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COMMITTEE D02 ON PETROLEUM PRODUCTS, LIQUID FUELS, AND LUBRICANTS

Issued: 03.29.2017

Reply to: Dan Worcester
Southwest Research Institute
6220 Culebra Rd.
San Antonio, TX 78238
Phone: 210.522.2405
Email: dworcester@swri.org

These are the unapproved minutes of the 03.28.2017 Sequence VI Conference Call.

The meeting was called to order at 9:10 AM Central Time by Chair Greg Miranda.

Agenda

The Agenda is the included as Attachment 1.

1.0 Roll Call

The Attendance list is Attachment 2. There were no member changes.

2. Approval of Meeting minutes from 02.23.2017 Seq. VI SP meeting.

Approve the Surveillance Panel minutes.

2.1 Greg made the motion and Jason seconded.

2.2 The vote received unanimous approval.

3. Old Business and Update Item Review

3.1 Update VIF LTMS requirements document Rich Grundza

TMC has updated the LTMS for VIF with the March 2017 update.

3.2 Finalize VIF procedural document by way of leading Procedure Update Task Force

Dan Worcester

The VIF procedure has been reviewed by Adrian, Dan and Rich. It is now posted on the TMC web site:

ftp://ftp.astmtmc.cmu.edu/docs/gas/sequencevi/procedure_and_ils/VIF/

Motion 1: Recommend to the Surveillance Panel that the facilitator complete edits on the VIF procedure and move that document to the approval ballot.

Dan Worcester, Rich Grundza 2nd Result: 13-0-2 Motion Passes

3.3 Develop plan/Design for test matrix to introduce short block engine hardware

Adrian Alfonso/Stats Group

See Attachment 3. Fours labs will run the VIE matrix on the GM Kit engines as indicated in the table below. Tests should be run in the same stand at each lab used for the VIE Precision Matrix. There are 52 OHT-2 engines remaining so this matrix needs to start soon. Greg will need a time line on when the matrix will start and complete. IAR and SwRI can have a stand available.

Action #1: Labs will report stand availability to Greg for the Kit matrix.

Run Order	Engine/Lab 1	Engine/Lab 2	Engine/Lab 3	Engine/Lab 4
1	542-2	544	1010-1	542-2
2	544	1010-1	542-2	1010-1
3	544	542-2	544	1010-1
4	1010-1	542-2	544	544
5	542-2	544	1010-1	542-2

Motion 2: Adopt the VIE matrix as shown in Attachment 3, page 4.

Adrian Alphonso, Rich Grundza 2nd Result: 14-0-1 Motion Passes

3.4 Develop recommendation to TMC for the testing of reference oils for next three VIF engine in each lab, per motion made on 2/23/17 at SP meeting.
This is the motion from the Surveillance Panel Face to Face meeting on 02.23.2017:

Motion: Next three Seq. VIF engines at each lab will conduct a 5th run reference test with analysis to be completed after the 5th reference test is reported. TMC will not assign Seq. VIF reference oils for a new engine on the same stand until the 5th test is reported to the TMC on the prior engine, unless a documented reason is provided for not conducting that 5th run test. Stats group will provide guidance to TMC on selection of reference oil assignment.

Robert Stockwell, Second: Jim Linden Result: 13-0-0 Motion Passes

The goal is for the VIF tests to run in the same stands used for the matrix. The 4 labs for the matrix will need to be defined as IAR and SwRI ran the matrix with Lubrizol providing 4 additional runs.

Action #2: A Task Force will be needed for the Kit VIF matrix.

Motion 3: The VIF short block kit matrix will run in the same stands as were used for the VIF matrix work.

Andy Ritchie, Adrian Alphonso 2nd Result: 13-0-2 Motion Passes

3.5 Review & revise VIE calibration requirements stated in procedure to accurately reflect agreements and understandings Rich Grundza
An Information Letter was generated to clarify that there would be 3 full length tests after the reference run.

3.6 Survey labs to gather status of currently calibrated VIE stands/engines in support of the introduction of BL5 Rich Grundza
BL-5 runs will need to be in calibrated stands. It runs compared to BL-2 and would then be approved for use. Rich will send a spread sheet with the run order.

3.7 Review VIF section to Seq. VI SP scope and objectives Greg Miranda
The VIF is part of the scope and objectives.

4. New Business

4.1 Review proposal for establishing Sequence VID-VIF equivalency
Satoshi Hirano, Toyota

See Attachment 4. This has comparison data to consider VID pass limits for 0W-16 oils run in the VIF test. The VID test is no longer available. Oil 543 has been run on both test types. See page 4 for comparison data. There are proposed pass limits on page 5. Andy

Ritchie offered to support the effort with 3 tests. This would take 3-4 months but give data on more than just oil 543. The two San Antonio labs would need to get calibrated VIF stands. CLOG would need to be involved in approval and give a recommendation to the Surveillance Panel. There will be further discussion at the next AOAP meeting in April. Labs would need to provide feedback on available stands.

4.2 Seq. VIE/VIF Procedure Revision Proposal: Oil Circulation Pump Update
Katerina Pecinovsky
Gould circulation pump G4125 is no longer available. The direct fit replacement is G4124A.

Motion 4: Update the Sequence VIE and VIF procedures, VIE section 6.6.5.2, to allow for the use of Viking Model #G4124A – a direct replacement for #G4125 which is no longer manufactured. This is a drop in replacement and no modifications should be required.

Katerina Pecinovsky, Dan Worcester 2nd Result: 10-0-4 Motion Passes

4.3 Continued discussion regarding observed Sequence VIE severity shift, post Precision Matrix Sequence VI SP
The industry control charts are in control for FEI 1 but 0.923 severe for FEI 2. The last 5 tests run have all passed on 3 oils – 2 on 1010-1, 2 on 542-2, and 1 on 544. The Stats Group is reviewing the data. Greg recommends we follow the work but take no further action at this time. Labs are donating a 5th test on each calibrated stand that would provide additional data and give the potential to get 5 runs per engine. IAR has completing their donated tests and SwRI has the last one running now.

Action #3: The GM Kit Build package is included as Attachment 5.

5.0 Next Meeting.

5.1 The next meeting will be a conference call in one month. Greg will send an agenda.

The meetings adjourned at 10:46 AM.

Sequence VI Surveillance Panel Conference Call Agenda
March 28, 2017 @ 10:00-11:30 EST

Audio Connection

Call-in Number: +1-415-655-0001
Conference Code: 198 775 940

Webex Meeting URL:
https://meetings.webex.com/collabs/#/meetings/detail?uuid=M7FEO11QEKX9E7P63CRKZC1M7M-20XT&rnd=97867.767001

1. **Roll Call (start 10:05 EST)**

   1.1. SP Membership changes and additions

2. **Approval of Meeting minutes from February 23, 2017 Seq. VI SP meeting**

3. **Action Item Review**

3.1	Update VIF LTMS requirements document	Rich Grundza
3.2	Finalize VIF procedural document by way of leading Procedure Update Task Force	Dan Worcester
3.3	Develop plan/Design for test matrix to introduce short block engine hardware	Adrian Alfonso/ Stats Group
3.4	Develop recommendation to TMC for the testing of reference oils for next three VIF engine in each lab, per motion made on 2/23/17 at SP meeting	Stats Group
3.5	Review & revise VIE calibration requirements stated in procedure to accurately reflect agreements and understandings	Rich Grundza
3.6	Survey labs to gather status of currently calibrated VIE stands/engines in support of the introduction of BL5	Rich Grundza
3.7	Review VIF section to Seq. VI SP scope and objectives	Greg Miranda

4. **New Business**

   4.1. Review proposal for establishing Sequence VID-VIF equivalency – Satoshi Hirano, Toyota

   4.2. Seq. VIE/VIF Procedure Revision Proposal: Oil Circulation Pump Update – Katerina Pecinovsky

4.3. Continued discussion regarding observed Sequence VIE severity shift, post Precision Matrix
– Sequence VI SP

5. Next Meeting

5.1. TBD

6. Meeting Adjourned

ASTM SEQUENCE VI

Name	Email/Phone	Company	Attend
Adrian Alfonso **Voting Member**	Phone: (210) 838-0431 Adrian.Alfonso@intertek.com	Intertek	**ATTEND**
Jason Bowden **Voting Member**	Phone: (440) 354-7007 jhbowden@ohtech.com	OHT	**ATTEND**
Amol Savant **Voting Member**	acsavant@valvoline.com	Valvoline	**ATTEND**
Tim Cushing **Voting Member**	Phone: (248) 881-3518 Timothy.Cushing@gm.com	General Motors	**ATTEND**
Rich Grundza **Voting Member**	Phone: (412) 365-1034 reg@astmtmc.cmu.edu	TMC	**ATTEND**
Jeff Hsu **Voting Member**	Phone: (832) 419-3482 j.hsu@shell.com	Shell	**ATTEND**
Teri Kowalski **Voting Member**	Phone: (734) 995-4032 Teri.Kowalski@tema.toyota.com	Toyota	**ATTEND**
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Katerina Pecinovsky **Voting Member**	Phone: Katerina.Pecinovsky@AftonChemical.com	Afton	**ATTEND**
Brianne Pentz **Voting Member**	Phone: Brianne.Pentz@bp.com	BP	**ATTEND**
Andy Ritchie **Voting Member**	Phone: (908) 474-2097 Andrew.Ritchie@infineum.com	Infineum	**ATTEND**
Ron Romano **Voting Member**	Phone: (313) 845-4068 rromano@ford.com	Ford	
Clifford Salvesen **Voting Member**	Phone: (856) 224-2954 Clifford.r.Salvesen@exxonmobil.com	ExxonMobil	**ATTEND**
Kaustav Sinha **Voting Member**	Phone: (713) 432-6642 LFNQ@chevron.com	Chevron Oronite	
Haiying Tang **Voting Member**	Phone: (248) 512-0593 HT146@Chrysler.com	Chrysler	
Dan Worcester **Voting Member**	Phone: (210) 522-2405 Dan.Worcester@swri.org	SwRI	**ATTEND**

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Tom Smith		Valvoline	
Hap Thompson	Hapjthom@aol.com	VIx Facilitator	ATTEND
Chris Taylor	Chris.Taylor@vpracingfuels.com	VP Racing Fuels	

ASTM SEQUENCE VI

Name	Email/Phone	Company	Attend

MOTION:	VIF PROCEDURE	VIE MATRIX	VIF MATRIX	PUMP
Adrian Alfonso **Voting Member**	APPROVE	APPROVE	APPROVE	APPROVE
Jason Bowden **Voting Member**	APPROVE	APPROVE	WAIVE	APPROVE
Amol Savant **Voting Member**	APPROVE	APPROVE	APPROVE	WAIVE
Tim Cushing **Voting Member**	APPROVE	APPROVE	APPROVE	APPROVE
Rich Grundza **Voting Member**	APPROVE	APPROVE	APPROVE	WAIVE
Jeff Hsu **Voting Member**	APPROVE	APPROVE	APPROVE	
Teri Kowalski **Voting Member**	APPROVE	APPROVE	APPROVE	APPROVE
Dan Lanctot **Voting Member**	WAIVE	WAIVE	WAIVE	WAIVE
Greg Miranda **Voting Member**	APPROVE	APPROVE	APPROVE	APPROVE
Katerina Pecinovsky **Voting Member**	APPROVE	APPROVE	APPROVE	APPROVE
Brianne Pentz **Voting Member**	WAIVE	APPROVE	APPROVE	WAIVE
Andy Ritchie **Voting Member**	APPROVE	APPROVE	APPROVE	APPROVE
Ron Romano **Voting Member**				
Clifford Salvesen **Voting Member**	APPROVE	APPROVE	APPROVE	APPROVE
Jo Martinez **Voting Member**	APPROVE	APPROVE	APPROVE	APPROVE
Haiying Tang **Voting Member**				
Dan Worcester **Voting Member**	APPROVE	APPROVE	APPROVE	APPROVE
VOTES	13 Y, 2 WAIVE	14 Y, 1 WAIVE	13 Y, 2 WAIVE	10 Y, 4 WAIVE

VIE/VIF ENGINE SHORT BLOCK PROVE-OUT MATRIX

Statistics Group

March 7, 2017

Statistics Group

- Arthur Andrews, ExxonMobil
- Doyle Boese, Infineum
- Jo Martinez, Chevron Oronite
- Kevin O'Malley, Lubrizol
- Martin Chadwick, Intertek
- Richard Grundza, TMC
- Lisa Dingwell, Afton
- Todd Dvorak, Afton
- Travis Kostan, SwRI

Task Force Request

The availability of current OEM built VIE/F engines is expected to be depleted by 3Q2017. The Task Force for introducing the new lab built engines is requesting the stats group to provide input on the best manner to introduce the new lab built engines to the system by May 31st, 2017. Please consider the questions below when providing your recommendations.

- Can the lab built engines be introduced through the normal referencing system?

  If lab built engines are introduced through the normal referencing system there will be no data to determine if the engine hour adjustment has changed for the new engines as references are conducted on the first run only in most cases. If the SP believes the new engines may exhibit a different engine hour adjustment a matrix of tests across the life of the engines is required.

- How should the VIE and VIF be incorporated into the introduction?

  A decision about the VIF should be made after VIE data is available.

- Do we need to reevaluate the engine hour adjustment?

  This cannot be answered without producing the data to determine if a significant difference is present. If there is a belief in the SP that it could change based on the technical understanding of the process then data should be produced to evaluate the difference.

If a matrix or donated tests are determined to be necessary we expect four labs with one stand in each to be available.

VIE Matrix Design

Objectives:

1. Address the introduction of new engines
2. Confirm oil discrimination and appropriateness of engine hour adjustment
3. Address uniform reference oil selection for each row

Run Order	Engine/Lab 1	Engine/Lab 2	Engine/Lab 3	Engine/Lab 4
1	542-2	544	1010-1	542-2
2	544	1010-1	542-2	1010-1
3	544	542-2	544	1010-1
4	1010-1	542-2	544	544
5	542-2	544	1010-1	542-2

Notes:

1: Consider using only stands from the VIE precision matrix.

2: Determine VIF design depending on VIE matrix results.

3: If this matrix proves the test is different additional data may be required.

TOYOTA

Proposal of Sequence VID-VIF Equivalency

Presented to Sequence VI Surveillance Panel

March 28th, 2017

TOYOTA MOTOR CORPORATION

Background

TOYOTA

- API EOLCS has invoked Provisional License due to the unavailability of Sequence VID Test.
  - SAE 0W-16 was added into the API SN/RC category relatively recently, and this may cause difficulties for the industry to provide the support data to apply the provisional license.
- The industry still needs to wait for a while until ILSAC GF-6 becomes available.
- Toyota decided to propose the equivalency between the Sequence VID and the VIF for the SAE 0W-16 to minimize the impact on the market.

Methodology

TOYOTA

- Data for the Equivalency Analysis
  - TMC543 data set is available for both Sequence VID and VIF
    - Seq VID Data ： Data utilized to establish the criteria for API SN/RC
    - Seq VIF Data ： Precision Matrix Data

- Equivalency Analysis
  - Analysis 1 ： Criteria based on Passing Probability
  - Analysis 2 ： Criteria calculated by VID/VIF ratio

Data Set for Analysis

TOYOTA

Sequence VID (Oil 400)[1]

From Toyota presentation to JAMA, ILSAC, & AOAP (July 7, 2015)

Lab	Hrs	FEI1	FEI2	FEI Sum
X	1293	1.03	1.26	2.29
X	1948	1.52	1.55	3.07
Y	1273	1.5	1.55	3.05
Y	2846	1.74	1.72	3.46
Mean		*1.45*	*1.52*	*2.97*
Std Dev		*0.30*	*0.19*	*0.49*

Oil 400 became TMC543

Sequence VIF (TMC543)[2]

From Sequence VIF Precision Matrix

Lab	Hrs	FEI1	FEI2	FEI Sum
A	369	1.62	2.23	3.85
G	621	1.56	1.64	3.2
G	820	1.73	1.78	3.51
A	995	1.88	2.35	4.23
G	544	2.02	2.3	4.32
A	972	1.67	2.23	3.9
B	646	2.34	2.6	4.94
Mean		*1.83*	*2.16*	*3.99*
Std Dev		*0.27*	*0.34*	*0.57*

[1] Engine hour adjustment for the Sequence VID is applied.

[2] The TMC543 VIF results are calculated using the n=18 matrix engine hour adjustment agreed to by the Sequence VI Surveillance Panel.

Analysis 1

TOYOTA

- Equal Probability of Passing
  - The limits in the VIF yields the same probability of pass for TMC543 in the VIF as the probability of Pass for Oil 400 in the VID.
  - The normal distribution is assumed for the test results.

		FEI2	FEI Sum
VID	*Current SN/RC limit*	*≥1.3*	*≥2.8*
VIF	Limits to allow TMC543 to pass the VIF equal to Oil 400 passing the VID	1.77	3.79
	Proposed limit for 0W-16 SN/RC	**≥1.8**	**≥3.8**

Analysis 2

TOYOTA

- Limit based on TMC543 / Oil 400 Ratio
  - The ratio between the VIF(TMC543 mean) and the VID(Oil 400 mean) is applied as an equivalency calculation factor.
    - VIF (TMC543) / VID (Oil 400) Ratios:
      - FEI2 : 2.16% / 1.52% = 1.42
      - FEI Sum : 3.99% / 2.97% = 1.34
    - Equivalent VIF Limit = VID Limit x VIF/VID Ratio
      - FEI2 : 1.3 x 1.42 = 1.85
      - FEI Sum : 2.8 x 1.34 = 3.75

		FEI2	FEI Sum
VID	*Current SN/RC limit*	*≥1.3*	*≥2.8*
VIF	Equivalent Limit	1.85	3.75
	Proposed limit for 0W-16 SN/RC	**≥1.8**	**≥3.8**

Summary

TOYOTA

- The VID(Oil 400) data and the VIF(TMC543) data were analyzed.
  - 2 types of analysis were conducted.
  - 2 analysis results agreed well each other.

- Toyota would like to propose following are the equivalent criteria of the VIF for API SN/RC 0W-16.

Analysis Type	Min FEI2	Min FEI Sum
SN/RC VID Limits	*1.3*	*2.8*
Probability	1.77 (1.8)	3.79 (3.8)
Ratio	1.85 (1.8)	3.75 (3.8)
Proposal of VIF Limits	***1.8***	***3.8***

Sequence VIE/F GM Kit Assembly Manual

NOTE: Follow cleaning procedure for short block and heads prior to final assembly. A Parts List is Attachment A.

The cleaning procedure applies to the following components of the KIT:

Quantity	Part Number	Description
1	12641093	HEAD ASM-CYL (W/ VLV)(LH,LY7)
1	12635560	HEAD ASM-CYL (W/ VLV)(RH, LY7)
1	19206165	BLOCK, SHORT HFV6

The parts listed above will be received with a CPC applied by the OEM to prevent corrosion of the parts. The CPC shall be removed from the parts prior to assembly of the engine. Once the parts have been cleaned it is recommended to assemble the engine and store in humidity and temperature controlled environment until is needed for installation on a stand. The engine shall not be assembled if rust is present.

Procedure:

Cleaning procedure for the Head assemblies (PNs: 12641093, 12635560):

1. Remove parts from package.

2. Spray parts with degreasing solvent, allow the parts to soak for 15-30 minutes covered with solvent and repeat spray with degreasing solvent as needed. Use a bristle brush as needed to assist in removing coating. Repeat this process as necessary until an optimum amount of CPC is removed from the parts. Two iterations of the process have been found to be sufficient.

3. Spray parts with 50/50 degreasing solvent and EF411 followed by air dry using clean dry compressed shop air to remove excess 50/50.

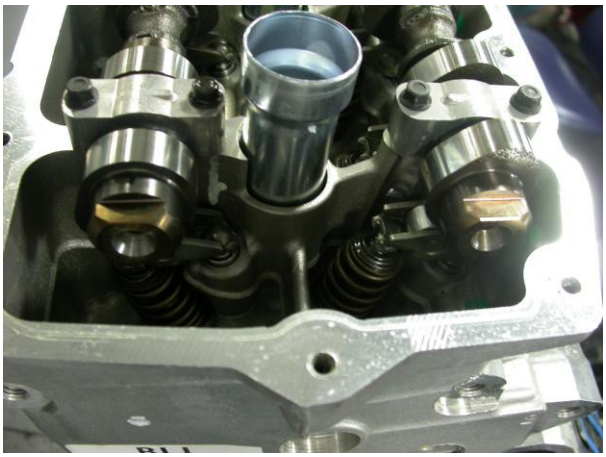
Cleaning procedure for the short block (PN: 19206165):

1. Remove parts from package

2. Position the block such that the cylinder bores are facing downwards. Positioning the short block will reduce the potential for dissolved CPC penetrating the short block.

Cylinder Head Installation/Camshaft Positioning

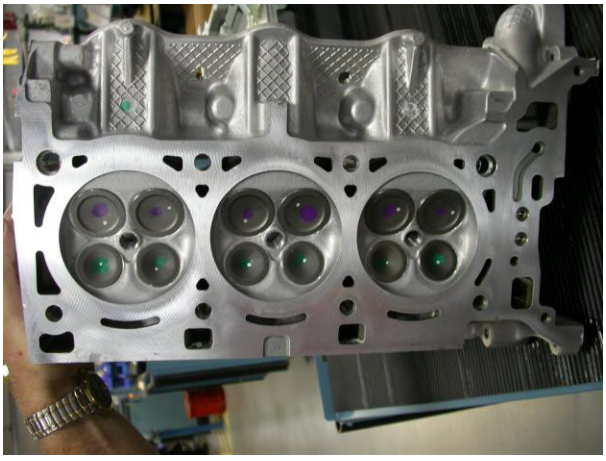
Important: This engine is NOT free a free spin engine. The camshafts must be properly positioned in the cylinder heads prior to installation. Using a large open end wrench on the hex cast into the camshaft behind the number one journal, position the camshafts so the flat on the back of each camshaft is parallel to the gasket seating surface for the cylinder head rocker cover.



Insure all four camshafts are positioned with flats parallel to rocker cover sealing surface.

WARNING: DO NOT USE THE CAM GEAR TO POSITION CAMS AS THE VALVE SPRING PRESSURE MAY CAUSE THE CAM TO ROTATE AFTER POSITIONING AND THE LEADING EDGES OF THE CAM GEARS ARE VERY SHARP.

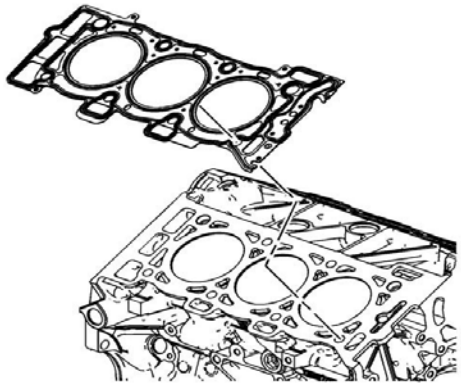
AS AN ADDED MEASURE OF PROTECTION, ROTATE THE CRANKSHAFT SO THERE ARE NO PISTONS AT TDC DURING CYLINDER HEAD INSTALLATION.



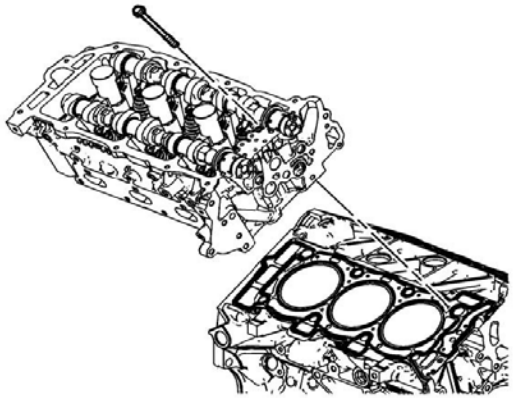
By position the flats parallel, you assure the cam lobes are all on a portion of the base circle and the engine will thereby be a free spin so you can rotate the crankshaft without the pistons hitting the valves.

Cylinder Head Installation-Right Side

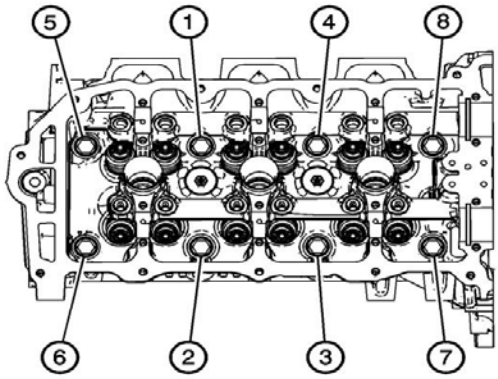
1) Clean the mating surfaces of the engine block, cylinder head and fastener bosses.
   Important: DO NOT allow oil on the cylinder head bolt bosses.
2) Insert dowel pin PN 12570326 in left and right side of block to align gaskets.
3) Install an NEW right cylinder head gasket using the deck face locating pins for retention.



4) Place the right cylinder head in position on the deck face.



5) Install new M11 cylinder head bolts. Tighten the first pass in sequence to 45 N·m. Tighten the second pass in sequence an additional 120º. For the bolt at the front, use 15 N·m and 60º.

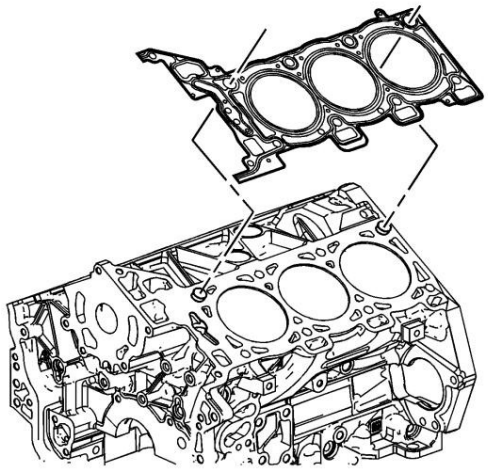


Cylinder Head Installation
Left Side

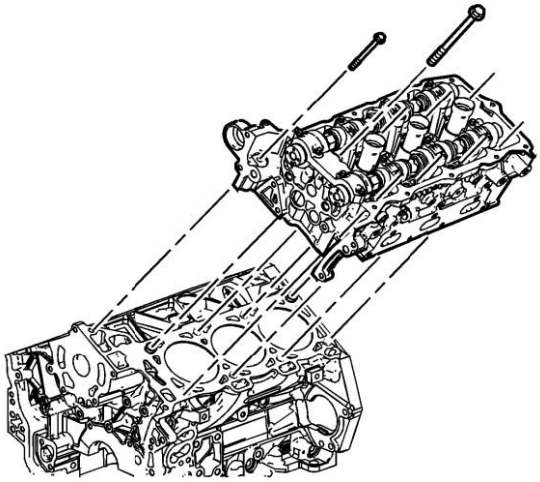
1) Clean the mating surfaces of the engine block deck, cylinder head and fastener bosses and inspect for imperfections.

Important: DO NOT allow oil on the cylinder head bolt bosses. Ensure all solvent from initial cleaning has been removed.

2) Install a NEW left cylinder head gasket using the deck face locating pins for retention.



3) Place the left cylinder head in position on the deck face.

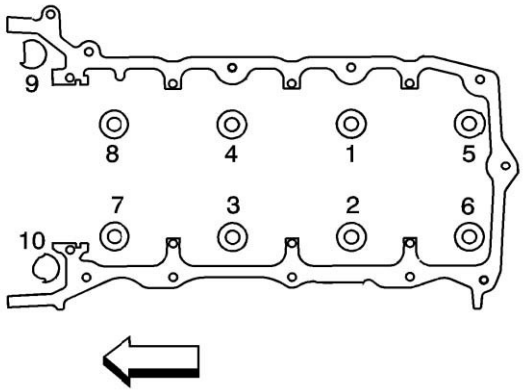


4) Install new M11 cylinder head bolts.

Tighten

4.1) Tighten the M11 cylinder head bolts (1 – 8) a first pass in sequence to 45 N·m.

4.2) Tighten the M11 cylinder head bolts a second pass in sequence an additional 120 degrees.



5) Install the 2 front M8 left cylinder head bolts.

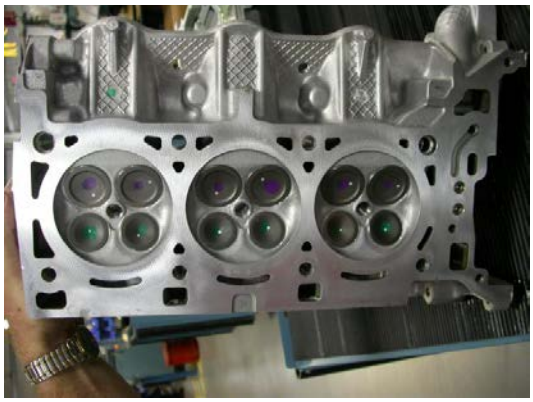
Tighten

5.1) Tighten the M8 cylinder head bolts a first pass to 15 N·m (11 lb ft).

5.2) Tighten the M8 cylinder head bolts a second pass in sequence an additional 60 degrees.

Timing Chain Installation Insure all four camshafts are positioned with flats parallel to rocker cover sealing surface.

By positioning flats parallel, you assure the cam lobes are all on a portion of the base circle and the engine will thereby be a free spin so you can rotate the crankshaft without the pistons hitting the valves.



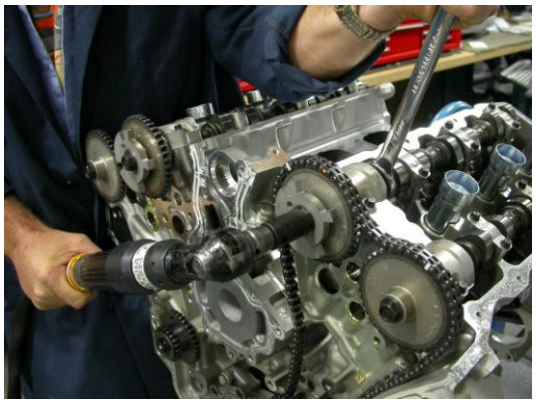
Install all four camshaft sprockets, i.e., intakes on the inside cams and exhausts on the outboard camshafts.

Left Intake

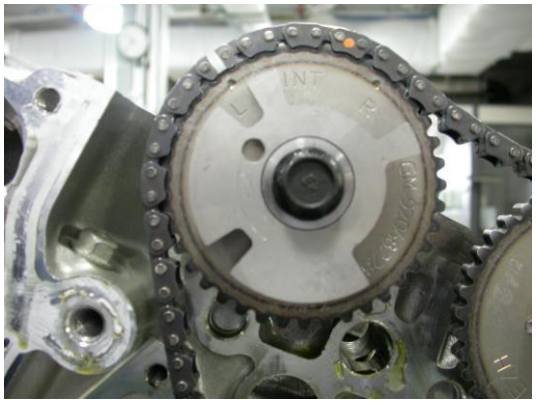
Left Exhaust

Right Intake

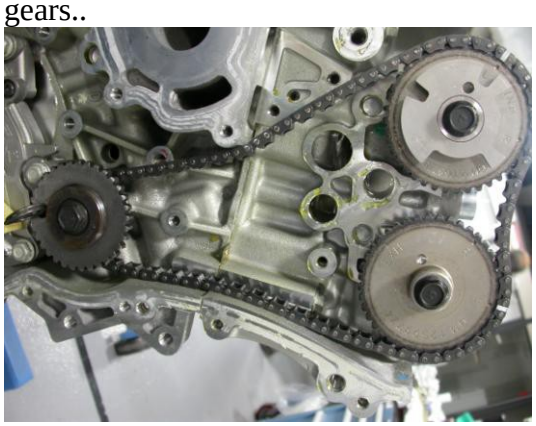
Right Exhaust



After installation you can torque all four fasteners to 58 +/- 7Nm. Holding camshafts on hex with open end wrench. Note: left side chain assembly was installed before photo taken.



Install left chain assembly with left side idler gear (do not remove grenade pin), aligning white marks on chain with dots or slots on cam gears identified as “L” Intake and “L” Exhaust on camshaft gears..



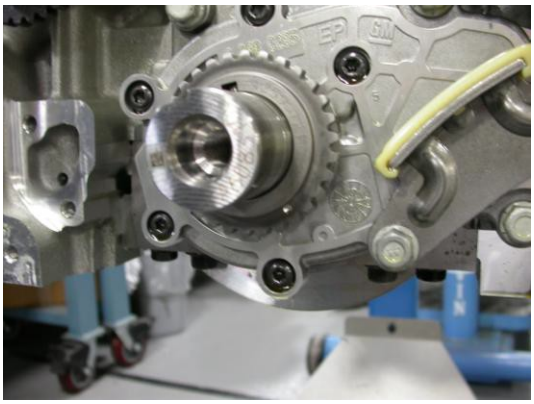
View of left side chain assembly with grenade pin in idler gear.

Left side idler w/grenade pin, 58 +/- 7Nm.

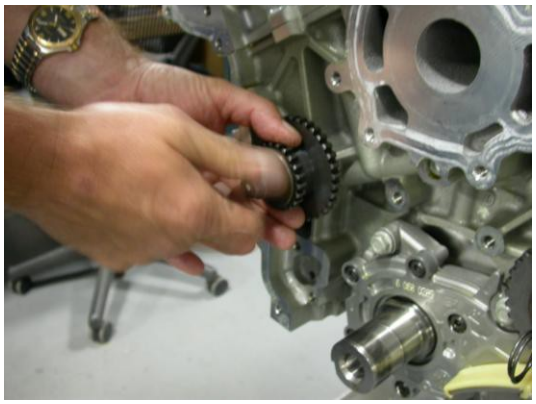
Install left side chain guides.

Install left side tensioner and gasket

Torque tensioner and chain guide fasteners to 23 +/- 3Nm.



View showing left side alignment dots.



Install right side idler gear and torque to 58 +/- 7Nm.

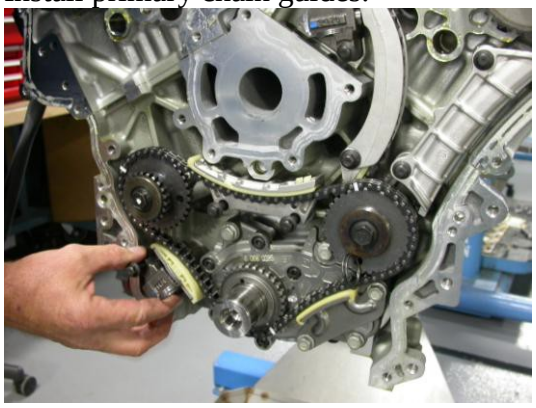
Make sure left side idler gear still has grenade pin holding chain assembly in proper position.

Install crankshaft gear and align dot for left side chain alignment. (Phase 1) alignment step in earlier write up.

Install primary chain assembly over left, right idlers and crankshaft gears with white identification marks aligned with marks on all three gears.

View of primary chain installed.

Install primary chain guides.

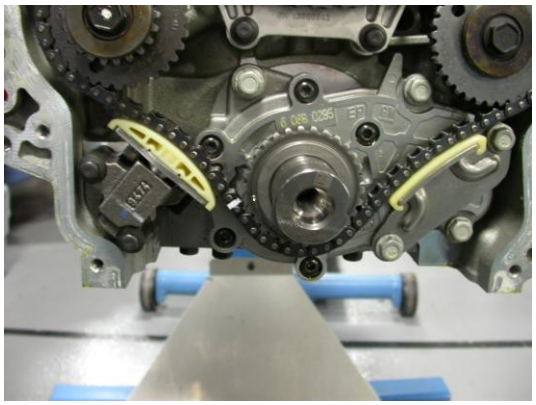


Install primary chain tensioner and gasket. Install tensioner bolt with bushing. Torque tensioner and guide fasteners to 23 +/- 3Nm.

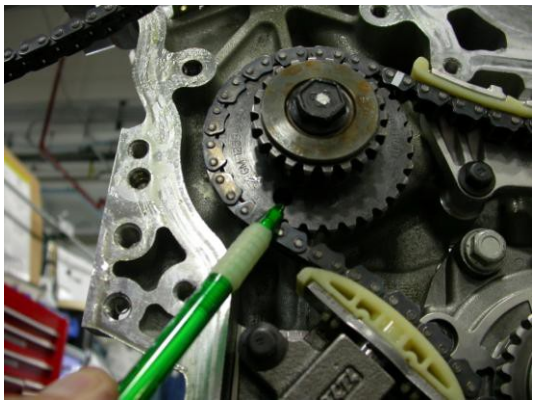
Right side idler gear.

Remove grenade pins from left side idler and tensioners for left side and primary chains.

Rotate crankshaft to right side alignment marks. (Phase 2 alignment).

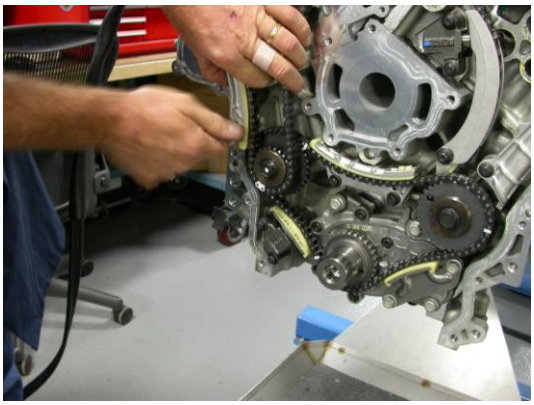


Note white mark on crankshaft gear and alignment mark on oil pump housing.



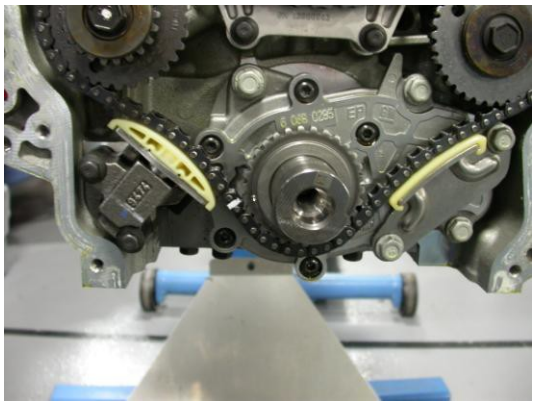
At this point, note hole in right side idler gear as noted by ink pin.

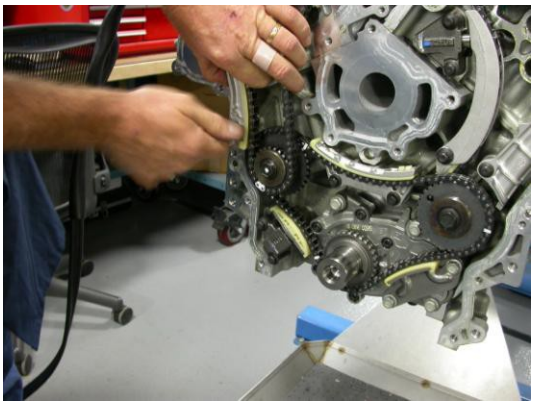
Align right side chain over idler with white link positioned at hole in right side idler and white marks positioned on cam gears at “R” Exhaust and “R” Intake.



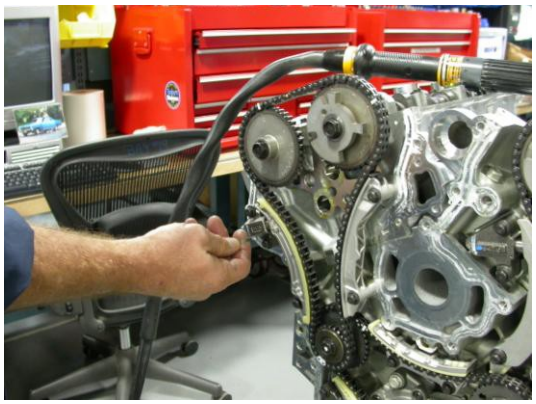
Holding chain together, install chain guides and tensioner. Note, the right bank is the hardest chain to keep tension on during the assembly process.

Torque tensioner and chain guides to 23 +/- 3Nm.

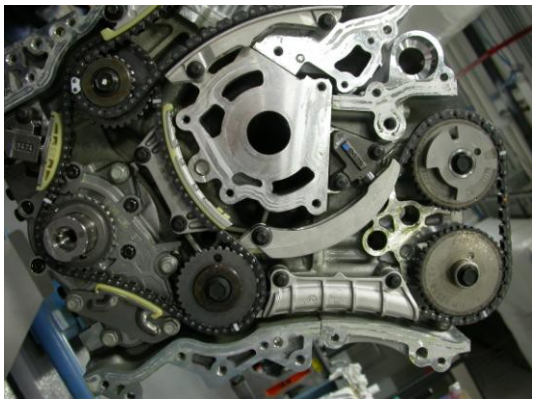




Check alignment on all four cam gears, primary chain idlers, and crank gear.



Remove grenade pin from right side chain tensioner.

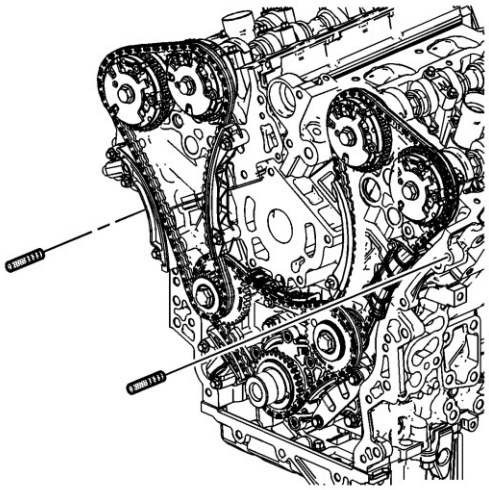


Rotate crankshaft clockwise two full rotations to confirm cam and crank marks are in correct alignment. Make sure chain assemblies do not jump on gears.

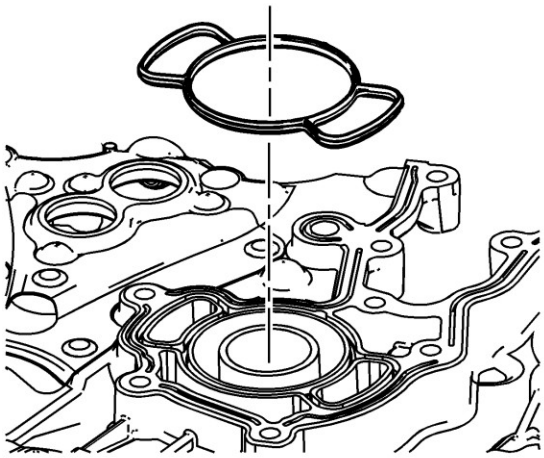
If everything looks good, you have successfully installed the chain assembly.

Front Cover Installation

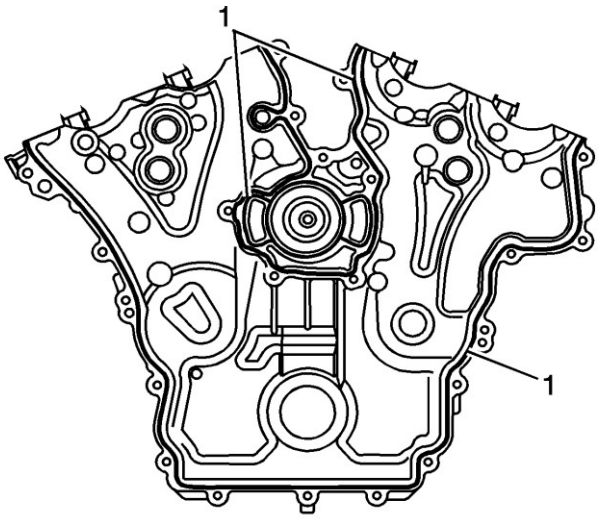
1) Install 8 mm (0.315 in) guide pins into the front cover positions at locations shown.



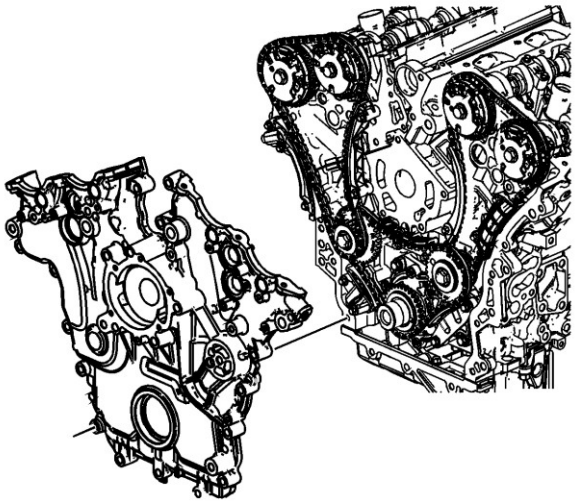
2) Inspect and/or install a NEW engine front cover to cylinder block seal if necessary.



3) Place a 3 mm bead of RTV sealant, GM P/N 12378521 on the engine front cover as shown (1).

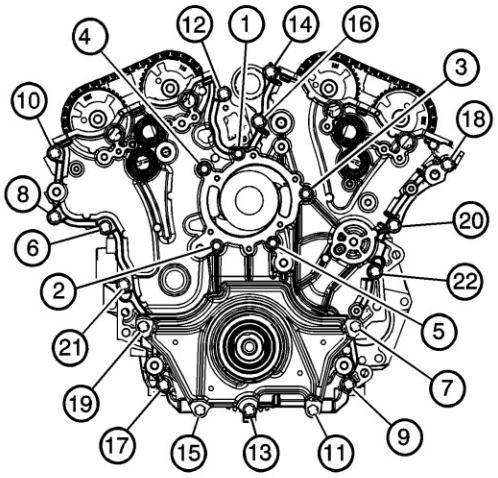


4) Place the engine front cover onto the guide pins and slide into position.



5) Loosely install the front cover bolts and install the engine front cover sound deadener.

6) Tighten the engine front cover bolts in the sequence shown (1-22).

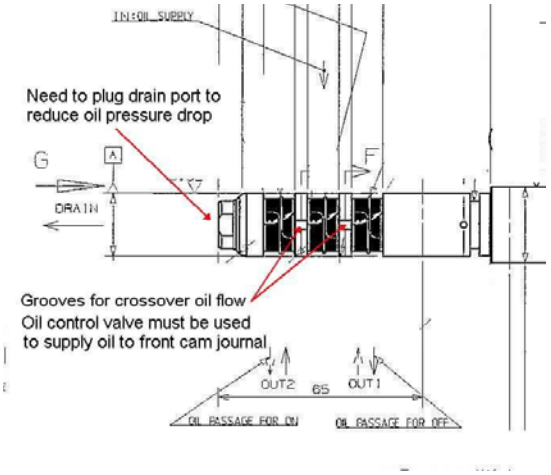


Tighten

Tighten the engine front cover bolts a first pass in sequence to 30-35 N·m

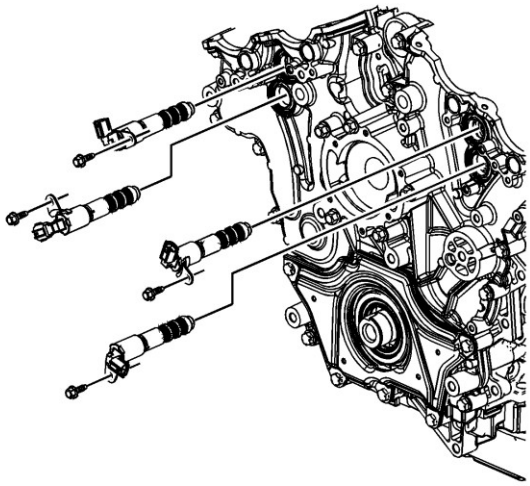
Tighten oil pan bolts [11, 13, 15] to 15-20 N·m.

VERY IMPORTANT!



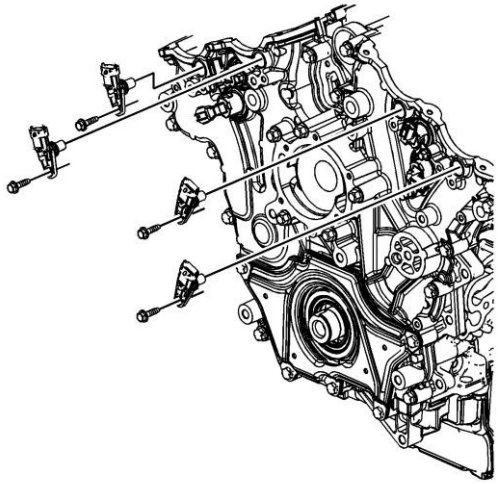
For Sequence VID test operation, the camshaft phaser oil control valves must be in place to provide lubrication to the front camshaft journals. The control valve drain ports must be welded closed to reduce excessive oil hemorrhaging through the control valves during engine operation as the valves are positioned in a manner that allows complete drainage through the spool valves.

7) Place the camshaft position actuator valves in position on the front cover.



Tighten
Tighten the camshaft position actuator valve bolts to 10 N·m

8) Place the camshaft position sensors in position on the front cover.



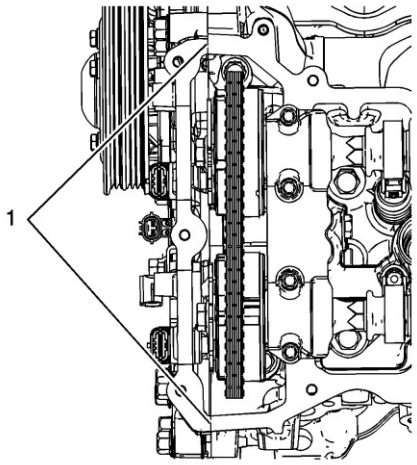
Tighten
Tighten the camshaft position sensor bolts to 10 N·m

Camshaft Cover Installation

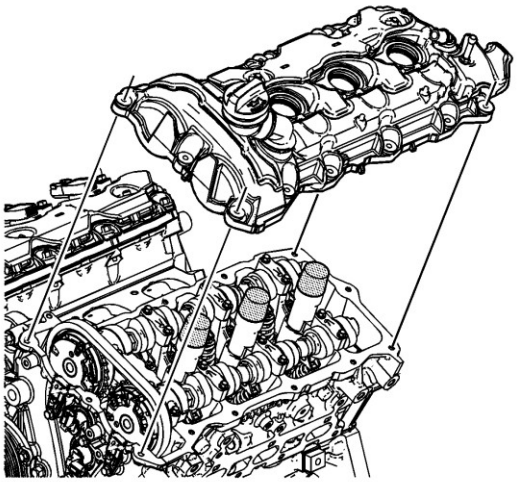
1) Wipe the camshaft cover sealing surface on the left cylinder head with a clean, lint-free cloth.

Place a bead 8 mm in diameter by 4 mm in height of RTV sealant,
GM P/N 12378521 or equivalent, on the engine front cover split lines (1).

2)

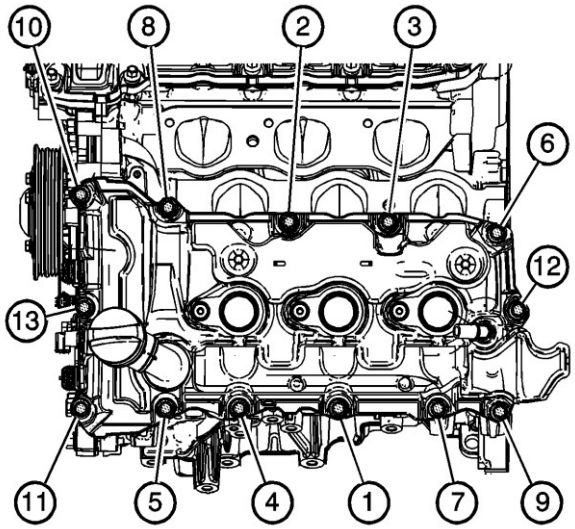


Place the left camshaft cover into position onto the left cylinder head.



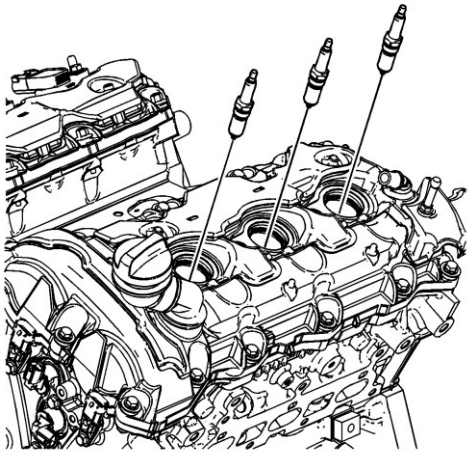
3) Tighten the left camshaft cover bolts in the sequence shown.

Tighten
Tighten the left camshaft cover bolts in the sequence to 10 N·m

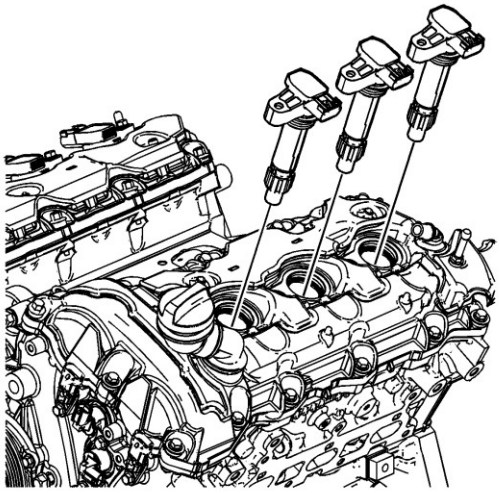


4) Install the NEW spark plugs into the left cylinder head. PN OHT6D-043-1.

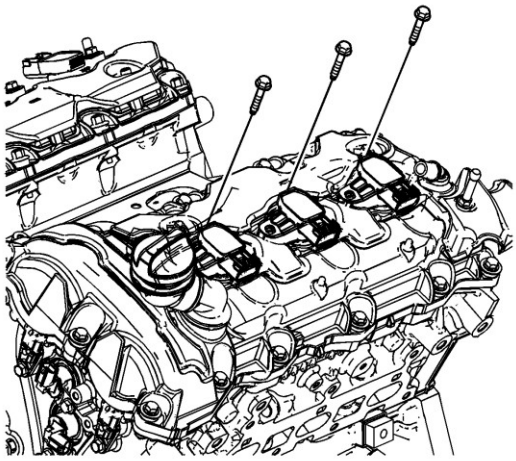
Tighten
Tighten the spark plugs to 20 N·m
5)



Install the ignition coils.



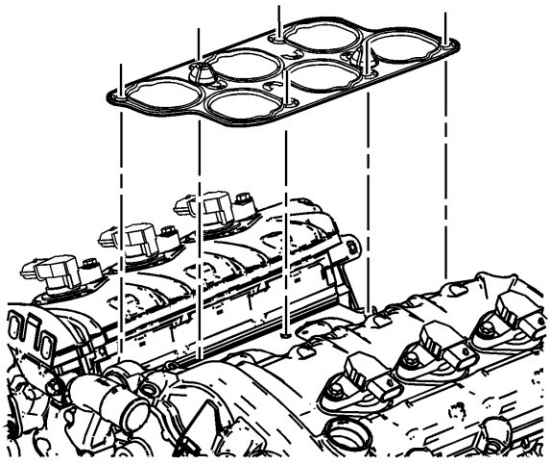
6) **Tighten**
Tighten the ignition coil bolts to 10 N·m



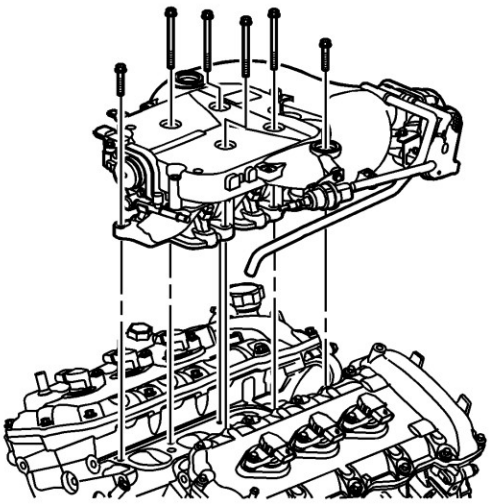
Repeat the same procedure for the right side camshaft cover

Intake Manifold Installation

1) Install the NEW intake manifold gasket and the lower intake manifold from the VID. Torque to 23 N·m



2) Install the VID intake manifold assembly



Important: Tighten the intake manifold bolts in a circular pattern starting from the center and moving outward

Tighten
Tighten the intake manifold bolts to 23 N·m

3)

4) Attachment 1

GM Build Kit Parts

Qty	Part No.	Description
1	12650231	Timing Chain Kit
1	12646464	Gasket Kit
1	12645465	SPROCKET-CR/SHF
1	12645465	Sprocket
1	12641093	HEAD ASM-CYL (W/ VLV)(LH,LY7)
4	12636175	Solenoid
1	12641095	HEAD ASM-CYL (W/ VLV)(RH, LY7)
1	12634318	Oil Filter Gasket
1	12630223	Water Pump Gasket
1	12625923	Thermostat Gasket
1	12623514	GUIDE ASM-TMG CHAIN
1	12623513	GUIDE ASM-TMG CHAIN
1	12622550	Seal, Water Pump
1	12615626	SENSOR ASM-CR/SHF POSN
1	12612839	SPROCKET ASM,TMG CHAIN IDLER (LH)
1	12612838	SPROCKET ASM,TMG CHAIN IDLER (RH)
1	12608750	Seal, CR/SHF Front Oil
1	12600462	GUIDE ASM-TMG CHAIN
1	12600461	GUIDE ASM-TMG CHAIN
1	12597417	GUIDE ASM-TMG CHAIN
4	12593717	Seal, CM/SHF Pos Actuator sol vlv
1	12576263	Ex Man Gasket
1	12576262	Ex Man Gasket
4	12570326	Pin, Head Location
1	12566837	Oil Pump Pick-up Seal
2	11610796	Bolt
4	11588734	Head Bolt, Short
4	11588279	Bolt
6	11588255	Bolt
1	11588252	Bolt - HVY HX FLG HD Red Body
1	11569873	Crankshaft Balancer Bolt
1	11561751	Plug, Eng Block Oil Gallery
6	11561619	Bolt
16	11518863	BOLT,CYL HD
1	19206165	Block, Short HFV6

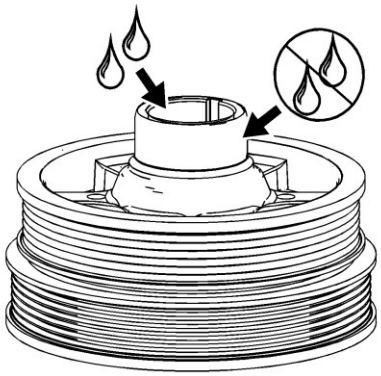
Front Balancer Installation

1) Install OHT Holding Fixture View Not Shown

2) Use the J 41998-B , nut, bearing and washer to install the crankshaft balancer

3) Apply lubricant to the inside of the crankshaft balancer hub bore

Important: Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.

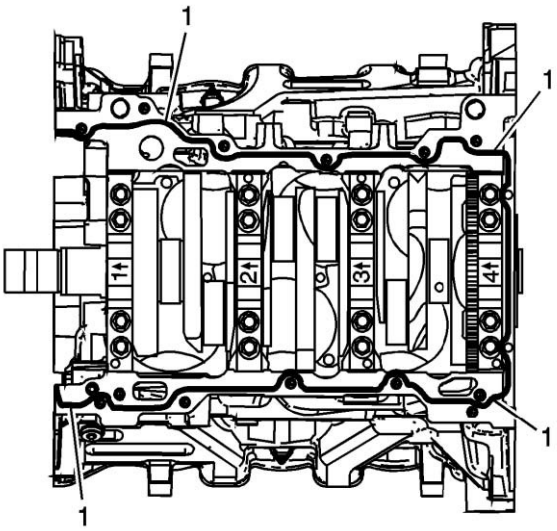


4) Place the crankshaft balancer in position on the crankshaft

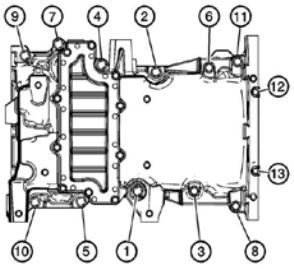
Important: Ensure the crankshaft balancer keyway is aligned with the crankshaft key

Oil Pan Installation

1) OHT6D-002-2
2) Wipe pan and block mating surfaces with a lint free cloth. The dowel pins are already installed on the short block
3) Place a 3 mm bead of RTV sealant, GM P/N 12378521, on the block pan rail and the crankshaft rear oil seal housing (1)

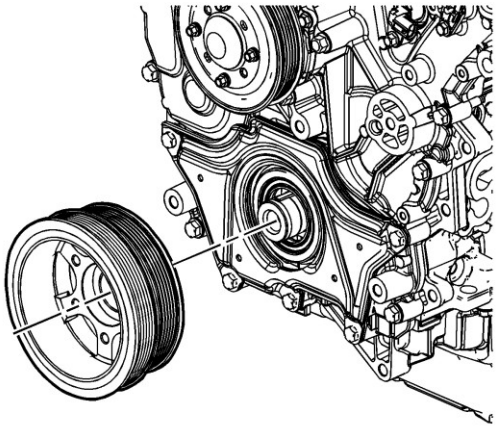


4) Position the oil pan (P/N) onto the block.
5) Loosely install the oil pan bolts.
6) Tighten the 8 mm bolts (1-11) to 23 N·m.
7) Tighten the 6 mm bolts (12, 13) to 10 N·m.



Note: View may not be representative of the VIE/F Oil Pan. Also any time the oil pan is removed and or installed, ensure the oil pickup tube “O-ring” is properly

installed.



5) Thread the J 41998-B in the crankshaft. Ensure you engage at least 10 threads of the J 41998-B before pressing the crankshaft balancer in place. Push the crankshaft balancer into position by tightening the nut on the J 41998-B until the large washer bottoms out on the crankshaft end.