Lars Grimsrud Said:

Part 1 - TIMING AND VACUUM ADVANCE 101

The most important concept to understand is that lean mixtures, such as at idle and steady highway cruise, take longer to burn than rich mixtures; idle in particular, as idle mixture is affected by exhaust gas dilution. This requires that lean mixtures have "the fire lit" earlier in the compression cycle (spark timing advanced), allowing more burn time so that peak cylinder pressure is reached just after TDC for peak efficiency and reduced exhaust gas temperature (wasted combustion energy). Rich mixtures, on the other hand, burn faster than lean mixtures, so they need to have "the fire lit" later in the compression cycle (spark timing retarded slightly) so maximum cylinder pressure is still achieved at the same point after TDC as with the lean mixture, for maximum efficiency.

The centrifugal advance system in a distributor advances spark timing purely as a function of engine rpm (irrespective of engine load or operating conditions), with the amount of advance and the rate at which it comes in determined by the weights and springs on top of the autocam mechanism. The amount of advance added by the distributor, combined with initial static timing, is "total timing" (i.e., the 34-36 degrees at high rpm that most SBC's like). Vacuum advance has absolutely nothing to do with total timing or performance, as when the throttle is opened, manifold vacuum drops essentially to zero, and the vacuum advance drops out entirely; it has no part in the "total timing" equation.

At idle, the engine needs additional spark advance in order to fire that lean, diluted mixture earlier in order to develop maximum cylinder pressure at the proper point, so the vacuum advance can (connected to manifold vacuum, not "ported" vacuum - more on that aberration later) is activated by the high manifold vacuum, and adds about 15 degrees of spark advance, on top of the initial static timing setting (i.e., if your static timing is at 10 degrees, at idle it's actually around 25 degrees with the vacuum advance connected). The same thing occurs at steady-state highway cruise; the mixture is lean, takes longer to burn, the load on the engine is low, the manifold vacuum is high, so the vacuum advance is again deployed, and if you had a timing light set up so you could see the balancer as you were going down the highway, you'd see about 50 degrees advance (10 degrees initial, 20-25 degrees from the centrifugal advance, and 15 degrees from the vacuum advance) at steady-state cruise (it only takes about 40 horsepower to cruise at 50mph).

When you accelerate, the mixture is instantly enriched (by the accelerator pump, power valve, etc.), burns faster, doesn't need the additional spark advance, and when the throttle plates open, manifold vacuum drops, and the vacuum advance can returns to zero, retarding the spark timing back to what is provided by the initial static timing plus the centrifugal advance provided by the distributor at that engine rpm; the vacuum advance doesn't come back into play until you back off the gas and manifold vacuum increases again as you return to steady-state cruise, when the mixture again becomes lean.

The key difference is that centrifugal advance (in the distributor autocam via weights and springs) is purely rpm-sensitive; nothing changes it except changes in rpm. Vacuum advance, on the other hand, responds to engine load and rapidly-changing operating conditions, providing the correct degree of spark advance at any point in time based on engine load, to deal with both lean and rich mixture conditions. By today's terms, this was a relatively crude mechanical system, but it did a good job of optimizing engine efficiency, throttle response, fuel economy, and idle cooling, with absolutely ZERO effect on wide-open throttle performance, as vacuum advance is inoperative under wide-open throttle conditions. In modern cars with computerized engine controllers, all those sensors and the controller change both mixture and spark timing 50 to 100 times per second, and we don't even HAVE a distributor any more - it's all electronic.

Now, to the widely-misunderstood manifold-vs.-ported vacuum aberration. After 30-40 years of controlling vacuum advance with full manifold vacuum, along came emissions requirements, years before catalytic converter technology had been developed, and all manner of crude band-aid systems were developed to try and reduce hydrocarbons and oxides of nitrogen in the exhaust stream. One of these band-aids was "ported spark", which moved the vacuum pickup orifice in the carburetor venturi from below the throttle plate (where it was exposed to full manifold vacuum at idle) to above the throttle plate, where it saw no manifold vacuum at all at idle. This meant the vacuum advance was inoperative at idle (retarding spark timing from its optimum value), and these applications also had VERY low initial static timing (usually 4 degrees or less, and some actually were set at 2 degrees AFTER TDC). This was done in order to increase exhaust gas temperature (due to "lighting the fire late") to improve the effectiveness of the "afterburning" of hydrocarbons by the air injected into the exhaust manifolds by the A.I.R. system; as a result, these engines ran like crap, and an enormous amount of wasted heat energy was transferred through the exhaust port walls into the coolant, causing them to run hot at idle - cylinder pressure fell off, engine temperatures went up, combustion efficiency went down the drain, and fuel economy went down with it.

If you look at the centrifugal advance calibrations for these "ported spark, late-timed" engines, you'll see that instead of having 20 degrees of advance, they had up to 34 degrees of advance in the distributor, in order to get back to the 34-36 degrees "total timing" at high rpm wide-open throttle to get some of the performance back. The vacuum advance still worked at steady-state highway cruise (lean mixture = low emissions), but it was inoperative at idle, which caused all manner of problems - "ported vacuum" was strictly an early, pre-converter crude emissions strategy, and nothing more.

What about the Harry high-school non-vacuum advance polished billet "whizbang" distributors you see in the Summit and Jeg's catalogs? They're JUNK on a street-driven car, but some people keep buying them because they're "race car" parts, so they must be "good for my car" - they're NOT. "Race cars" run at wide-open throttle, rich mixture, full load, and high rpm all the time, so they don't need a system (vacuum advance) to deal with the full range of driving conditions encountered in street operation. Anyone driving a street-driven car without manifold-connected vacuum advance is sacrificing idle cooling, throttle response, engine efficiency, and fuel economy, probably because they don't understand what vacuum advance is, how it works, and what it's for - there are lots of long-time experienced "mechanics" who don't understand the principles and operation of vacuum advance either, so they're not alone.

Vacuum advance calibrations are different between stock engines and modified engines, especially if you have a lot of cam and have relatively low manifold vacuum at idle. Most stock vacuum advance cans aren't fully-deployed until they see about 15" Hg. Manifold vacuum, so those cans don't work very well on a modified engine; with less than 15" Hg. at a rough idle, the stock can will "dither" in and out in response to the rapidly-changing manifold vacuum, constantly varying the amount of vacuum advance, which creates an unstable idle. Modified engines with more cam that generate less than 15" Hg. of vacuum at idle need a vacuum advance can that's fully-deployed at least 1", preferably 2" of vacuum less than idle vacuum level so idle advance is solid and stable; the Echlin #VC-1810 advance can (about $10 at NAPA) provides the same amount of advance as the stock can (15 degrees), but is fully-deployed at only 8" of vacuum, so there is no variation in idle timing even with a stout cam.

For peak engine performance, driveability, idle cooling and efficiency in a street-driven car, you need vacuum advance, connected to full manifold vacuum. Absolutely. Positively. Don't ask Summit or Jeg's about it – they don't understand it, they're on commission, and they want to sell "race car" parts.

Part 2 - Distributor Vacuum Advance Control Units

I've been seeing a lot of discussion and questions regarding distributor vacuum advance control units; what do they do, which ones are best, what was used on what, etc., etc. To clarify some of this, I thought I'd summarize a few facts and definitions, and provide a complete part number and specification listing for all vacuum advance control units used by Chevrolet on the points-style distributors. I'm also providing a listing of the specs for all other GM (non-Chevrolet) control units, but without the specific application listed for each (it would take me a bit too much time to research each part number by application across each of the GM Motor Divisions – it took me long enough to compile just the Chevy stuff…!). This latest revision to this paper also includes the HEI listings (the HEI distributors use a longer control unit, so the non-HEI and HEI vacuum advance control units CANNOT be interchanged).

As always, I'm going to include the disclaimer that many of these are my own comments and opinions based on my personal tuning experience. Others may have differing opinions & tuning techniques from those presented here. I have made every attempt to present factual, technically accurate data wherever possible. If you find factual errors in this information, please let me know so I can correct it.

Background

The vacuum advance control unit on the distributor is intended to advance the ignition timing above and beyond the limits of the mechanical advance (mechanical advance consists of the initial timing plus the centrifugal advance that the distributor adds as rpm comes up) under light to medium throttle settings. When the load on the engine is light or moderate, the timing can be advanced to improve fuel economy and throttle response. Once the engine load increases, this "over-advance" condition must be eliminated to produce peak power and to eliminate the possibility of detonation ("engine knock"). A control unit that responds to engine vacuum performs this job remarkably well.

Most GM V8 engines (not including “fast-burn” style heads), and specifically Chevys, will produce peak torque and power at wide open throttle with a total timing advance of 36 degrees (some will take 38). Also, a GM V8 engine, under light load and steady-state cruise, will accept a maximum timing advance of about 52 degrees. Some will take up to 54 degrees advance under these conditions. Once you advance the timing beyond this, the engine/car will start to “chug” or “jerk” at cruise due to the over-advanced timing condition. Anything less than 52 degrees produces less than optimum fuel economy at cruise speed.

The additional timing produced by the vacuum advance control unit must be tailored and matched to the engine and the distributor’s mechanical advance curve. The following considerations must be made when selecting a vacuum advance spec:

How much engine vacuum is produced at cruise? If max vacuum at cruise, on a car with a radical cam, is only 15 inches Hg, a vacuum advance control unit that needs 18 inches to peg out would be a poor selection.

How much centrifugal advance (“total timing”) is in effect at cruise rpm? If the distributor has very stiff centrifugal advance springs in it that allow maximum timing to only come in near red-line rpm, the vacuum advance control unit can be allowed to pull in more advance without the risk of exceeding the 52-degree maximum limit. If the engine has an advance curve that allows a full 36-degree mechanical advance at cruise rpm, the vacuum advance unit can only be allowed to pull in 16 more degrees of advance.

Are you using “ported” or “manifold” vacuum to the distributor? “Ported” vacuum allows little or no vacuum to the distributor at idle. “Manifold” vacuum allows actual manifold vacuum to the distributor at all times.

Does your engine require additional timing advance at idle in order to idle properly? Radical cams will often require over 16 degrees of timing advance at idle in order to produce acceptable idle characteristics. If all of this initial advance is created by advancing the mechanical timing, the total mechanical advance may exceed the 36-degree limit by a significant margin. An appropriately selected vacuum advance unit, plugged into manifold vacuum, can provide the needed extra timing at idle to allow a fair idle, while maintaining maximum mechanical timing at 36. A tuning note on this: If you choose to run straight manifold vacuum to your vacuum advance in order to gain the additional timing advance at idle, you must select a vacuum advance control unit that pulls in all of the advance at a vacuum level 2” below (numerically less than) the manifold vacuum present at idle. If the vacuum advance control unit is not fully pulled in at idle, it will be somewhere in its mid-range, and it will fluctuate and vary the timing while the engine is idling. This will cause erratic timing with associated unstable idle rpm. A second tuning note on this: Advancing the timing at idle can assist in lowering engine temperatures. If you have an overheating problem at idle, and you have verified proper operation of your cooling system components, you can try running manifold vacuum to an appropriately selected vacuum advance unit as noted above. This will lower engine temps, but it will also increase hydrocarbon emissions on emission-controlled vehicles.

Thus, we see that there are many variables in the selection of an appropriate control unit. Yet, we should keep in mind that the control unit is somewhat of a "finesse" or "final tuning" aid to obtain a final, refined state of tune; we use it to just "tweak" the car a little bit to provide that last little bit of optimization for driveability and economy. The vacuum advance unit is not used for primary tuning, nor does it have an effect on power or performance at wide open throttle.

With these general (and a little bit vague, I know…) concepts in mind, let's review a few concepts and terms. Then it's on to the master listing of specs and parts…..:

Part Number

There are many different sources for these control units. Borg Warner, Echlin, Wells, and others all sell them in their own boxes and with their own part numbers. Actually, there are very few manufacturers of the actual units: Dana Engine Controls in Connecticut manufactures the units for all three of the brands just mentioned, so it doesn't make much difference who you buy from: They're made by the same manufacturer. The part numbers I have listed here are the NAPA/Echlin part numbers, simply because they are available in any part of the country.

ID#

Every vacuum advance control unit built by Dana, and sold under virtually any brand name (including GM), has a stamped ID number right on top of the mounting plate extension. This ID, cross referenced below, will give you all specifications for the unit. So now, when you're shopping in a junkyard, you'll be able to quickly identify the "good" vs. the "bad" control units.

Starts @ "Hg

Vacuum is measured in "inches of Mercury." Mercury has the chemical symbol "Hg." Thus, manifold vacuum is measured and referred to as "Hg. The "Start" spec for the control unit is a range of the minimum vacuum required to get the control unit to just barely start moving. When selecting this specification, consideration should be made to the amount of vacuum that a given engine produces, and what the load is on the engine at this specification. For example, an engine with a very radical cam may be under very light load at 7 inches Hg, and can tolerate a little vacuum advance at this load level. Your mom's Caprice, on the other hand, has such a mild cam that you don't want the vacuum to start coming in until 9 – 10 inches Hg. For most street driven vehicle performance applications, starting the vacuum advance at about 8" Hg produces good results.

Max Advance

Since the vacuum advance control unit is a part of the distributor, the number of degrees of vacuum advance is specified in DISTRIBUTOR degrees – NOT crankshaft degrees. When talking about these control units, it is important that you know whether the person you're talking to is referring to the distributor degrees, or if he's talking crankshaft degrees. All of the listings shown in the following chart, and in any shop manual & technical spec sheet, will refer to distributor degrees of vacuum advance. You must DOUBLE this number to obtain crankshaft degrees (which is what you "see" with your timing light).

Thus, a vacuum advance control unit with 8 degrees of maximum advance produces 16 degrees of ignition advance in relationship to the crankshaft. When selecting a unit for max advance spec, the total centrifugal timing at cruise must be considered. Thus, a car set up to produce 36 degrees of total mechanical advance at 2500 rpm needs a vacuum advance control unit producing 16 degrees of crankshaft advance. This would be an 8-degree vacuum advance control unit.

Max Advance @ "Hg

This is the range of manifold vacuum at which the maximum vacuum advance is pegged out. In selecting this specification, you must consider the vacuum produced at cruise speed and light throttle application. If your engine never produces 20" Hg, you better not select a control unit requiring 21" Hg to work.

Part 3 - Vacuum Canister Part Number & Specs

The following listing (Non-HEI) is as follows: The first two part number listings are the two numbers that are most commonly used in a Chevrolet performance application. The "B1" can is the most versatile and user-friendly unit for a good performance street engine. As you can see, it was selected by GM for use in most high performance engines due to its ideal specs. The "B28" can was used on fuel injected engines and a few select engines that produced very poor vacuum at idle. The advance comes in very quick on this unit – too quick for many performance engines. Do not use this very quick unit unless you have a cam/engine combination that really needs an advance like this. It can be used as a tuning aid for problem engines that do not respond well to other timing combinations, and can be successfully used in applications where direct manifold vacuum is applied to the can (see paragraph and discussion on this above)

After this, the listing is by Echlin part number. The Chevrolet applications are listed first by application, followed by a complete listing of all of the units used on any GM product (all GM units are interchangeable, so you can use a Cadillac or GMC Truck unit on your Vette, if that's what you want to do).

Non-HEI Distributors:

P/N ID# Application Starts @ "Hg Max Adv

(Distr. Degrees @ "Hg.)

VC680 B1 1959 – 63 All Chevrolet 8-11 8 @ 16-18

1964 Corvette exc. FI

1964 Impala, Chevy II

1965 396 High Perf.

1965-67 283, 409

1966-68 327 exc. Powerglide

1967-68 All 396

1969 Corvette 427 High Perf.

1969 396 Exc. High Perf.

1969 Corvette 350 TI

1969-70 302 Camaro

1970 400 4-bbl

1970 396 High Perf.

1970 Corvette 350 High Perf.

1973-74 454 Exc. HEI

VC1810 B28 1965 409 High Perf. 3-5 8 @ 5.75-8

1965 327 High Perf.

1966 327 High Perf.

1964-67 Corvette High Perf. FI

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VC1605 B9 1965 impala 396 Exc. High Perf. 7-9 10.3 @ 16-18

1965 327 All Exc. FI

1969 327 Camaro, Chevelle, Impala

1969-70 Corvette 350 Exc. High Perf.

1969-70 350 4-bbl Premium Fuel

1970 350 Camaro, Chevelle, Impala High Perf.

1971-72 350 2-bbl AT

1971-72 307 All

VC1675 B13 1968 327 Camaro Powerglide 9-11 8 @ 16-18

1968 327 Impala AT

1968 307 AT

1968 302, 307, 327, 350 Camaro, Chevy II

1970 350 Camaro, Chevelle Exc. High Perf.

VC1760 B19 1969 350 Camaro, Chevelle, Impala 4-bbl 5.5-8 12 @ 14-18

1969-70 350 2-bbl

VC1765 B20 1965 396 Impala High Perf 5-7 8 @ 11-13

1966-67 Corvette Exc. High Perf.

1966-67 Impala 427 Exc. High Perf.

1966-68 327 Powerglide Exc. High Perf.

1969 307 All

1969-70 396, 427 Camaro, Chevelle High Perf.

1970 400 2-bbl

1970 307 MT

1973 Camaro 350 High Perf.

VC1801 B21 1971 350 2-bbl 7-9 10 @ 16-18

1971-72 400, 402

1971-72 307 AT

VC1802 B22 1971-72 350 4-bbl 7-9 8 @ 14-16

Other Part Numbers & Specs:

VC700 B3 8-10 11.5 @ 19-21

VC1415 M1 6-8 10 @ 13-15

VC1420 M2 5-7 11 @ 16-17

VC1650 B12 8-10 10 @ 15-17

VC1725 B18 8-10 12 @ 13-16

VC1740 A5 6-8 12 @ 15-17.5

VC1755 A7 8-10 12.5 @ 18-20.5

VC1804 B24 6.5-8.5 10 @ 12-14

VC1805 M13 6-8 12 @ 14.5-15.5

VC1807 B25 5-7 8 @ 13-15

VC1808 B26 5-7 8 @ 11-13

VC1809 B27 5-7 9 @ 10-12

VC1812 B30 5-7 12 @ 11.75-14

The following listing (HEI) is as follows: The first four part number listings are the 4 numbers that are most commonly used in a Chevrolet performance application. The “AR12” can is the most versatile and user-friendly unit for a good performance street engine. The AR 15 and AR23 are almost identical, with only slight variations in their “start-stop” specs. The “AR31” can is the HEI equivalent to the “B28” Hi-Perf can used on the early engines: The advance comes in very quick on this unit – too quick for many performance engines. Do not use this very quick unit unless you have a cam/engine combination that really needs an advance like this. It can be used as a tuning aid for problem engines that do not respond well to other timing combinations, and can be successfully used in applications where direct manifold vacuum is applied to the can (see paragraph and discussion on this above)

After this, the listing is by Echlin part number. All GM HEI vacuum advance units are interchangeable, so you can use a Cadillac or GMC Truck unit on your Vette, if that's what you want to do.

HEI Distributors:

P/N ID# Application Starts @ "Hg Max Adv

(Distr. Degrees @ "Hg.)

VC1838 AR12 1975 350 Buick 7-9 7 @ 10-12

VC1843 AR15 1977 305 All Exc. Hi Alt, Exc, Calif. 3-5 7.5 @ 9-11

1974 400 All w/2-bbl

1977 305 El Camino

1976 262 Monza Exc. Calif

1976 350 Vette Hi Perf, Incl. Calif

1975 350 Z-28

1977 305 Buick Skylark

VC1853 AR23 1976 350 All Calif. 5-7 7.5 @ 11-12.5

1976 350 Vette Calif., Exc. Hi Perf

1976 400 All, Exc. Calif

1975 350 4-bbl

1974 350 All w/1112528 Distr.

1978 350/400 Heavy Duty Truck, Exc. Calif, Exc. Hi Alt.

VC1862 AR31 2-4 8 @ 6-8

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VC1703 N/A 1978-79 Vette Special Hi Perf N/A N/A

1979 305 El Camino Calif.

1978-79 350 Blazer & Suburban

1979 Buick 305/350

VC1825 AR1 1976 454 Caprice, Impala 3-5 9 @ 6-8

1975 454 Caprice, Chevelle, Monte, Suburban

VC1826 AR2 5-7 12 @ 10-13

VC1827 AR3 5-7 9 @ 9-11

VC1828 AR4 1975-76 350 Buick & Olds 6-9 10 @ 12-14

1976 350 Pontiac

VC1831 AR7 6-8 12 @ 14-16

VC1832 AR8 1975-76 455 Buick Electra 4-6 12 @ 12-14

VC1833 AS1 1975-76 500 Cadillac Exc. Calif. 4-6 14 @ 15-16

VC1834 AR9 4-6 13 @ 13-16

VC1835 AS2 1975-76 350 Olds 5.5-7.5 12 @ 15-17

VC1836 AR10 1977 305 All Hi Alt, Exc. Calif. 3-5 9 @ 11-13

1977 350 All exc. Calif.

1977 350 Vette Exc. Calif, Exc. Hi Perf

1976 305 All Exc. Calif

1976 350 All Exc. Vette, Exc. Calif

1976 350 Vette Exc. Calif., Exc. Hi Perf

1975 262, 350 All w/2-bbl carb

1975 350 All 4-bbl w/ 1112880 & 1112888 Distr.

1977 305 Chev Truck Light Duty

1975-76 350 El Camino 2-bbl

VC1837 AR11 1976 305 Blazer, Exc. Calif 6-8 12.5 @ 10.5-13.5

1976 350/400/455 Pontiac 4-bbl

VC1839 AR13 4-6 12 @ 11-13

VC1840 AR14 1975-76 350/400/455 Pontiac Firebird 6-8 10 @ 9-12

VC1841 AS3 1975-76 500 Cadillac Calif. 5-7 10 @ 13-14

VC1842 AS4 1976 350 Olds Cutlass 5-7 12 @ 13-15

VC1844 AR16 3-5 12 @ 13.5-15.5

VC1845 AS5 1978-79 425 Cadillac w/F.I. 4-6 14 @ 14-16

1977 425 Cadillac

VC1846 AR17 1977 301 Buick Skylark 3-6 13 @ 10-13

1977 301 Pontiac

VC1847 AS6 1978 403 Motor Home 4-6 12 @ 12-14

1977-79 350/403 Buick LeSabre Hi Alt, Riviera, Olds

1977-79 350/403 Pontiac Hi Alt

VC1848 AR18 4-6 12 @ 9-12

VC1849 AR19 4-6 12 @ 7-10

VC1850 AR20 1977 350/400 Pontiac 4-6 10 @ 8-11

VC1851 AR21 1977-79 350 Buick LeSabre, Century 5-7 12 @ 11-13

1978-79 350 Pontiac

VC1852 AR22 77-78 305/350/400 Chev Truck, Heavy Duty 7-9 5 @ 12-14

1975-76 350/400 Chev Truck Heavy Duty

VC1854 AR24 3-5 13 @ 10-13

VC1855 AS7 1977-79 260 Olds Cutlass 3-5 15 @ 10-12

VC1856 AR25 3-6 15 @ 10-14

VC1857 AR26 3-6 12 @ 13-16

VC1858 AR27 1978-79 305 All 3-6 9 @ 11-13

1978 350 Camaro

1978 305 Chev Truck, M/T, Light Duty

1978 350 Chev Truck Hi Alt

1978 305/350 Buick & Olds

1978-79 305 Pontiac

VC1859 AR28 1979 350 Vette Exc Hi Perf 3-6 10 @ 9-12

1978-79 305 w/1103282 Distr., Incl. El Camino A/T

1979 350 Camaro, Impala, Nova, Malibu, Monte

1979 350 Suburban

1979 350 Buick Century

1978 305/350 Buick & Olds

1978-79 305 Pontiac Hi Alt.

VC1860 AR29 3-6 12 @ 10-13

VC1861 AR30 1978-79 301Buick 3-5 13 @ 11-13

1979 301 Olds

1978-79 301 Pontiac

VC1863 AR32 2-4 10 @ 11-13

VC1864 AR33 1978 305 Chev Truck, A/T, Light Duty 4.5-6.5 13 @ 11-13

VC1865 AR34 1973-74 350 Vette Special Hi Perf 3-5 15 @ 8.5-11.5

VC1866 AS8 1978-79 425 Cadillac w/carb 3-5 14 @ 13-15

VC1867 AS9 2-4 10 @ 8-10

VC1868 AR35 1979 305 Chev Truck & El Camino 2-4 10 @ 6-9

1979 305 Buick & Olds

1979 305 Pontiac A/T

VC1869 AS10 2-4 12 @ 8-11

by Lars Grimsrud

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