SURGEON GENERAL'S WARNING ABOUT BOREDOM.
Reading the following material may cause extreme drowsiness and readers are cautioned....etc., etc., blah, blah, you know the rest.

OVERVIEW CONCERNING CONSIDERATIONS FOR EVALUATION / SELECTION OF INJECTION OILS IN SEMI-MODERN TWO-STROKE MOTORCYCLE ENGINES SOLD IN THE NORTH AMERICAN MARKET. (catchy title, eh ??)

This information concerns high speed air cooled Japanese made engines produced during the period 1966 to 1976. Engine sizes varied from 50cc to 750cc piston displacement with numbers of cylinders from 1 to 3. Induction systems were of two types: piston port and rotary valve. Manufacturers concerned are Kawasaki (Autolube?) and Suzuki (Posilube, later CCI [Crankcase-Cylinder Injection]), who used the same type of oil injection systems on their bikes with injection pumps from the same manufacturer (Mikuni). These are both of the "once through" type, although both manufacturers did employ an unburned oil/gas (liquid) scavenging system in certain models toward the end of production. Yamaha is not considered as their engines used a more rudimentary injection system and Honda was not a large builder of two stroke engines during this period. Note that volume export of such bikes/engines discussed here was basically over by the end of the 1977 model year, with the exception of off-road motorcycles.

Both Kawasaki and Suzuki oil injection systems typically injected oil into the engine in two places: the inlet air tract and the crankshaft main bearing(s), regardless of induction system design. Evidently it was felt that the previously universally employed system of mixing the oil with the gasoline was unsuitable for higher engine speeds and higher crankshaft bearing loading in these more modern engines. Specific power ratings were increasing and putting unusual strains on all engine components.

The first "modern" multicylinder high output engine was a 3 cylinder air cooled Kawasaki engine with 60 HP (probably gross rated) of 498cc displacement, supplied in a motorcycle designated H1, or more popularly, Mach III. This motorcycle was released for sale in the fall of 1968. The engine featured the first production all-electronic CD ignition system with surface-gap type spark plugs and piston port induction. Rotary valve induction, which Kawasaki had been using quite successfully in their various twin cylinder engines to this point, was not used because of physical design considerations. It is interesting to note that Kawasaki's earlier production 350cc rotary valve twin produced 42 HP and thus a 500cc rotary valve engine would have been expected to produce 500/350 x 42 or ~60 HP. Kawasaki achieved rotary valve performance with a piston port design, quite an accomplishment. However the H1 engine was quite "peaky" and lacked the torque that would have been expected in a rotary valve engine of the same displacement. Nonetheless, this engine represented a quantum leap in performance at that time, when you consider a 1 litre engine in the same state of tune, by extrapolation, would have produced 120 HP. This latter figure is comparable to today's four stroke motorcycle engines with four valves per cylinder, fully programmed electronic ignitions, exotic camshaft timing and modern manufacturing methods that produce power in this range. Some modern high performance engines also include digital fuel injection. Kawasaki did produce a “one off” “square four” water cooled two stroke of about 1 litre displacement (power unknown), but chose not to proceed with production. Suzuki did produce/sell a 750cc 3 cylinder water cooled two stroke producing about 67 HP, but the engine was quite conservatively designed/ported when compared to the Kawasakis of the day.

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Emissions were also becoming a consideration and it was felt that properly metered oil injection held the promise of more uniform injection with oil going in the right amounts exactly where and when required. By reducing "over-oiling" and its resultant visible exhaust smoke caused by owners running too low (numerically) oil/gasoline ratios in an attempt to prevent piston seizures, it was hoped that two stroke engines would become more popular/saleable. Piston seizures were more common than necessary, probably in part due to poorly formulated two stroke oils and/or improper usage of four stroke oils in place of injector oils. Even at this time, "oil burning" two strokes were viewed as "unclean" because of the over-oiling practices of most owners, when compared to four stroke engines. North America had never experienced mass usage of two stroke engined motorcycles and cars, as in Europe, and this "non-exposure" helped to tilt popular opinion against two stroke engines when the Japanese started their motorcycle export campaign. The two factors that kept the two stroke engine in favour for motorcycles were: a) its performance/weight ratio, which was far superior when compared to four stroke engines of the same period, and: b) lower cost of manufacture/purchase compared to four stroke engined bikes. Oil technology had advanced sufficiently to allow such a metered oil injection system starting about 1966. All oils at this time were mineral (non-synthetic) types. Refiners had been learning to eliminate non-combustibles ("heavy ends") from their injection oils as well as enhancing the oils in other ways, probably as an outgrowth of the requirements of car/truck manufacturers.

1. Two stroke engine injection oils and their additive "packages" are faced with a variety of sometimes conflicting requirements:

a) correct viscosity for proper film strength in close tolerance bearings and for piston ring/cylinder wall sealing
b) anti-scuff/anti-seize properties to prevent premature piston skirt/ring wear/seizure
c) anti-oxidant requirements to prevent sludge formation
d) water dispersant qualities (intake air is full of moisture, in most locales)
e) anti-rust (for when the engine is not running)
f) "pumpability" through the injection pump/system in the expected temperature range
g) "burnability" is a prime consideration, with lower combustion chamber temperatures (compared to four stroke engines)
h) cleaning agent, or detergent, to keep unburned/partially burned fuel and oil from clogging up the engine
i) compatibility with elastomers

2. Keeping in mind that the injection systems are of the "once through" style and combustion chamber temperature are somewhat lower than in four stroke engines, individual additives can be used in smaller quantities than in an equivalent four stroke engine oil:

a) correct viscosity can be decided upon fairly easily by looking at bearing clearances/loads/speeds (startup/operating) and selecting a suitable base oil to give a starting point for the final product. Bearings require a certain "film strength" to operate with a minimum of friction. As well, two stroke engines rely heavily on piston ring sealing for power output and proper viscosity plays an important role in this area. Too heavy an oil will cause power loss through "drag", while too light an oil will not give proper film strength for complete ring sealing. Mineral oils tend to thicken as they get colder and thin out as they get hotter. Modern "viscosity index improver" (VII) additives can alleviate this problem. Injection systems have somewhat of an advantage here, as the oil is used only once and the reservoir is typically located away from engine heat. Thus, stable startup/operating viscosity is relatively easily maintained within a narrow range. VII's are typically used sparingly in injection oils, mainly with a view toward higher ambient temperature operation. Burnability is a consideration with "low/no ash" base oils favoured. Viscosity of injection oils is typically in the range of SAE 20 - 25.

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b) anti-scuff/anti-seize properties are usually taken care of by the same additive. Care must be taken to include just the right amount so as not to increase deposits mentioned in 1.g. This additive must be capable of being as completely burned as possible to lower visible and invisible emissions as well. Another consideration is deposition in bearings, thus reducing tolerances there. These additives are usually considered "secret" by refiners, but typically include some type of zinc based anti-wear compound.
Piston/ring/cylinder clearances (hot/cold) are major considerations here. Also boundary lubrication conditions must be considered, as air cooled engines have less consistent temperatures throughout the whole cylinder wall. Temperature stability in a mobile air cooled two stroke engine is devoutly desired but seldom achieved for a variety of obvious reasons. Localized "hot spots" can cause lubrication failure if this additive/amount is not carefully selected. Highly tuned two stroke engine power output is influenced quite strongly by engine temperature.

c) again, anti-oxidant additive technology for oil has been known and proven for at least 40 years, so only the quantity and burnability have to be decided on. Once-through usage alleviates the main problem of "sludging" but oil stored in the injection system for long time periods and remnants in various engine areas/components must be considered.

d) water dispersant additives are quite well developed at this time. The only decision is the amount, with consideration of the range of water loading (relative humidity) in the inlet air stream and, again, burnability.

e) anti-rust additives follow the same considerations as 2.c and d. Since the engines under consideration use close tolerance alloy steel ball/roller bearings extensively in crankshaft construction as well as cast iron cylinder liners and cast iron piston rings, any rust formation in/on any of these parts can cause serious problems.

f) consideration must be given to the fact that the injection pump, for a given throttle opening and engine speed, pumps at a fixed rate, so viscosity changes in the injection oil have a direct effect on the amount of oil delivered to the engine. See also 2.a.

g) burnability is a prime consideration for a variety of reasons. The additives mentioned above must do their normal jobs but must also be capable of being burned as completely as possible with the least amount of visible and invisible pollution. They must be of a low/no ash type so as not to form deposits that cause spark plug fouling, compression changes due to piston crown deposition, exhaust port/pipe restriction/blockage or piston ring sticking/seizure in the ring groove during/after combustion. All additives are selected with the burnability foremost in mind.

h) detergent technology is also quite well known nowadays. Considerations are, again, quantity and burnability. Detergents are also required to "clean up" after the other additives have done their respective jobs. The detergent, though, must not interfere with the anti-rust additive. If the additive package can be sufficiently small in quantity to start with and is suitably low in ash content after use, then the detergent's job is relatively simple.

i) elastomers (o rings and lip type seals) are used quite extensively in two stroke engine crankshaft design for crank chamber sealing. The effects of the commonly used base oils and additives was quite well known as to their impacts on elastomers and no problems (i.e. swelling, disintegration, abnormal wear) were experienced at this time.

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3. Modern synthetic injector oils have some important advantages over mineral based injector oils:
a) more accurate initial viscosity due to more homogenous base oils because of man-made molecules versus naturally occurring complex mixes of molecules in mineral oils, thus more consistent film strengths that are also “slipprier”
b) ability to withstand higher temperatures ("hot spots") in all engine areas
c) ability to stay more closely "in grade" during temperature changes lessens the requirement for VII additives
d) naturally occurring detergency also lessens the requirement for such additives, when compared to mineral oils
e) little/no oxidation effect experienced as oxygen typically will not combine with synthetic molecular structure, so, again, less additives are required

4. Four problems, however, arise when using modern synthetic injector oils in older engines:

a) in older, original engines, the higher detergency of synthetics leads to a condition of “dirt washout” where deposits left by previous usage of mineral oil in sealing areas are removed by the synthetic oil thus leading to leaks, both gaseous and liquid.
b) elastomer compatibility has been a problem with some earlier elastomers in combination with early synthetics. The synthetic oil manufacturers have modified their oils to cater for this and the problem has all but disappeared.
c) low friction synthetics will sometimes reduce the friction necessary for proper break-in of new piston rings. Evidence suggests that new rings be broken in with a mineral injection oil. This problem needs more study at this time.
d) oil compatibility/miscibility for mineral vs. synthetic oils was a problem with the early synthetics. This has now been overcome for the most part.

Please also keep in mind, if you own a two stroke bike from this period, that the original injection pump was designed to supply oil at a 20:1 ratio, which was great for the mineral oils of that era. Modern injector oils, both mineral and synthetic, are far better at their job than the oils of yesterday and thus can be injected at rates as lean as 50:1 in some cases. Using modern oils with injection pumps set for twice the delivery rate necessary can result in a lot of visible pollution as well as lots of unburned oil/gas mixture lying in the exhaust system or even being thrown out the back of the mufflers. You should consult with the oil manufacturer of your choice as to the optimum ratio for your particular bike and then adjust the injection pump accordingly. It helps greatly to have a graph of the injection pump output performance at various engine speeds and actuating arm angles when discussing the subject with oil manufacturers. You can also use the empirical method of adjusting the pump leaner while performing multiple spark plug and muffler baffle inspections until you are satisfied with the results. This method is best used by someone thoroughly familiar with the procedure. Severe engine damage can result if the injection system is leaned out too much.

Sources: various refiners lubrication hand books/manuals, 30 years actual experience, a little hearsay

Of course, this could be a complete load of balls, too, as the Brits say. LOLOLOLOL

Nonetheless,