

THE TECHNICAL EVOLUTION OF THE ZR-1

Marc Haibeck

Are the '95 models really that much
better?

- ▣ From Lotus, Brian Kid has an official road map to the changes.



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DATE: 6 OCT '93 PAGE 1 OF 13

SUBJECT: LTS- SERVICE TRAINING

RICK

1. ATTACHED IS THE FIRST OF THE TRAINING PACKAGES FOR YOUR TRAINING SESSION 14/15 OCTOBER. I HAVE MAINLY PRODUCED IT IN OHP SLIDE FORMAT, WHICH I HOPE IS OK.
2. AVAILABLE BY TO-MORROW, I HOPE, WILL BE:-
 - 1) LTS HISTORICAL BACKGROUND - IN HAND-OUT FORMAT, + SOME G.A.'S
 - 2) BASIC ENGINE SPECIFICATION - SLIDES
 - 3) RELIABILITY PERFORMANCE - SLIDES
 - 4) QUALITY - ONE SLIDE STATING THE OBVIOUS.
 - 5) ENGINE REPAIRS/ REBUILDS - SLIDES OF MISCORUSSER INFORMATION.



MAJOR CHANGES TO LT5

FEATURE	91 MY	92 MY	93 MY	94 MY	95 MY
Power (BHP)	375	C/O	405	C/O	C/O
Torque (LBS FT)	370	C/O	385	C/O	C/O
RPM (Max Power)	6000	C/O	5800	C/O	C/O
Emissions HC/CO/NOx	.252/1.75/.61	C/O	.209/1.13/.38	C/O	C/O
Base Engine Changes	<ol style="list-style-type: none"> 1. Exhaust valve stem seals. 2. Oil level sensor - revised oil pan. 3. Purge solenoid in Vee. 4. Revised wiring harness. 	<ol style="list-style-type: none"> 1. Vacuum system - IACV solenoid/filter 2. Clutch pilot bearing. 3. Revised DMFW. 4. Revised wiring harness. 	<ol style="list-style-type: none"> 1. Cylinder case/ /crk case - 4 bolt fix 2. Revised oil pan - baffles, oil pump. 3. Cyl heads - revised ports/valves. 4. Injector hsg - revised ports. 5. Plenum - revised. 6. Revised front cover. 7. Revised camshafts. 8. Strengthened pistons. 9. Lightened con-rods. 10. EGR. 11. Two-piece exhaust manifold. 12. Revised fuel rail/injectors. 13. Revised gasket material. 14. 'Qualified' Duplex chains. 15. Revised 'Vee' drain. 16. Revised wiring harness. 	<p>- 94½ - A L Dunn Cylinder Head</p>	
				C/O	C/O



CHANGE	MODEL YEAR	REASON FOR CHANGE	IMPLICATIONS
91 MY			
1a. Exhaust valve stem seals. b. Exhaust valve guides commonised with inlet valve guides.	91 - 95	Improve oil consumption.	Exhaust valve stem seals can be fitted to 90 MY engines only if inlet guides fitted to replace exhaust guides.
2a. Oil level sensor fitted. b. Oil pan modified.	91 - 92 91 - 92	CPC Requirement. To accommodate oil level sensor.	Cannot be fitted to 90 MY. 90 MY oil pan cannot be fitted to 91-92 MY engines. 91 MY oil pan can be fitted to 90 MY engines with blanking plug 12550827*. *(To be provisioned by GMSPO).



MAJOR CHANGES TO LT5 - 91-95 MY

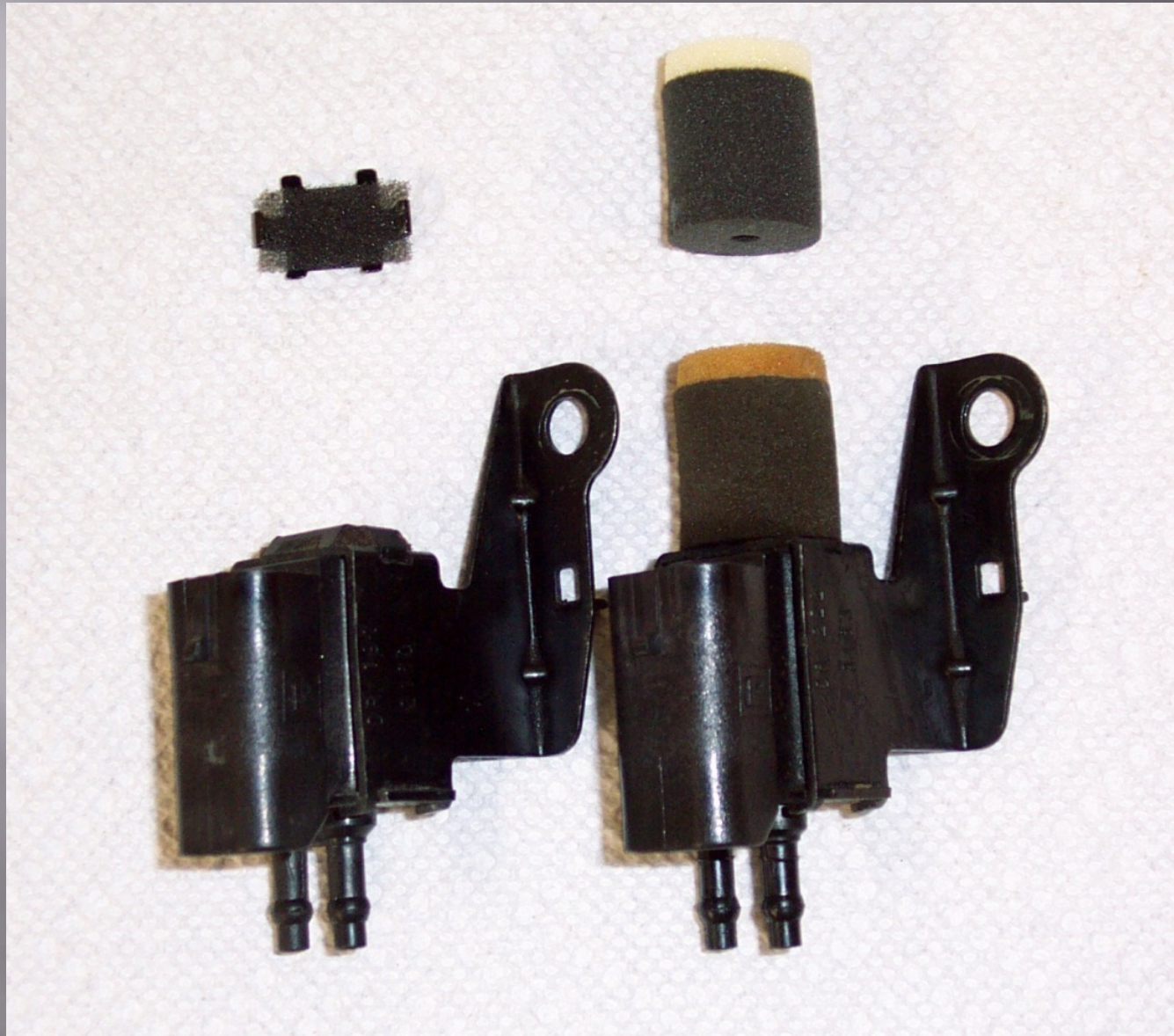
CHANGE	MODEL YEAR	REASON FOR CHANGE	IMPLICATIONS
3. Purge solenoid positioned in 'Vee'.	91 - 95	CPC Requirement.	Associated change to purge system and wiring harness.
4. Revised wiring harness.	91	To accommodate 'Vee' mounted solenoid and oil level sensor.	Not interchangeable 90 MY.



MAJOR CHANGES TO LT5 - 91-95 MY

CHANGE	MODEL YEAR	REASON FOR CHANGE	IMPLICATIONS
92 MY			
1. Vacuum system - inlet air control valve (IACV) solenoid filter.	92 - 93	Improve reliability. Filtered system to reduce ingress of dirt into IACV actuating system.	Can be used to back-service 90-91 MY engines.
2. Revised dual mass flywheel (DMFW).	92 - 95	To reduce transmission noise.	Should be used to back-service 90-91 MY engines. See service pocket booklet.
3. Revised clutch pilot bearing.	92 - 95	To reduce bearing screech.	Should be fitted where possible - see service bulletin 92-230-6 and service pocket booklet.
4. Revised wiring harness.	92	To cater for ASR, A/C anticipate.	Harnesses were re-worked to permit retention of 90-91 MY exhaust system (O ₂ sensors).

Item 3. I recommend the roller pilot bearing PN 14061685.



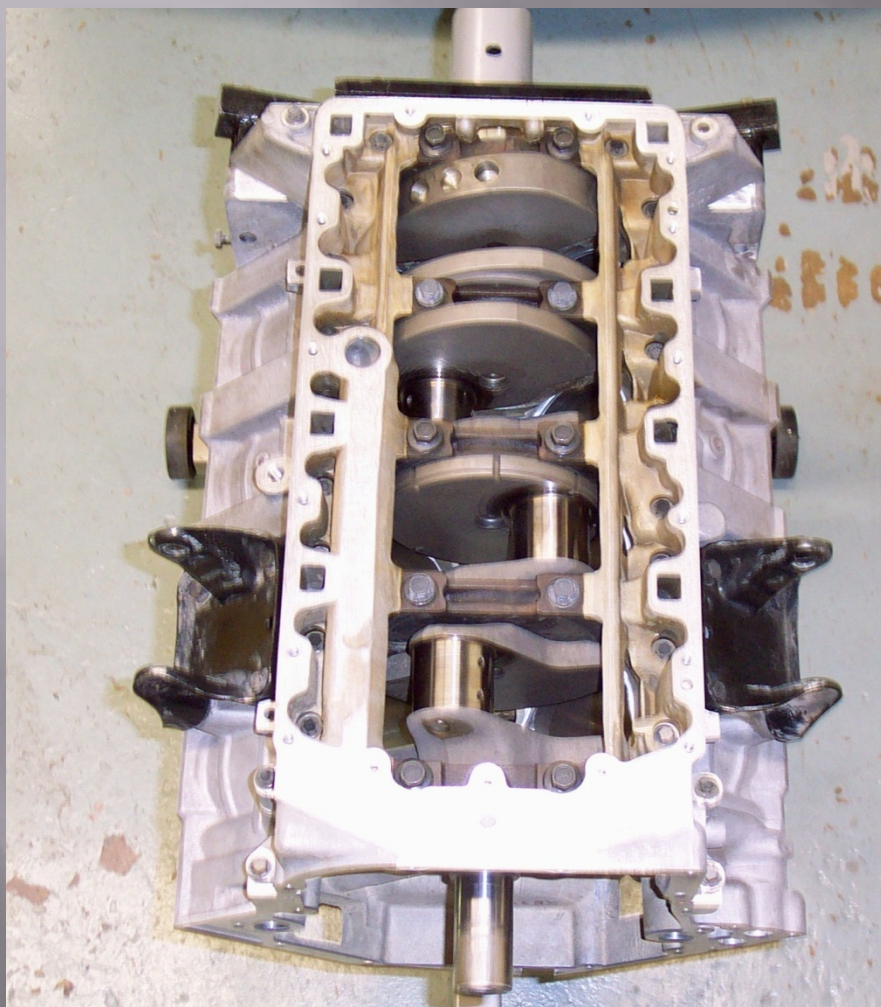
At about the '92 ½ model year point, GM began installing a new oil cooler hose assembly.



MAJOR CHANGES TO LT5 - 91-95 MY

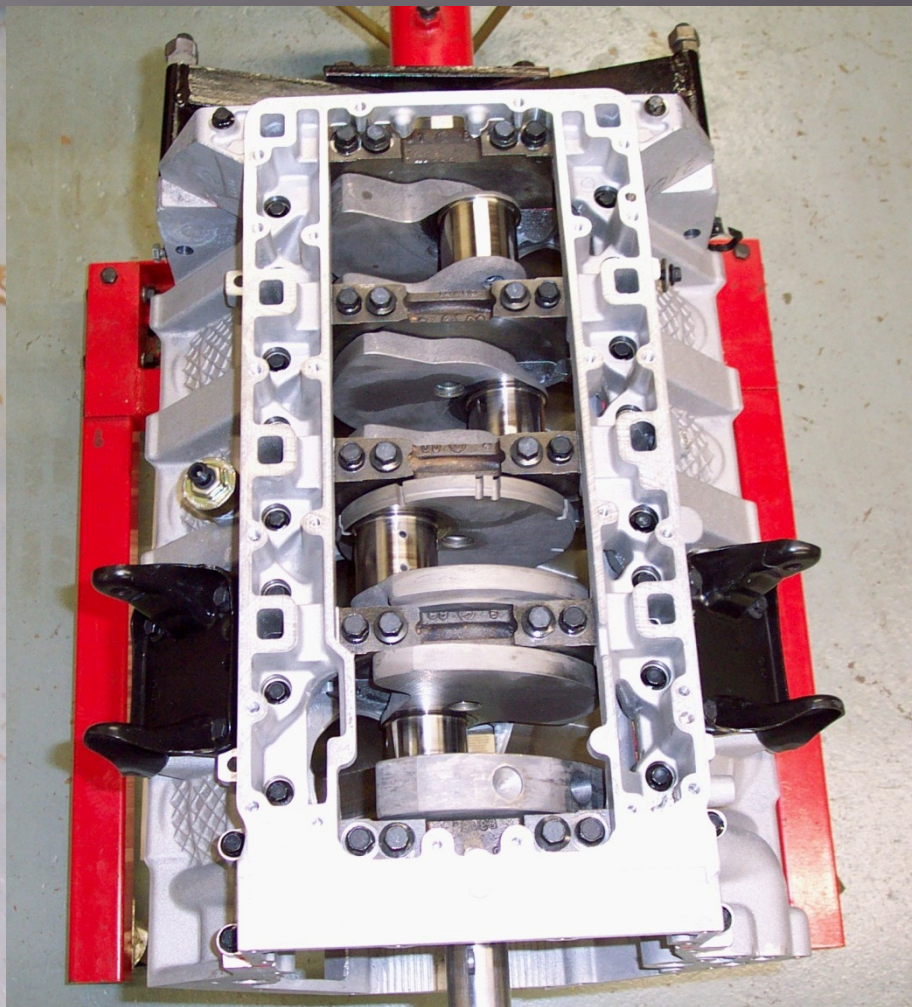
CHANGE	MODEL YEAR	REASON FOR CHANGE	IMPLICATIONS
93-95 MY			
1. Cylinder case, crankcase re-design.	93 - 95	Four-bolt fastening of main bearing panels introduced to ensure cylinder case/crankcase integrity at higher power outputs.	Revised main bearing bolt pattern - revised tightening torques. Parts not interchangeable 90-92 MY.
2. Oil pan, baffle, windage tray, oil pick-up asm, oil pump.	93-95	Design revised in-line with revised cylinder case/crankcase design.	Revised assembly procedure. Parts not interchangeable 90-92 MY.

'90 - '92



10 12 mm diameter bolts

'93 - '95

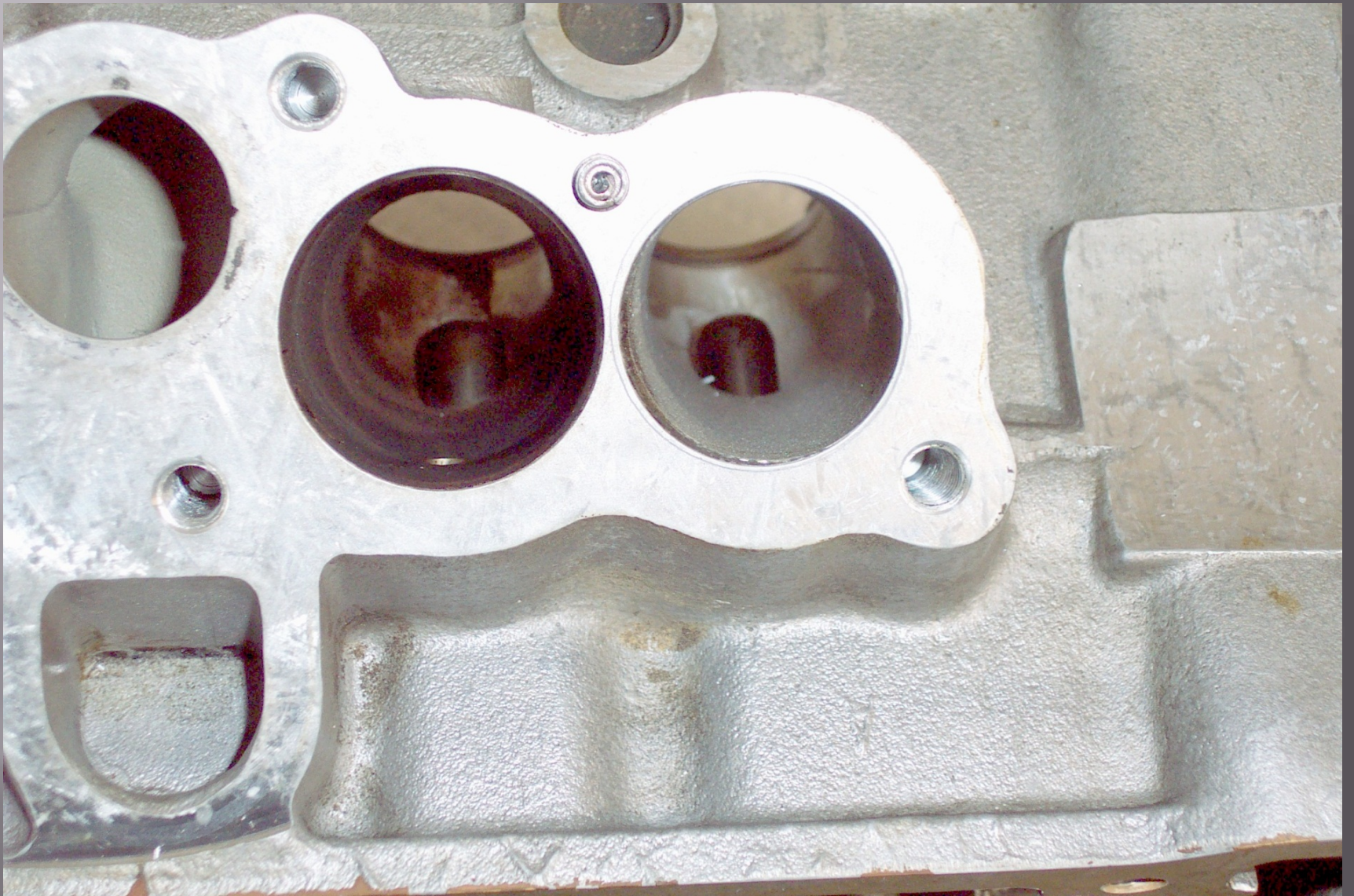


10 8 mm plus 10 10 mm dia. bolts

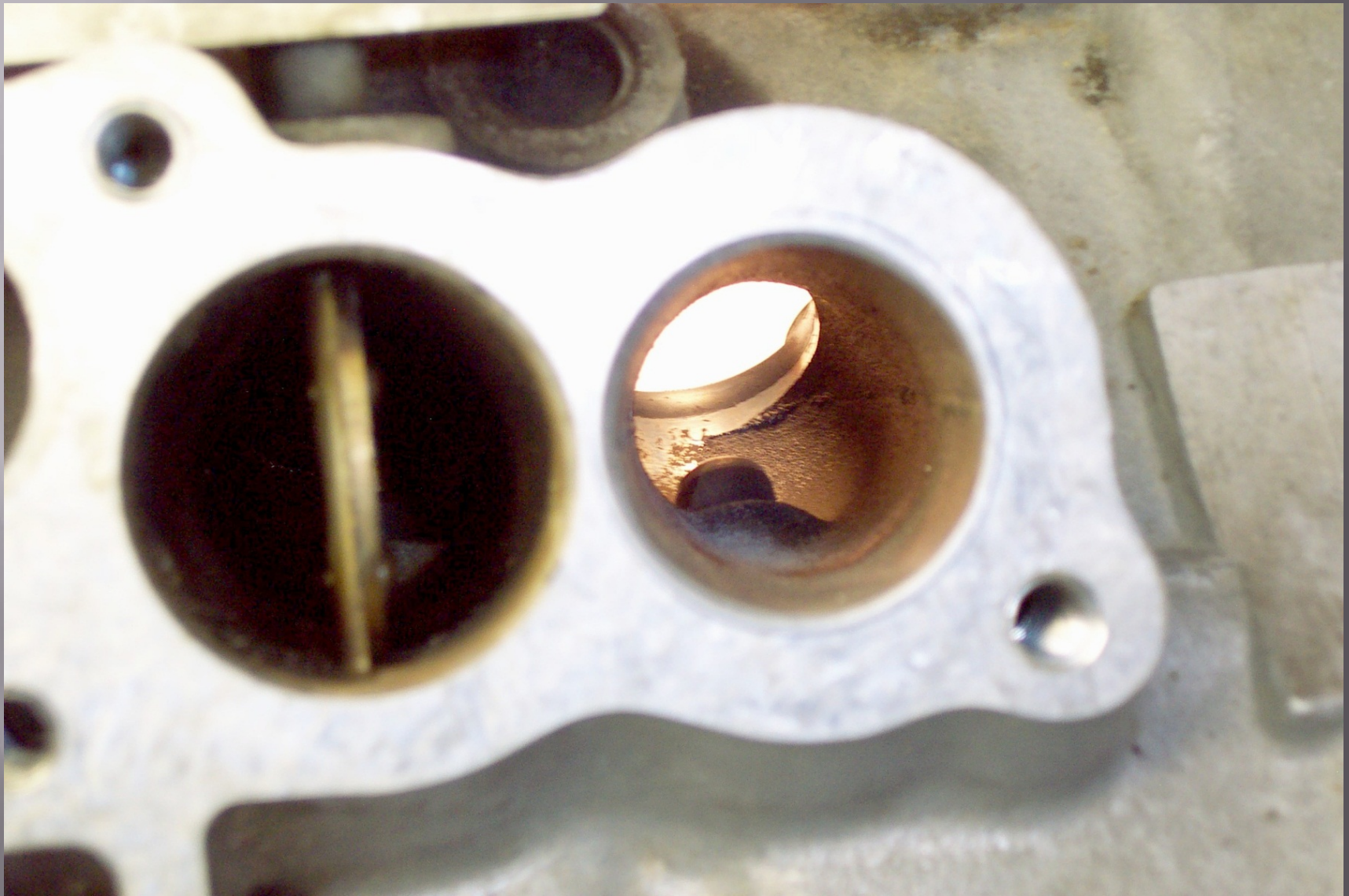
MAJOR CHANGES TO LT5 - 91-95 MY



CHANGE	MODEL YEAR	REASON FOR CHANGE	IMPLICATIONS
<p>3. Cylinder head ASMs</p> <p>a) Inlet ports enlarged.</p> <p>b) Inlet/exhaust valve faces revised.</p> <p>c) Valve seats revised.</p> <p>d) Exhaust system fastener pattern revised.</p> <p>e) A L Dunn cylinder heads introduced.</p>	<p>93 - 95</p>	<p>To improve airflow and increase power and torque.</p> <p>To permit fitment of two-piece anti-reversion exhaust manifold.</p> <p>Non-availability of Birmal heads.</p>	<p>93-95 MY cylinder heads not interchangeable with 90-92 MY heads.</p> <p>Valves not interchangeable with 90-92 parts.</p> <p>Not interchangeable with 90-92 exhaust system.</p> <p>A L Dunn heads can be used to replace Birmal heads - but for R/H heads chain tensioner kit is required:-</p> <p>10199004 - Gasket</p> <p>10215914 - Tensioner sleeve</p> <p>10215915 - Housing - chain tensioner</p> <p>10067520 - Seal - tensioner</p>



Dunn cylinder #1 ports. 34 mm primary.

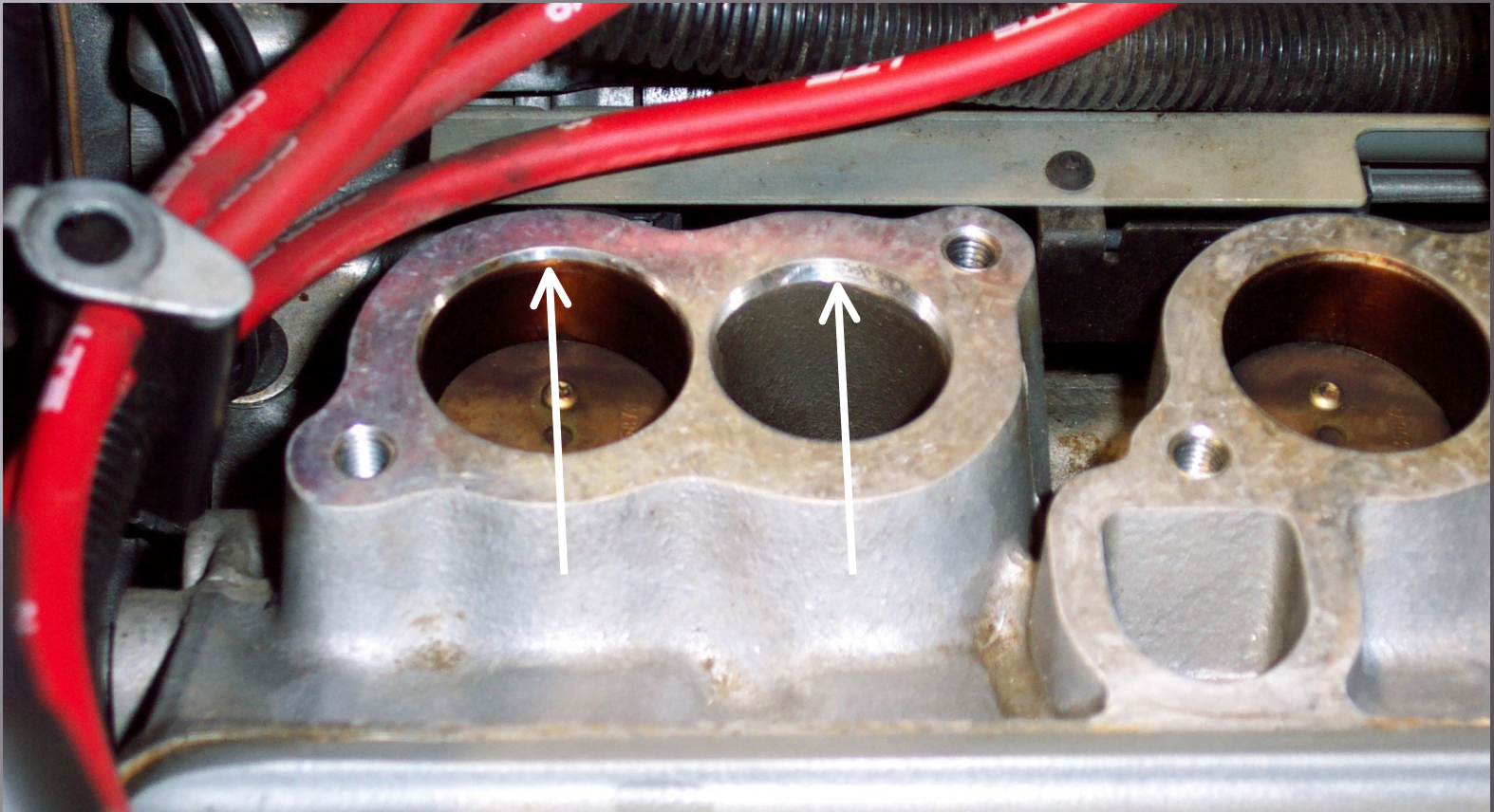


'91 Birmal cylinder #1 ports. 33mm primary.

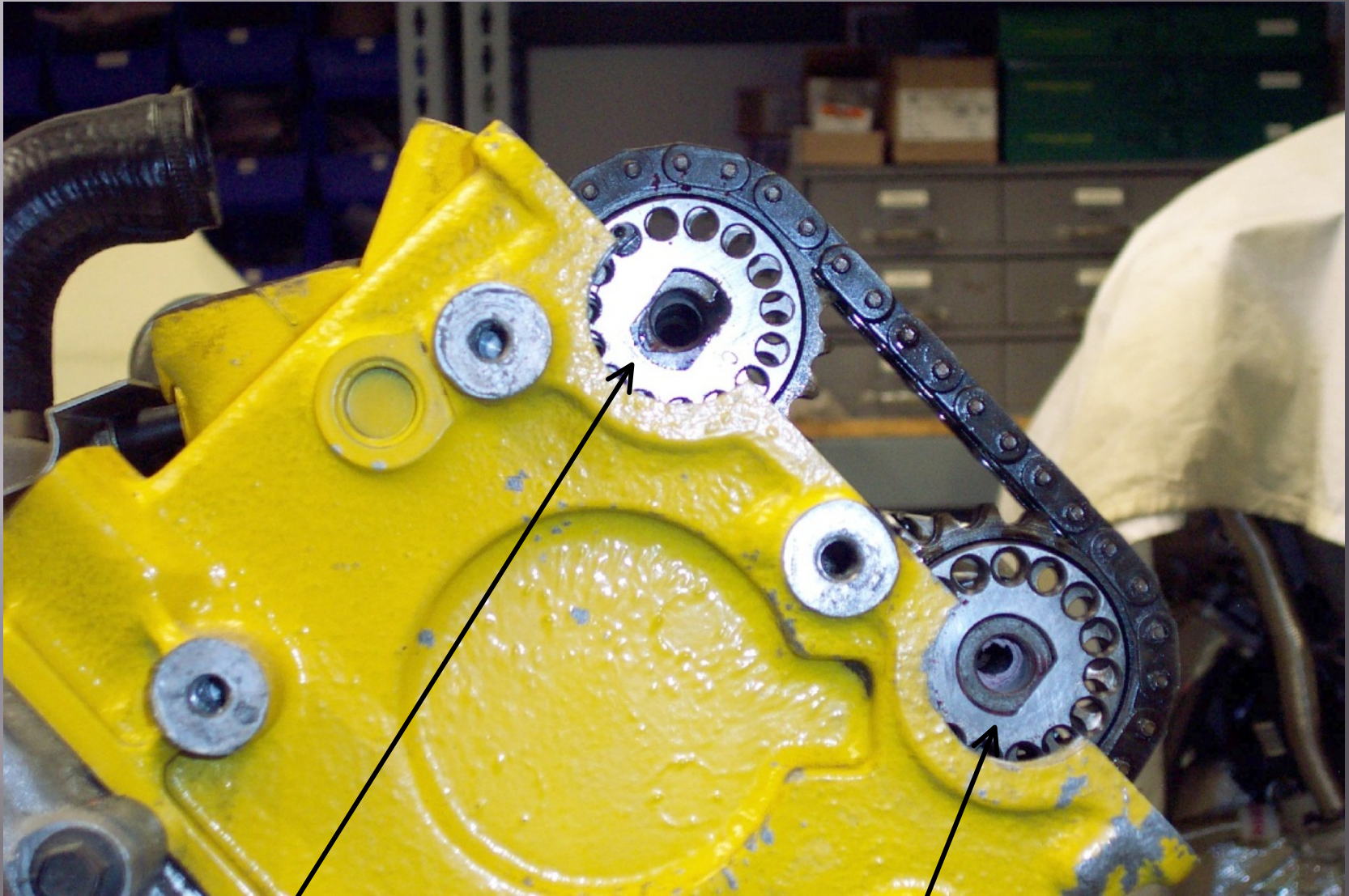


MAJOR CHANGES TO LT5 - 91-95 MY

CHANGE	MODEL YEAR	REASON FOR CHANGE	IMPLICATIONS
4. Injector housings - revised ports	93 - 95	Improve airflow, power, torque.	Non interchangeable 90-92 parts.
5. Plenum - revised.	93 - 95	To accommodate EGR, differential pressure switch, EGR control.	Not interchangeable 90-92 parts.
6. Front cover revised.	93 - 95	To accommodate revised cylinder case/crankcase	Not interchangeable 90-92 parts.
7. Revised camshafts.	93 - 95	Twin drive flats - improve timing accuracy. Exhaust cams only - timing change to improve torque.	Not interchangeable 90-92 parts.



Cylinder head to injector housing port mismatch on a '91.



Two flats on '93 - '95. +/- 1 deg.

One flat on '90 - '92. +/- 2 degs.



MAJOR CHANGES TO LT5 - 91-95 MY

CHANGE	MODEL YEAR	REASON FOR CHANGE	IMPLICATIONS
8. Piston asm -/27.	93 - 95		
a) Strengthened piston - /27.	93 - 95	Ensure piston integrity to cater for higher power output.	Not interchangeable 90 - 92 (-/27 piston is heavier than -/13 90-92 piston).
b) Revised piston pin/retainers.		To cater for higher power output.	Not interchangeable 90-92 parts.
c) Piston ring pack.		Improve oil consumption.	May be back serviced to 90-92 engines to improve oil consumption.

MAJOR CHANGES TO LT5 - 91-95 MY



CHANGE	MODEL YEAR	REASON FOR CHANGE	IMPLICATIONS
9. Connecting Rods.	93 - 95	Lightened to reduce reciprocating loads and minimise cylinder case/crankshaft loadings.	Not interchangeable 90-92 parts
10. EGR system introduced.	93 - 95	Improve emissions.	New parts - cannot be fitted 90-92 engines.
11. Two-piece anti-reversion exhaust manifold and catalyts and head shields.	93 - 95	Minimise possibility of engine ingesting fragments from catalyst.	New parts - not interchangeable 90-92 parts.
12. Revised fuel rail/injectors.	93 - 95	Commonised fuel injectors.	Not interchangeable 90-92 parts.
13. 'Qualified' Duplex camshaft secondary chains.	93 - 95	To assure fatigue life of chains.	Should be used to back service 90-92.



MAJOR CHANGES TO LT5 - 91-95 MY

CHANGE	MODEL YEAR	REASON FOR CHANGE	IMPLICATIONS
14. Gaskets - harder material.	93 - 95	Reduce gasket relaxation and loss of fastener clamp loads - minimise oil leaks.	All Reinz 'soft' gaskets except throttle body/ to air intake changed to 'hard' material for 93 - 95. All gaskets can be back serviced except oil pan and front cover.
15. Revised 'Vee' drain.	93 - 95	Improve drainage from 'Vee' to reduce starter failures.	Service bulletin 92-307-6 issued to cover 90-92 engines.
16. Revised wiring harness.	93 - 95	To accommodate EGR, differential pressure switch, revised O ₂ sensors, etc.	Not interchangeable 90-92 parts.

Graham Behan was the engineer in charge for the 1993 model year upgrade program. Graham describes more details about the upgrades for the 405 HP engine.

'93 Model Year Changes:

From the
"ZR-1 Legend"
publication
March 1998

The strategy.

LT1 Exhaust system.

Improved Dunn
cylinder heads.

So the story continues. Following the resolution of the cam scuff problem and the resumption of production I took responsibility for the 1993 MY upgrade programme. The intended route for the performance upgrade had been to increase the lift and duration of the secondary cam profile. This had resulted in engines which met the power target, at higher peak rpm, but had reduced bottom end torque, something for which the LT5 had always been criticized. So I decided to follow a different route, the exhaust system back pressure was planned to drop 2" hg which would give us 6 bhp and we concluded that we could get the rest from detailed modifications to the engine. The planned changes were revised to include: matching the inlet system at the plenum-injector housing interface, the injector housing-head interface, re-profiling the ports, fitting a larger valve throat cutter, hand blending of the intersection of the machining, three-angle machining of the valve seat and inlet valve, two-angle machining of the exhaust valve and changing the exhaust cam timing, whilst retaining the current production camshafts. The machining and blending of the ports would not have been necessary if we had decided on this route from the start, but now it was too late for a tooling change to the production core boxes.

At this time we learned that the production source for cylinder heads, Birmal, would no longer be producing semi-permanent mould parts. So we now needed to re-source the heads. Birmal produced a large quantity of parts and the tooling was then moved to A. L. Dunn. Since the tooling required refurbishment, we could now take the opportunity to modify the port core boxes. The new heads would also incorporate the low pressure reservoir to eliminate tensioner rattle on start-up and a revised water jacket, basically limiting the water flow from between the inlet valves. The resultant heads had increased port flow over the machined, blended port of the Birmal parts. Due to the limited production in the 92-95 MY's, there were only about

It's Spring!

130 engines which were built using these heads.

There were several other changes scheduled for 1993. The parts affected were as follows:

- Valves (revised back angles)
- Seats (3-angle inlets and 2-angle exhausts)
- Heads (port-machining, hand-blending, increased throat diameter, and deletion of the exhaust stud)
- Revised cam timing (exhaust 114 degrees to 110)
- Injector housings (revised machining)
- Injectors (common shape and part changes for alcohol fuel resistance)
- Plenum (machining changes for EGR and port matching)
- Addition of EGR system components
- Crankshaft (reduced mass and revised balance)
- Rods (reduced mass)
- Piston pin (reduced mass)
- Piston (reduced mass and revised clip retention)
- TV damper (tune to accommodate internal mass and balance changes)
- New cylinder case (4 bolt mains)
- Valve retainers (extra fitted spring length)
- Exhaust manifold (two piece)
- Calibration (revised spark/fuel and port throttle strategy)
- Oil pan (revised windage tray and baffles)
- Oil pick up
- Oil pump
- Spark plugs (platinum)
- Oil (synthetic)
- V drain (increased diameter-angled hole)

From the above list you can see that the 93 MY change was a little more than a simple performance upgrade; it was a significant change to the engine systems and structure.

Many other component changes were originally scheduled but were weaned out of the programme for all kinds of reasons including cost, timing and technical considerations. Our first engines were running at 400 + bhp in late 1990; the revised specification engines were at 405 bhp by late February 1991. The 405 bhp was realized in GM Test 1 spec, which means with full vehicle inlet and exhaust

system, in GM Test 20 form, i.e. dyno headers and no inlet restriction, the 1993 MY engine produced 445 bhp with optimized spark and fuel (LBT/MBT).

Since Lotus had design, development and production support responsibility for the LT5, the team was split into three groups: current engineering, 1993 MY and 1995 MY. The 93 MY engines were now completing 400 hours plus of dyno testing at WOT on the GM Corporate durability test cycle without major failures, so the attention was focussed on the proposed 1995 MY upgrade. This was to include more significant changes and the performance targets were a torque increase and 475 bhp. In order to do this, we incorporated a Lotus-patented cam profile switching system which allowed us to have two discrete cam profiles, one for optimum torque and one for optimum power. This mechanism could be fitted in the space of the production hydraulic lifter and switched hydraulically at the crossover point in the torque curves. Engines were built to the high torque and the high power specifications and used as test mules for the 95 development. Two engine sets of the full spec engines had just arrived at Lotus when, following a meeting in Detroit, word came back that the 95 MY upgrade programme was cancelled and the LT5 would cease production at the end of 1995 MY.

This was a time for mixed emotions for the people who had given so much of their lives to this programme for the past few years and had developed such rapport with the other members of the LT5 family, both in the UK and in the USA. Many scenarios were conceived and proposed to keep the LT5 in production, some wilder than others, but at the end of the day we just carried on with the improvements we had scheduled for the remainder of the production life of the engine.



Subsequent to the publication of his article Graham added the knock sensor to the list. The structural changes to the cylinder block altered the fundamental frequency of the block. The knock control system was revised to match.

Noise Reduction

Beginning with the '92 GM service manual a section about noise reduction was provided.

The list of noise sources was increased each year. Most of the remedies were implemented by '94. The '95 cars received the most attention to noise. The '95 service manual documents about 67 noises that may occur in the ZR-1.

A few examples...

SECTION 10-1A

NOISE REDUCTION

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. Fasteners that are not reused, and those requiring thread-locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

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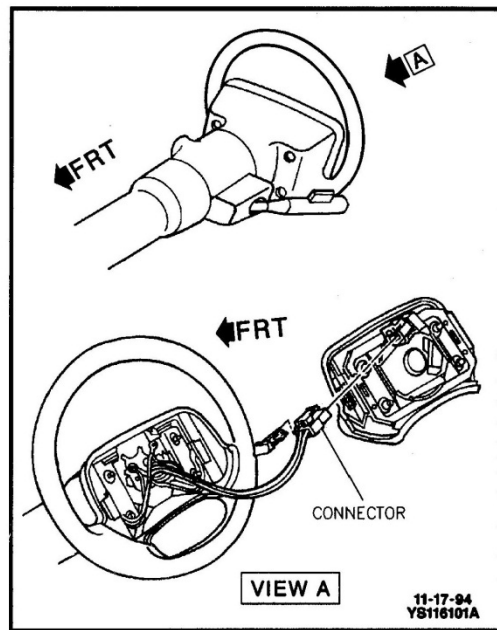


Figure 15 - Instrument Panel - Hood Latch

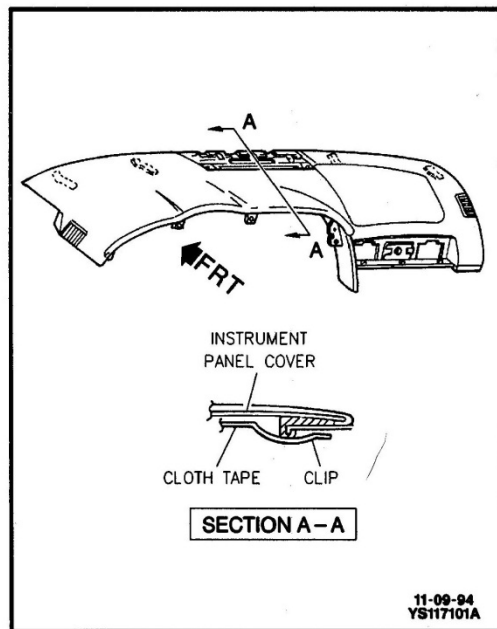


Figure 16 - Instrument Panel - Steering Wheel

SYMPTOM:

Buzz from steering wheel.

POSSIBLE CAUSE:

Air bag electrical connector and/or retainer vibrating against metal shield.

DIAGNOSIS:

Road test for buzz.

CORRECTIVE ACTION:

Remove air bag module and wrap assembled connector in foam tape.

See SECTION 9J for air bag module removal.

SYMPTOM:

Itch from instrument panel upper trim pad at windshield.

POSSIBLE CAUSE:

Trim pad retaining clips.

DIAGNOSIS:

Remove trim pad and check retaining clips for damaged or missing plastisol.

CORRECTIVE ACTION:

Install cloth tape completely around each trim pad retaining clip. Use caution not to bend clips.

See SECTION 8C for trim pad removal.

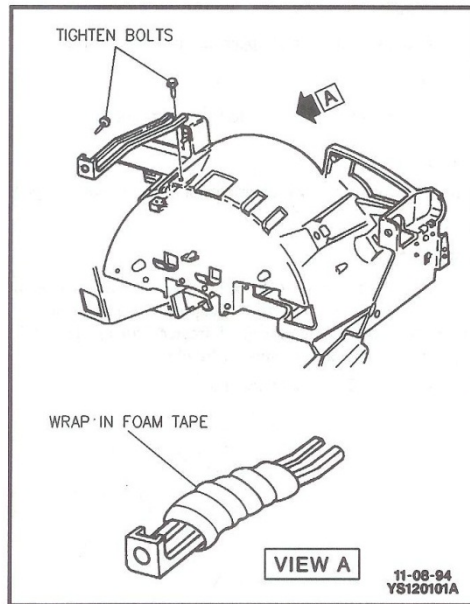


Figure 19 - Instrument Panel - Support Bracket

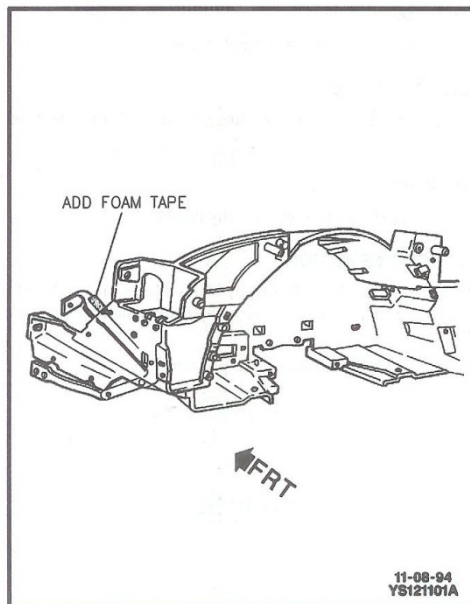


Figure 20 - Instrument Panel - Outer Knee Bolster Bracket

SYMPTOM:

Buzz or rattle at driver's side of instrument panel (I/P).

POSSIBLE CAUSE:

Loose instrument panel upper support bracket bolts and/or support bracket contacting upper trim pad or I/P.

DIAGNOSIS:

Remove I/P upper trim pad and visually inspect.

CORRECTIVE ACTION:

Tighten bolts. Wrap bracket in foam tape. See SECTION 8C for upper trim pad removal.

SYMPTOM:

Rattle at left side of instrument panel (I/P).

POSSIBLE CAUSE:

Driver's knee bolster outer bracket contacting HVAC air duct.

DIAGNOSIS:

Remove I/P upper trim pad and visually inspect.

CORRECTIVE ACTION:

Wrap knee bolster outer bracket with foam tape at area of contact.

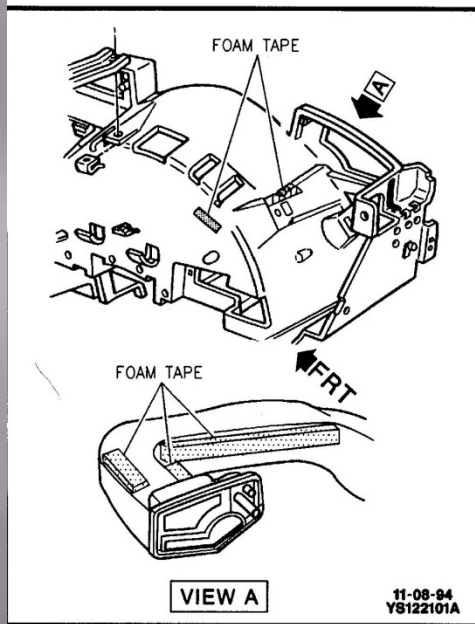


Figure 21 - Instrument Panel - Air Distribution Duct - LH

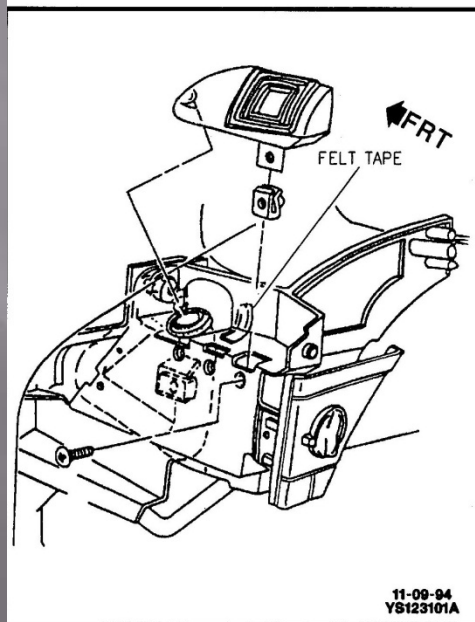


Figure 22 - Instrument Panel - Side Window Defogger Outlet

SYMPTOM:

Rattle at top of instrument panel near I/P cluster.

POSSIBLE CAUSE:

A/C air distribution rattling on top of instrument panel.

DIAGNOSIS:

Remove instrument panel upper trim pad and visually inspect.

CORRECTIVE ACTION:

Pull up on the air distribution duct and install a 1/8 inch thick foam tape insulator to the instrument panel and air duct in area of contact.

See SECTION 8C for upper trim pad removal.

SYMPTOM:

Buzz coming from left side of instrument panel.

POSSIBLE CAUSE:

Side window defogger duct outlet buzzing on instrument panel.

DIAGNOSIS:

Remove the side window defogger duct outlet grill and apply pressure to the duct outlet while test driving.

CORRECTIVE ACTION:

Remove instrument panel upper trim pad and side window defogger duct outlet. Install 1/2 inch by 3 inch section of felt tape to the instrument panel where shown.

See SECTION 8C for upper trim pad removal.

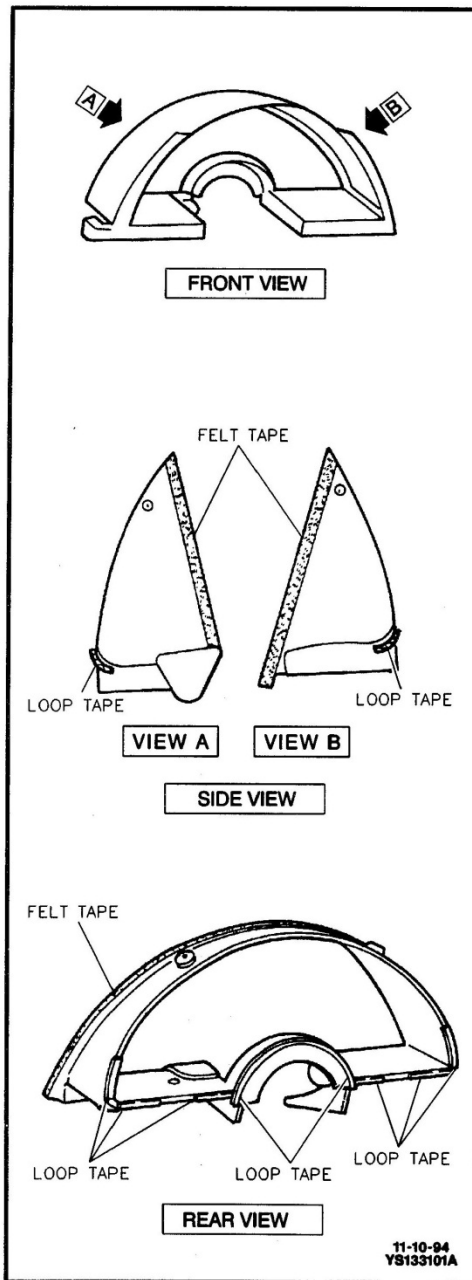
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Figure 31 - Instrument Panel - Cluster Trim Plate

SYMPTOM:

Squeak, rattle, buzz, itch from instrument panel (I/P) cluster

POSSIBLE CAUSE:

- Cluster trim plate contacting I/P.
- Cluster trim plate contacting cluster.
- Other possible causes with repair headings in quotes:
 - Cluster trim plate contacting "Headlamp switch."
 - Cluster trim plate contacting "Door Trim Panel at I/P."
 - "Cluster Lens" contacting I/P.

DIAGNOSIS:

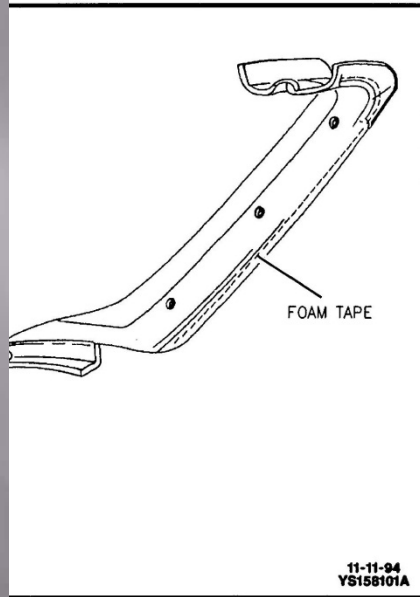
- Test drive. Apply pressure to trim plate. Listen for noise change.
- Visually inspect.

CORRECTIVE ACTION:

Remove cluster trim plate.

- Install loop portion of hook and loop tape in 50mm (2 in) long strips to rear of trim plate as shown in rear view.
- Install loop tape around steering column opening as shown in rear view.
- Install felt tape behind front upper edge of trim plate shown in side and rear views.
 - Install tape just up to the edge so that it does not show when trim plate is installed.

See SECTION 8C for trim plate removal.



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Figure 57 – Roof – A-Pillar Moldings

SYMPTOM:

Itch coming from A-pillar.

POSSIBLE CAUSE:

A-pillar garnish molding contacting A-pillar weatherstrip.

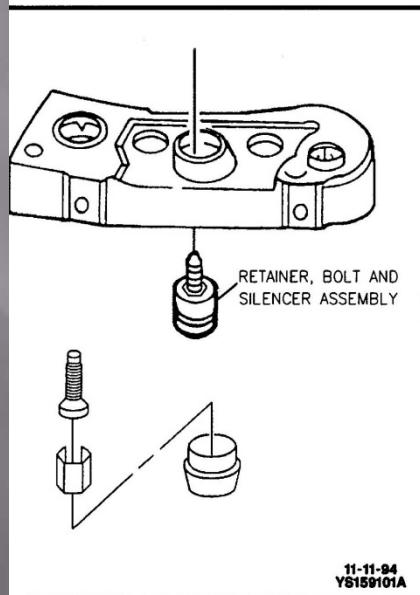
DIAGNOSIS:

Push on weatherstrip along outside edge of molding and listen for itch to change.

CORRECTIVE ACTION:

Remove garnish molding and install foam tape to inside of outer lip along entire length of molding.

See SECTION 10-2 for molding removal.



11-11-94
YS159101A

Figure 58 – Roof – Hold-Down Bolts

SYMPTOM:

Jingle coming from top corner of windshield with roof panel or convertible hardtop removed.

POSSIBLE CAUSE:

Front hold-down captive bolt loose in retainer.

DIAGNOSIS:

Test drive and touch bolt to verify.

CORRECTIVE ACTION:

Replace bolt, retainer, and silencer.

See SECTION 10-9A for bolt removal.