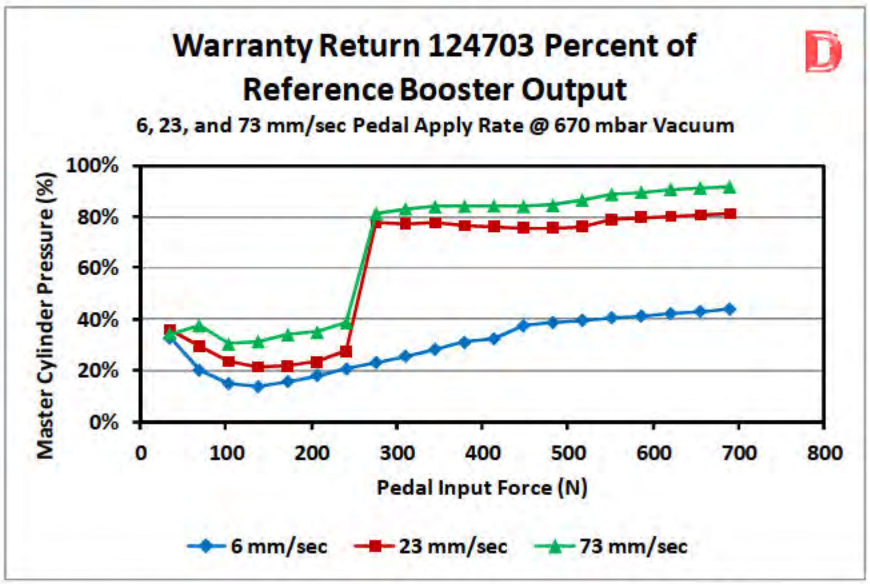
Diaphragm 124703 (VIN JM7TB1MA1C0310698)

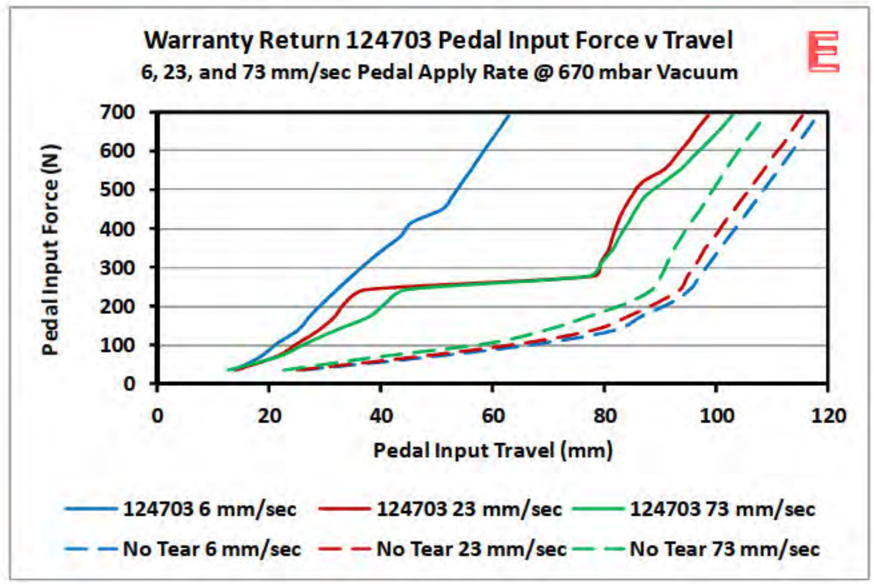
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin			T2 Thickness Near Tear (mm)
											Dimension 1 (micron)	Dimension 2 (micron)	Composition	
8	124703	Sep-11	2D30864905	JM7TB1MA1[redacted]	23,013	Saudi Arabia	T2	6:00	27	27	122	39	Pre-cured Rubber	1.32





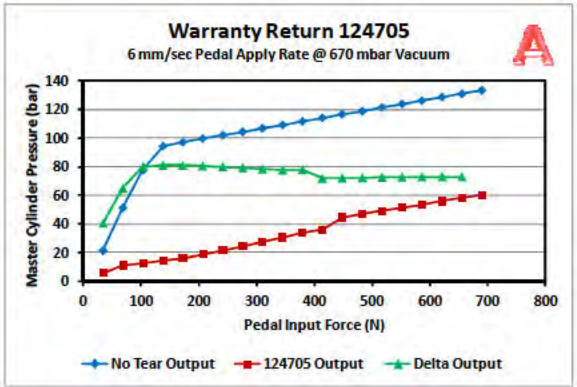


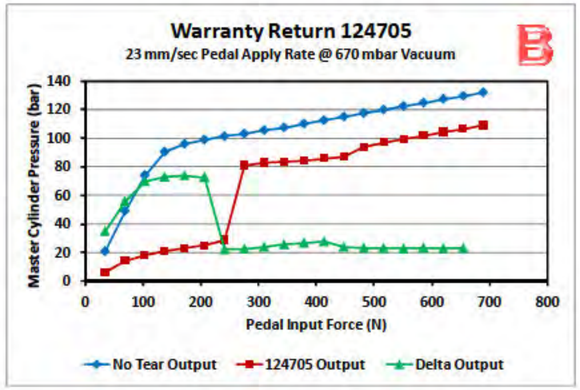


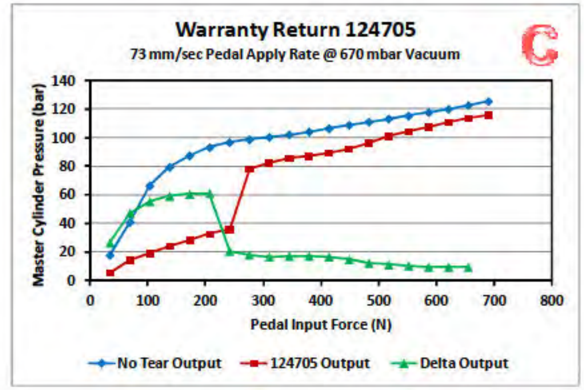


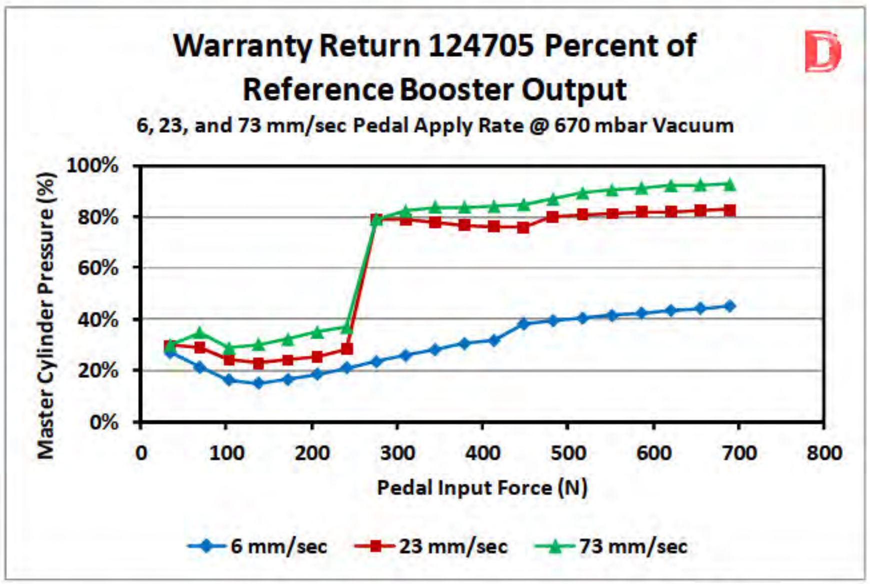
Diaphragm 124705 (VIN JM7TB19AXA0207883)

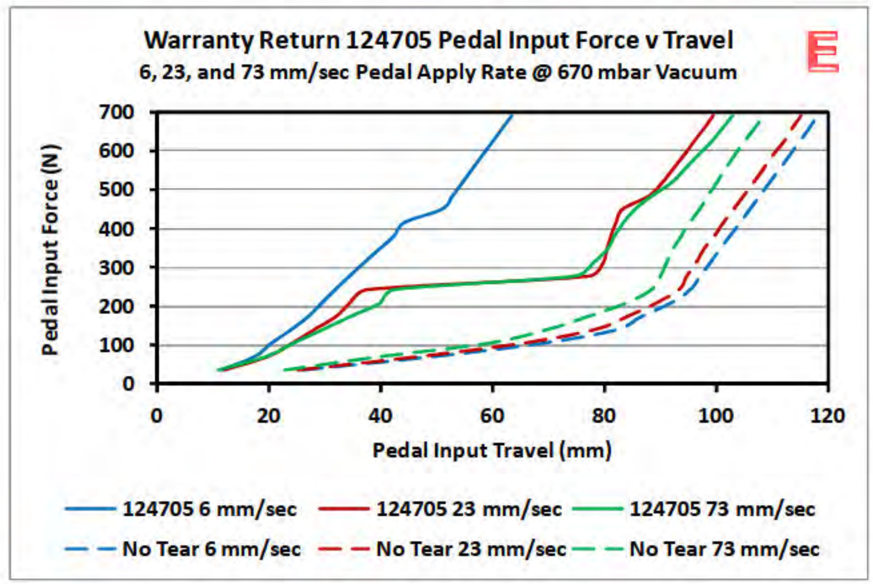
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin Dimension 1 (micron)	Particle at Tear Origin Dimension 2 (micron)	Particle at Tear Origin Composition	T2 Thickness Near Tear (mm)
10	124705	Jul-11	2D32071032	JM7TB19AXA[redacted]	56,545	Saudi Arabia	T2	10:00	28	28	138	110	Pre-cured Rubber	1.41





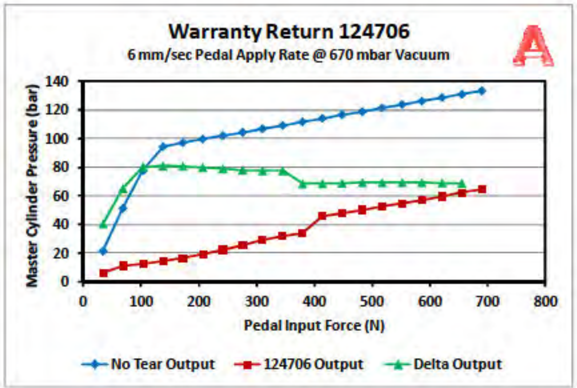


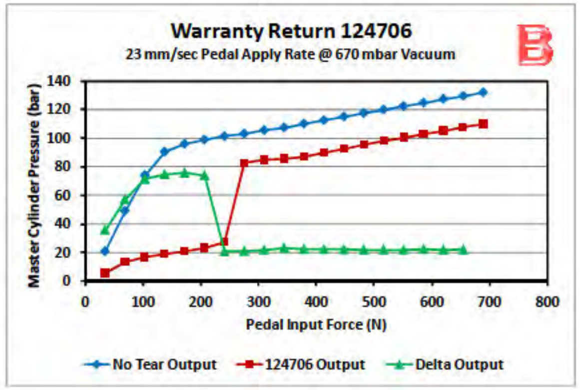


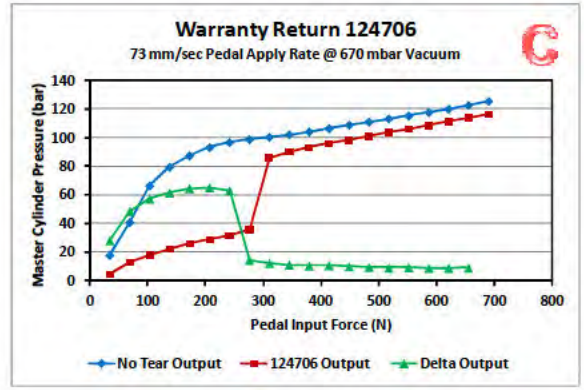


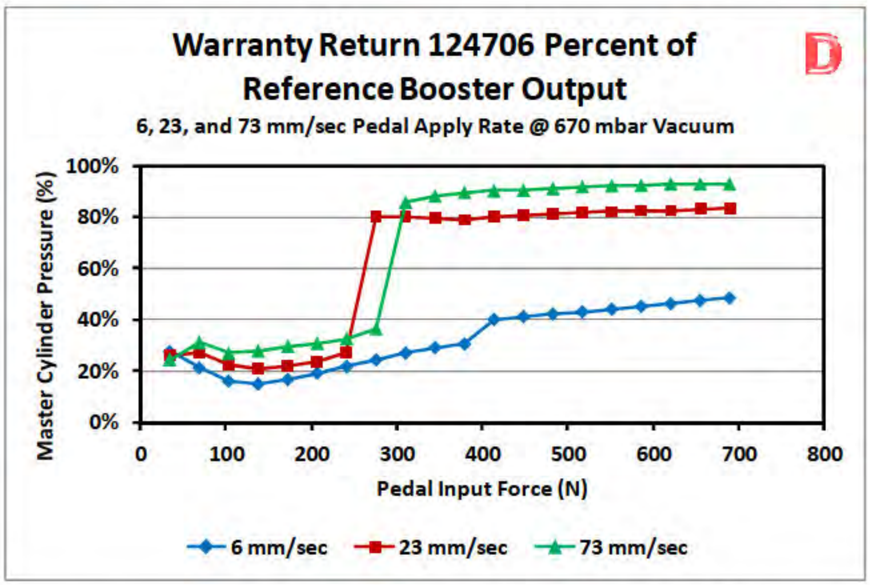
Diaphragm 124706 (VIN JM7TB19A9B0301366)

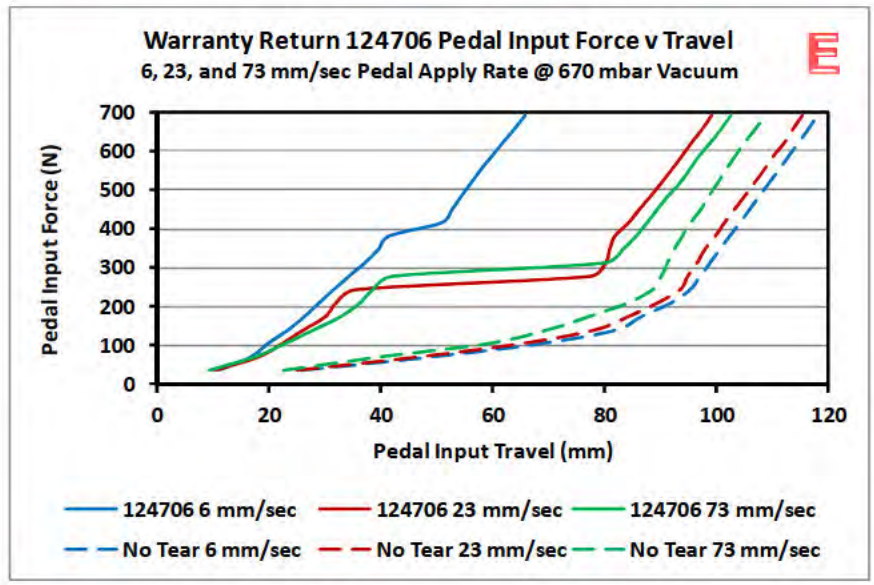
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin: Dimension 1 (micron)	Particle at Tear Origin: Dimension 2 (micron)	Particle at Tear Origin: Composition	T2 Thickness Near Tear (mm)
11	124706	Aug-10	2D32071032	JM7TB19A9[redacted]	35,375	Saudi Arabia	T2	4:00	29	29	106	71	Pre-cured Rubber	1.05





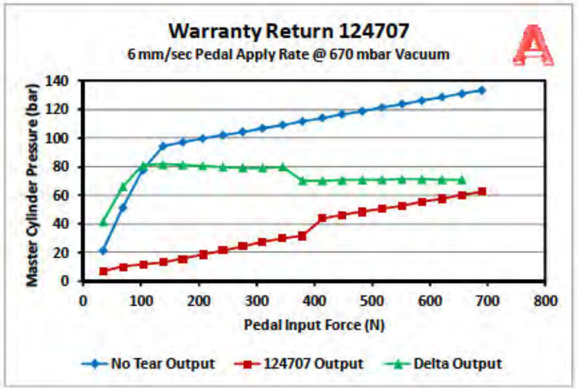


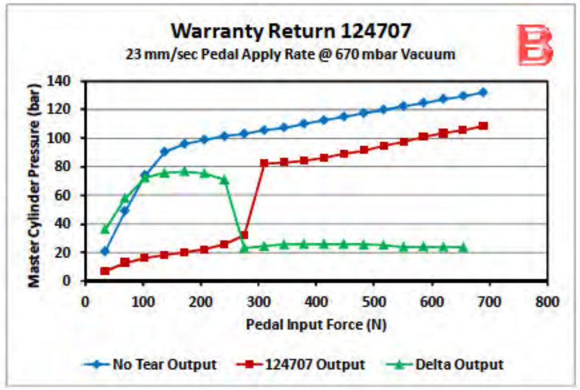


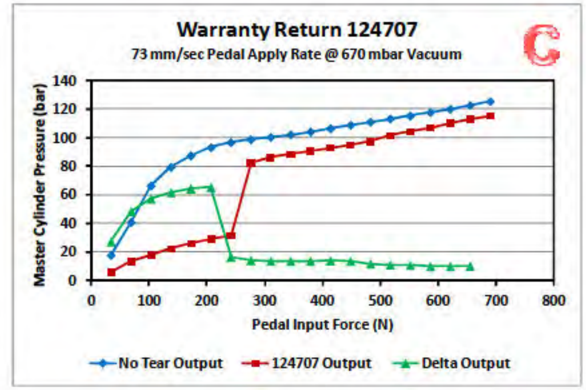


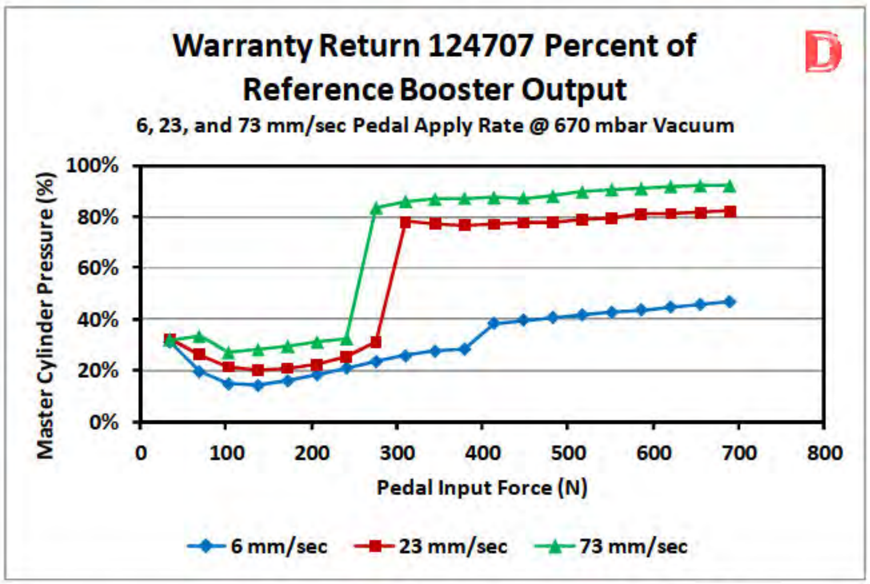
Diaphragm 124707 (VIN JM7TB19A3B0304540)

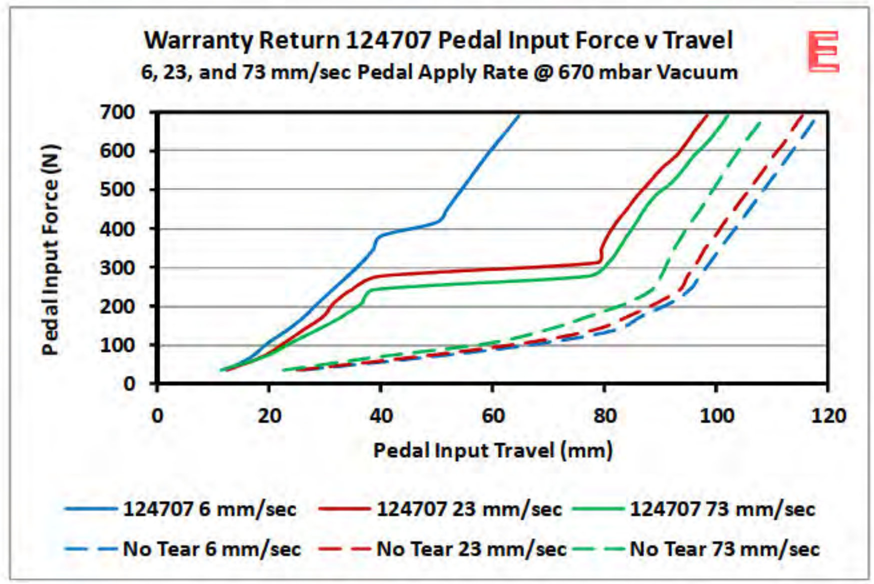
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin: Dimension 1 (micron)	Particle at Tear Origin: Dimension 2 (micron)	Particle at Tear Origin: Composition	T2 Thickness Near Tear (mm)
12	124707	Nov-10	2D32071032	JM7TB19A3[redacted]	41,813	Saudi Arabia	T2	6:30	30	30	190	104	Pre-cured Rubber	1.11





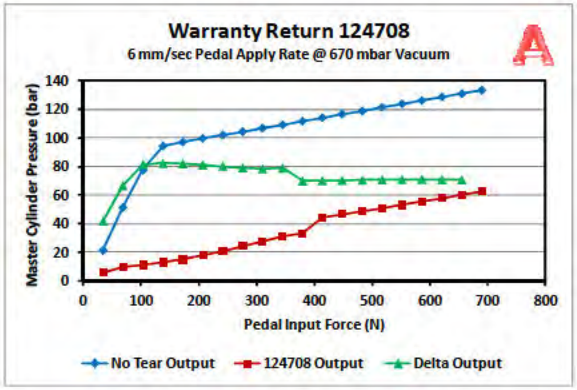


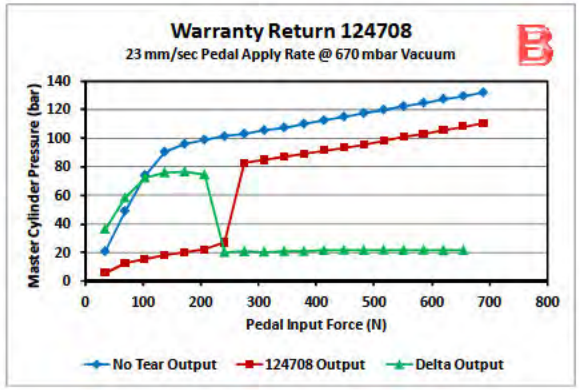


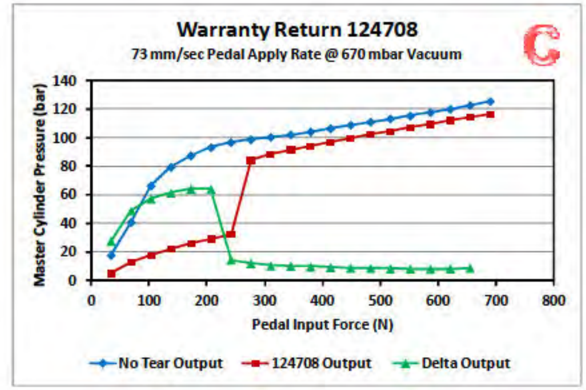


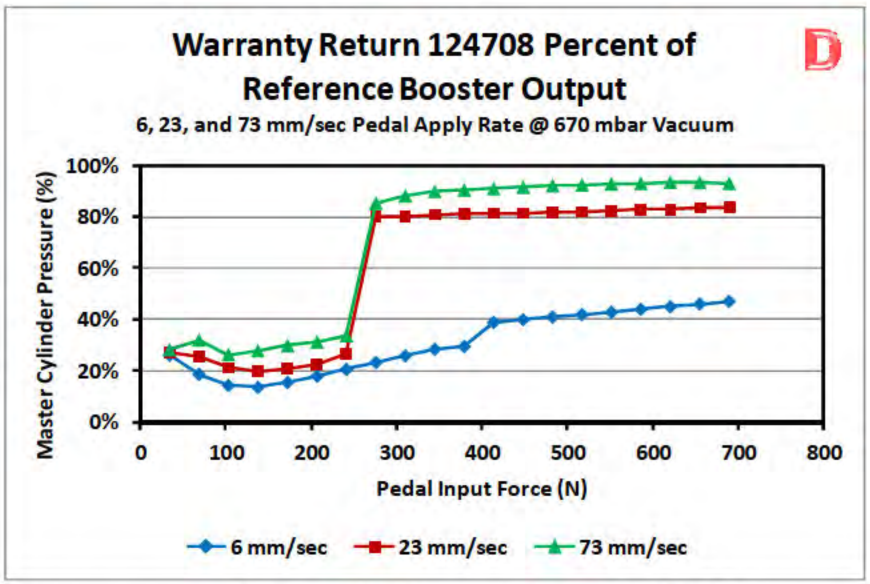
Diaphragm 124708 (VIN JM7TB19A3B0301363)

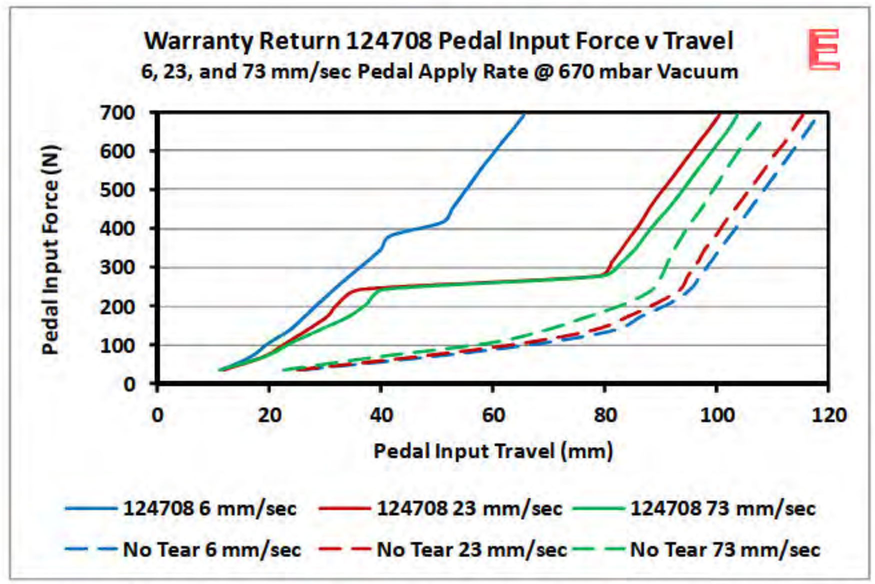
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin			T2 Thickness Near Tear (mm)
											Dimension 1 (micron)	Dimension 2 (micron)	Composition	
13	124708	Aug-11	2D32805305	JM7TB19A3[redacted]	24,866	Saudi Arabia	T2	6:00	32	32	159	123	Pre-cured Rubber	1.18





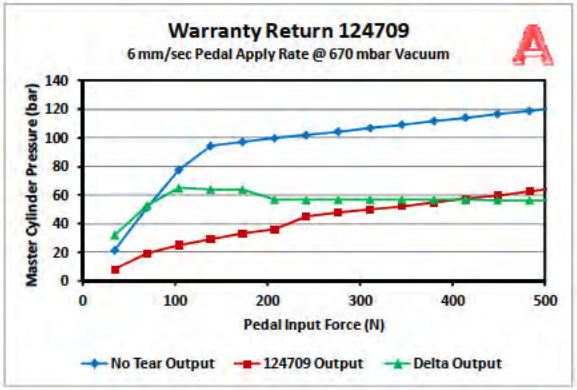


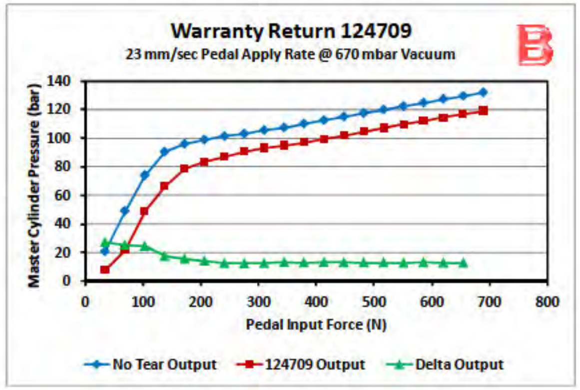


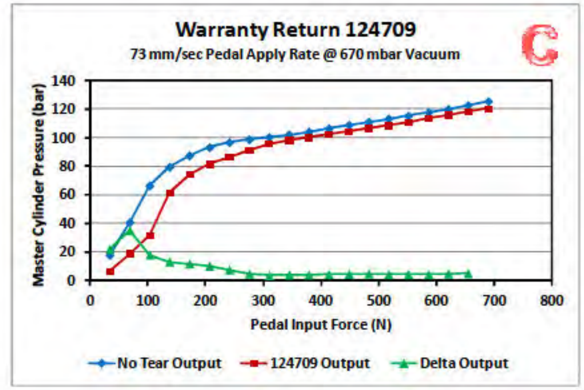


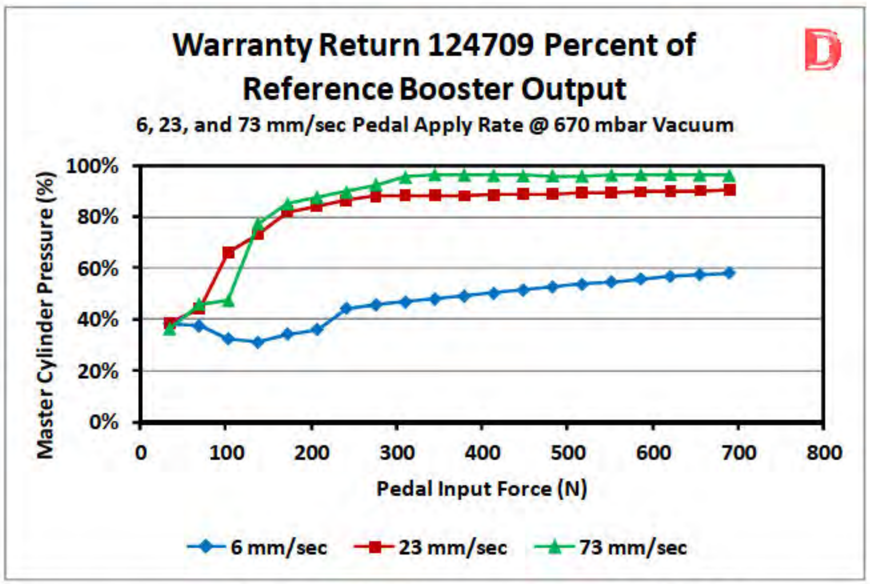
Diaphragm 124709 (VIN JM7TB19A980100818)

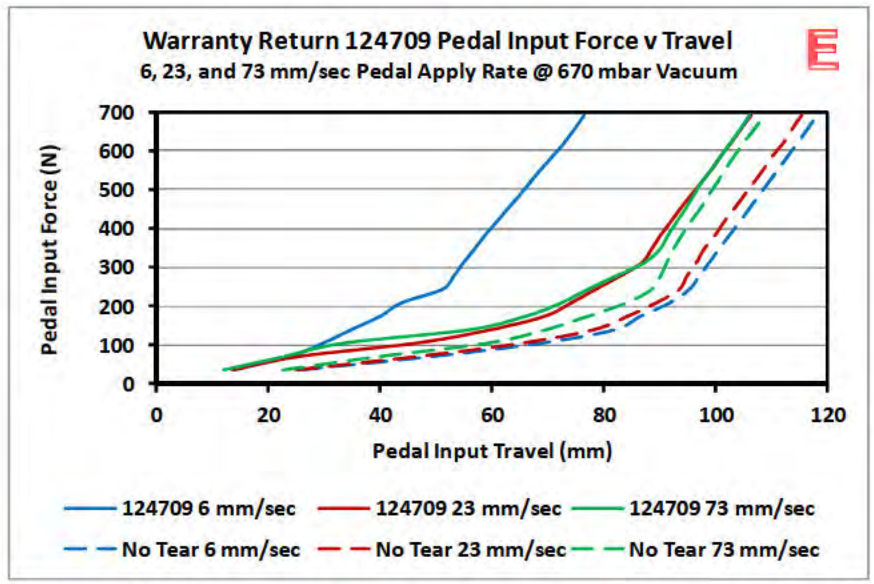
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin			T2 Thickness Near Tear (mm)
											Dimension 1 (micron)	Dimension 2 (micron)	Composition	
14	124709	Jan-10	2D31311741	JM7TB19A[redacted]	84,306	Saudi Arabia	T2	10:00	24	24	152	144	Pre-cured Rubber	1.13





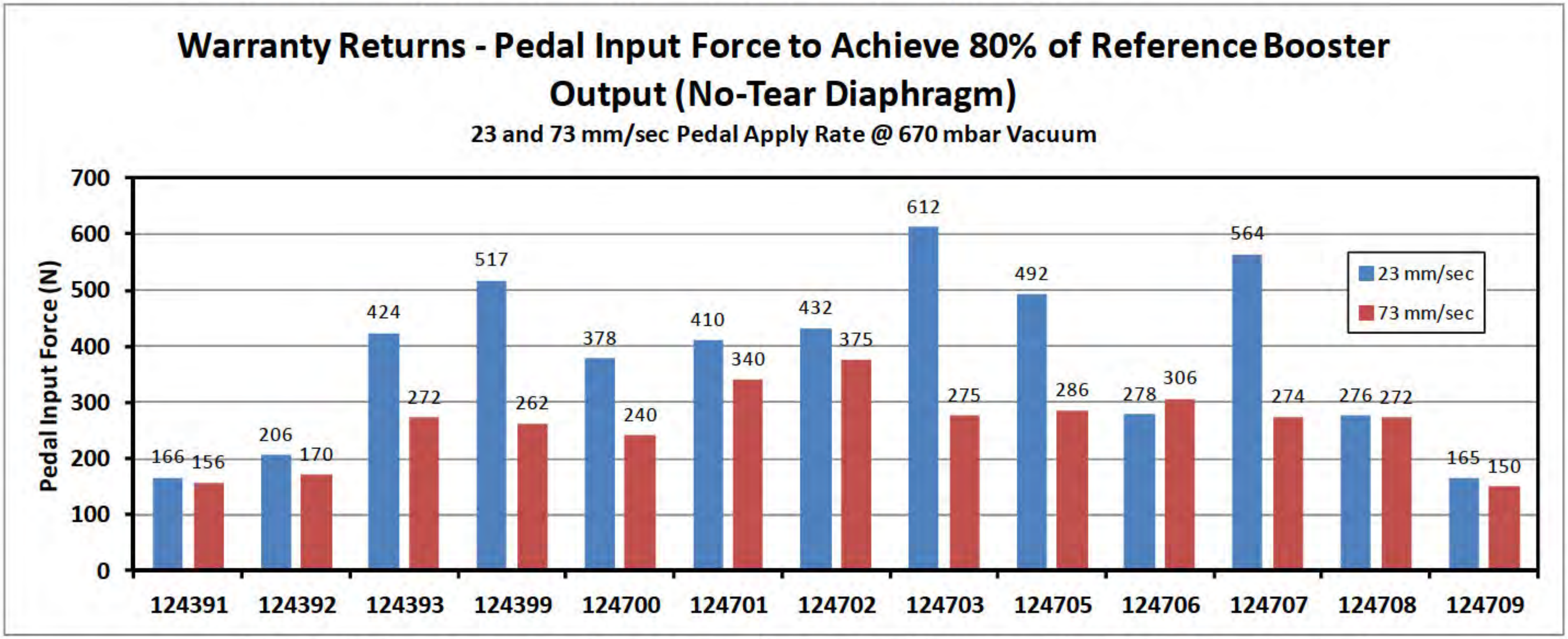






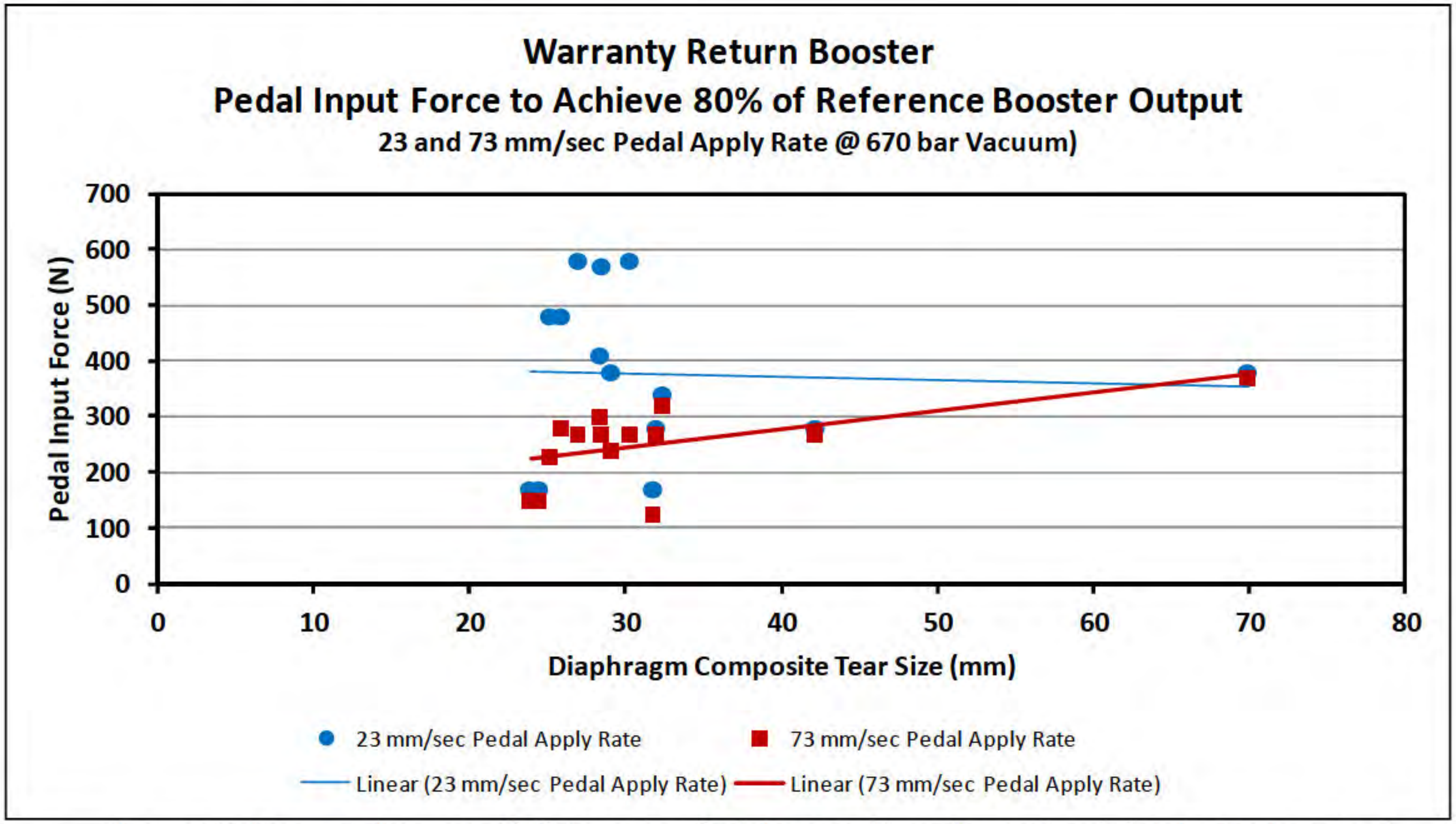
Warranty Return Boost Recovery

- **This warranty data set suggests booster function will partially return in a booster with a torn diaphragm if driver increases pedal input force and pedal apply speed**
  - Graphical summary of pedal input force to achieve 80% of no-tear booster (reference) output for each warranty return tested at 23 and 73 mm/sec brake pedal apply speed
  - With faster pedal apply speeds boosters with torn diaphragms recover to achieve 80% of reference output from booster without a torn diaphragm



Warranty Return Boost Recovery

- **Graphical summary of pedal input force to achieve 80% of reference booster output as a function of warranty return diaphragm tear size shows:**
  - **At pedal apply rate of 23 mm/sec, input force is variable (low correlation)**
  - **At pedal apply rate of 73 mm/sec, input force is consistent and increasing with tear size (good correlation)**



Warranty Return Performance Analysis

- **Conclusion**
  - In all 13 returned booster assemblies evaluated:
    - Booster performance indicated some level of recovery as the input pedal force and pedal apply speed increased
    - Booster recovery rate is more consistent with faster pedal apply speeds
    - Difference in booster output performance compared to a booster without a torn diaphragm is less with faster pedal apply speeds
  - Based on this warranty data set and previous investigations on tear propagation and booster function with torn diaphragms, it is TRW's position that:
    - Driver is likely to experience adequate warning of a booster diaphragm tear through increased pedal apply forces to achieve desired vehicle deceleration
    - As diaphragm tear propagates in an affected booster, driver can recover approximately 80% of lost boost function by increasing brake pedal apply speed and apply force dependent on the size of the diaphragm tear
    - A composite diaphragm tear of approximately 30 mm or less (majority of warranty returned boosters with torn diaphragm) consistently provides booster recovery with increasing brake pedal apply speed and apply force

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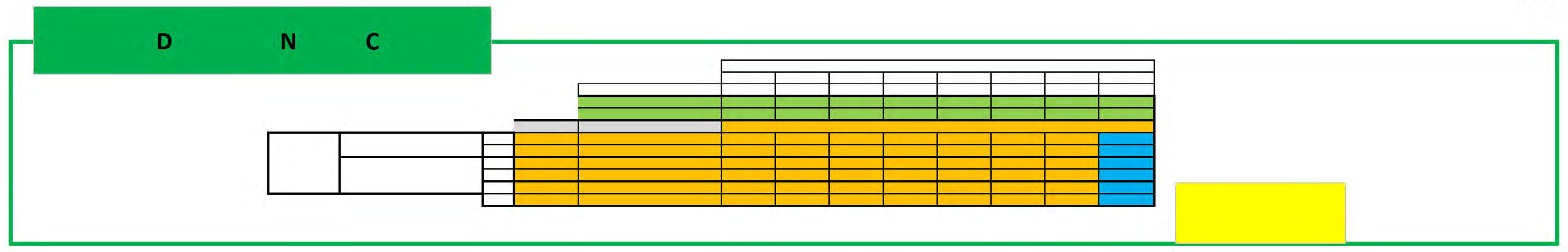
APPENDIX 8

Action List Material

Material 3-3 Stopping Distance



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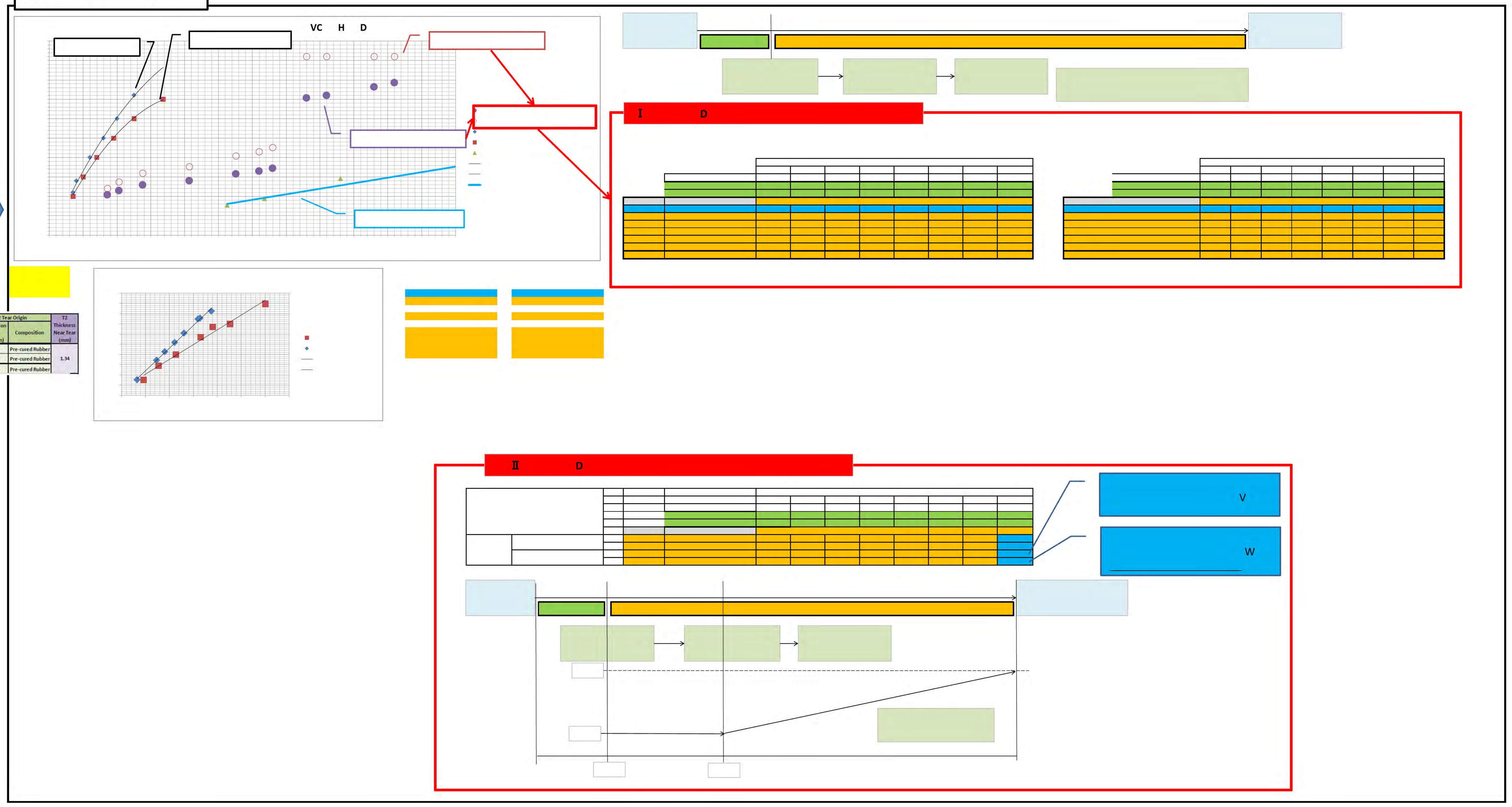
Diaphragm 124702 (VIN JM7TB19A6B[redacted]

P R

No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin: Dimension 1 (micron)	Particle at Tear Origin: Dimension 2 (micron)	Particle at Tear Origin: Composition	T2 Thickness Near Tear (mm)
7	124702	Jul-10	2D30864905	JM7TB19A6B0300966	20,500	Saudi Arabia	Tear 1 T2	11:00	24	70	157	130	Pre-cured Rubber	1.34
							Tear 2 T2	12:00	22		244	163	Pre-cured Rubber	
							Tear 3 T2	0:30	24		155	114	Pre-cured Rubber	

P P V



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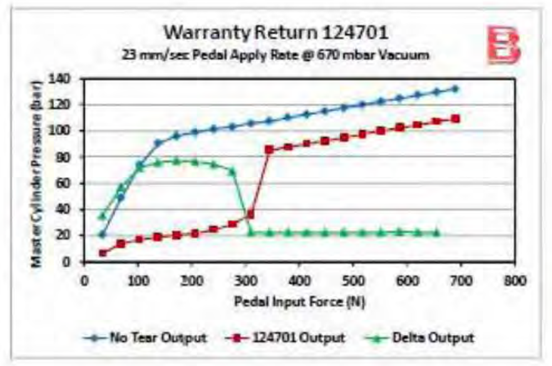
Diaphragm 124701 (VIN JM3TB3DV8C[redacted]



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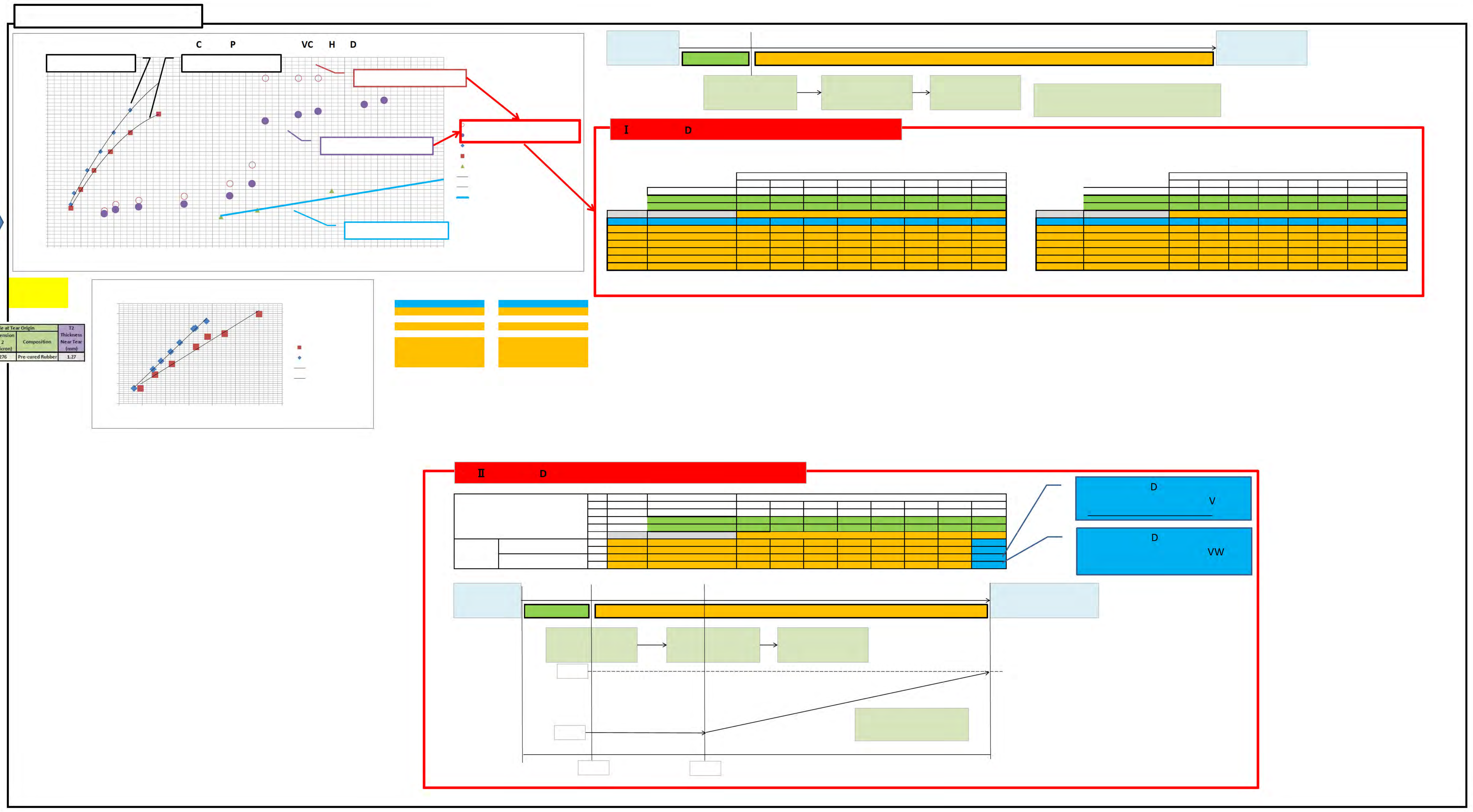
No.	TRW Diaphragm ID	Hutchinson Diaphragm Date Code	Mazda Field Number	Vehicle VIN No.	Reported Mileage (km)	Country	Tear @ Location	Tear Clock Position	Tear Length (mm)	Composite Tear Length (mm)	Particle at Tear Origin: Dimension 1 (micron)	Particle at Tear Origin: Dimension 2 (micron)	Particle at Tear Origin: Composition	T2 Thickness Near Tear (mm)
6	124701	Dec-11	2D32212729	JM3TB3DV8C0355962	18,335	U.S.A.	T2	4:30	32	32	371	276	Pre-cured Rubber	1.27



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APPENDIX 8

Action List Material

Material 3-4 Break Performance

J50C Brake Performance

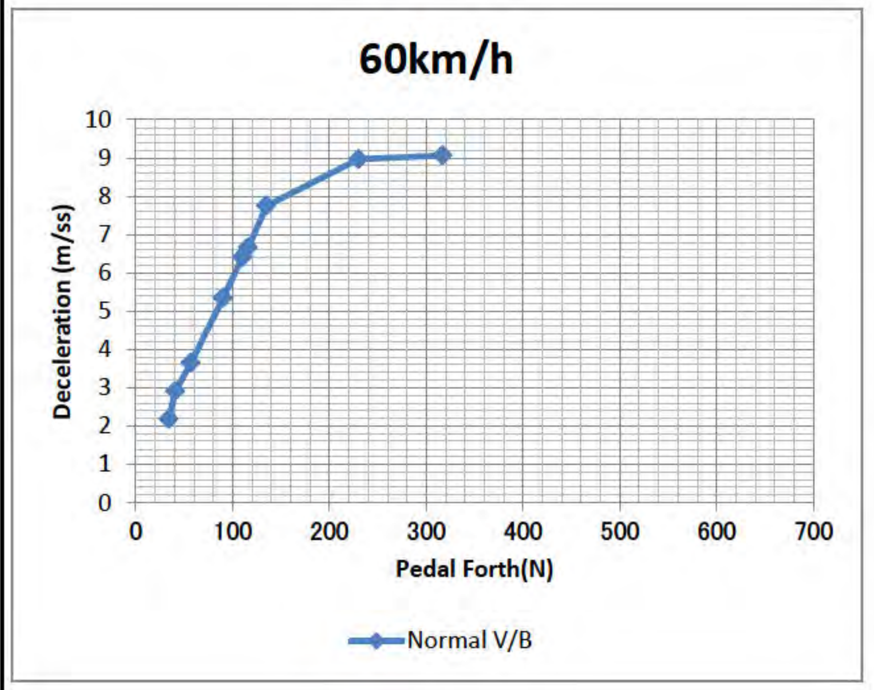
Brake Performance Development Group
Masumoto/Metsugi

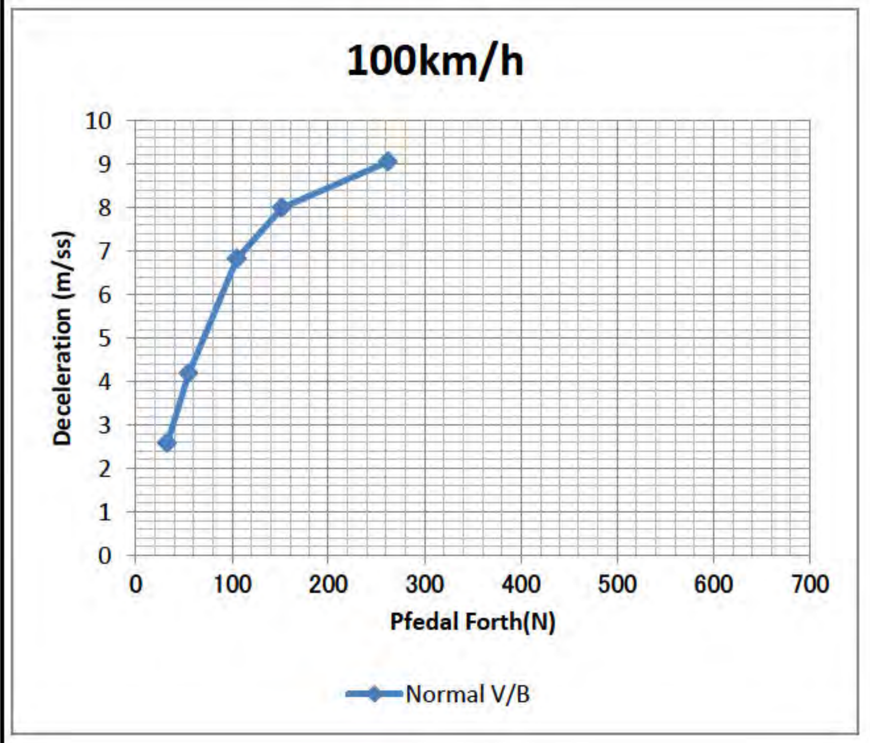
■Test Vehicle
J50C MP (09210) 4WD 6AT 20"Tire / Ft;17"+VC030H Rr;17"+D6306
Weight;2750kg (1342kg / 1408kg) GVWM

■Pedal Apply Rate : 25~50mm/sec

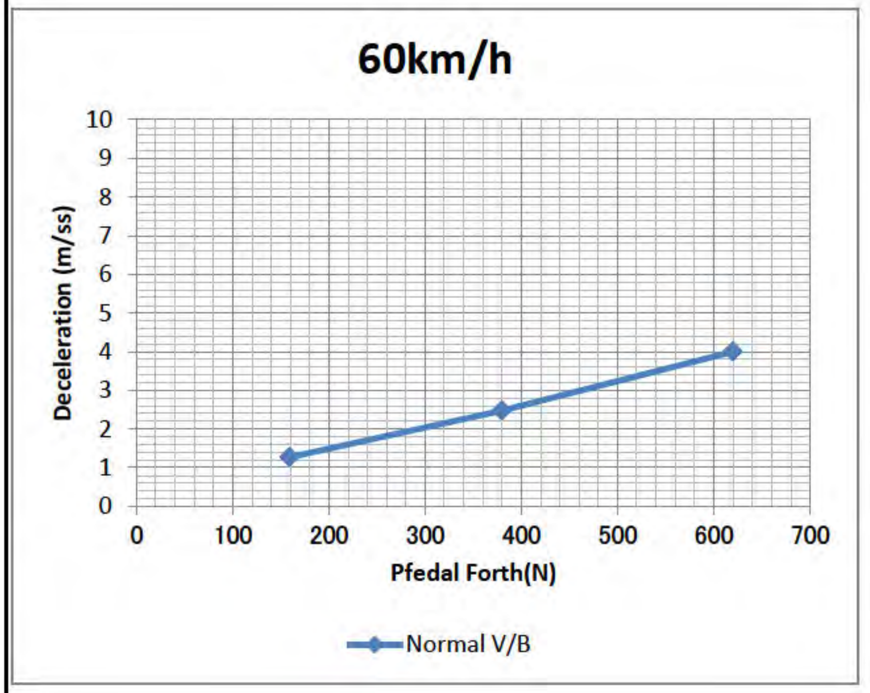
■ Worst Case Booster which we use for a test

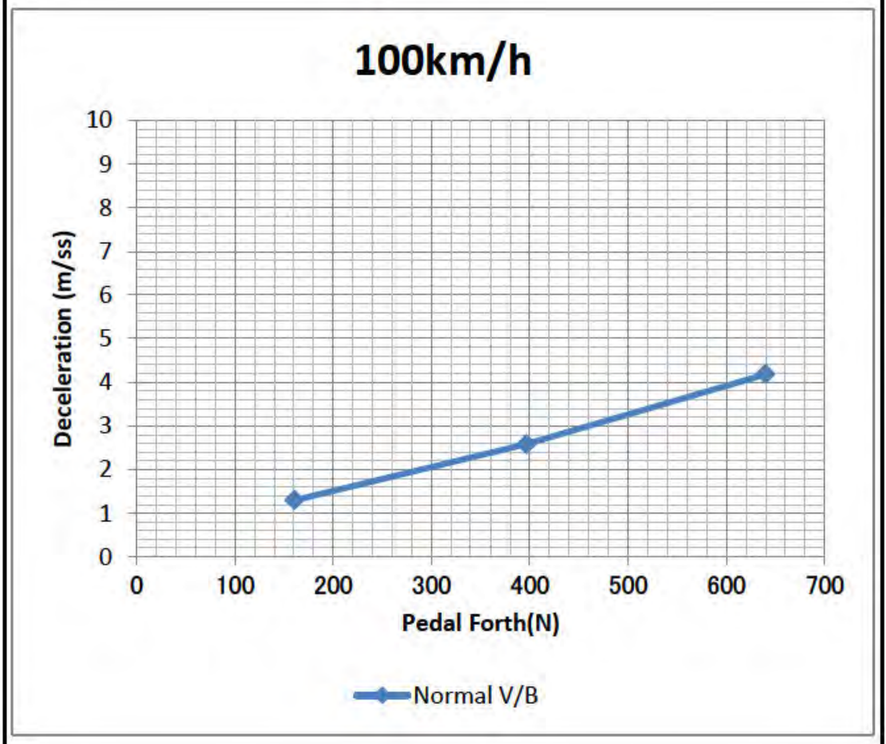
Normal Booster (Fully Operational Booster Assembly)
Booster=Mass Production Parts



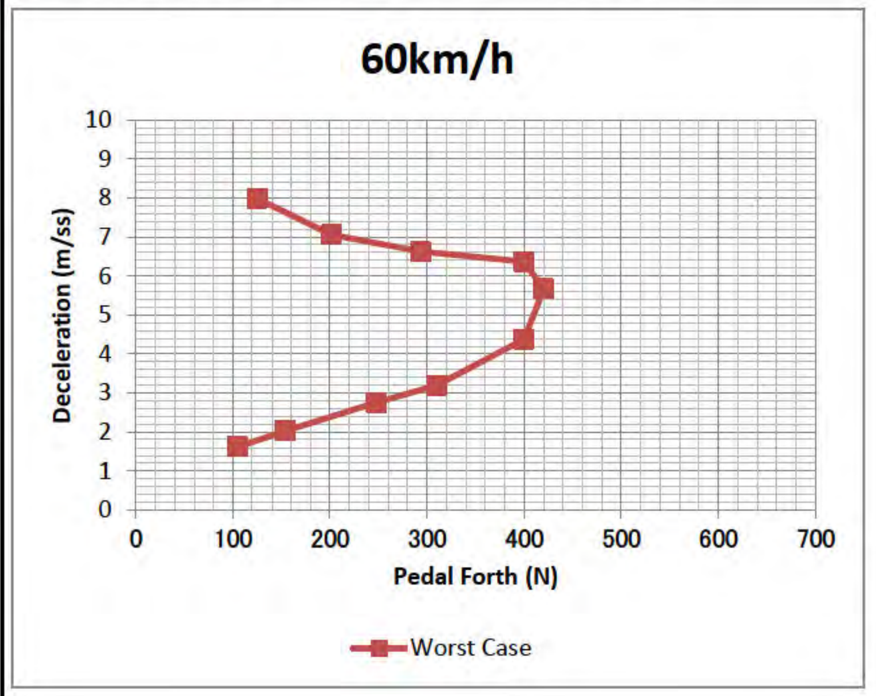


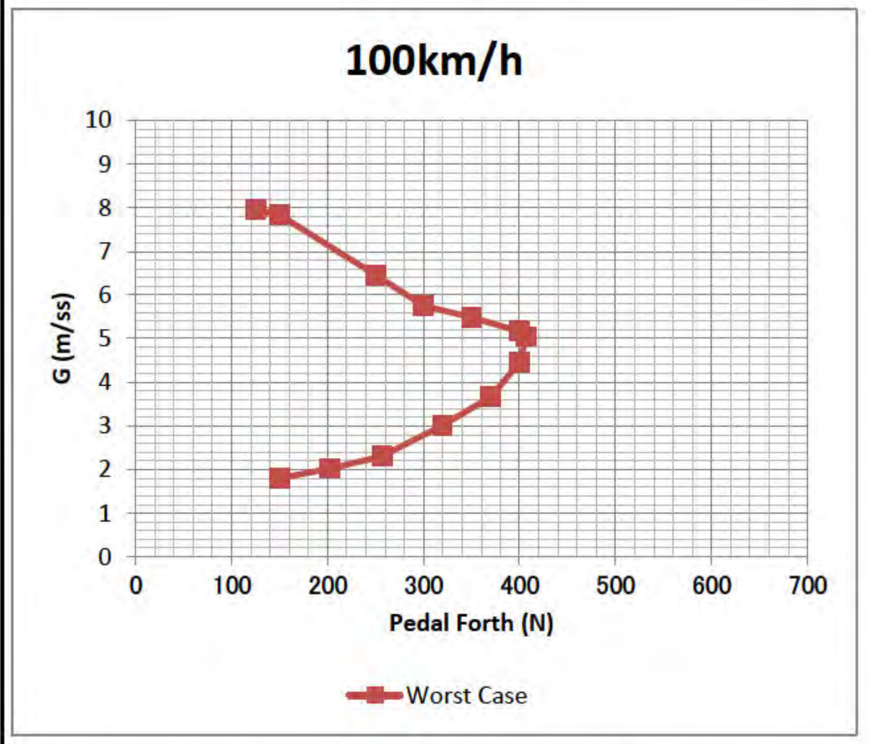
Normal Booster (Complete Loss of Brake Power Assist)
Booster=Mass Production Parts





Worst Case Booster (Warranty Return Nooster)
Sample No. B127983
Mile:32195miles Tear Size:25mm Leak Rate:53.5mbar/sec





Driver Continue brake pedal apply, air flow through tear is restriced. Then power assist function revive and pedal forth is decreased.

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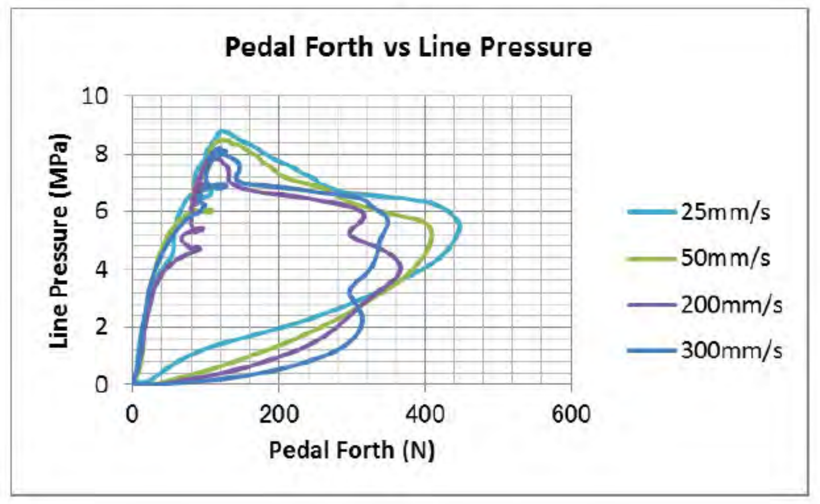
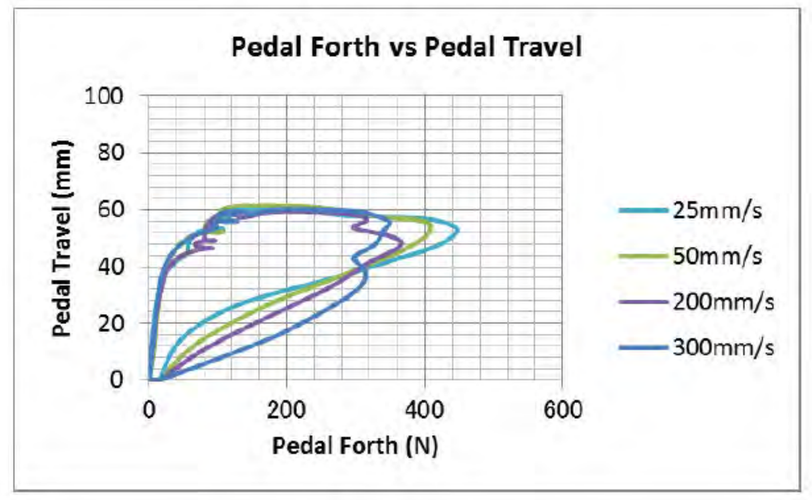
bra

■Characteristics of every pedal apply rate





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APPENDIX 8

Action List Material

Material 3-5 Supplier Report 25 Mar 2014

Mazda J50C Brake Booster
Warranty Return Group 2
Vacuum Leak and Booster Function Evaluation

March 25, 2014

ADVANCED THINKING / SMART THINKING / GREEN THINKING

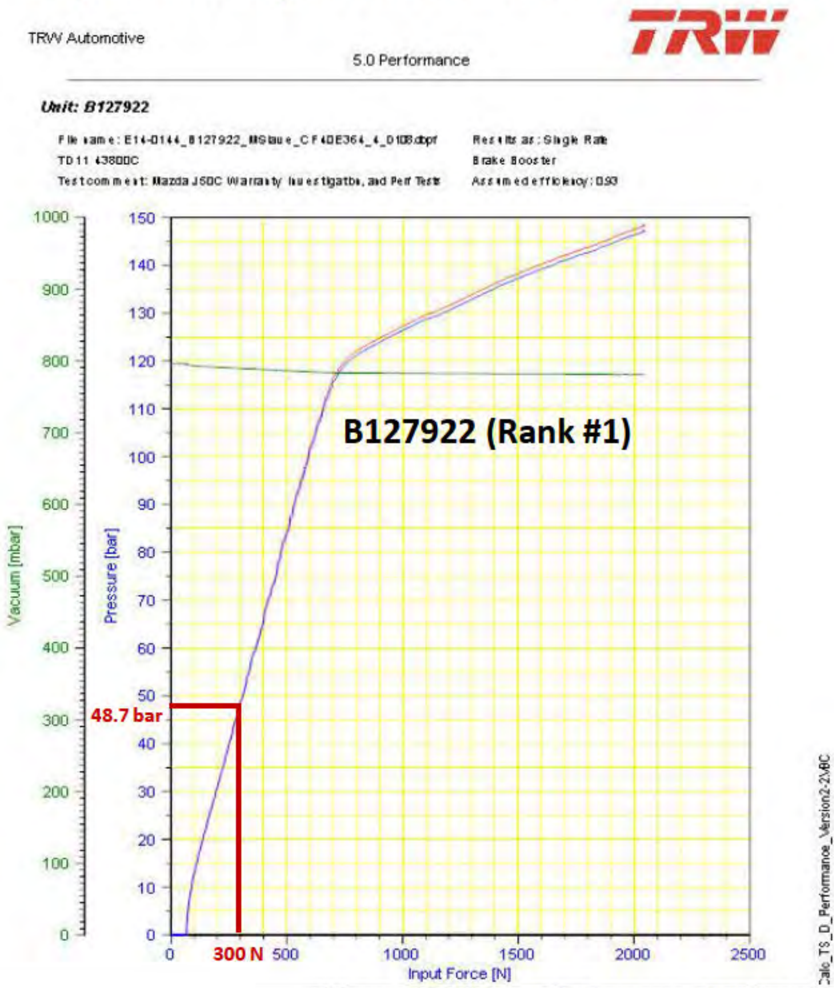
Warranty Return Vacuum Leak & Performance Evaluation

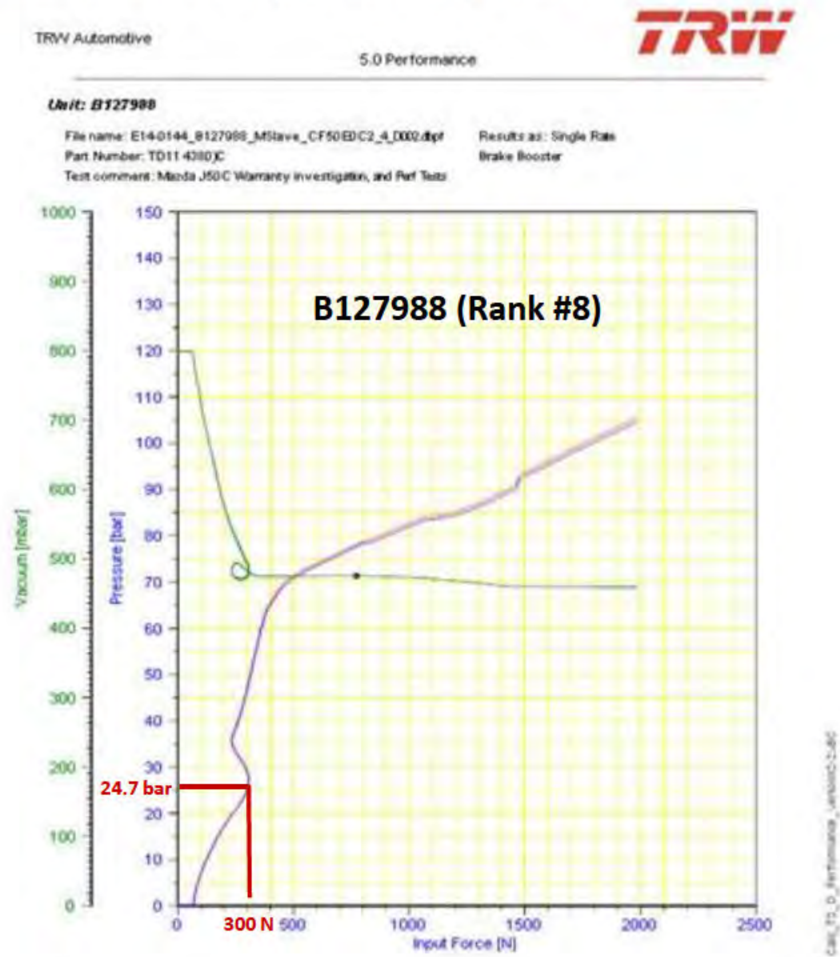
- Tabular summary of eight Mazda warranty boosters analyzed for leak rate, performance, and tear size
- At Mazda's request, samples ranked by lowest to highest vacuum leak rate

TRW Sample Identification Number	Mazda Repair Order Number	VIN Number	Reported Vehicle Mileage (miles)	Vacuum Leak Test Result (mbar / 15 seconds) Requirement: 20 mbar Maximum (≤ 1.33 mbar/sec)	Diaphragm: Number of tears and tear length: (mm)	Overall Ranking: 1 = Best OK 8 = Worst NOK
B127984	300837	JM3TB2DA4C[redacted]	24,702	Rest position: 7 mbar Leak rate: 0.47 mbar/sec	2 tears through at 23 and 18 mm 2 tears surface only at 11 and 12 mm	1
B127989	68209	JM3TB3BV0C[redacted]	12,089	Rest position: 97 mbar Leak rate: 6.5 mbar/sec	1 tear through at 26 mm	2
B127987	107257	JM3TB2CVXC[redacted]	11,890	Rest position: 156 mbar Leak rate: 10.4 mbar/sec	1 tear through at 27 mm 2 tears surface only at 24 and 15 mm	3
B127985	221850	JM3TB2DA48[redacted]	24,760	Rest position: 263 mbar Leak rate: 17.5 mbar/sec	1 tear through at 30 mm	4
B127986	207631	JM3TB3CV4B[redacted]	72,056	Rest position: 334 mbar Leak rate: 22.3 mbar/sec	1 tear through at 25 mm	5
B127990	N/A	N/A	N/A	Rest position: 386 mbar Leak rate: 25.7 mbar/sec	1 tear through at 28 mm	6
B127983	939468	JM3TB2BA9[redacted]	32,195	Rest position: 532 mbar Leak rate: 35.5 mbar/sec	1 tear through at 25 mm	7
B127988	5507	JM3TB3DV8B[redacted]	31,404	Rest position: 640 mbar Leak rate: 42.7 mbar/sec	1 tear through at 23 mm	8

Warranty Return Vacuum Leak & Performance Evaluation

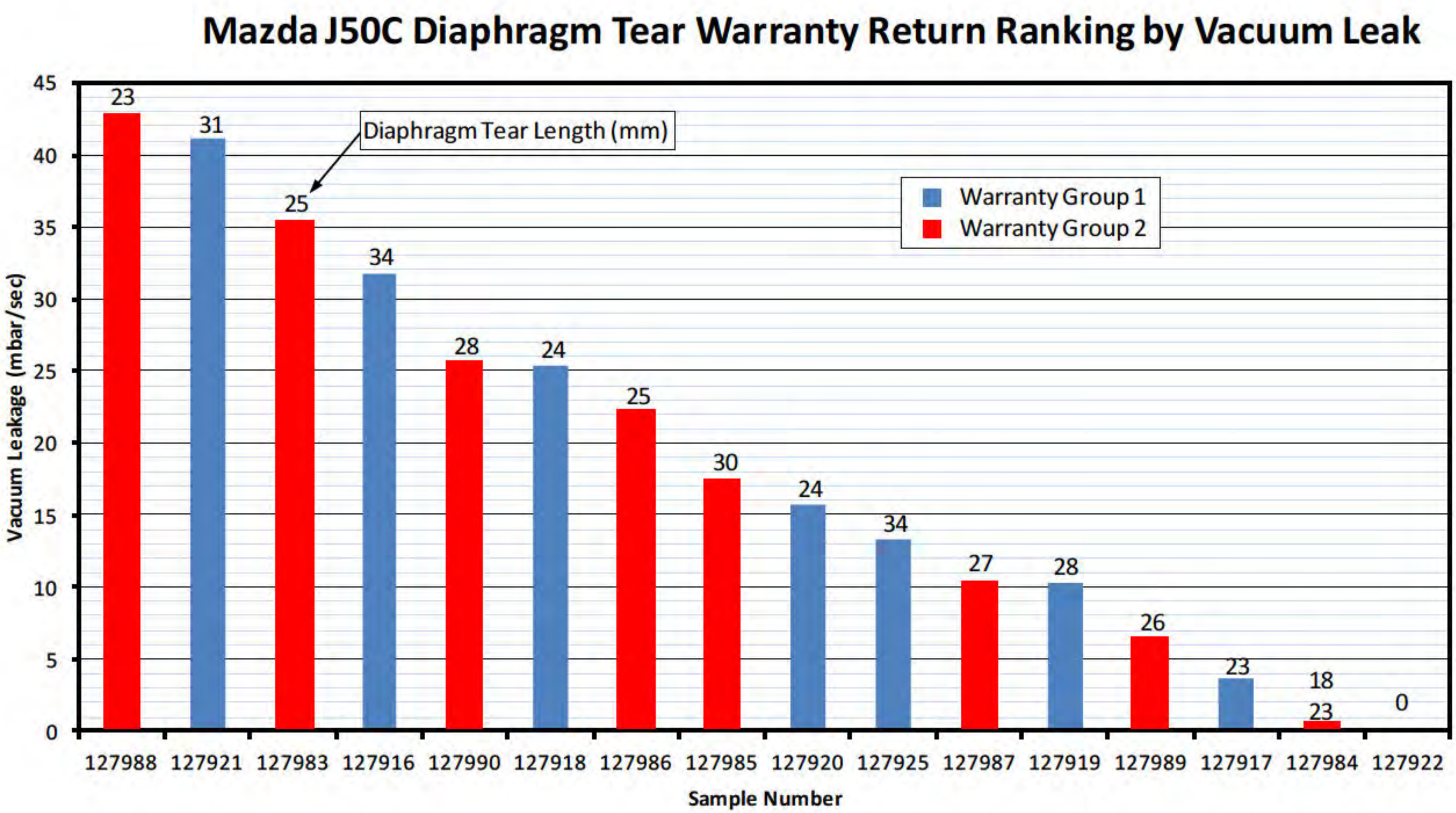
- **Comparison of warranty booster ranked Group 1 #1 and Group 2 #8**
- **Master cylinder pressure output at 300 N booster input force (103 N pedal input force) difference between #1 and # 8 is 24 bar (49% output reduction)**





Warranty Return Vacuum Leak & Diaphragm Tear

Comparison of Group 1 and 2 Warranty Return Boosters

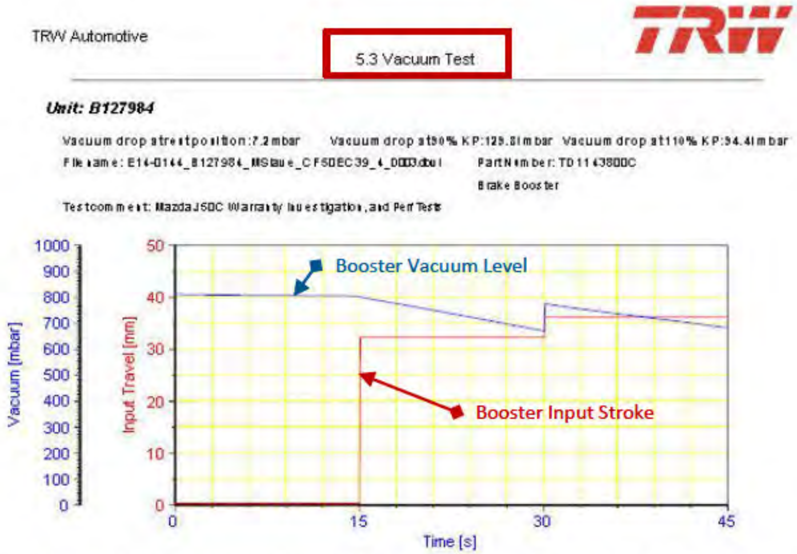


Appendix:

Graphical output of vacuum leak and performance evaluations for warranty booster returns

Appendix: Vacuum Leak and Performance - Rank #1

- Sample: **B127984** Mazda R/O: **300837** VIN: **JM3TB2DA4C**[redacted]
- Vehicle Mileage: **24,702 Miles** Tear Size: **41 mm** Leak Rate**: 0.5 mbar/sec**

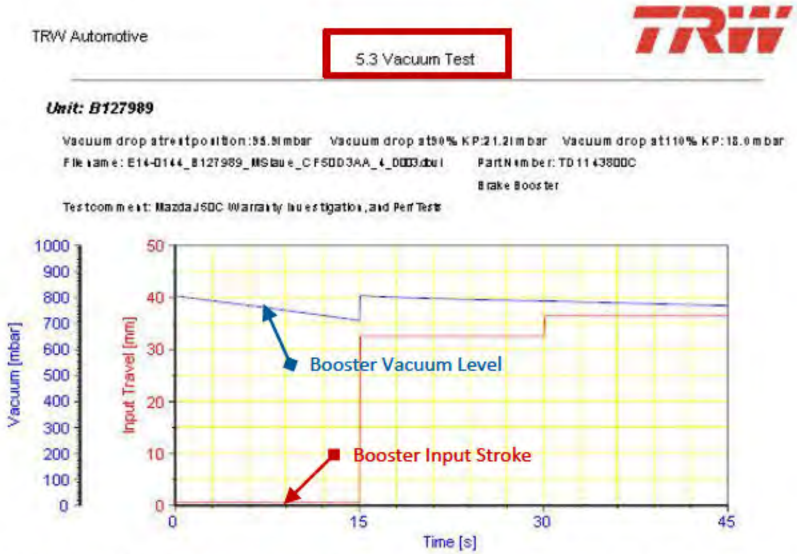


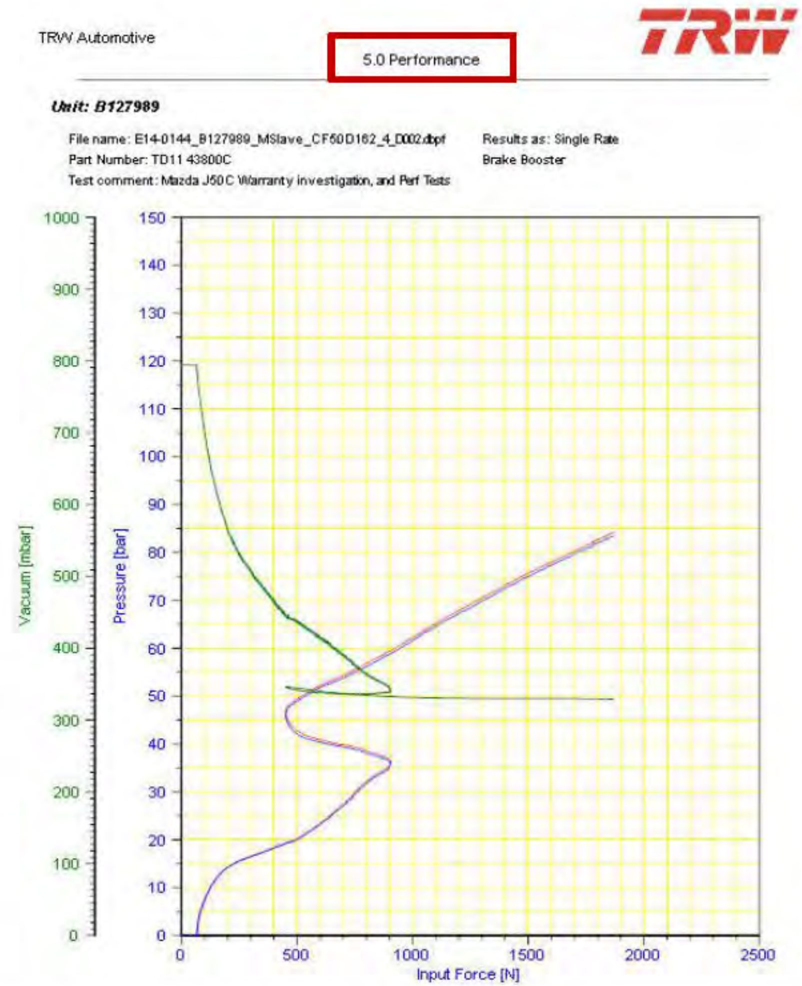
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

Appendix: Vacuum Leak and Performance - Rank #2

- Sample: **B127989** Mazda R/O: **68209** VIN: **JM3TB3BV0C**[redacted]
- Vehicle Mileage: **12,089** Miles Tear Size: **26 mm** Leak Rate**: 6.5 mbar/sec**



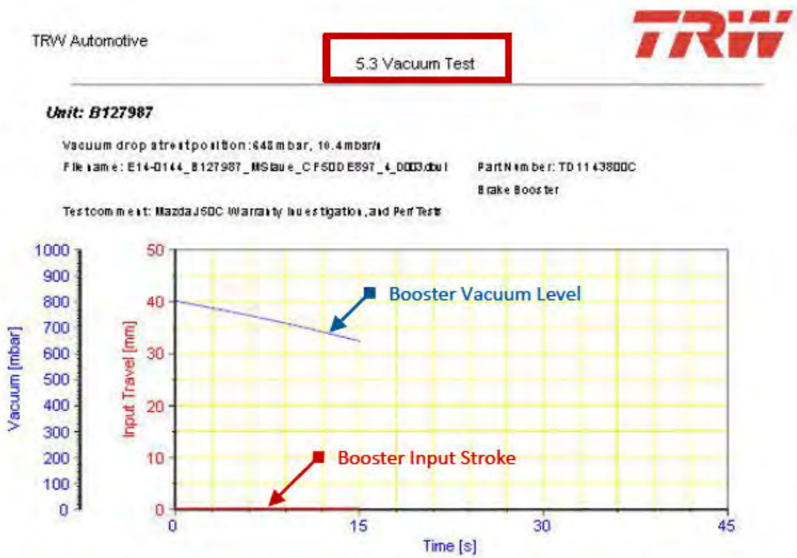


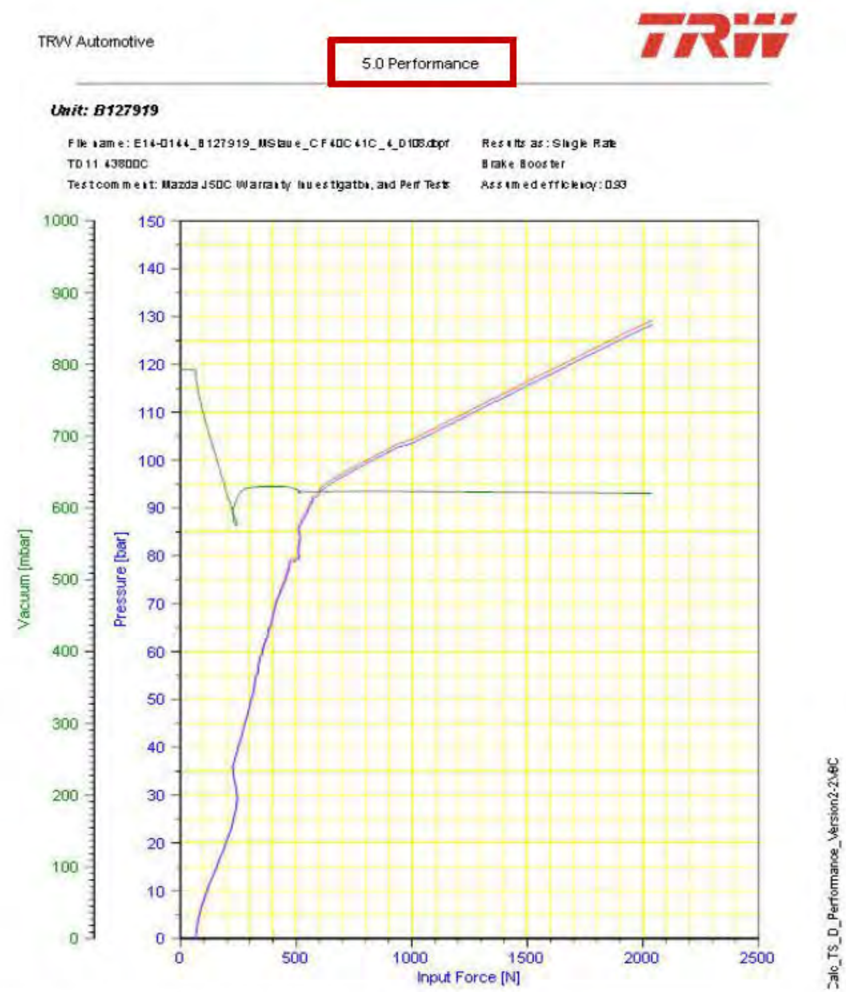
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

Appendix: Vacuum Leak and Performance - Rank #3

- Sample: **B127987** Mazda R/O: **107257** VIN: **JM3TB2CVX**[redacted]
- Vehicle Mileage: **11,890** Miles Tear Size: **27 mm** Leak Rate**: 10.4 mbar/sec**



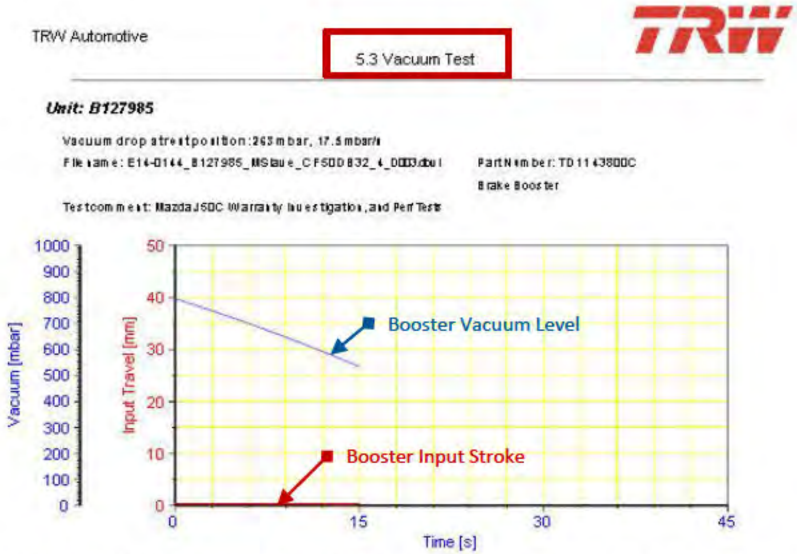


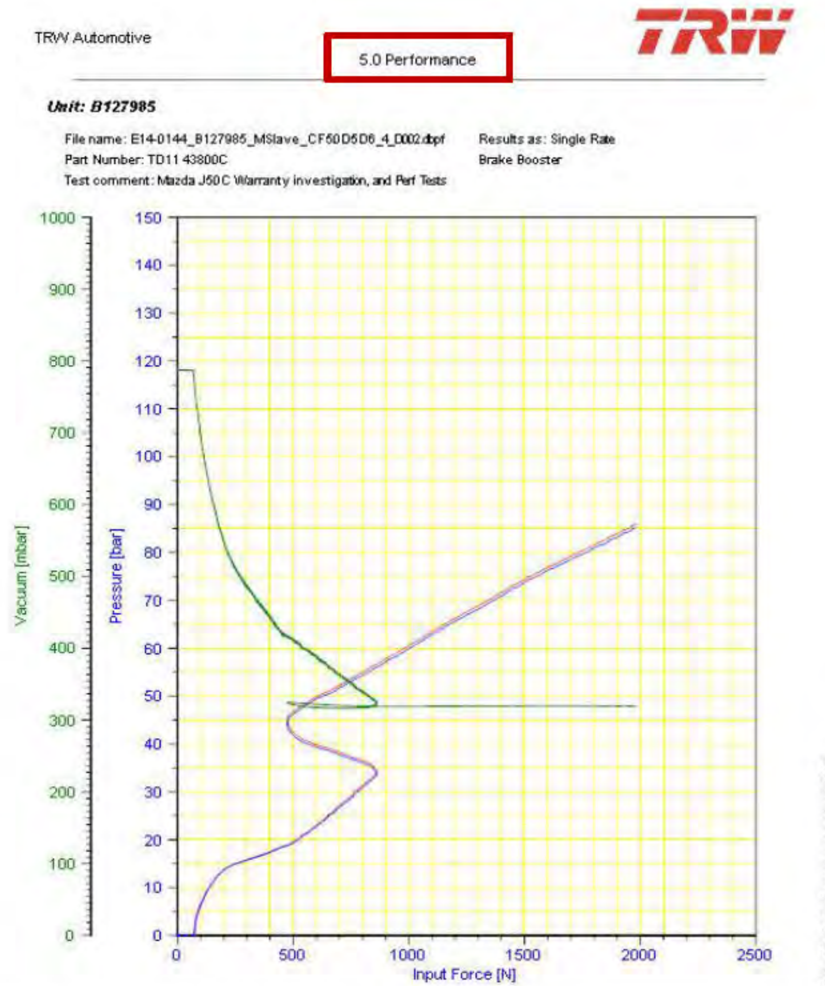
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

Appendix: Vacuum Leak and Performance - Rank #4

- Sample: **B127986** Mazda R/O: **207631** VIN: **JM3TB3CV4B**[redacted]
- Vehicle Mileage: **72,056** Miles Tear Size: **25 mm** Leak Rate**: 17.5 mbar/sec**



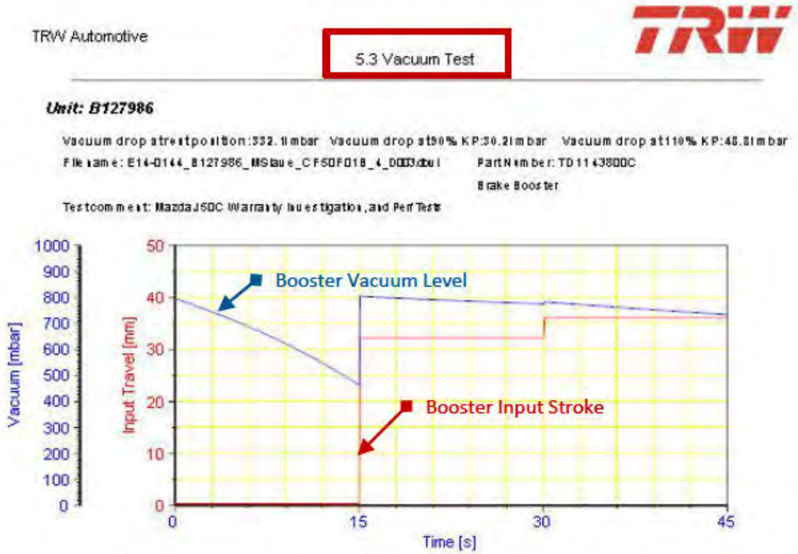


Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

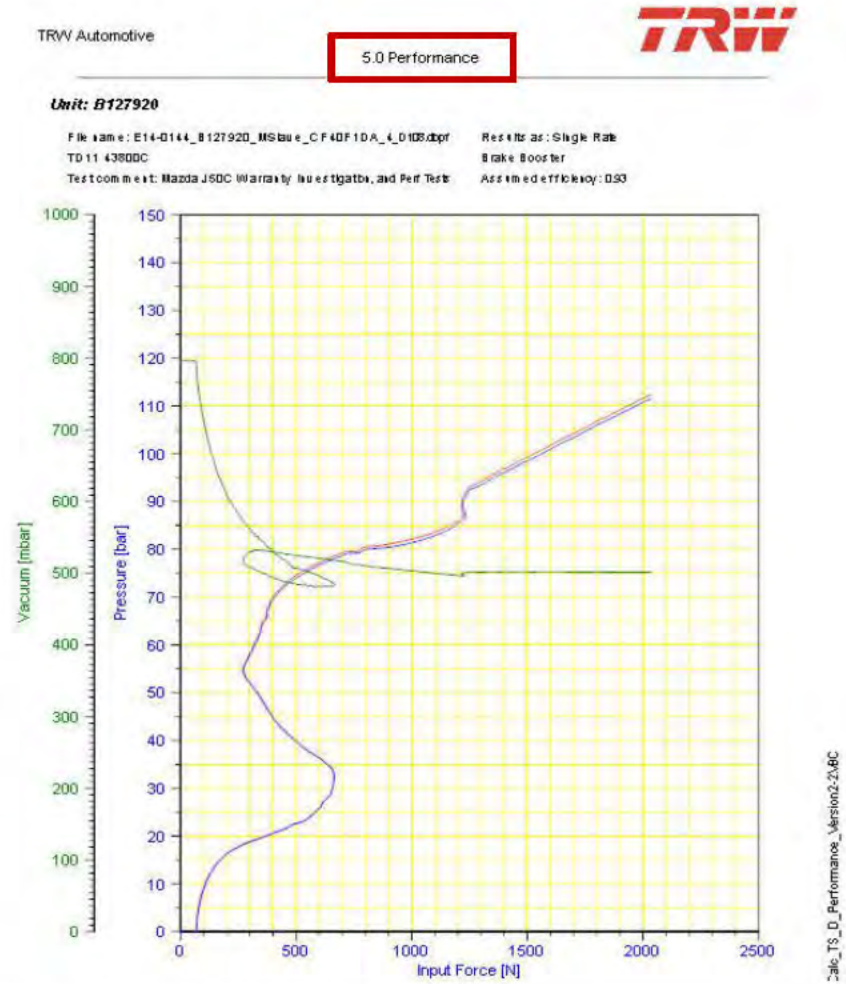
Appendix: Vacuum Leak and Performance - Rank #5

- Sample: **B127986** Mazda R/O: **207631** VIN: **JM3TB3CV4B**[redacted]
- Vehicle Mileage: **72,056** Miles Tear Size: **25 mm** Leak Rate**: 22.3 mbar/sec**



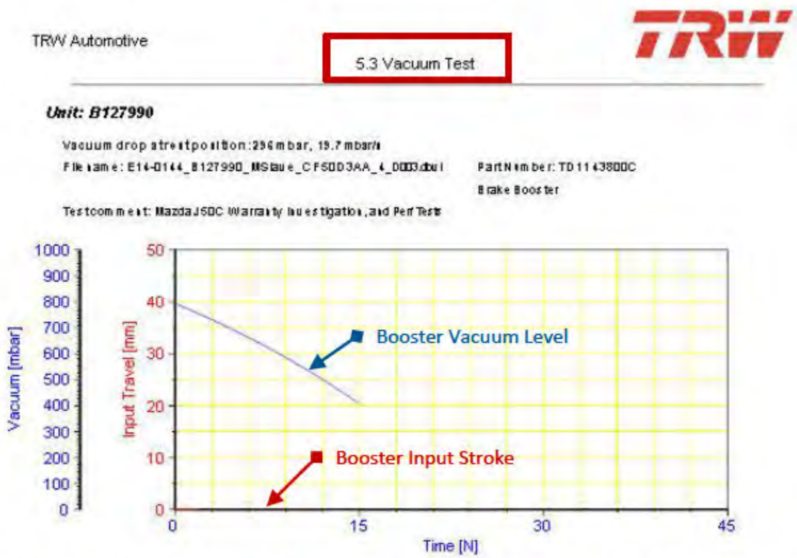
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers



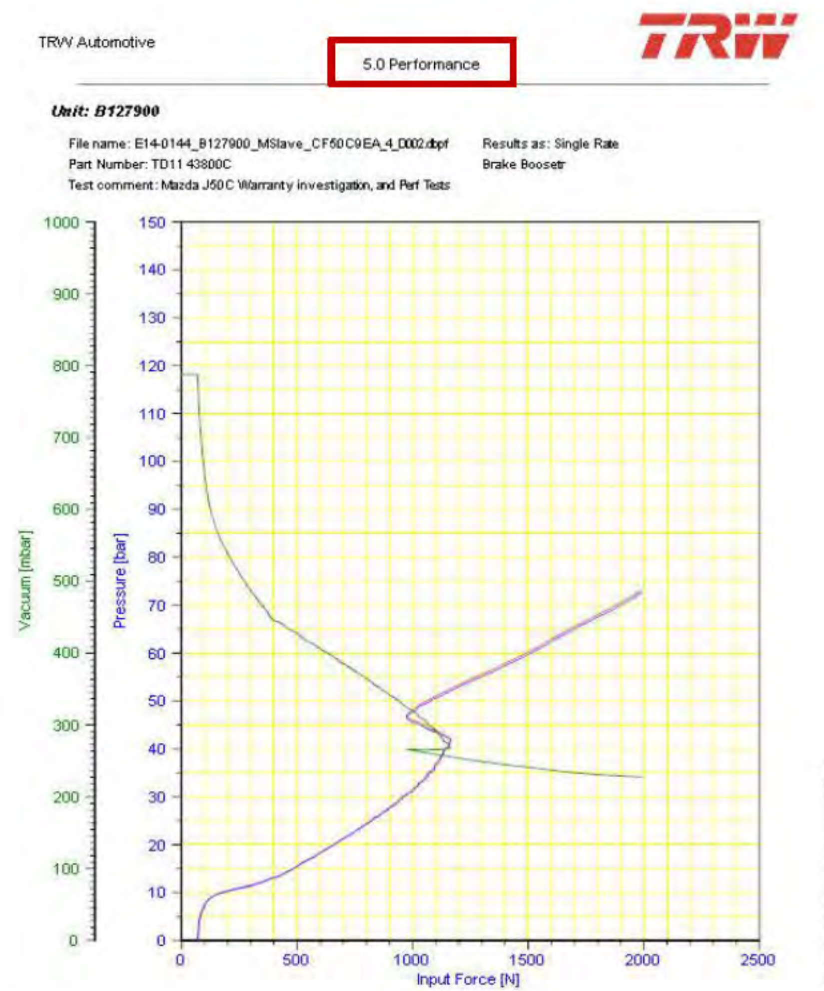
Appendix: Vacuum Leak and Performance - Rank #6

- Sample: **B127990** Mazda R/O: **N/A** VIN: **N/A**
- Vehicle Mileage: **N/A** Miles Tear Size: **28 mm** Leak Rate**: 25.7 mbar/sec**



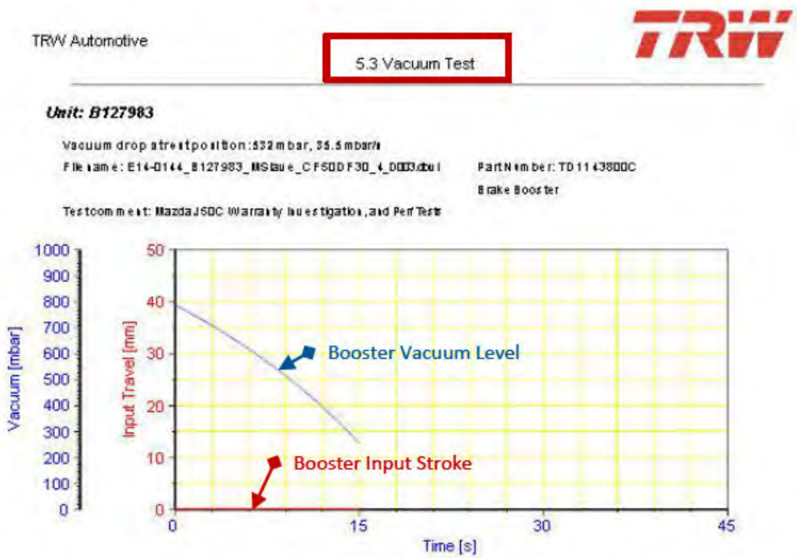
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

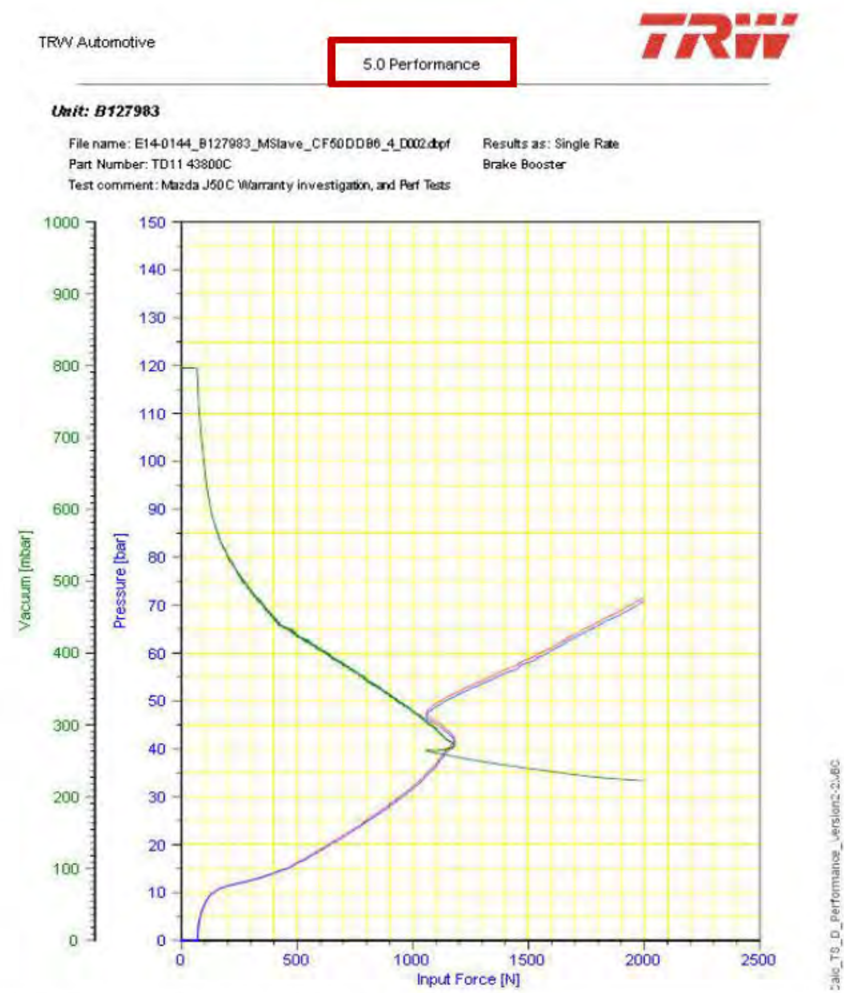
Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers



Appendix: Vacuum Leak and Performance - Rank #7

- Sample: **B127983** Mazda R/O: **939468** VIN: **JM3TB2BA9B**[redacted]
- Vehicle Mileage: **32,195** Miles Tear Size: **25 mm** Leak Rate**: 35.5 mbar/sec**



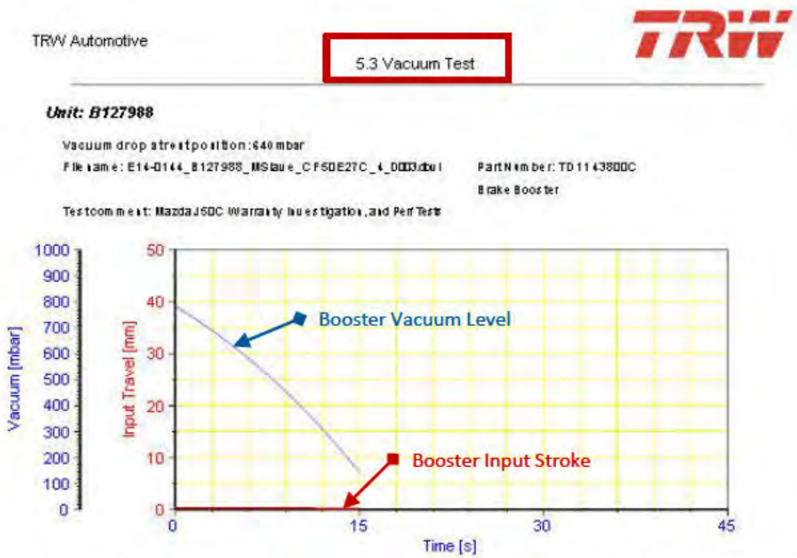


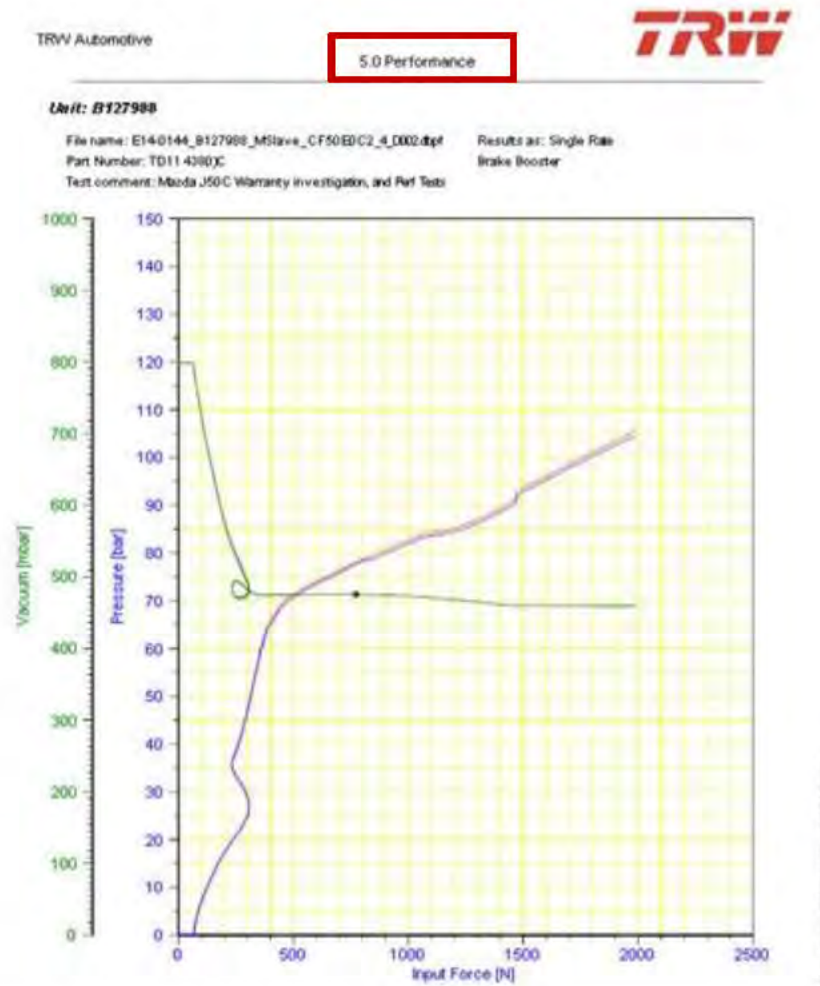
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

Appendix: Vacuum Leak and Performance - Rank #8

- Sample: **B127988** Mazda R/O: **5507** VIN: **JM3TB3DV8B**[redacted]
- Vehicle Mileage: **31,404** Miles Tear Size: **23 mm** Leak Rate**: 42.7 mbar/sec**





Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

Mazda J50C Brake Booster
Warranty Return Group 1
Vacuum Leak and Booster Function Evaluation

March 20, 2014

ADVANCED THINKING / SMART THINKING / GREEN THINKING

Warranty Return Vacuum Leak & Performance Evaluation

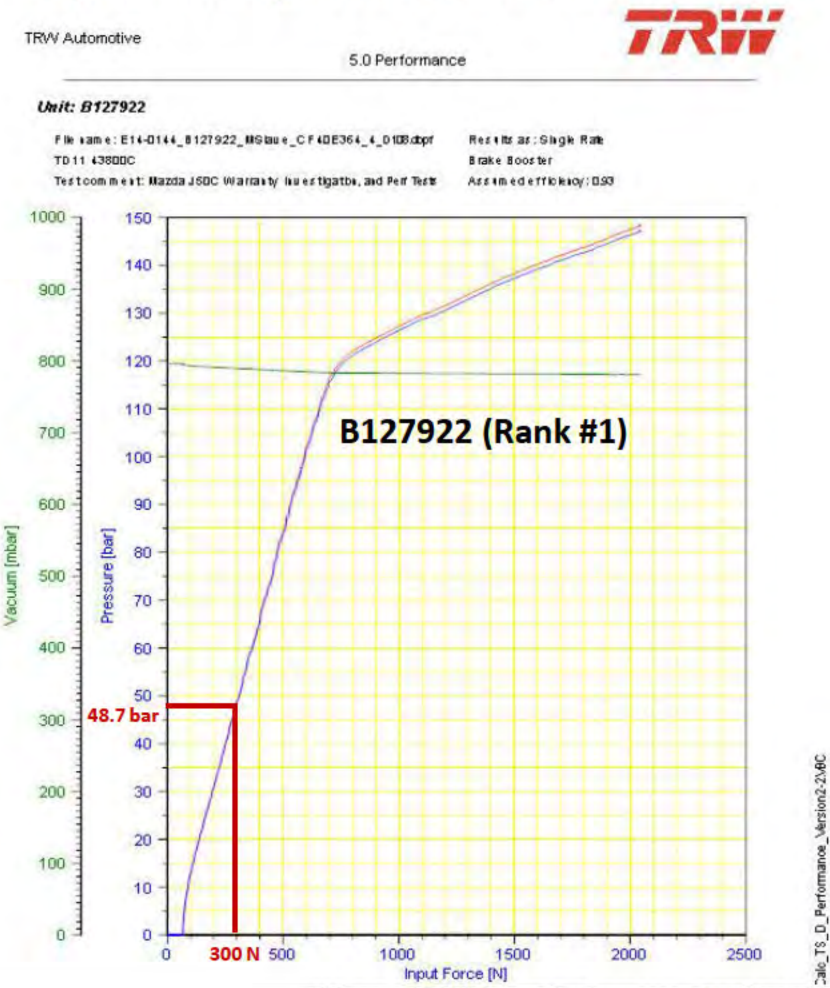
TRW

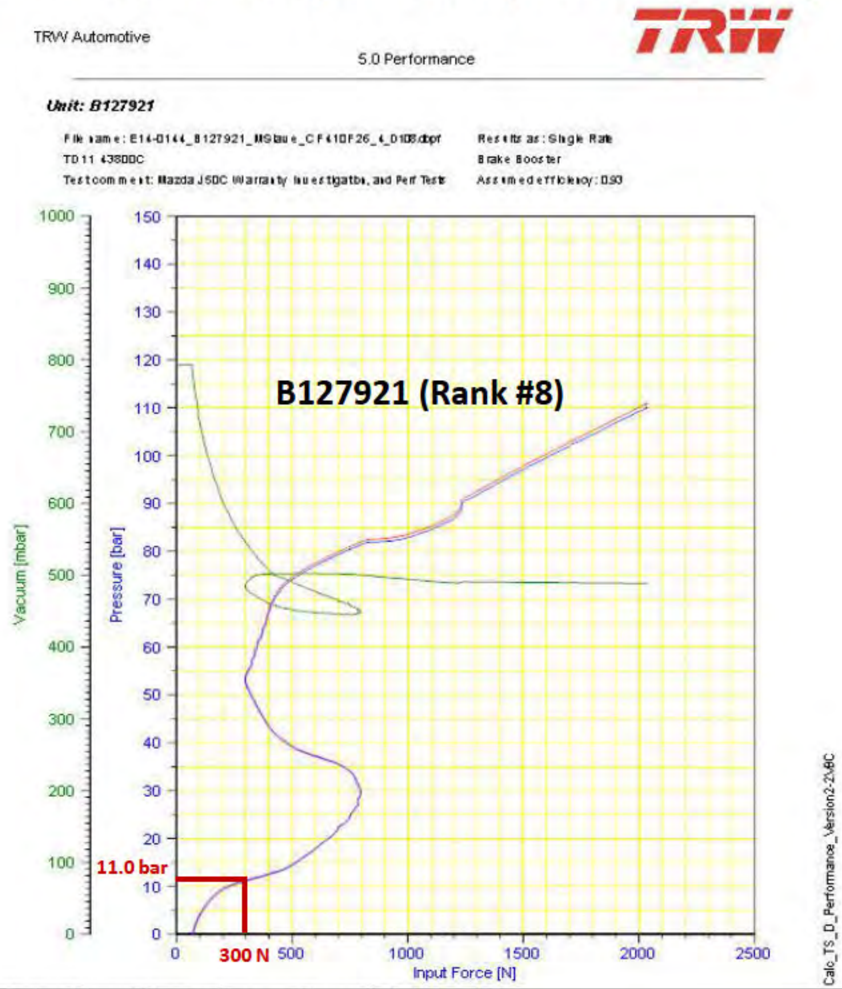
- Tabular summary of eight Mazda warranty boosters analyzed for leak rate, performance, and tear size
- At Mazda's request, samples ranked by lowest to highest vacuum leak rate

TRW Sample Identification Number	Mazda Repair Order Number	VIN Number	Reported Vehicle Mileage (miles)	Vacuum Leak Test Result (mbar / 15 seconds) Requirement: 20 mbar Maximum (≤ 1.33 mbar/sec)	Diaphragm: Number of tears and tear length: (mm)	Overall Ranking: 1 = Best OK 8 = Worst NOK
B127922	1250562	JM3TB2DA4C[redacted]	29,971	All positions tested: 0 mbar Leak rate: 0 mbar/sec	no tear	1
B127917	134392	JM3TB3DV2C[redacted]	19,379	Rest position: 52 mbar Leak rate: 3.7 mbar/sec	1 tear through at 23 mm 1 tear surface only at 17 mm	2
B127919	788851	JM3TB2CA6C[redacted]	26,904	Rest position: 151 mbar Leak rate: 10.3 mbar/sec	1 tear through at 28 mm	3
B127925	6003420/1	JM3TB2CA2C[redacted]	26,109	Rest position: 190 mbar Leak rate: 13.3 mbar/sec	1 tear through at 34 mm	4
B127920	311718	JM3TB2CA3C[redacted]	20,056	Rest position: 385 mbar Leak rate: 15.7 mbar/sec	1 tear through at 24 mm	5
B127918	791564	JM3TB2CA6C[redacted]	18,729	Rest position: 372 mbar Leak rate: 25.4 mbar/sec	1 tear through at 24 mm	6
B127916	4886	JM3TB2BA2[redacted]	25,579	Rest position: 810 mbar Leak rate: 31.8 mbar/sec	1 tear through at 34 mm	7
B127921	789989	JM3TB2DA7C[redacted]	26,048	Rest position: 585 mbar Leak rate: 41.2 mbar/sec	1 tear through at 31 mm	8

Warranty Return Vacuum Leak & Performance Evaluation

- **Comparison of warranty booster ranked #1 and #8**
- **Master cylinder pressure output at 300 N booster input force (103 N pedal input force) difference between #1 and # 8 is 37.7 bar (77% output reduction)**



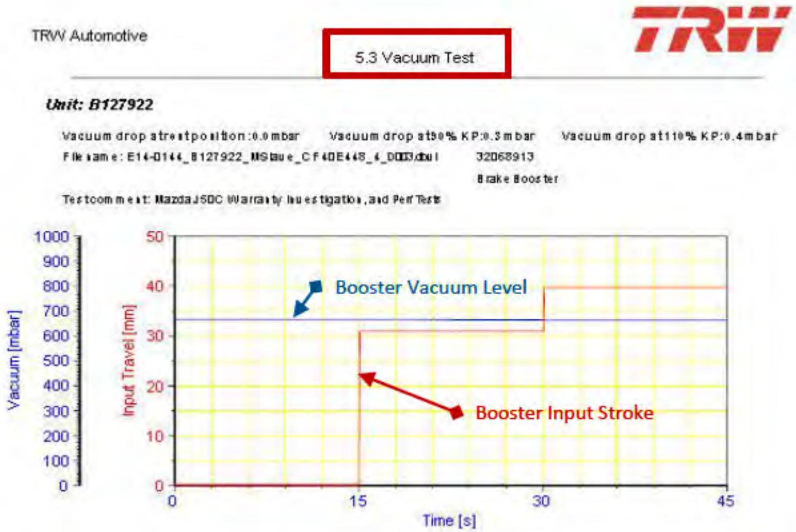


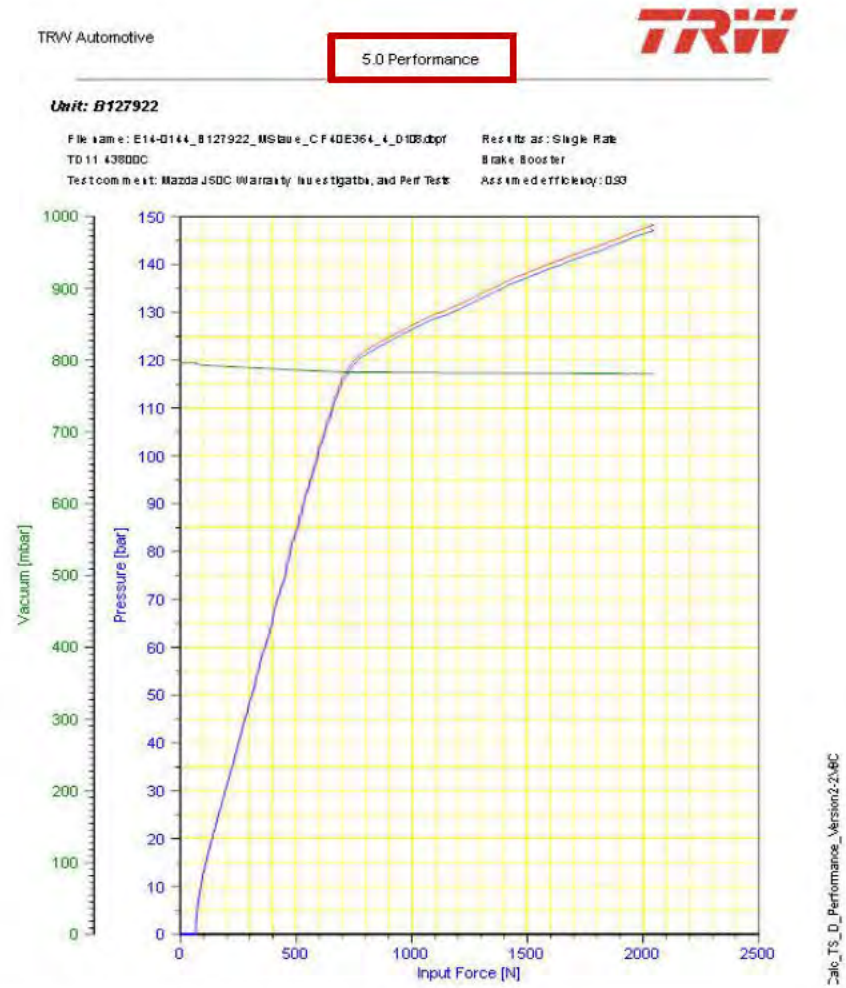
Appendix:

Graphical output of vacuum leak and performance evaluations for warranty booster returns

Appendix: Vacuum Leak and Performance - Rank #1

- Sample: **B127922** Mazda R/O: **1250562** VIN: **JM3TB2DA4C**[redacted]
- Vehicle Mileage: **29,971 Miles** Tear Size: **No Tear** Leak Rate**: 0 mbar/sec**



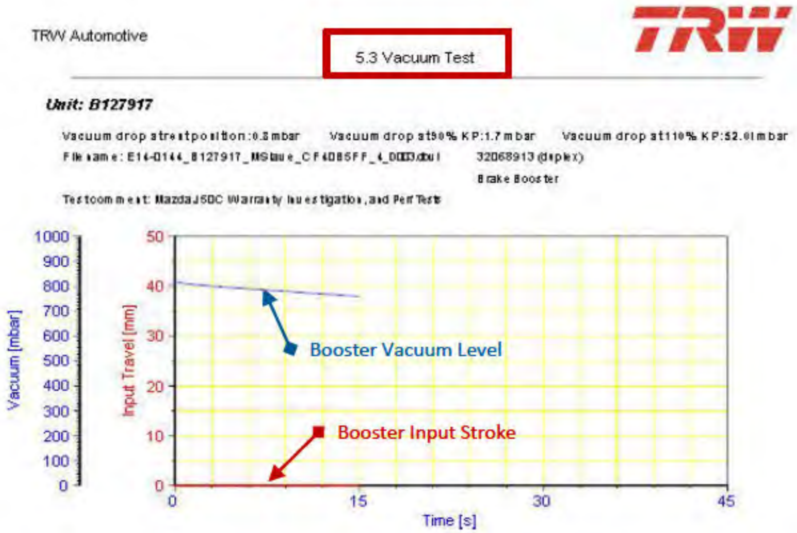


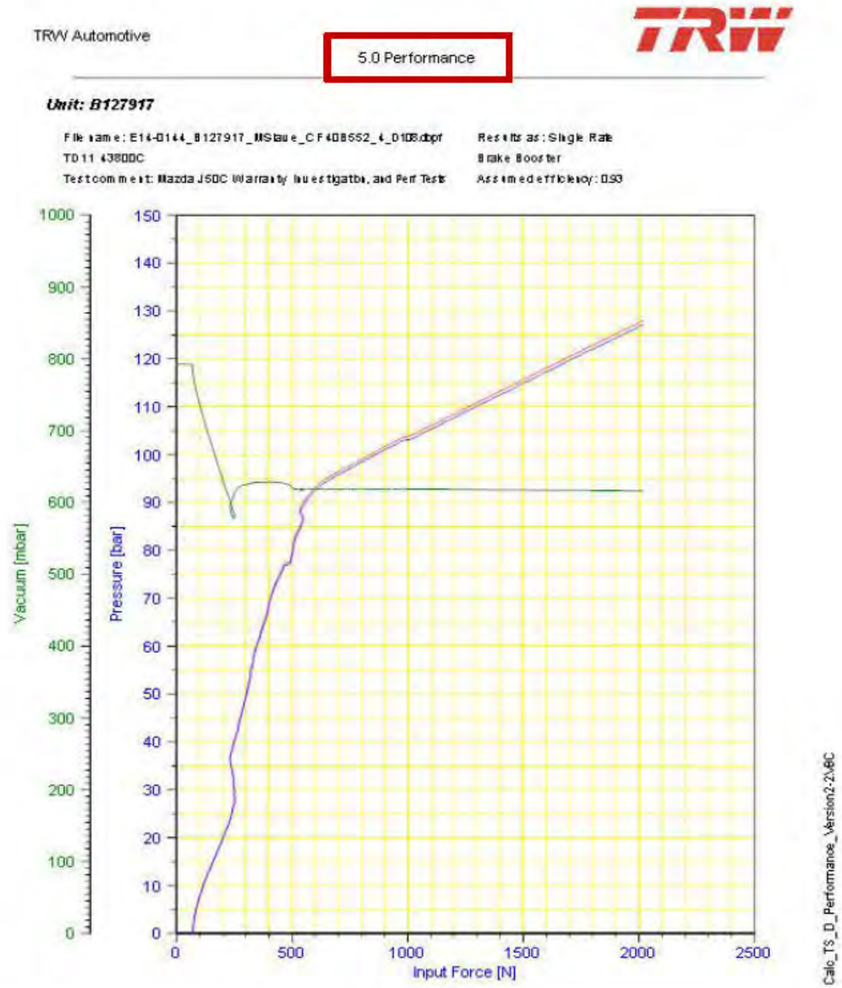
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

Appendix: Vacuum Leak and Performance - Rank #2

- Sample: **B127917** Mazda R/O: **134392** VIN: **JM3TB3DV2[redacted]**
- Vehicle Mileage: **19,379** Miles Tear Size: **23 mm** Leak Rate**: 3.7 mbar/sec**



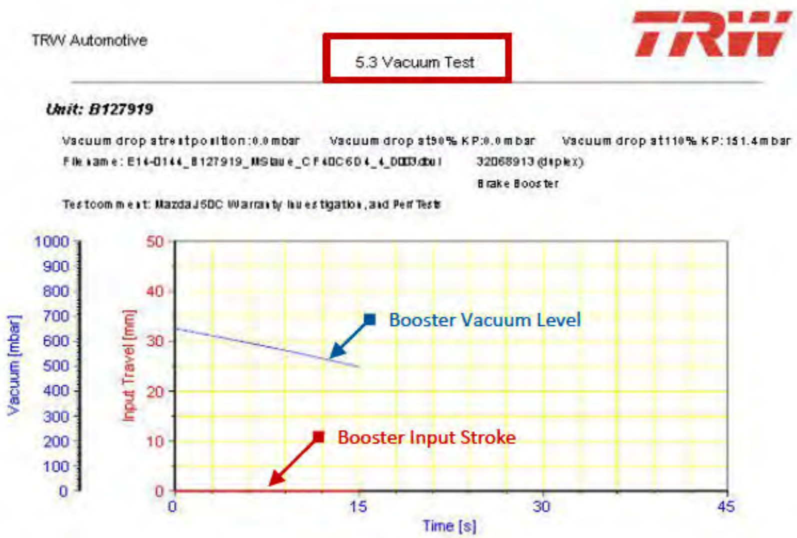


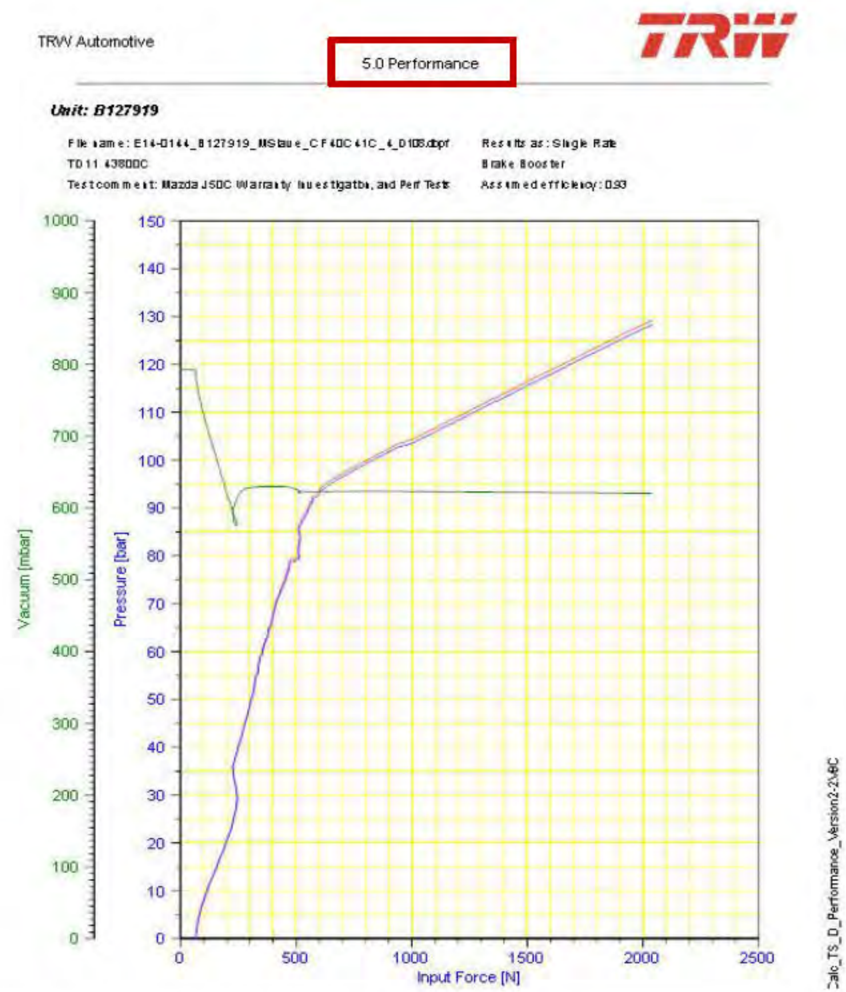
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

Appendix: Vacuum Leak and Performance - Rank #3

- Sample: **B127919** Mazda R/O: **788851** VIN: **JM3TB2CA6**[redacted]
- Vehicle Mileage: **26,904** Miles Tear Size: **28 mm** Leak Rate**: 10.3 mbar/sec**



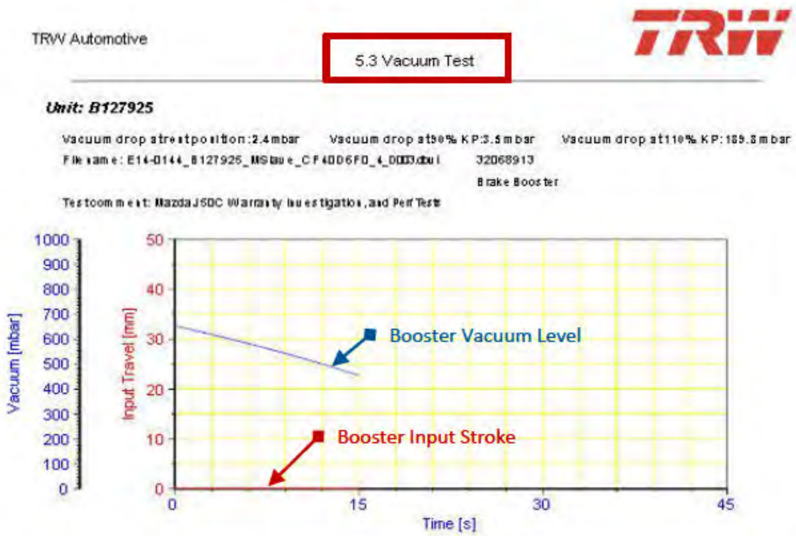


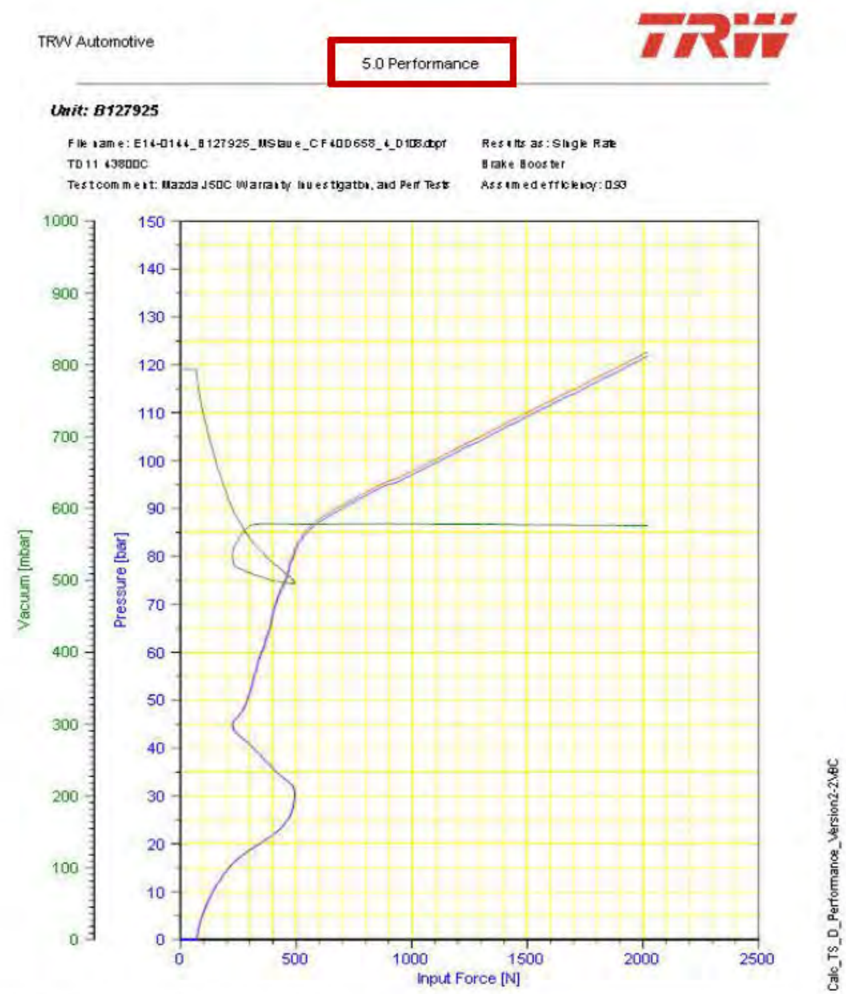
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

Appendix: Vacuum Leak and Performance - Rank #4

- Sample: **B127925** Mazda R/O: **6003420/1** VIN: **JM3TB2CA2**[redacted]
- Vehicle Mileage: **26,109** Miles Tear Size: **34 mm** Leak Rate**: 13.3 mbar/sec**





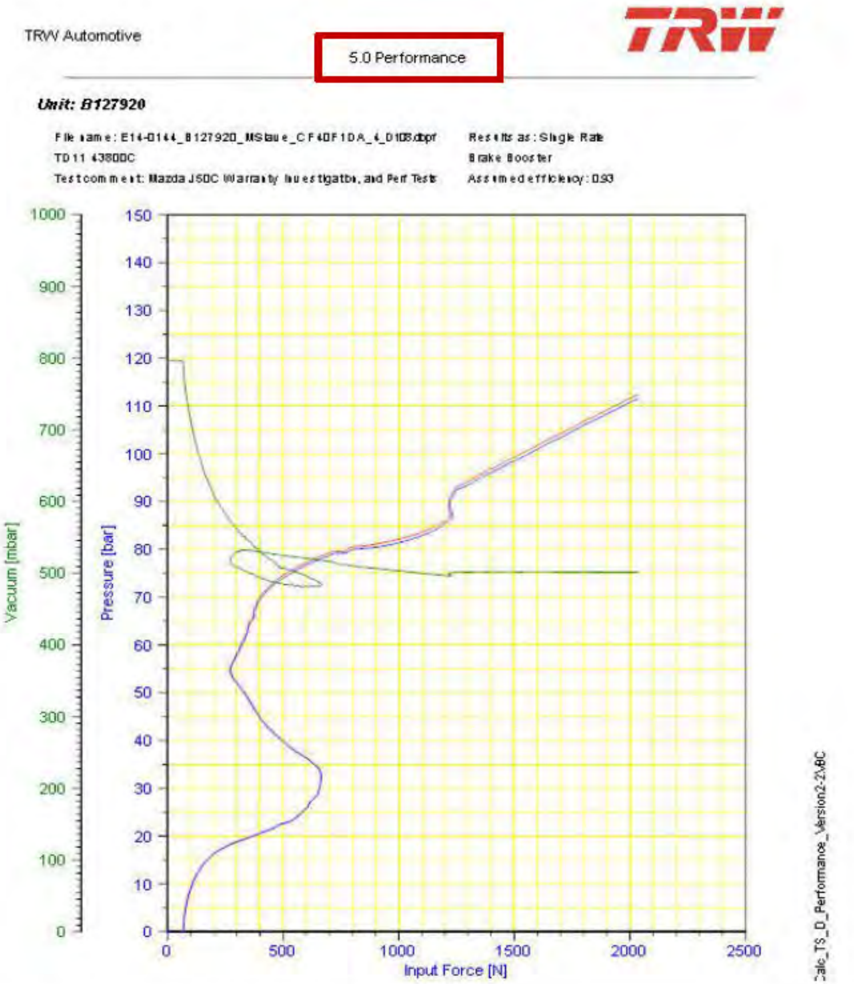
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

Appendix: Vacuum Leak and Performance - Rank #5

- Sample: **B127920** Mazda R/O: **311718** VIN: **JM3TB2CA3C**[redacted]
- Vehicle Mileage: **20,056** Miles Tear Size: **24 mm** Leak Rate**: 15.7 mbar/sec**

No graphing data of vacuum test available

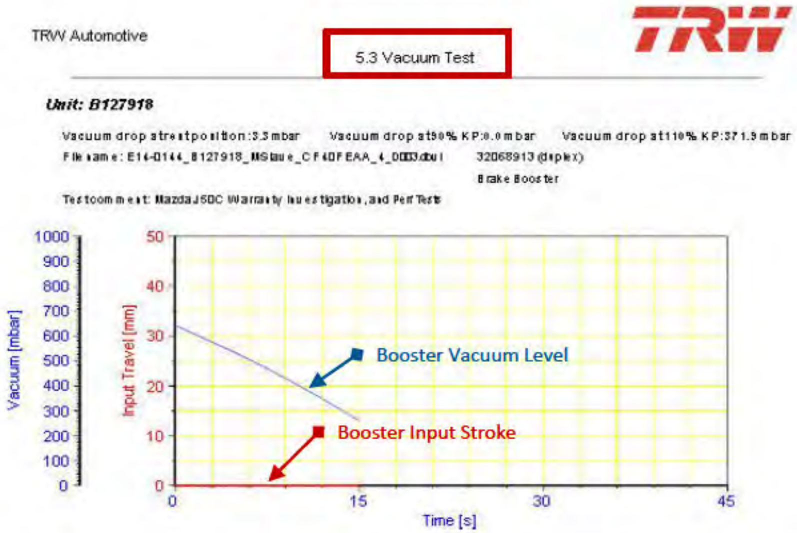


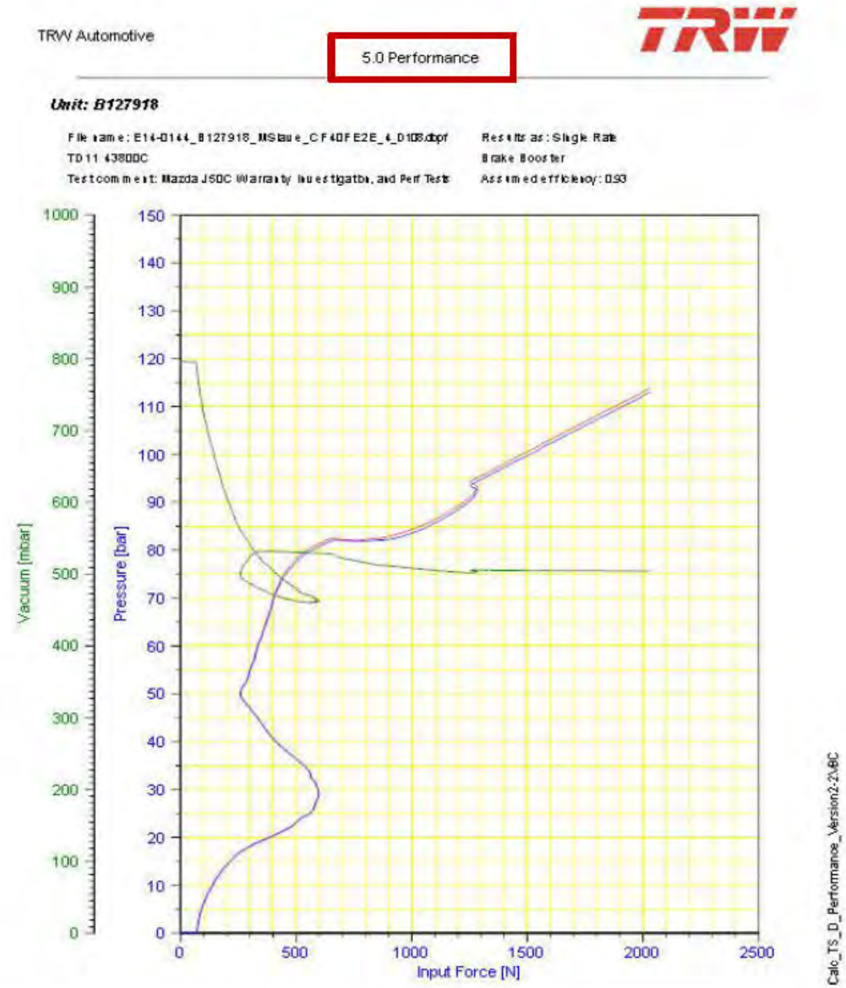
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

Appendix: Vacuum Leak and Performance - Rank #6

- Sample: **B127918** Mazda R/O: **791564** VIN: **JM3TB2CA6[redacted]**
- Vehicle Mileage: **18,729** Miles Tear Size: **24 mm** Leak Rate: **25.4 mbar/sec**



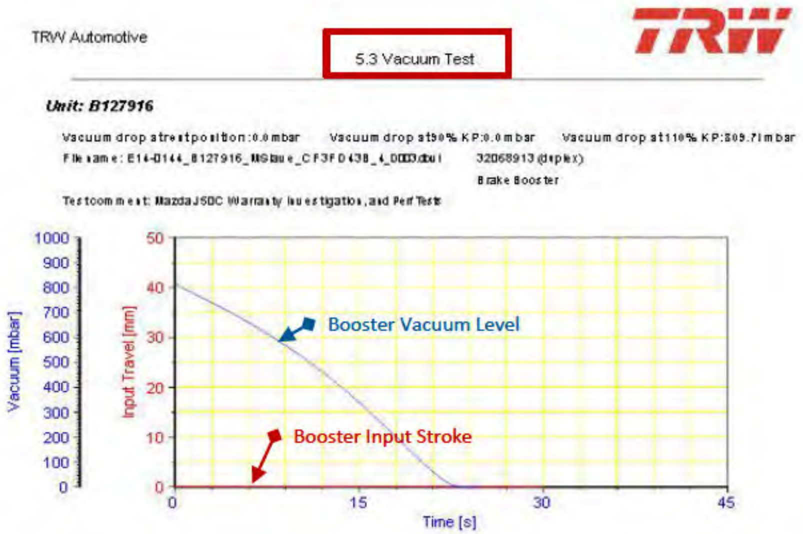


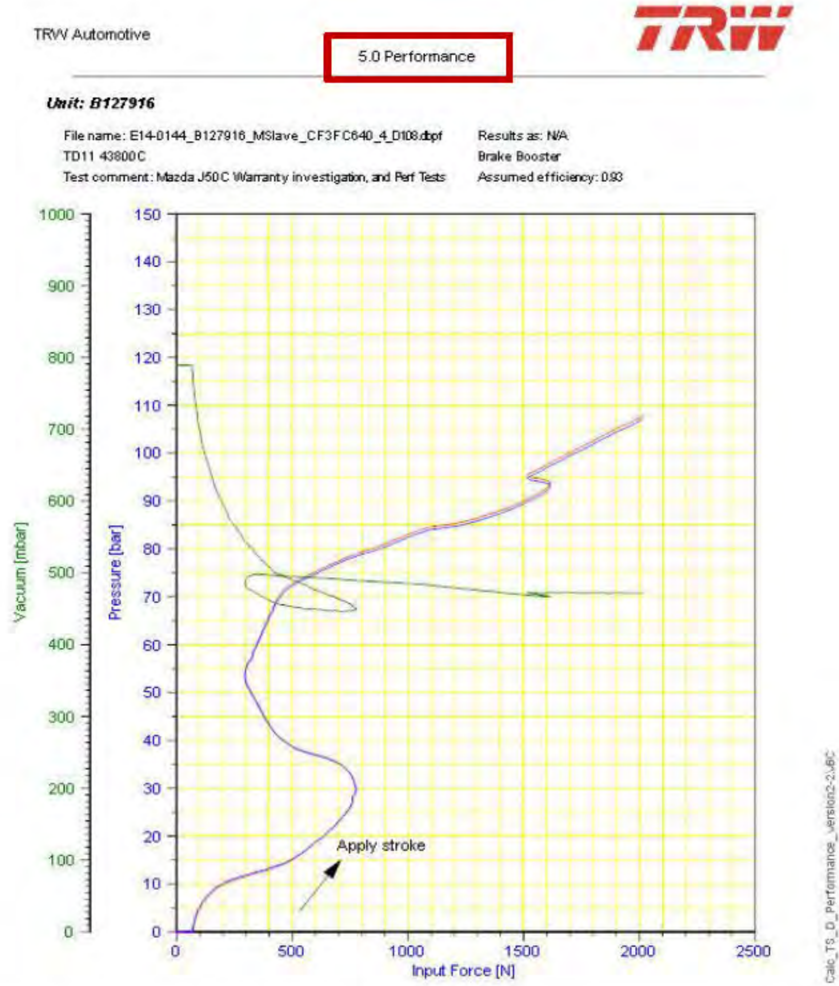
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

Appendix: Vacuum Leak and Performance - Rank #7

- Sample: **B127916** Mazda R/O: **4886** VIN: **JM3TB2BA2C**[redacted]
- Vehicle Mileage: **25,579** Miles Tear Size: **34 mm** Leak Rate**: 31.8 mbar/sec**



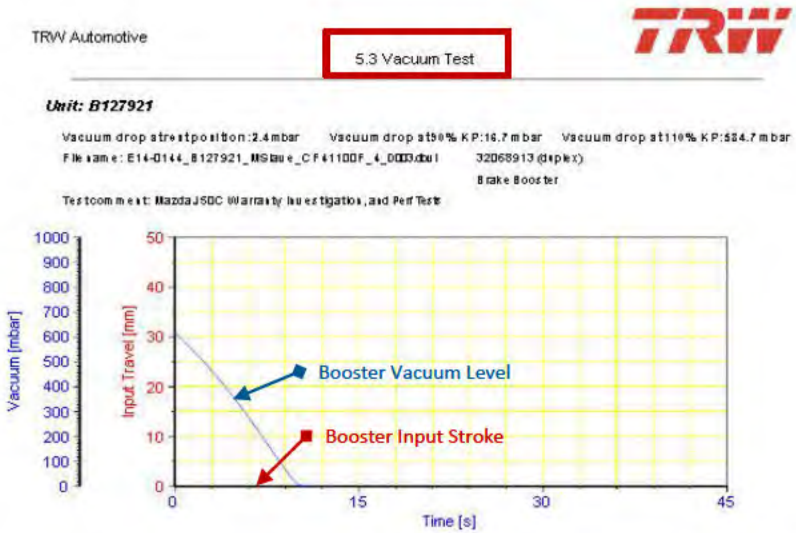


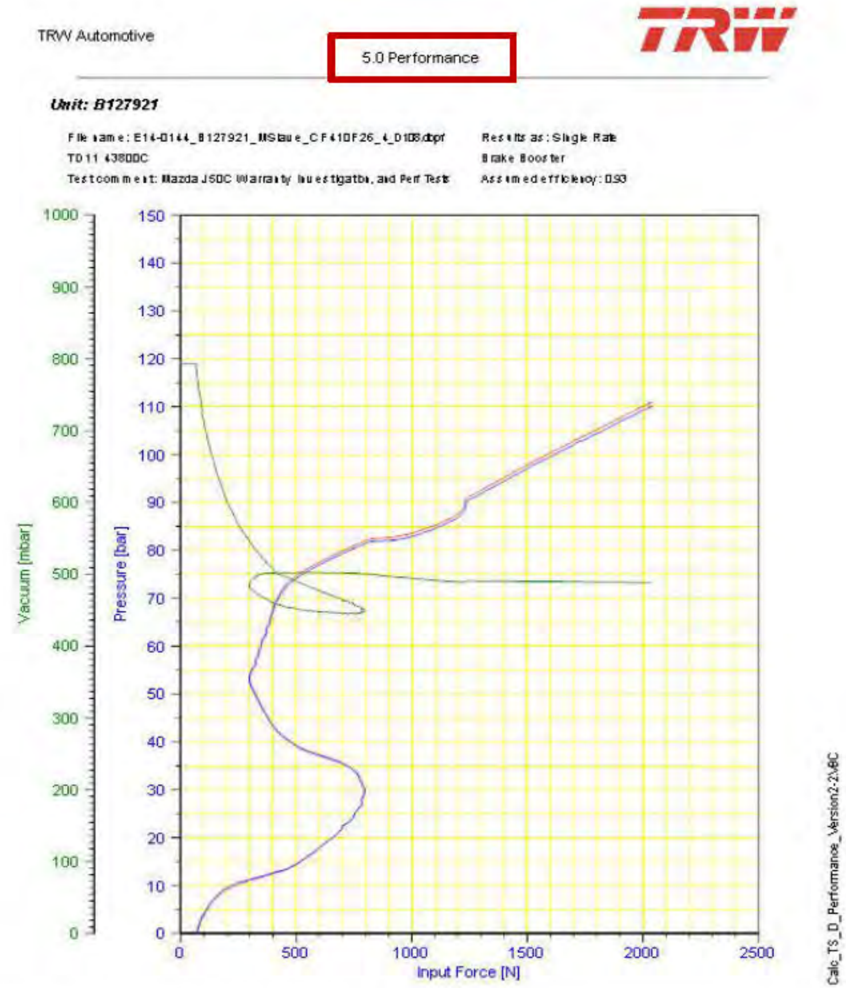
Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

Appendix: Vacuum Leak and Performance - Rank #8

- Sample: **B127921** Mazda R/O: **789989** VIN: **JM3TB2DA7[redacted]**
- Vehicle Mileage: **26,048** Miles Tear Size: **31 mm** Leak Rate**: 41.2 mbar/sec**





Vacuum Test measures booster vacuum decay (mbar) over a 15 second time period after vacuum stabilization with a master cylinder mounted onto booster and at 3 booster input stroke positions (test halted if vacuum leak rate exceeds 20 mbar over 15 seconds for any booster input stroke position)

Booster performance test measures master cylinder output pressure (bar) v. booster input force (N) at constant vacuum target of 800 mbar and booster input travel rate of 2 mm/second using standard brake consumers

PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 3-6 Selection of Worst Samples

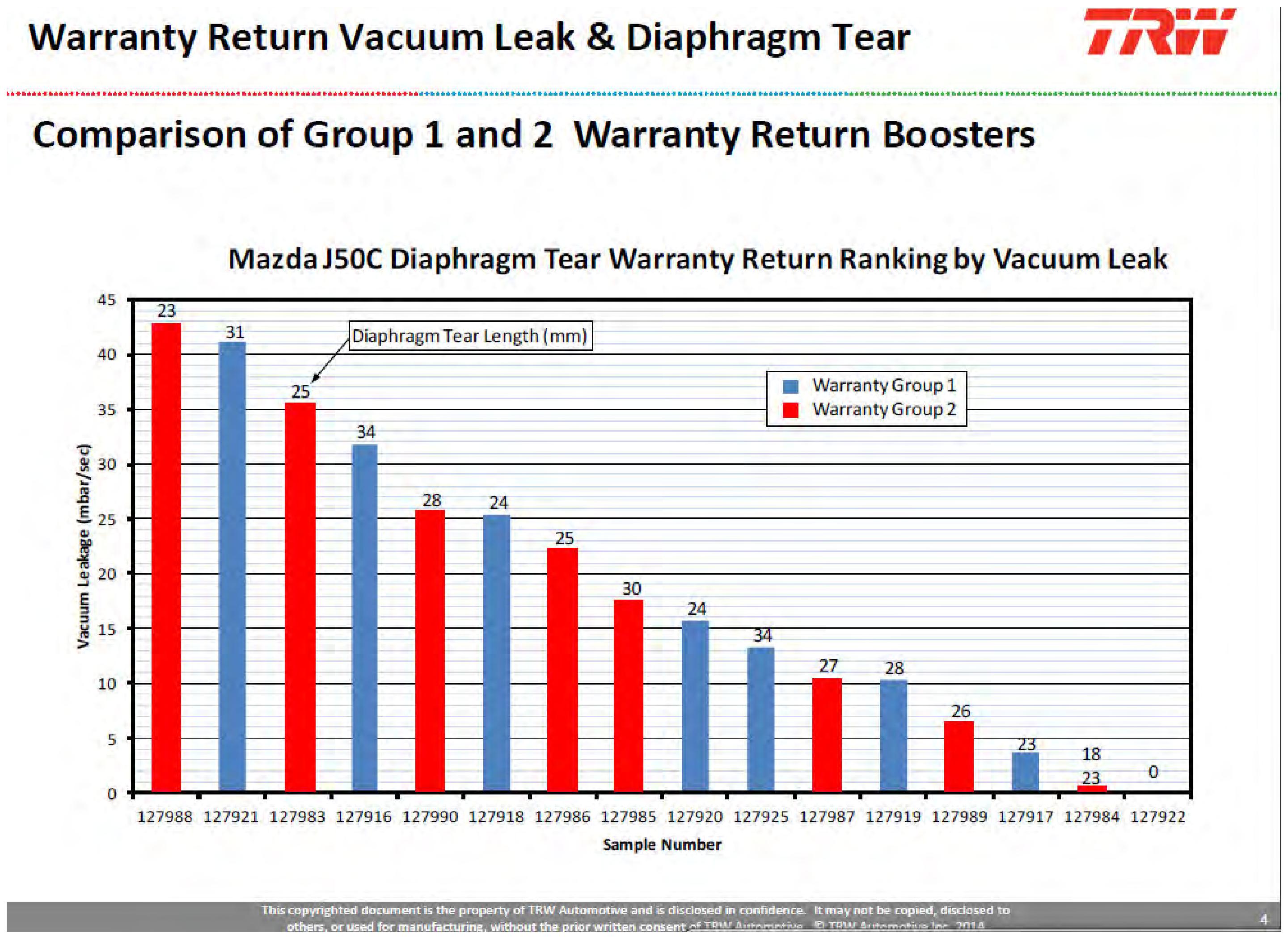
■Selection of Worst Samples

Mazda selected the worst samples with the highest decreasing ratio regarding booster output characteristics
Stratified by Leak rate and tear length and arrange the boosters in the highest decreasing ratio.

Group1: prepared for submitting samples to NHTSA (first collection)
Group2:prepared for test in Mazda(second collection)
Regarding Group2, considered overall ranking and reconsidered ouput characteristics(*1)

Detailed data is Material 3-5 Supplier Report 25 Mar 2014

	TRW Sample identification Nunber	Warranty Return Group	Group1 overall ranking 1=Best ok 8=WorstNOK	Group2 overall ranking 1=Best ok 8=WorstNOK	*1 Group2 output reduction at300N ranking 8=Worst	Leak rate mbar/sec	diaphragm Tear length mm	MasterCylinder pressure Output (bar) at 300N Booster	output reduction at 300N	
1	B127988	2		8	3	42.7	23	24.7	48%	
2	B127921	1	8			41.2	31	11	77%	←samples submitted to NHTSA were stratified from Group1and considered Leak rate and the worst Tear length
3	B127983	2		7	8	35.5	25	12	75%	←used for test in Mazda and panneler evaluation (considered output characteristec.That is why rank 7)
4	B127916	1	7			31.8	34	12	75%	←to NHTSA
5	B127990	2		6	7	25.7	28	12	75%	
6	B127918	1	6			25.4	24	18	62%	←to NHTSA
7	B127986	2		5	4	22.3	25	20	58%	
8	B127985	2		4	6	17.5	30	17	64%	
9	B127920	1	5			15.7	24	19	60%	←to NHTSA
10	B127925	1	4			13.3	34	19	60%	←to NHTSA
11	B127987	2		3	1	10.4	27	48	-1%	
12	B127919	1	3			10.3	28	49	-3%	←to NHTSA
13	B127989	2		2	5	6.5	26	17	64%	
14	B127917	1	2			3.7	23	50	-5%	
15	B127984	2		1	2	0.47	23	28	41%	
16	B127922	1	1			0	0	47.5	-	←Normal part



PE14-005

MAZDA

4/15/2014

APPENDIX 8

Action List Material

Material 3-7 FMVSS Test Result

J50C Brake Performance (FMVSS135 Test Result of Worst Case Booster))

Brake Performance Development Group
Masumoto/Metsugi

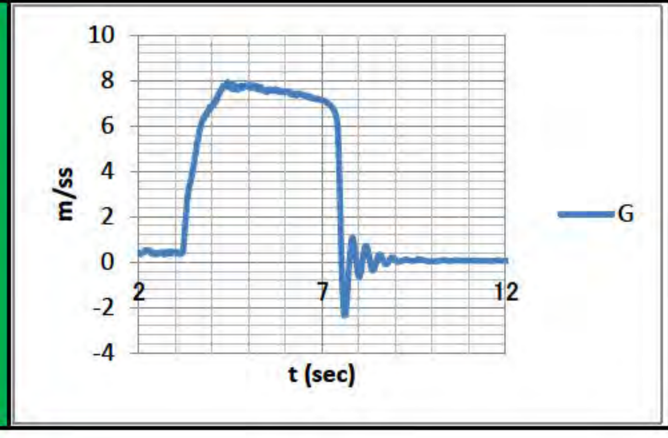
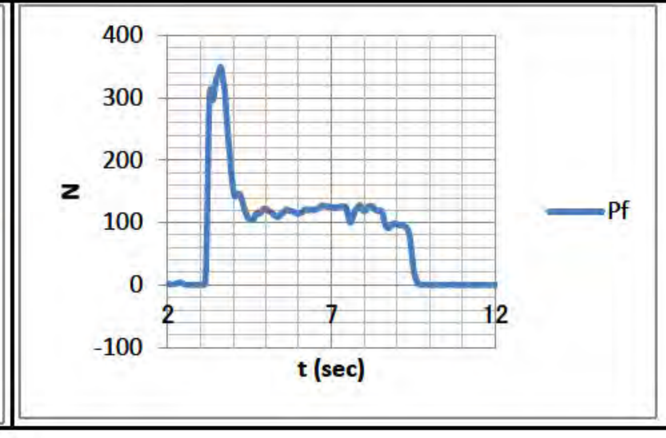
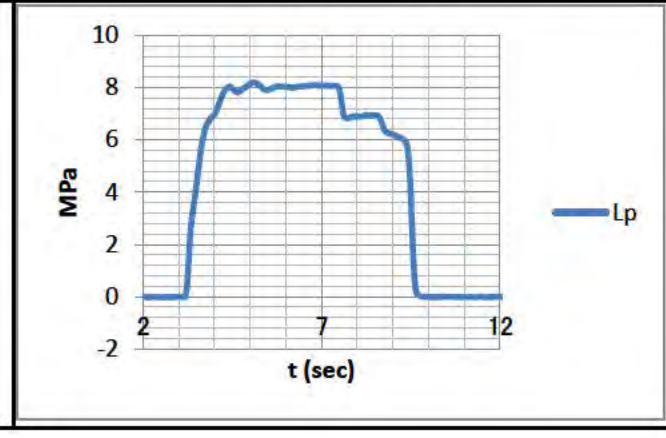
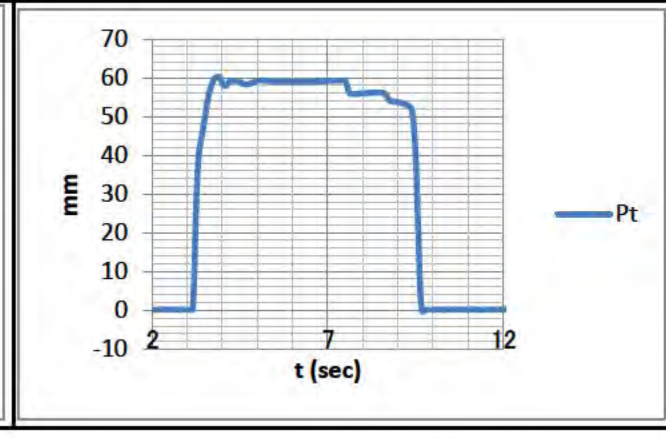
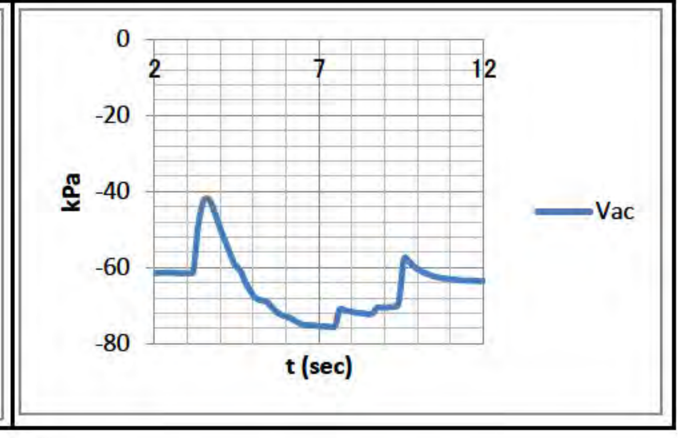
■Test Vehicle
J50C MP (09210) 4WD 6AT 20″Tire / Ft;17″+VC030H Rr;17″+D6306
Weight;2750kg (1342kg / 1408kg) GVWM

Booster = Worst Case Booster (Warranty Return Booster Sample No. B127983)
Mile;32.195Miles Tear Size;25mm Leak Rate;35.5mbar/sec

【Comment】

Brake Performance using Worst Case Booster meet FMVSS135.

■FMVSS135 Test Result

	Initial Speed (km/h)	Stopping Distance (m)	Stopping Distance 100km/h Revision (m)	Pedal Forth (N)	Deceleration(AVE) (m/ss)	Judgement	Deceleration (m/ss)	Pedal force (N)	Pressure (Mpa)	Pedal Stroke (mm)	Vacuum (kPa)
Standard	100km/h	–	70m or less	500N or less	–				＊Before ABS Operation,Pressure Constant Apply which occur maximun deceleration.		
FMVSS135	101.29	63.27	61.80	350N (peak)	7.48	OK					

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4/15/2014

APPENDIX 8

Action List Material

Material 3-8 Booster Characteristics

Booster Characteristics of worst case Booster

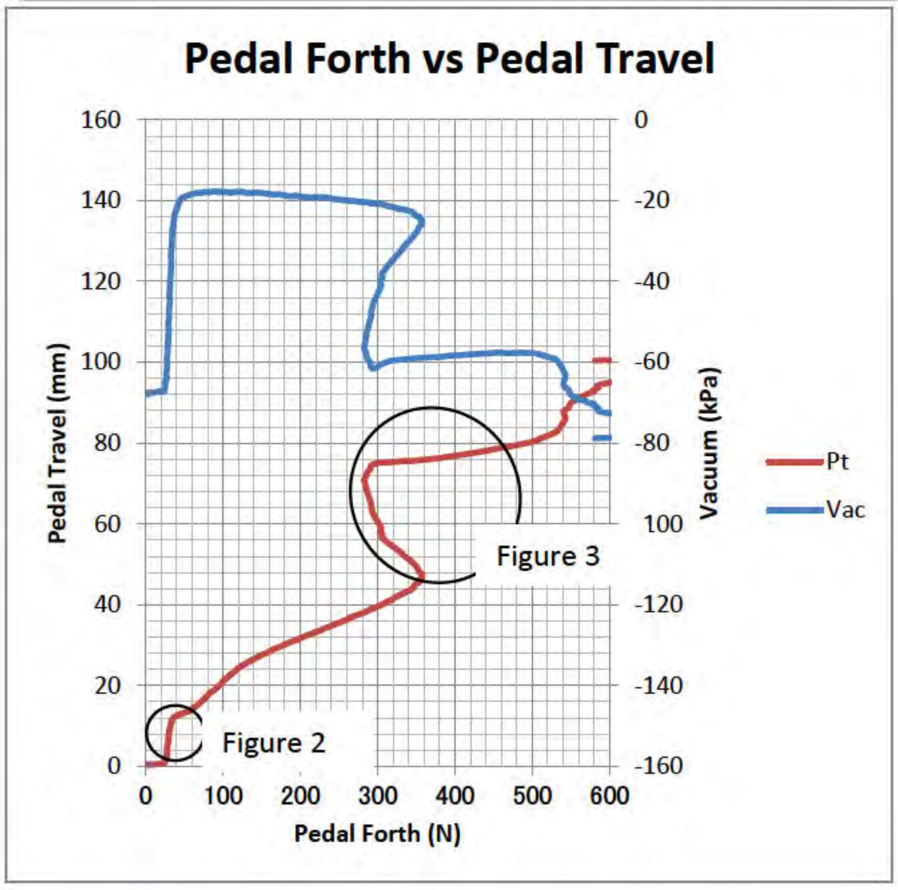
2014.4.4
Brake Performance Development Group
Metsugi

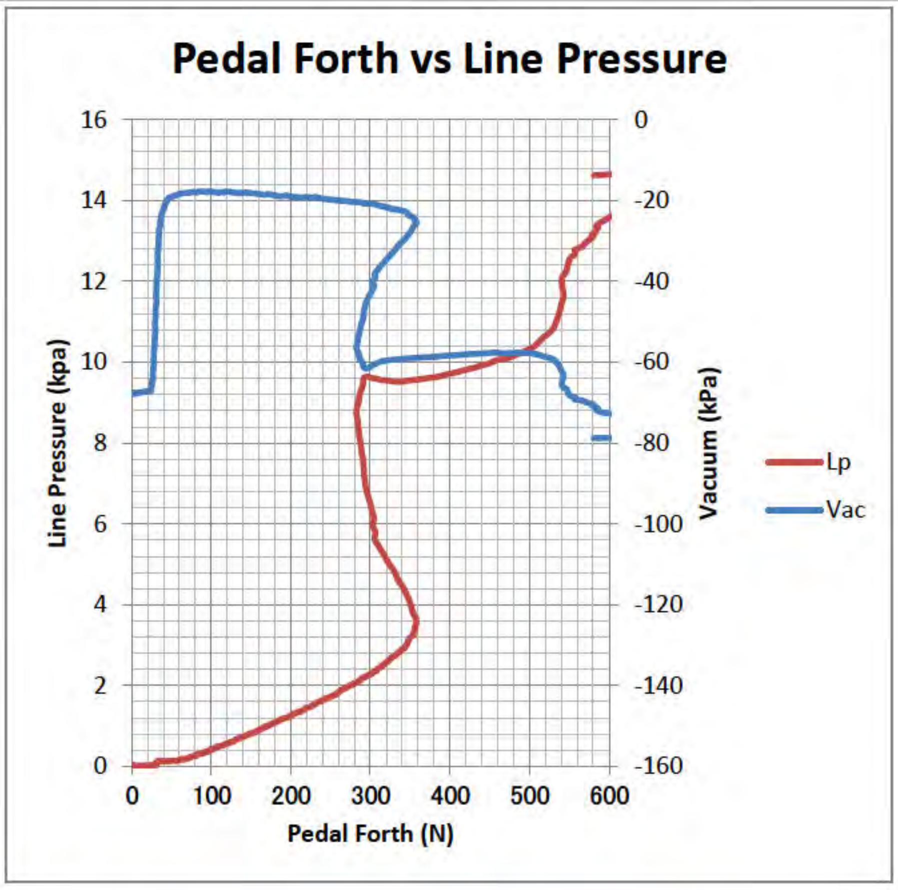
■Test Vehicle
J50C MP (09210) 4WD 6AT 20″Tire / Ft;17″+VC030H Rr;17″+D6306
Weight;2750kg (1342kg / 1408kg) GVWM

Booster = Worst Case Booster (Warranty Return Booster Sample No. B127983)
Mile;32.195Miles Tear Size;25mm Leak Rate;35.5mbar/sec

Booster is attached to a Vehicle.

Pedal Appl] Rate ; 4mm/sec





Pedal Travel (figure 2) ; Just after Pedal Apply ⇒ 12mm ⇒ 30mm ⇒ 46mm
Hiss Noise ; sign ⇒ occur ⇒ occur ⇒ Nise is gone
Pedal Travel (figure 3) ; 55mm ⇒ 60mm ⇒ 70mm ⇒ 80mm ⇒ 90mm
Cralinetist Noise ; sign ⇒ occur ⇒peak ⇒ peak ⇒ Noise is gone

Figure 3